

AIR POWER

Journal of Air Power and Space Studies

Vol. 17 No. 3 • Monsoon 2022
(July-September)



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BLOCKCHAINING THE ATMANIRBHAR IAF FIGHTER

SUKHCHAIN SINGH

On line identity and reputation will be decentralised. We will own the data that belongs to us.

—William Mougayar

INTRODUCTION

Is Satoshi Nakamoto the faceless creator of the bitcoin or is it the Australian computer scientist Craig Wright, who has claimed to be the architect of the bitcoin? There is a mystery about the inventor of the disruptive blockchain technology.¹ Many associate blockchain technology only with the hyped cryptocurrency and its use in the financial sector. By and large, most fail to appreciate the digital revolution it has set in motion in the way transactional data is managed in a distributed and secure manner in all walks of the digital world of business and industry. The blockchain is an evolving technology

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1. "Mystery of Who Invented Bitcoin Hangs Over Scientist's Trial", updated: November 2, 2021, 12:45 PM IST, *LiveMint* (with inputs from Bloomberg), at <https://www.livemint.com/market/mystery-of-who-invented-bitcoin-hangs-over-scientist-s-trial-11635836698574.html>. Accessed on February 25, 2022.

In the aviation industry, errors have to be ruthlessly eradicated which is ensured by timely availability of information and its dissemination to all levels of the manufacturing process.

that has the capability to offer decentralised trust, data security and integrity, traceability, transparency, visibility, and auditability across various domains in the aerospace and defence industries.² Many applications in the battlefield operation management, border control, use of Smart War-fighting Array of Reconfigurable Modules (SWARMS) in search and rescue, operational logistics and supply chain management are being actively pursued in military aviation.³

In the aviation industry, errors have to be ruthlessly eradicated which is ensured by timely availability of information and its dissemination to all levels of the manufacturing process. Blockchain technology has the structure to provide a trusted record of the process and its execution, tools and materials use as per the laid-out documentation, people skills, machine settings, etc. This ability, suitably enforced by Artificial Intelligence (AI) and machine learning, will ensure compliance and weed out variability from the aviation products. Use of the Internet of Things (IoT) and other innovations will create a very strict conformal ecosystem which will ensure systemic quality control of the entire aviation manufacturing and supply chain.⁴ The global aviation manufacture and operations sectors largely follow the traditional systems developed in the late Seventies. The smooth flow of data and information between the various industry players has always been fraught with delays and inconsistencies. The blockchain is a welcome disruptive technology for

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2. Raja Wasim Ahmada, Haya Hasana, IbrarYaqooba, Khaled Salaha, Raja Jayaramanb and Mohammed Omar, "Blockchain for Aerospace and Defense: Opportunities and Open Research Challenges", at https://www.researchgate.net/publication/345830528_Blockchain_for_Aerospace_and_Defense_Opportunities_and_Open_Research_Challenges. Accessed on February 25, 2022.
 3. Ibid.
 4. Robert J. Rencher, Jason Kelley and Kevin Donaldson, "Monetizing Blockchain: A Tailwind for Aviation", at <https://www.ibm.com/downloads/cas/5JLAYLZE>. Accessed on February 25, 2022.

the seamless exchange of data with trust in the aviation arena that will transform this sector's ecosystem.⁵

Digital reinvention⁶ is now making it possible for all individual partners to reimagine and collaborate among themselves and with the end users. The Indian aviation industry should not lose this "digital reinvention" of blockchain technology to knit the entire Indian aviation ecosystem as part of *Atmanirbhar Bharat* in the development of the Indian fighter programme.

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A PRIMER ON BLOCKCHAIN TECHNOLOGY

In a blockchain, the information is structured and stored in a series of blocks. Starting from the first block, known as the genesis block, each block in the chain is linked to the preceding block with a hash. A hash is an encryption algorithm like the SHA256 Hash which is unique and any change in the input data will change the hash value. Thus, each hash of the block has the data of interest, the hash of its own block and the hash of the previous block in the chain. Once the block has been created and put in the chain, the unique hash value of the block and its previous block hash value ensures that any tampering of the block data will be detected in its hash value. This novel process constructs a secure blockchain architecture.⁷

Even though hashes are excellent anti-tampering algorithms, it is now feasible with high end computing systems to recalculate all hashes in the chain and, hence, revalidate the blockchain acceptability after deliberate

