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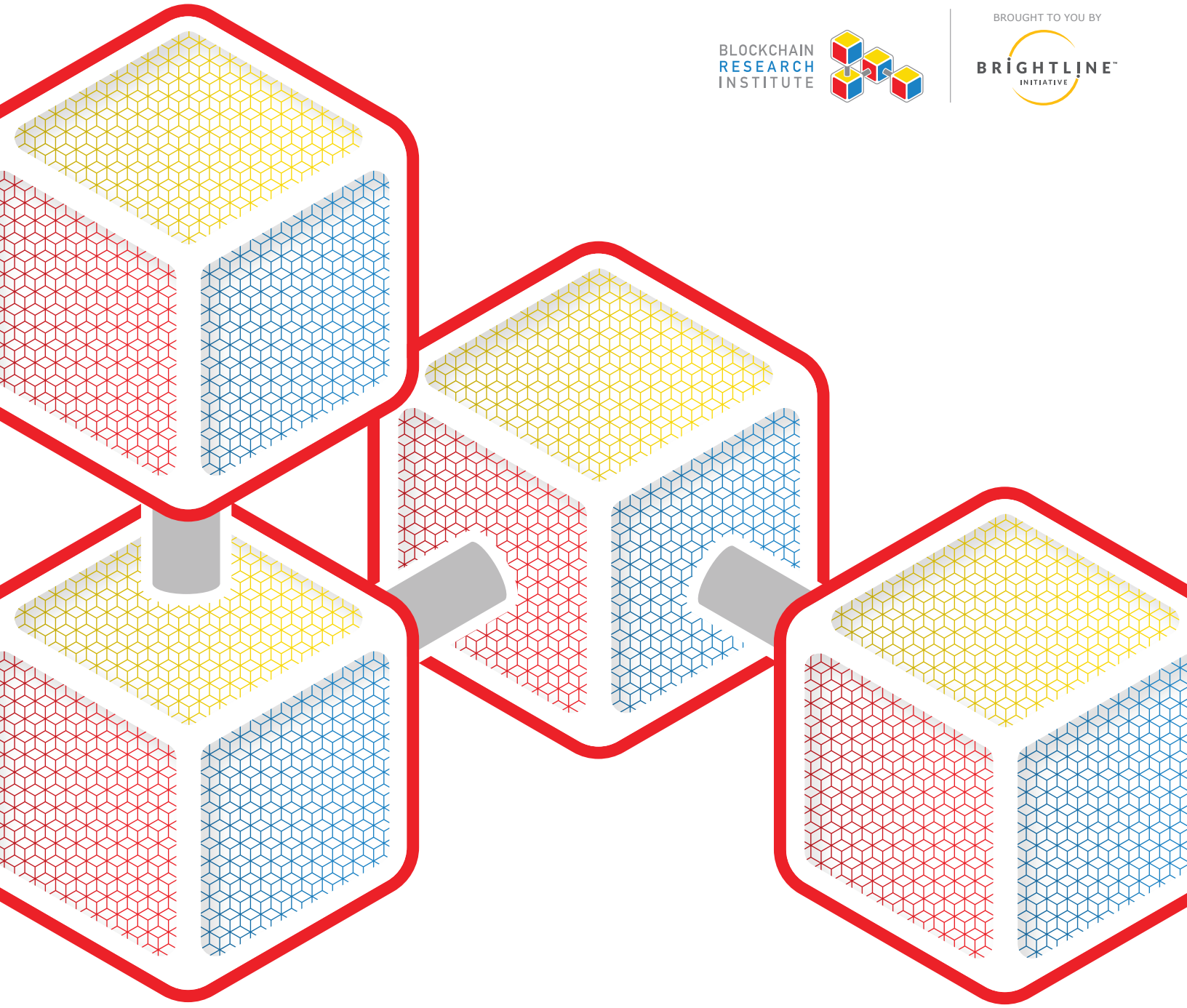


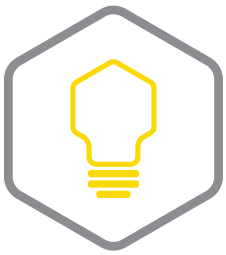
BLOCKCHAIN TAKES OFF

How Distributed Ledger Technology Will Transform Airlines

Chami Akmeemana
Blockchain Learning Group

October 2017

A BLOCKCHAIN RESEARCH INSTITUTE BIG IDEA WHITEPAPER



Realizing the new promise of the digital economy

In 1994, Don Tapscott coined the phrase, "the digital economy," with his book of that title. It discussed how the Web and the Internet of information would bring important changes in business and society. Today the Internet of value creates profound new possibilities.

In 2017, Don and Alex Tapscott launched the Blockchain Research Institute to help realize the new promise of the digital economy. We research the strategic implications of blockchain technology and produce practical insights to contribute global blockchain knowledge and help our members navigate this revolution.

Our findings, conclusions, and recommendations are initially proprietary to our members and ultimately released to the public in support of our mission. To find out more, please visit www.blockchainresearchinstitute.org.

Blockchain Research Institute, 2018

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Message from the Executive Director

We are excited to share this research on blockchain technology as a result of an exclusive partnership between the Brightline Initiative and the Blockchain Research Institute, the leading knowledge network on the study of the strategic implications of blockchain in organizations, industries, and our society.

The Brightline Initiative is a coalition led by the Project Management Institute, together with leading global organizations dedicated to helping executives bridge the expensive and unproductive gap between strategy design and delivery.

In this research project, Chami Akmeemana—CEO of Blockchain Learning Group and Blockscale Solutions—looks at innovation to improve the passenger experience in terms of ticketing efficiencies, frequent flyer rewards, luggage chain of custody, and passenger compensation. He also explores how the airline industry could use blockchain technology to improve crew flight bookings, aircraft maintenance-repair-overhaul, safety record keeping, charter flights, and cargo handling and customs clearing.

We continue our mission to develop and share thought leadership and best practices on different topics related to strategy implementation. We hope this research can help senior leaders to increase their knowledge and understanding of blockchain technology, and how they can use it to overcome challenges and improve their success in implementing strategy.

RICARDO VIANA VARGAS
Executive Director
Brightline Initiative

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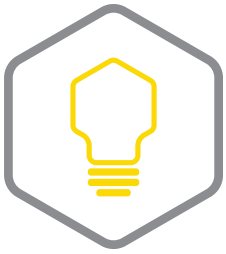
Foreword



The airline industry is surely one of the toughest. Historically, incumbents have been plagued by razor thin profit margins, high risk, unpredictable fuel and labor prices, and new challengers with disruptive business models. It is also subject to exogenous events like terrorism, capricious government actions, or natural disasters such as the April 2010 closing of the European air space because of a volcanic eruption in Iceland. With social media, any mistake makes headlines or goes viral.