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5. Vikas Kaushik, "Blockchain for Aviation Industry: Fasten Seatbelts for the Take-off", August 7, 2019, at <https://www.techaheadcorp.com/blog/blockchain-for-aviation-industry/>. Accessed on February 25, 2022.
 6. Greg Land, Anthony Marshall, Brian O'Rourke and Steve Peterson, "Here, There and Everywhere: Digital Reinvention in Travel", IBM Institute for Business Value, September 2017, at <https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=GBE03878USEN&>. Accessed on February 25, 2022.
 7. Barbara Thompson, "Blockchain Tutorial: Learn Blockchain Technology (Examples)", at <https://www.guru99.com/blockchain-tutorial.html>. Accessed on February 27, 2022.

tampering of the data in the block/blocks. To circumvent this problem, a value is inserted in the block called a nonce value, generated by miners in the chain network. This concept is called the proof-of-work in blockchain technology. The miners are given a target value during the verification which will complete the proof-of-work which covers all the data of the block, and check whether the hash value of the current block is less than the target. The nonce is a random whole number which is adjusted by the miners, so that it becomes a valid number to be used for hashing the value of the block. The nonce is the number which can be used only once. Along with this number, the hash value of that block will get rehashed and create a difficult algorithm. Thus, both hashing and proof-of-work are the methods applied in the blockchain to make it secure.⁸

The blockchain network is a distributed peer-peer network to avoid any control by a single centralised entity and all the nodes have equal jurisdictions on the traffic of the blockchain. Through a consensus protocol, these nodes agree to the validity of, and accept, which blocks can be linked to the chain. Nodes in the network will reject blocks which have been tampered with. This consensus of nodes is the core of the blockchain technology which ensures that the information stored on the blockchain is accurate and trustworthy.⁹

There are many variants of blockchains in implementation. The public blockchain is a type of blockchain that is visible to everyone on the network and will allow anyone to verify and add a block of transactions to the blockchain. On the other hand, the private blockchain is within a single organisation and will permit identified and very limited number of individuals of the organisation to verify and add transaction blocks. However, everyone on the network will generally be allowed to view it. In the consortium blockchain, only a group of organisations can verify and add transactions and the blockchain ledger can be opened by, and is restricted to, select groups only. Consortium blockchains are used across organisations and are controlled by pre-authorised nodes only.¹⁰

8. Ibid.

9. Ibid.

10. Ibid.

In a nutshell, a blockchain is a digital record of transactions that is duplicated and distributed across the entire network of computer systems. Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's record, called a ledger. Since this disruptive technology provides transparency, trust, data security, and transactional accuracy, it is quite suitable,¹¹ and needs to be seriously considered for the military aviation sector and the associated ecosystem.

Another interesting variant comprises the probabilistic blockchains, that are utilising the blockchain concept of architecture and are being increasingly used for decision-making and risk assessment applications in multi-trust domains.¹² In such industries and for various other applications, the participating players not only compete but collaborate as well, but without full trust in each other. To ensure a trust relationship, it is imperative to distribute the decision-making amongst them, without any centralised agency. Blockchains, by their inherent architecture and design, are capable of meeting this requirement in networking the multi-trust domain and also providing security from outside attackers trying to take over the decision-making control. The decision-making in such group involves a wider view of the global environment and may include access to private information.¹³ In the military aviation sector and industrial ecosystem, this is a challenge when all the stakeholders in operations, design, manufacture, certification, regulation, service providers and users collaborate and compete with each other in furtherance of the application of national air power.

BLOCKCHAIN IN AEROSPACE AND DEFENCE (A&D) INDUSTRIES

The A&D industries deploy a mix of traditional paper-based documentation and computer data bases to record the various processes and meet the

11. Ibid.

12. Tara Salman, Raj Jain, Lav Gupta, "Probabilistic Blockchains: A Blockchain Paradigm for Collaborative Decision-Making", Conference, IEEE UEMCON 2018. https://www.researchgate.net/publication/333486562_Probabilistic_Blockchains_A_Blockchain_Paradigm_for_Collaborative_Decision-Making#pf2. Accessed on February 27, 2022.

13. Ibid.

In the aircraft components supply chain, the visibility of records at all levels of the organisation increases the trust among the stakeholders in operating a reliable aircraft compliant with the statutory regulations and policies.

strict compliance requirements of the aviation regulators. These are subject to input errors, duplication, risk of tampering, loss of data, accidentally or by intention, and associated privacy concerns. Blockchain technology is the disruptive concept in the A&D industry for providing single, synchronised, secure, and immutable records of the data and consensus-based decisions to execute transactions.¹⁴ This is the basis of smart contracts. Smart contracts are self-implementing instruments that are executed when pre-defined conditions are met to ensure trust within the contributing

units. In the aircraft components supply chain, the visibility of records at all levels of the organisation increases the trust among the stakeholders in operating a reliable aircraft compliant with the statutory regulations and policies.¹⁵ However, the existing deployment and maturity of the blockchain technology across the ecosystem does not allow the full potential of smart contracts to be employed in the aviation sector. Use of the blockchain Oracles acting as middle ware between the blockchain and the outside world is necessary for the implementation of smart contacts.¹⁶ This is an important consideration in the framework for implementation of smart contacts for the A&D industry.