As a result, many airlines have failed or been acquired. The top three US survivors—American Airlines, Delta, and United—have all faced bankruptcy at some point. Perhaps because of these challenges, it is an industry driven to innovation. I remember collaborating with the legendary chief information officer of American Airlines, Max Hopper, who pioneered the development of the semi-automated business research environment—SABRE, for short—a computerized reservation system. Since then, there have been numerous major advances in operations (e.g., yield management) and aircraft technology.

Chances are you're like me and spend a lot of time on airplanes. So the prospect of deep improvement in the airline industry is a welcome one. It turns out that blockchain will enable a whole new set of possibilities for passenger services, business processes, new revenues, and industry-wide problem solving. It may well be that blockchain is the most significant development for airlines since the introduction of the computer.

This is the first of our industry-specific whitepapers. We're delighted that Chami Akmeemana has taken on this project. Chami is a founder and board member of the Blockchain Association of Australia. He focuses on several important areas.

First, he looks at innovation to improve the passenger experience in terms of ticketing efficiencies, frequent flyer rewards, and passenger compensation. Second, he examines how blockchain can bring airlines and their partners much closer together. Third, he explores areas where blockchain can revolutionize logistics—from crew flight bookings, maintenance, and safety record keeping, to maximizing the capacity of charter flight, and addressing inefficiencies in cargo, customs, and clearing. Finally, he makes a number of recommendations that airline executives and their industry partners will find valuable.

As blockchain itself takes off, the airline industry should, too. Chami's lucid work shows how.

DON TAPSCOTT
Co-Founder and Executive Chairman
Blockchain Research Institute

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Idea in brief

- The airline industry is ripe for disruption from unexpected competitors and innovative applications. Blockchain's potential for changing the method of doing business is enormous for the modern airline, whether a newcomer to the game or an established operator.
- Executives should be examining this technology as a means of addressing regulatory requirements, customer expectations, and such external factors as the price of oil, labor costs, and even the weather, all of which affect industry performance.
- Blockchain shows promise for providing critical capability across the airline industry—not just minimizing points of pain but also allowing business model innovation.
- Blockchain can improve any airline process that requires custody and escrow, data reconciliation, identity management, provenance, settlement, and triple entry accounting. The animating power of smart contracts, distributed applications, and easy access to huge amounts of data will help to boost the bottom line.
- Airline operations could profit from targeted testing of blockchain technology to reduce costs, improve safety and security, coordinate with partners and regulators, and improve employee and customer satisfaction.

The words blockchain and bitcoin are often interchanged in conversation and, though they are related terms, blockchain is the technology that is relevant to business operations.

The new potential: Blockchain is more than bitcoin

The words *blockchain* and *bitcoin* are often interchanged in conversation and, though they are related terms, blockchain is the technology that is relevant to business operations. A global peer-to-peer network, blockchain is open and distributed, secure and unalterable. It enables both the creation of value and the trading of value using distributed ledger technology (DLT) and can enable other technology capabilities, including artificial intelligence, robotics and the Internet of Things.[1] It allows the creation of systems that connect organizations that may not trust each other, and brings them to consensus for operations. Through a data structure that contains a chain of proofs that must hold true, the blockchain verifies a history of transactions and verifies that the data has not been altered or tampered with. Blockchain technology ensures the integrity of the data in the structure.

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Bitcoin, perhaps the best-known of the digital currencies, is one of many applications that utilize the blockchain platform. Cybercurrency is a disruptive agent in the financial world. Cybercurrency's volatility, along with some notorious hacking scandals, has raised concerns about the technology. The hacks, however, are weaknesses not in the blockchain but in the exchanges that use it. The need for careful system design and operation is underscored by these early stumbles in the realm of cybercurrency.

Contracts are the defining structure of modern commerce; controlling economic, legal and political systems as well as social structure. With blockchain, the digital world is becoming the repository of data and transactions of all types. Blockchain sits atop the Internet as a peer-to-peer network of secure data exchange. As foundation technology, it could support a range of applications that meet economic and social needs for secure transactions.

A network with only one member is not yet a network, and a network that includes only parts of an ecosystem does not serve the system.[2] Nevertheless, there are many areas of exploration to utilize this important new tool. Airlines represent an interesting example of an industry made up of many related parts that could benefit from the streamlining and security that blockchain applications could provide.

With an average of only $7.54 profit per passenger carried, airlines are very vulnerable to external factors such as the price of fuel, labor costs, and regulatory changes.

Under pressure: The issues facing the airline industry

Airlines with onerous regulatory and compliance requirements are large in complexity, if not always in scale, and their operations are geographically dispersed (only five countries in the world—all European microstates—lack an airport[3]). In addition to government regulation, there are industry watchdogs assuring safety and oversight [e.g., International Air Transport Association (IATA) and International Civilian Aviation Organisation (ICAO), the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA)].

With an average of only $7.54 profit per passenger carried, airlines are very vulnerable to external factors such as the price of fuel, labor costs, and regulatory changes.[4] Low cost carriers and ultra-low-cost carriers undercut ticket pricing by offering restricted service and flying point-to-point routes that avoid the traditional hub-and-spoke routes of full service carriers. Next-generation aircraft have lowered operating costs and expanded competition in the long-haul market.

More travelers are booking through search engines and travel websites that find the lowest price for a given route. Airlines using existing global distribution services (GDS) are facing rising prices for their support. Data analytics is expensive, and the data giants

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like Google impose costly subscriptions for the granular data most airlines believe they need to be competitive. In a lowest-price-wins marketplace, full service carriers are losing market share to enterprises that can adapt, find operational cost savings, and offer acceptable customer service.

From conference calls to augmented reality, virtual meeting technologies are reducing the need for business travel. These new services facilitate conversations and virtual collaboration and shrink corporate travel budgets.

The largest airline operators have consolidated and built up systems over decades, and rely on legacy technologies for many parts of their operations, including passenger information, flight scheduling, security, and maintenance. The new kids on the tarmac do not have the legacy IT or union contract burdens of existing carriers, and can leapfrog the limitations of the incumbents to provide an enhanced or cheaper product or service.

Plenty of external factors put airlines under immense pressures. Advances in technologies have the potential to improve every facet of the customer experience and airline operations, and boost the bottom line for operators of all sizes.

Blockchain is the second era of the Internet.

Digital technology could change the world… again

In the early 1990s, when the Internet first emerged as a new technology, it was perceived as a messaging channel. That assumption quickly changed. The decades that followed saw the Internet become the foundation for the 21st century digital economy.

Blockchain is the second era of the Internet. While Internet hacks, trolls, security breaches, and the inability to protect data privacy have limited many transactions and impeded collaboration opportunities to date, blockchain offers the ability to ensure the integrity and privacy of data and protect value exchanged among an unlimited numbers of users via a global peer-to-peer network[5].

Today’s emerging technologies are breathtaking in their glamour and capabilities, moving us rapidly toward the world that existed in science fiction movies of only a few years ago. All of these technologies are vying for attention, development, and budget. In the competitive landscape of the airline industry, few organizations can afford to invest in all these ideas at the same time.

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Smart contracts

In 1994 when the World Wide Web had only about 10,000 sites, Nick Szabo, an American cryptographer, first proposed the concept of smart contracts.[6] Contracts are the traditional manner in which relationships are formalized. There are marriage contracts, property contracts, and performance contracts. The fundamental components of a contract are:

Observability: all parties to the contract can see the other parties and their performance.

Verifiability: the ability to prove (or disprove) that a contract has been fulfilled.

Privity: Only the parties to the contract, and trusted third parties, will have knowledge and control over the contract and only a dispute will break the trust.

Enforceability: as simple as preserving one's reputation, or as complex as contract law and economics.

According to Szabo's vision, smart contracts can provide all the components of more traditional contract arrangements. They digitally transmit information and execute certain types of decisions. Smart contracts secure, enforce and execute the settlement of agreements between people or organizations and, through blockchain, can provide built-in controls, settlement and enforcement.[7]

The reduction in size of sensors and the geometric increase in connectivity enable aircraft, airports, and passengers to create more and more data points.

Prioritizing the opportunities of technology

From the most mature of the latest technology enhancements—and therefore the easiest to adopt—to beyond-the-horizon ideas, there are many innovations coming to the table.

Internet of Things, big data, and analytics

in size of sensors and the geometric increase in connectivity enable aircraft, airports, and passengers to create more and more data points. Analytics scans the data to evaluate past performance and predict future events. For example, a sensor tripping in an engine would be detected without raising alarm, but when additional sensors trip, in a repeatable way, it creates an alert for maintenance. This could prevent an expensive flight cancellation, diversion, or even downtime for major maintenance due to failure.[8]

Machine learning and artificial intelligence

Teams of people, with access to reams of historical data, would require months or years to synthesize and process value from that data, whereas advancements like IBM's Watson can achieve the same result in minutes. A severe weather event or an airport ground stop can trigger costly disruptions to schedules and leave equipment, passengers, cargo, and crew out of position. An AI system to process real time data and present a path to return to normal operations is on the wish list for every operator.

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Three dimensional, virtual/augmented reality and motion tracking

In May 2017, IATA introduced RampVR, the first virtual reality-training program for ground crews. Next is augmented reality to transform the workflow of technicians.[9] These technologies overlay critical information in an operator's field of vision and enable the operator to manipulate data in order to identify and address issues on the fly, thereby preventing downstream disruptions. The cumulative effect on crew hours or airport curfews, flight cancellations, and aircraft out of position should be positive.[10]

Drones have the potential to disrupt supply chains in a multitude of industries.

Drone technology

Unmanned aircraft are already in use by modern militaries, and drones have the potential to disrupt supply chains in a multitude of industries. It may be a some time before the flying public buy tickets on a pilotless aircraft, but cargo carriers might find ways to adopt this technology in a shorter timeframe. Meanwhile, a single-person cockpit with a ground-based first officer who could "fly" second in command on a number of flights simultaneously is being explored.[11]

Robotics, renewable energy and energy storage

As more powerful batteries are reduced to small- or even micro-size, large computational systems can be built at a scale that fits in a pocket. Autonomous robots with baggage and cargo movement simplified and tracked by sensors could streamline ramp operations.

Solar powered, self-driving ground vehicles could revolutionize ground movement at airports. Aircraft taxiing managed by robotic electric tugs, which deliver the aircraft to the active runway for take-off and collect the aircraft after landing, could reduce fuel costs. Robotic transports would be aware of other traffic and runway status and layouts, simplifying air traffic communication.

Wearable and nanotech

More sophisticated and capable computers are appearing in previously unimagined places—even internally. Airlines could monitor crew fatigue, crew position, perhaps even crew fitness to fly.

Airlines could monitor crew fatigue, crew position, perhaps even crew fitness to fly.

Quantum computing

Aircraft and airlines generate large quantities of data, and having the ability to process this wealth of information using faster computers could transform how airlines mine those data to find a competitive edge.

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Though many of these ideas are still years or longer in the future, we may be surprised to see the development timelines shorten as new capabilities come on line. Blockchain-based ideas may be closer to reality than many realize.

Making the case for blockchain

The features of blockchain technology include:

- Immutable record
- Data security
- Single source of truth
- Business logistics and automation with smart contracts
- Provenance of assets
- Trans-border potential
- Lower transaction costs

The potential for streamlining, creating lean, smooth processes, and reducing manual checks and balances, combined with the power of smart contracts and distributed applications, and easy access to huge amounts of data, will improve the customer experience and the bottom line for airlines.

Blockchain applications have the potential to provide a common protocol that will allow airlines to link seamlessly with partners and vendors, to automate and reduce friction in business processes and provide a platform for additional revenue.

Blockchain can affect a process that requires one or more of the following:

- Custody/escrow
- Data reconciliation
- Identity management
- Provenance
- Tokenization
- Settlement
- Triple entry accounting

Blockchain applications have the potential to provide a common protocol that will allow airlines to link seamlessly with partners and vendors, to automate and reduce friction in business processes, and provide a platform for additional revenue.

Blockchain opportunities for airlines

Moving passengers and commodities from one place to another is the stock in trade of the airline industry. Blockchain integration could help the airlines to offer customers more secure and reliable service, improve satisfaction, and generate ancillary revenues through better loyalty programs or onboard services.

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The distributed ledger technology (DLT) of blockchain can improve transactional flows, assure trust, and provide an immutable record. In the global war on terrorism, airlines are increasingly on the front line of passenger identification and verification as well as protecting passengers from harm. In the competitive framework of the travel industry, airlines are in a constant battle for travel revenue and customer loyalty.

Increasing security: Tamperproof systems

Increasingly sophisticated security.

Airlines, like all 21st century enterprises, face a spectrum of security pressures, from ever-more-sophisticated cyber-attacks to outright terrorism. With the expansion of connectivity, on-board challenges to security grow along with threats from the cyber world. As equipment and material are increasingly connected, more and more elements of operations could be vulnerable to hacking. Overprivileged SmartApps have already been shown to open vulnerabilities to hacking that demand design considerations.[12] Air travel is at the frontline of preventative measures in the war against global terrorism. Increased security checks and passenger identification continue to play a primary role in the modern flying experience.

The distributed ledger technology (DLT) of blockchain can improve transactional flows, assure trust, and provide an immutable record.

Verifying identity: The digital ID

Related to security is the ability to create digital identities for passengers, pilots, airport personnel, equipment, and even parts of an aircraft.