Having updated and, if required, real-time information of the aircraft configuration and maintenance history can allow for enhancing the availability of the platform and reduce costs on its operations. This is the unique opportunity to utilise the blockchain as a powerful tool and create innovative revenue models for the manufacturers, maintenance companies, as well as start-ups in the aviation industry.¹⁷

14. Ahmada, et al., n. 2.

15. Ibid.

16. Ibid.

17. Chuck Marx, Rachel Parker Sealy, and Scott Thompson: "How Blockchain Can Improve the Aviation Industry", Strategy + Business, TECH & INNOVATION, June 7, 2019, Autumn 2019,

Creation of a “digital birth certificate” by the blockchain is possible for every part of the aircraft, and it can be updated for all operational and maintenance transaction events, including movement in the entire supply chain ecosystem. Once this is amalgamated into the “digital twin” of the aircraft, it can provide the complete history of the aircraft, from the assembly line till it is retired from service, or in the case of a civil aircraft, till returned to the lessor. Access to these blockchained ledgers can be permitted to various users appropriately for the requisite visibility by ensuring that the participants have access only to the information they’re entitled to have access to. This will ensure visibility as well as safeguard business data from the competitors.¹⁸

Aircraft maintenance has traditionally comprised preventive and scheduled maintenance activities. As a disruptive philosophy, the predictive maintenance can be gleaned out of the blockchained configuration and history ledger before the aircraft goes off line.

Aircraft maintenance has traditionally comprised preventive and scheduled maintenance activities. As a disruptive philosophy, the predictive maintenance can be gleaned out of the blockchained configuration and history ledger before the aircraft goes off line. The capability to forecast the maintenance expenditure for each aircraft with confidence, with predictive ability, would considerably alter the economics of fixed-price Maintenance Repair and Overhaul (MRO) contracts and provide a competitive edge to those with access to real-time blockchain-enabled data.¹⁹

As India ramps up its A&D industry, the after sales follow-on support will become an important and critical business activity. MRO companies will have to source aircraft components and it can be difficult to locate the vendor with the right part and at the right price, which is aviation certified and with the desired delivery schedule. Industries in a blockchain-powered

Issue 96, at <https://www.strategy-business.com/article/How-blockchain-can-improve-the-aviation-industry>. Accessed on February 27, 2020.

18. Ibid.

19. Ibid.

aerospace ecosystem could cut out the intermediaries, using a trustworthy source with traceability and optimum delivery times and thereby reducing costs. The Indian Original Equipment Manufacturers (OEMs) in the blockchain could forecast the life span of parts or systems and modify their production processes to ensure just-in-time delivery and improve customer service, while cutting their own inventory costs.²⁰

The Skill India project can get a boost by using blockchain validation in aviation trades and proficiencies. The validated credentials could become part of the worker's profile on the blockchain, and entities with the appropriate permissions would be able to access the verified qualifications and certifications of those who have undertaken the maintenance intervention, thereby, generating trust and confidence in the aircraft's health.²¹

INDIAN INITIATIVE AND THRUST

A new digital paradigm of ushering in the use of blockchain technology as a national strategy has been initiated by India. A national blockchain framework is to be established as a centralised ecosystem in e-governance. The Ministry of Electronics and Information Technology (MeitY) has identified 44 key areas, including pharma, farming, education and energy in this framework. India will join the club comprising China, the UAE, US, Brazil, Chile, Canada, Singapore and Switzerland which are major champions of the use of blockchain technology.²² The national strategy expounds a comprehensive vision, development and implementation strategy for a national blockchain platform. It includes the development of various domain applications and their sand box testing on the national infrastructure to ensure interoperability across different platforms.²³

20. Ibid.

21. Ibid.

22. "Blockchain Tech is the Future", *The Hindu, Business Line*, December 20, 2021, at <https://www.thehindubusinessline.com/opinion/blockchain-tech-is-the-future/article37999487.ece>. Accessed on February 28, 2022.

23. "National Strategy on Blockchain: Towards Enabling Trusted Digital Platforms," Ministry of Electronics & Information Technology, Government of India, December 2021, at https://www.meity.gov.in/writereaddata/files/National_BCT_Strategy.pdf. Accessed on February 28, 2022.