> *With the blockchain, implemented correctly, you have the means to use the information that you want to share with anyone globally at any location in the world, yet be able to maintain user privacy by keeping the raw data on their personal devices or mobile devices. That's going to revolutionize the way that we deal with identity and identity management.*[13]
>
> Armin Ebrahimi, CEO and founder, ShoCard

Each unique digital ID is associated with a unique entity; and, as in the real world, there are interactions between the entities. For example, an individual has personal facts such as education, job credentials, past purchases, travel and hotel reservations, and so on. Each of these transactions could be digitized and entered on a blockchain. For an individual, this creates a timestamped web of transactions that would be impossible to alter or fabricate because of the interconnected nature of the blockchain. Any attempt to do so would be rejected by the other nodes in the network and the fraudulent data would not be written to the chain.

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Streamlining operations and simplifying relationships

Passenger preparation and processing

Anticipated growth in passenger numbers means the existing problem of reliable passenger identification is going to become continually burdensome. With heightened concern over safety, even a small failure in airline and airport security can have deadly consequences.

The ability to identify a passenger quickly and securely has numerous benefits:

- Details can be verified when a reservation is made, thereby reducing some manual checks by TSA or border agents, reducing errors, and shortening queues.
- Customer requirements—such as special assistance, wheelchairs, or dietary needs—could be communicated in a data bundle.
- Airlines could customize offers to potential customers based on known preferences, such as city breaks or family connections, and secure the business before getting into a price war with other airlines in traditional booking systems.
- Revenue integrity is threatened by inauthentic bookings. Glitches and duplications mean empty seats and missed revenue. Associating each booking with a digital ID ultimately leads to fuller flights and more profitability.

With heightened concern over safety, even a small failure in airline and airport security can have deadly consequences.

Overbooking

There are often more ticketed passengers in the waiting area than there are seats on the departing aircraft. The flying public, however, believes "I have paid for this seat. Therefore, it is mine!" Here are some of the more common reasons why an airline has too few seats:

- Flight cancellations, weight restrictions, technical problems, weather, or ticketing system glitches
- Passengers who miss connections and fly on the next available flight
- Rebooking of late or delayed passengers
- Passengers who lack visas and must return to point of origin
- Passengers who have flexible tickets and can change their travel plans at the last minute
- Repositioning and "dead-heading" of personnel

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To ensure full flights, some airlines overbook. With the margins so low, every full seat counts. When all the booked passengers on an overbooked flight arrive at the airport with reservations, the gate staff must manage passenger accommodation. Costs can climb as travelers become savvier to compensation techniques and demand more for denied boarding.

Digital IDs will allow reservations to relate automatically to loyalty programs, giving airlines a much clearer picture of their customers and opening new revenue opportunities.

The best case for the overall profitability of the airline would be that every seat is full and no one who holds a ticket is turned away. Airlines walk a fine line between maintaining schedules, handling weather, airport ground stops, and technical issues, while maximizing capacity and maintaining customer loyalty. Blockchain will help ease the burden on the airline in a number of key areas:

- Speeding up checks at security check points
- Ensuring that passengers have the correct paperwork prior to boarding
- Improving booking integrity to avoid false and duplicate bookings

Loyalty programs

Digital IDs will allow reservations to relate automatically to loyalty programs, giving airlines a much clearer picture of their customers and opening new revenue opportunities.

Rich data on enterprise customers and partners resides in siloed systems throughout the industry. If an organization can design a way to merge the data with the transactional records on the blockchain, it would certainly provide efficiencies and time and cost savings in this low margin industry. The challenge is to justify the time and cost expenditure to make blockchain applications a reality.

One possible area to use as a proof of concept could be loyalty programs. The first use of a blockchain was to power a non-government issued currency, namely bitcoin. Airlines have been using non-government issued currency for years: loyalty miles. Were air miles to be tokenized on the blockchain, passengers could pay for goods and services in a secure system without needing third party involvement of credit card processing. Just as the air miles programs permit now, tokens could be purchased for future use, or exchanged for goods other than tickets.

Currently there are some 17.5 trillion unused air miles and airlines are working to reduce the liability exposure.

Points that accumulate and remain unused become a liability for airlines. Currently there are some 17.5 trillion unused air miles and airlines are working to reduce the liability exposure by increasing the number of points needed for redemption, building in expiration dates, or promoting use of the points for gifts and services rather than airfare.[14] One start-up has broken into the loyalty program area with an application that sits outside the airline systems, and offers the benefits of the blockchain functionality.

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As loyalty programs have proliferated across industries—retail, financial services, and other sectors—the average household now holds membership in up to 29 different programs. That's over three billion membership accounts![15] Early adoption of this disruptive entry to the loyalty market might help program owners to relieve the accounting pressure of the unredeemed earnings, while offering benefits to customers across other redemption channels, all the while improving their own customer-knowledge and testing the utility of a blockchain solution. Ultimately, the merging of programs under a major anchor airline or hotel chain, could add to the customer experience (Figure 1).

One of the benefits of cryptocurrency was the removal of the central authority for processing payments along with the extra costs for processing.

One risk in cooperative programs is the pooling and sharing of data, which will give early adopters an advantage in controlling the form. Just as online travel agencies disrupted the way consumers book their flights (costing the airlines dearly in fees and subscription costs), the disruptors in the loyalty arena could outrun the program operators by establishing solutions that will cost the airlines membership and fees.[16]

Branded tokens, not co-branded credit cards

Many airlines issue co-branded credit cards to make ancillary revenues from the transactional costs and the interest on outstanding balances. In today's world, banks and credit card companies charge a percentage of sales from sellers to provide them the ability to accept customers' credit cards for payments. One of the benefits of cryptocurrency was the removal of the central authority for processing payments—the so-called "trusted third party"—along

Figure 1: Improving the passenger experience

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with the extra costs for processing. Just as bitcoin has disrupted the currency sector, airlines could replace the credit card intermediary with a blockchain application.

One of the benefits of blockchain transactions is the potential for considerably lower costs. However, these transactional costs are linked directly to the underlying value of the tokens; the more the token is worth in fiat currency, the higher the transactional costs are likely to be. A flat rate for transaction processing would make it possible for airlines to generate ancillary revenues from micro-transactions. Credit card processing fees are a disincentive for low-value sales. The low transactional costs of a blockchain solution might tempt airlines to explore the ancillary revenue potential for on-board refreshments, entertainment and services that were not economic in a credit card world. With minimal targets, say $5 per flight, a typical Tier II airline operating around 600 flights per day could generate an additional $1 million in revenue over the year.

Airlines could replace the credit card intermediary with a blockchain application.

Luggage chain of custody

Luggage loss rates are at historic lows and continue to decline year-on-year. Nevertheless, the current number of bags mishandled according to SITA is 5.73 bags per 1,000 passengers for a total of 21.6 million cases.[17] From a passenger point of view there is no tool to track personally their luggage once it has been checked in at the origin airport (although personal sensors with smart-phone connectivity are coming on the market, as are RFID solutions for airline-supplied bag tags). Only on arrival does the passenger realize there is a problem. By then, the week's wardrobe could be anywhere.