However, this is silent for the A&D industry, specifically the aviation domain, where the technology has the potential to make supply chains more secure and efficient, protect sensitive data and communications, and enable more effective identity management.

MILITARY BLOCKCHAIN DEPLOYMENT CANVAS

The capability of the war-fighter to track the data from its origin and its content, routing through various intermediary centres generates the trust in the data to take appropriate military intervention to a given operational situation. This sensor-to-shooter cycle has to be based on the ability to verify the trust and eliminate any man in the middle attack on the information. This is known as data provenance²⁴ and is becoming increasingly important in any information exchange within the armed forces. A “blockchain light”²⁵ technology is being evaluated by the US Army which does not require heavy computational power and consensus-based architecture to add data like in the traditional blockchain.

The aviation sector is a complex web of various participating industries that are partnering, collaborating and competing among themselves and generating an environment for start-ups. The traceability of the origins of designs, materials, manufacture, delivery routes in the supply chain, unauthorised modifications, etc to avoid counterfeits being deployed on the war-fighter is to be ensured. With so many players in the aviation environment, there are bound to be areas of dispute and the obvious choice is to have the inter and intra data of the industry on a trusted blockchain, particularly, for critical weapons and systems.²⁶ This is now the developing environment of the Indian military aviation fighters’ programme and, hence,

24. Lauren C. Williams, “Blockchain Light’ May Help Army Ensure Data Trustworthiness, Defence Systems”, July 22, 2021, at <https://defensesystems.com/it-infrastructure/2021/07/blockchain-light-may-help-army-ensure-data-trustworthiness/195258/>. Accessed on February 28, 2022.

25. Ibid.

26. Quintin Audrey, Vanholme Robin, Wauters Gilles and Georges Clementz, “Blockchain in Defence: A Breakthrough?” , FINABEL European Army Interoperability Centre, at <https://finabel.org/wp-content/uploads/2020/09/FFT-Blockchain.pdf>. Accessed on February 28, 2022.

the case to blockchain the Indian aviation industry for verified identity *ab-initio* into the programme.

This assumes greater importance with the use of Commercial Off the Shelf (COTS) hardware and software in aviation subsystems. Creating the provenance of every CPU, system motherboards, firmware component and the resident software is crucial in the entire loop, from the “cradle to the cockpit”.²⁷ With the increasing use of 3D printing in aviation manufacture, trust while transferring design files assumes critical importance to ensure conformance and avoid counterfeits in the supply chain, and this is easily addressed by deploying the blockchain-based process to secure the 3D printing systems.²⁸ This, at some time in the future, will be used in the manufacture of military-standard components directly in the field for which India must be prepared.

The employment of blockchain technology in the military is an evolution and not a revolution as yet. It will introduce greater efficiency initially but as it proliferates into all aspects of the defence industry and the operational environment, it will graduate into a disruptive technology. The US Defence Advanced Research Projects Agency (DARPA) is progressing to weaponising the blockchain and Lockheed has incorporated blockchain networks into its development processes.²⁹ The immutability of data continues to be an issue of concern. Data vulnerability in the military aviation ecosystem limits its deployment. This will increase only gradually as technology matures.³⁰

INDIA A&D BLOCKCHAIN PROPOSAL

Digital India is an established route for the rapid growth of the Indian industrial ecosystem, and blockchain technology is one disruptive technology in the Indian aviation sector. However, to avoid digital cultural shocks in this nascent industry, it is considered sensible to implement it in manageable pilot projects in the various realms of manufacture and

27. Ibid.

28. Ibid.

29. Ibid.

30. Ibid.

associated sectoral domains.³¹ A consortium based blockchain model is most suitable for the multipolar aerospace industry. The consortium members institute governance, oversight, and audit mechanisms, and establish rules for their involvement in the group. Valid permission rules need to be formulated to share, view and modify the sensitive information within this group.³² The Directorate General of Civil Aviation (DGCA) and the Centre for Military Airworthiness and Certification (CEMILAC) will need to be on board to generate trust in the architecture for the various documentations as enshrined in the national policy formulations. The trust that it ensures the same level of reliability, audit ability and transparency as of the existing system is essential for acceptability.³³

Skill India initiatives in the aviation sector can benefit immensely from the blockchains. Certifications and authentication of skilled personnel in various trades and branches across the entire aviation sector e.g. air crew, cabin crew, ground handlers, airport staff, air security, refuelling services providers, ramp technical staff and specialist trades in the MRO sector can be easily supported and streamlined without any intermediaries.³⁴ In such a use case for the blockchain, all design alternatives like public versus private and permissioned versus permission-less, need to be studied for an appropriate and optimum solution.³⁵ The blockchain provides seamless and verifiable documentation across manufacturers to airlines and MRO service providers. Lufthansa Industry Solutions has launched the initiative Blockchain for Aviation (BC4A) to amalgamate all fields of aviation domain knowledge and to cooperatively exploit

31. Chuck Marx, Rachel Parker Sealy, and Scott Thompson, "How Blockchain can Improve the Aviation Industry", Strategy + Business, TECH & INNOVATION, June 7, 2019, Autumn, Issue 96, at <https://www.strategy-business.com/article/How-blockchain-can-improve-the-aviation-industry>. Accessed on February 28, 2022.