Typically, there are three types of baggage issues:

1. Stolen bags
2. Bags or their contents are damaged or destroyed
3. Bags delayed by baggage handling infrastructure at the airport, missed connection, or weight restriction

Using blockchain for tracking, a baggage tag is scanned throughout its journey; and, at key points, the baggage-handling software would write an event to the blockchain recording a hand-off.

In a possible blockchain-enabled scenario, a bag is dropped off at check-in, where custody is accepted by the airline, which then loads the bag onto the plane. In a multi-leg trip, the luggage changes from one airline via the intermediate airport to the next airline. If the airport uses contractors for baggage handling, this adds to the chances for a problem.

Using blockchain for tracking, a baggage tag could be scanned throughout its journey; and, at key points, the baggage-handling software could write an event to the blockchain recording a hand-off. An app could confirm the data from the blockchain and deliver real-time updates to the customer's smartphone. For luggage that is damaged or destroyed, smart contracts could be written to automatically trigger compensation pay-outs.

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Passenger compensation

As we have seen lately, airlines are having a rough time in the media regarding customer experiences and questions raised over the rights of passengers. The European Parliament has been a strong advocate for passenger rights and levels of compensation. The EASA (European Aviation Safety Agency) mandates that, should a flight be severely delayed, canceled, or otherwise interrupted, the airline will pay the passenger a set compensation.[18]

For an airline canceling a long-haul flight, the regulatory requirement might result in a compensation of up to €600 per passenger meaning a cost of €150,000-€180,000 depending on the type of aircraft and seat configuration. There is pressure from lobby groups in North America and around the world to make airlines more accountable to their passengers by adopting a similar passenger charter. It may be that the regulatory authorities, such as the FAA governing the US airline industry, could demand that compensation events happen automatically by using blockchain-based smart contracts.

Regulatory authorities could demand that compensation events happen automatically by using blockchain-based smart contracts.

One proof-of-concept test of a compensation application was recently launched as a Dapp on the Ethereum mainnet.[19] The application being tested was a travel insurance offer that compensated customers for late arrivals using data garnered from flightstats.com. While the outcome of the test revealed some flaws and bugs, the general result was very positive.

> *Through an entry form, what previously required, and still, currently, requires, whole insurance departments and even skyscrapers, is turned into just 1s and 0s.*[20]
>
> Andrew Quentson, CryptoCoinsNews

In North America, the airline community is opposed to considering adopting a passenger charter and has lobbied the US government to avoid implementing a similar manifesto. However, should regulations be imposed on the industry by a disgruntled public, the blockchain solution could be a simple way to work through a mandated compensation requirement.

> *Flight delay insurance has a few interesting properties which make it a perfect use case for implementing what the insurance industry calls "parametric insurance" in a smart contract: Short term risks (a few days to weeks), wide availability of data to calculate risks and trigger payout events, and (relatively) small premiums and payouts.* [21]
>
> Stephan Karpischek, co-founder of Etherisc, a project focused on building a platform for decentralized insurance applications

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An airline is not an island: Bringing airlines and partners closer

Operation of a modern airline company is completely reliant on partners, vendors, and ground operations to function safely. From initial purchase or lease of an aircraft, through ongoing maintenance, to working with airports, regulatory authorities and governments as well as the passengers, many places in the industry are candidates for applications to streamline and automate as well as collaborate. Trust of data between many parties is a critical component.

With millions of dollars on the line it is absolutely worth ensuring that the plane is genuine and as advertised.

Aircraft ownership and wet leasing

With millions of dollars on the line it is absolutely worth ensuring that the plane is genuine and as advertised. Buying a plane is a laborious and time-consuming process, consisting of due diligence and careful checks as paper records are located, authenticated, and referenced back to the aircraft where necessary.

The records maintained on an aircraft start as the plane is being assembled. This record could be referenced on the blockchain and the manufacturer could track and record every component fitted to the aircraft, thus providing complete part and module provenance. Records of assembly and transfer of ownership could also be written to the blockchain as part of a smart contract on consummation of the purchase agreement.

Aircraft ownership and transfer are examples of bureaucratic processes that can be streamlined. Smart contracts provide a rapid and lean process, handled by smart contract logic with the final transaction also recorded on the blockchain. This is especially useful for wet lease or part ownership situations where additional contractual stipulations need to be recorded and upheld. Another advantage of smart contracts on a blockchain is the ability of an airline operator to respond to short-term capacity fluctuations by completing a wet lease agreement in a shorter period.

Ensuring part provenance is essential to safe operation.

When the time comes for the aircraft to be re-sold by the airline, the historical data—parts provenance, history, maintenance, and repair records—are available to a prospective buyer. Because of the immutable nature of the blockchain, the information cannot be falsified after the fact. This simplifies due diligence and reduces administrative costs. As the industry learned with the Partnair Flight 394 incident in which an unapproved part was the cause of the loss of 55 passengers and crew, ensuring part provenance is essential to safe operation.[22] Blockchain would simplify record keeping.

Airport collaborative decision making (ACDM)

Key performance indicators for operational airline executives include on-time arrival and turnaround times. We can easily see why, as there is so much at stake for operators. An aircraft is only earning

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revenue when it is flying. With large airlines, the costs of missing these key performance indicators (KPIs) runs into hundreds of millions of dollars. Southwest Airlines believes that its carefully designed and orchestrated 10 and 15 minute turnaround times save the need for 35 additional aircraft—a saving of $1.3 billion.[23]

In the cargo segment, a single freighter aircraft may represent more than $50 million of revenue and some cargo carriers, as a competitive angle, guarantee customers a next-day delivery or it is free. It is not unheard of for an empty aircraft to be flying circuits in order to be available to divert to an aircraft stuck on the ground (AOG) to collect a stranded cargo. It is cheaper to run empty rescue flights than to risk missing a connection to a distribution hub.

Consider the different parties involved. They have to work seamlessly together to get passengers, bags, and cargo offloaded; to have the plane cleaned, fueled, and prepared for the next flight, quickly and, above all, safely. Airlines aim to turn around a typical short-haul flight within 30 minutes.

In the window of time from engine shutdown, the jetway needs to be positioned so that passengers can disembark (including wheelchairs for passengers who require them), cargo doors must be opened and cargo and passenger luggage offloaded.

It is cheaper to run empty rescue flights than to risk missing a connection to a distribution hub.

Bags must be tracked and correctly directed to connecting flights. Arriving bags delivered to the terminal carousel for passengers to collect.

An aircraft might need more fuel for the next leg. Waste management will drain the onboard septic system, catering will be restocked and cleaners will prepare the cabin.

Flight crew will have prepared the aircraft's flight management system for the next flight, run pre-flight checks, checked for Notices to Airmen (NOTAMS) and other weather conditions and ensured that a flight plan has been filed.

During this same time passengers will be boarded, luggage loaded, final weight and balance checks made and signed off by the captain, and engine start and pushback requests made.

Once permission is given, the ground crew will check that all the doors and hatches are closed, and will supervise the pushback to ensure the aircraft is safe to manoeuvre and the engines can be started without affecting other aircraft or facilities.

Those personnel work for many separate companies and organizations that each have their own systems and databases and that all need information from each other. Is the gate correctly assigned and does the airline know this? Are work teams in the right place at the right time in order to ensure that the turnaround happens as planned? What happens if a fault is reported on the

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inbound flight and a replacement aircraft is needed? What happens if a gate is occupied by another flight with a mechanical hold? Is de-icing causing delays? Is there a ground stop or bad weather at the destination that would prevent the flight departing? And so on.

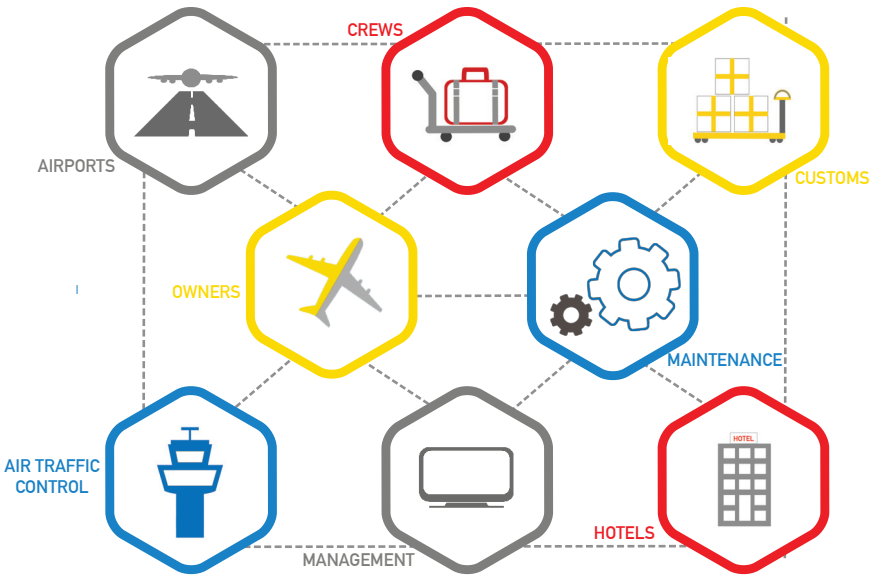
Who has the correct information from one moment to the next? Just planning takes time and breaks in the process can collapse the entire system. Typically, airlines pay for the use of airport slots at busy hubs. These are very expensive to retain and it is possible to lose the rights to a specific slot if an airline repeatedly misses their assigned window.

With so many institutions and systems requiring up-to-date information, breaking down silos and sharing data has become a hot topic. This would be perfect ground for a consortium-permissioned blockchain where each party would write to the chain and allow each party to see a true picture of what is happening in real-time without having to divulge sensitive information (Figure 2). Additionally, a multi-signature subscriber smart contract could be used by all parties so that a flight departure clearance is held until all parties have digitally verified that steps and checks have been completed.

A multi-signature subscriber smart contract could be used by all parties so that a flight departure clearance is held until all parties have digitally verified that steps and checks have been completed.

Decision-making would be collaborative and would result in fewer delays. With each of the parties involved, reading and writing updates to a central and shared source of truth, information such as the timestamp of events stored on the blockchain, would be available for scrutiny. It would be possible to spot trends in flight delay situations. In future, systems will be able to interrogate the blockchain and pull other data stores such as passenger information and code-share

Figure 2: Bringing airlines and partners closer



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connections. Then parties with permission can run this data through analytics models to highlight pain points, make adaptations, and ultimately predict situations before they occur.

Flight planning and air traffic control charges

Airlines send a schedule of flight data to the various government or regulatory authorities responsible for air traffic control (ATC) services a month or two ahead of scheduled flights. This forms the basis for the ATC invoices that are issued to an airline. During that month, flight schedules can undergo significant changes as flights are re-routed or canceled to accommodate the operational ups and downs of the real world. The number of flights scheduled may vary significantly from the number actually flown. The current process is for the airline to manually compare the proposed flight data that was sent to the ATC authorities in advance with the records of what was actually flown in a given time period. This manual reconciliation process is time consuming and error-prone. It depends on how the information is stored at the airline and the capabilities of the tools at the airline's disposal as well as the number and competence of the staff assigned to reconcile the data. Once the reconciliation is done, an agreement needs to be made with the ATC authorities to approve the tally and finalize the payment.

Using blockchain, a flight plan data would be encoded and sent for each completed flight with the associated payments automatically calculated and transmitted by the aircraft in real time.

Using blockchain, a flight plan data would be encoded and sent for each completed flight with the associated payments automatically calculated and transmitted by the aircraft in real time. The aircraft would be equipped with a digital wallet, and be stocked up with currency (plus contingency) in much the same way that the aircraft is fueled. Once in the air, aircraft positioning would be accurately plotted to ensure that payments happen directly and all the transactions would be recorded on the blockchain.

The same principle could also apply to landing fees. The aircraft would receive automatic notification of its assigned runway and available gate, as well as triggering cleaning and catering and generating payments, including under wing services. Essentially, the aircraft contracts and pays for its own services in real-time, eliminating the need for monthly invoicing and time consuming reconciliation tasks, which are problematic because of the complexity related to the source of truth. For example, a service provider might be invoicing for a flight, which the airline believes, was canceled—who is right? How much time and communication is needed to resolve this? By using the capabilities of the blockchain to offer the single source of truth, together with the auditable record of transactions, a lot of the expense of doing business can be returned to the bottom line.

Maintenance/repair/overhaul (MRO)

In today's world, the requirements for maintenance events for an aircraft are held in a series of separate original equipment manufacturer (OEM) databases. Airbus or Boeing has data for

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airframes, and Rolls Royce or GE maintains the data for engines. Then there are airline-specific items for elements related to the cabin interior, and regulatory requirements such as seatbelt and life jacket inspection intervals.

By using blockchain, mandatory maintenance events and service intervals or landing cycles would be set in advance as per manufacturers and regulatory requirements and any non-conformity appear in the aircraft record.

Smart contracts would track the lifecycle of critical parts and notify the operator when a part is due for replacement.

Replacement parts from every supplier could have their own digital identity, making spare part provenance easily achievable and preventing counterfeit parts from entering the supply chain. The serial number for each part is recorded and assigned a digital ID by the OEM or other approved parts manufacturer. Smart contracts would track the lifecycle of critical parts and notify the operator when a part is due for replacement.[24]

Lufthansa Systems and others are looking to build a blockchain fabric to connect databases and provide an immutable electronic record.[25]

> *BC4A—blockchain for aviation—is a Lufthansa Industry Solutions initiative to bring aviation and blockchain experts together to work on Use Cases where the aviation industry can benefit from applying the blockchain technology. Innovation/proof-of-technology projects together with Lufthansa Technik have been started and are currently developing prototypes for the most promising Use Cases within the aviation maintenance, repair, and overhaul field.*[26]
>
> Thilo Knoop, consultant/project manager, Lufthansa Industry Solutions

Hotel booking for flight crews

A typical large airline today uses a hotel brokerage firm such as API or Hotel Connections to book rooms for flight crew layovers. Bookings are based on the planned schedule sent as a data file or in some cases through a customer interface between the crew scheduling system and the hotel booking system. Any number of problems could disrupt this schedule and make it both expensive and time-consuming to reconcile which hotels were actually needed on any given date.

Crew members' digital IDs would be automatically assigned to a room while the flight is in transit to the layover city, both confirming the arrival and speeding up the check-in process.

The hotel brokerages use paper contracts to secure the necessary bookings. These could be replaced with smart contracts entered on the blockchain and outfitted with alerts set to trigger when a contract is due to expire, or if there has been a breach in agreed terms. Crew members' digital IDs would be automatically assigned to a room while the flight is in transit to the layover city, both confirming the arrival and speeding up the check-in process with trusted information and eliminating the need to build multiple interfaces from the crew management system to the brokerage firm and then to the hotel database.

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Smart contracts within the blockchain could also prevent circumvention of the contractual booking processes with the brokerage firm. The Australian firm WebJet is actively looking at hotel bookings and developing smart contracts with Microsoft to streamline the hotel booking process and to reduce the need for manual interventions and reconciliations.[27]

Airline business process disruption

The power of blockchain comes from the ability to share data and value between trusted parties across an untrusted network. There are use cases, however, where blockchain technology can be leveraged within a single organization: the airline itself. Using blockchain, an airline can benefit from using a single protocol to connect internal systems more rapidly and at lower cost than building a point-to-point application protocol interface (API).

Maximizing decentralization

While new user-facing systems have been updated to improve the customer experience and the look and feel of the interface, underlying systems are often based on very old technology. There is a false economy in keeping these legacy systems, which are both expensive to maintain and very inflexible. Getting data into and out of these systems (perhaps by a weekly export/import of a data file) is slow and frustrating in the pace of today's market place and limits the organization's ability to make real-time adjustments. While an operator would like to update all of the old technologies, large-scale projects to replace legacy systems often run over budget and over time, that is, if they aren't canceled before completion.

Connectivity of data will allow airlines to get a rich picture of the correlation between random events and downstream issues, which might lead to a flight cancellation.

Airlines are generating huge volumes of data even by comparison to new operations in today's world.

- Reservation systems
- Loyalty programs
- Flight scheduling and market analysis
- Flight operations
- Crew planning
- Aircraft maintenance
- Catering
- Sales and marketing
- Financial systems

Typically, none of these systems is connected and they operate within very narrow channels of communication. It would certainly not make financial sense to build bespoke interfaces between all of them. With blockchain, the communication protocols already exist to create a uniform interface. Digital IDs can be tracked and reports produced on interaction between IDs. This connectivity of data

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will allow airlines to get a rich picture of the correlation between random events and downstream issues, which might lead to a flight cancellation. With the ability to connect the dots, airlines analyzing trends and patterns can use data to improve the overall customer experience as well as reduce costs and mitigate unplanned expense.

Ultimately, airlines will be forced to migrate away from expensive and inflexible legacy systems. Blockchain connectivity will allow for both a short-term solution and planning related to the long-term data analytics, which will allow an airline to maintain a competitive edge.

Charter flights

Traditional airlines draft a route schedule many years in advance and then tweak their schedules as market conditions dictate. An alternate to the traditional airline model is more like a taxi service where planes are chartered for a short duration. In this model, the customer pays a charter airline for the privilege of flying when and where they need. This means that customers are often paying for space that is not used or needed, which is ideal if the purpose is increased security or privacy. However, if the customer just needs a small number of seats for a specific event, then the charter price becomes unnecessarily expensive. As we have seen with peer-to-peer business models such as Uber and Airbnb, disruption occurs by exploiting untapped resources. In this case, a smart contract could be drawn up on the blockchain stating that the customer will charter the flight at a given rate for a certain number of passengers. Once the origin and destination are known, the flight could be made "public" and remaining seats sold off. The smart contract would determine the new rate to the customer with each seat sold.

An alternate to the traditional airline model is more like a taxi service where planes are chartered for a short duration.

The effect of this would be to reduce chartering costs and make specific point-to-point seats available to the public with possibly lower ticket prices than a regularly scheduled flight.

Cargo and customs clearing

Cargo handling is a lucrative business segment for most airlines. Cargo handling is facing a lot of pressure and anticipating additional competition as drone technology matures.[28] One way to remain competitive is to reduce costs and improve speed-of-transit of customer cargo.

Once cargo goods are digitally tracked and validated on the blockchain and the sender as well as receiver are also digitally bonded to the transaction as recorded on the blockchain ledger, it would be possible to reduce customs clearing times with import duties due paid via smart contracts. In fact, as soon as the transaction is listed as ready for dispatch, the smart contract would be able to calculate the customs duty and send a message via an app to the recipient to arrange payment before the goods even leave the sender. This transparency and validation will allow for faster processing and a reduction in paperwork and time for the customers.

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This immutable record will also benefit the government border agencies, as less time is spent tracing paper trails and reconciling import duties with monies received.

Limitations of blockchain for airlines

Given its novelty, we may need time to leverage its full potential. Identifying the problems it can solve and developing a complete network of users ready to apply it is still years away. Bringing an entire industry ecosystem into the blockchain realm requires complex coordination.

There are numerous examples of use cases for a blockchain solution. As with any new technology, including the Internet in its early days, challenges do lie ahead.

Trade-offs exist and proposed solutions for how data is held on a public blockchain need to be tested and fine-tuned. Data can be encrypted, however decoding homomorphic encrypted data is cutting-edge computing technology. It requires substantially more processing power and therefore slows down transaction speeds. For an airline use case, an early decision in the design phase would be needed on how much data needs to be shared, and with which parties as well as how much would need encryption. The more data encrypted, the more power and therefore more costs are required to run the system.

Airlines can lead the way in developing blockchain solutions by active engagement in the research.

There is a lack of true expertise in this world of blockchain today. Initiating proof of concept and prototypes with skilled resources is difficult and expensive. With the Internet development, early protocols were put through trials, were fully tested and lessons learned implemented, all in the confines of academic institutions. The concepts were then honed via the US military before mass adoption and commercialization. What we are seeing today is small steps being taken in the commercial sector that run the risk of being discarded as failures before they are fully explored. Airlines can lead the way in developing blockchain solutions by active engagement in the research and by nominating blockchain champions within their IT teams to identify specific pain points affecting their own airline and, by association, the industry.

When preparing for a production system, decisions will be made right at the start for the trade-offs between performance, security and price. The more members who need to access to the data, and the more validation of blocks, the higher the price of the project. In the world of IT hardware, the old performance maxim has been rewritten. We can ask three things from an IT project: performance, reliability, and price, but we can only have two. This is also true for blockchain proofs of concept with the considerations being performance, security, and price.

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reduce risk through decentralization, which is something that many blockchain advisors use as a selling point. However, a substantial amount of centralization is still required for a private and consortium blockchain. How is it decided who is permissioned and to what level? Who determines the validation thresholds for the block validation and other core protocol variables?

Sharding is a type of partitioning that separates very large databases into smaller, faster, and more easily managed parts.

Potentially, blockchain can hold vast amounts of data. However, the ability to implement complex queries on this data is limited today. With the advent of sharding, the ability of blockchain to both improve local performance and manage complex queries on a global scale will create impacts to performance in returning the information.[29] With an airline's global reach this is a critical challenge.

When comparing a centralized system today with an equivalent blockchain solution, the existing system will almost certainly outperform a blockchain in terms of transaction throughputs. In some examples, there is talk of a hybrid solution, where an opening position is read off the blockchain into a high-speed transactional system for processing and then at the close of business the closing balances are recorded to the blockchain. For example, all the data changes on a flight might be carried out within an operations system, and only the final flight details of passenger manifesto, fuel and any delay codes would be written back to the blockchain.

Blockchains are new and widely misunderstood. Governments and regulators do not have policies developed to respond to this technology. The airline industry is both heavily regulated and reliant on consensus across multiple national governments and industry regulators such as the FAA or EASA. Work to develop blockchain solutions would benefit from regulatory involvement at the start in order to avoid development of a solution that becomes quickly obsolete or needs rework due to a regulatory change.

A blockchain aims to reduce risk through decentralization, which is something that many blockchain advisors use as a selling point.

Despite being called smart contracts, the legality of such software might also need thorough investigation, especially with multiple parties affected by a single smart contract. In reality, the smart contract is likely to be unenforceable by law and would be more of a business understanding between the parties with more traditional contractual devices employed as needed.

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Conclusion and recommendations

Blockchain has immense potential to enhance all industries, and the airline industry has specific elements that make it a top candidate for applying this technology. Innovative technologies are always met with skepticism and resistance. However, history has shown those industries that do not embrace change may succumb to market pressures and ultimately fail. Nokia and Blackberry in the telecom world are prime examples.

Blockchain has the potential to streamline business processes and reduce the friction in doing business both internally and with partners, suppliers, and vendors. Blockchain technology can breakdown silos and provide a more collaborative platform. Airlines that will get the most from blockchain will be looking beyond their own organizations to build mutually beneficial solutions with partners. Collaboration will maximize return on investment (ROI) and reduce operational overhead, often by removing the need for third parties.

What can a forward-looking strategic team do in the airline business today?

Airlines that will get the most from blockchain will be looking beyond their own organization to build mutually beneficial solutions with partners.

Educate

- **Nominate a blockchain champion.** Ask this champion to evaluate blockchain solutions and work with internal departments, airports, manufacturers, regulatory agencies and software vendors to understand how blockchain is being adopted and how new developments will impact the airline.
- **Work with the blockchain experts.** Collaboration will build a better understanding of what blockchain technology can do and what it cannot to avoid expensive failures.
- **Host a workshop at your airline.** Invite blockchain experts to talk to your key staff to share and cross-pollinate specific business process details with blockchain know-how to help establish a nursery for new and innovative ideas.

Participate

- **Join the blockchain community.** New associations, such as the Chamber of Digital Commerce and the Blockchain Research Institute, are sprouting up and would welcome input from the experts in an arena as significant as the airline industry. By bringing real world operational issues to the blockchain community, new opportunities can be explored and incubated. Now is the time to participate in the space and participate in driving the changes forward.

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- **Organize a hackathon.** Invite a variety of software vendors, schools and colleges, and airline experts to come together in order to develop solutions to real pain-point-specific challenges for your airline.

Innovate

- **Prove a concept**. Once your airline team has identified specific use cases, establish a project to build a case study and prototype.

- **Write a whitepaper.** Share your experiences with the wider community to push the boundaries forward. Perhaps in the process of the development of the prototype, you collectively worked on an innovative solution that will heighten your airline's profile within the community. Use this momentum to generate a fresh brand of industry leadership.

- **Examine how blockchain will affect the industry**. Airline regulators have an excellent opportunity to make blockchain a talking point at the next conference. Invite a keynote speaker on the topic. The more the industry discusses and understands this technology, the easier it will be to draft new guidelines for the airlines and participants to pursue.

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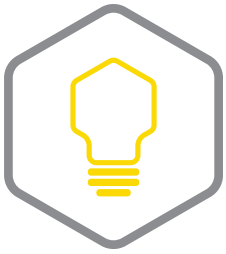

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Chami Akmeemana is a serial entrepreneur with several successful exits. He is CEO of Blockchain Learning Group and Blockscale Solutions. He was a director at ConsenSys Inc. He is also the former fintech advisor to the Ontario Securities Commission and was the managing director of global markets at the Global Risk Institute. He sits on several start-up boards in the blockchain, artificial intelligence, and virtual reality/augmented reality space. A former semi-professional rugby player, he volunteers with a number of youth charities in Australia, Canada, and Sri Lanka.

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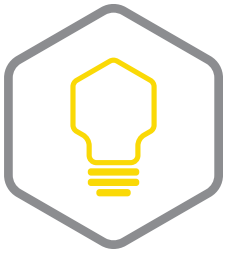

About the Blockchain Research Institute

Co-founded in 2017 by Don and Alex Tapscott, the Blockchain Research Institute is a knowledge network organized to help realize the new promise of the digital economy. It builds on their yearlong investigation of distributed ledger technology, which culminated in the publication of their critically acclaimed book, *Blockchain Revolution* (Portfolio|Penguin).

Our syndicated research program, which is funded by major corporations and government agencies, aims to fill a large gap in the global understanding of blockchain technology and its strategic implications for business, government, and society.

Our global team of blockchain experts is dedicated to exploring, understanding, documenting, and informing leaders of the market opportunities and implementation challenges of this nascent technology.

Research areas include financial services, manufacturing, retail, energy and resources, technology, media, telecommunications, healthcare, and government as well as the management of organizations, the transformation of the corporation, and the regulation of innovation. We also explore blockchain's potential role in the Internet of Things, robotics and autonomous machines, artificial intelligence, and other emerging technologies.

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