32. Ibid.

33. Ibid.

34. "Blockchain in Aviation: Exploring the Fundamentals, Use Cases, and Industry Initiatives", IATA White Paper, October 2018, at <https://www.iata.org/content/assets/2d997082f3c84c7cba001f506edd2c2e/blockchain-in-aviation-white-paper.pdf>. Accessed on February 28, 2022.

35. Ibid.

To ensure the security of confidential information, the shared ledgers in the blockchain need to be permissioned with great care. To ensure the trust, the processes in this blockchain must be transparent, with high integrity and good communication between SCM components.

the potentials of blockchain technology.³⁶ The global aviation industry is using blockchains to position itself competitively for the future. However, it is aggressively testing and migrating to it in small measures so as to not disturb the existing processes.³⁷

The Indian aviation industry supply chain has to be efficient and meet the *atmanirbhar* demands of the armed forces. A consortium military blockchain for Military Supply Chain Management (MSCM) is a necessity that can no longer be shied away from. The military authority and non-military authority-based

organisations will be part of this consortium. To ensure the security of confidential information, the shared ledgers in the blockchain need to be permissioned with great care. To ensure the trust, the processes in this blockchain must be transparent, with high integrity and good communication between SCM components.³⁸ This will ensure the following in the MSCM: establishing trust in the used parts market, linking the entire supply chain, making record keeping easier and tracking every part in the stock.³⁹ An

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36. Dr Lars Schwabe, Director Data Analytics. AI & Blockchain, "Lufthansa Industry Solutions: Generating More Transparency in Aviation with Blockchain Technology", at [https://www.lufthansa-industry-solutions.com/de-en/solutions-products/aviation/generating-more-transparency-in-aviation-with-blockchain-technology#:~:text=Blockchain%20technology%20is%20still%20in,Blockchain%20for%20Aviation%20\(BC4A\)](https://www.lufthansa-industry-solutions.com/de-en/solutions-products/aviation/generating-more-transparency-in-aviation-with-blockchain-technology#:~:text=Blockchain%20technology%20is%20still%20in,Blockchain%20for%20Aviation%20(BC4A)). Accessed on February 28, 2022.
37. Bernhard Kube, VP Technology Consulting, "Lufthansa Industry Solutions: Blockchain Makes Trust Digital", at <https://www.lufthansa-industry-solutions.com/de-en/solutions-products/technology-consulting/blockchain-makes-trust-digital>. Accessed on February 28, 2022.
38. Sharifah Saadiah and Syarifah Bahiyah Rahayu, "Consortium Blockchain for Military Supply Chain", Cyber Security Centre, National Defence University of Malaysia, Kuala Lumpur, at <https://turcomat.org/index.php/turkbilmat/article/download/1011/3768/8266>. Accessed on February 28, 2022. Syarifah Bahiyah Rahayu, Sharmelen AL Vasanthan, Afiqah M. Azahari and Joe Chai, Cyber Security and Digital Revolution Industry Centre, "Military Supply Chain Management and Blockchain Development", National Defence University of Malaysia, at <https://airconline.com/csit/papers/vol11/csit111608.pdf>. Accessed on February 28, 2022.
39. Kathryn Kearney, "Honeywell Aerospace: Four Ways Blockchain will Change Aircraft Maintenance", at <https://aerospace.honeywell.com/us/en/learn/about-us/blogs/four-ways-blockchain-will-change-aircraft-maintenance>. Accessed on February 28, 2022.

aviation industry framework around the blockchain has the potential to renovate the process of ensuring military aircraft airworthiness. Now is the time to consider how it could be used to build trust and drive innovation for the armed forces.⁴⁰

CAUTIOUS ROADMAP

A national strategy for the implementation of the blockchain in India, as discussed, is already in place.⁴¹ In the case of the A&D industry, the industry needs to be nudged to start deploying applications internally on non-sensitive data to gain confidence on the security and trust in its efficiency in various processes. Once satisfied, but in an aggressive timeframe, it can then initiate extending it to the partners in the environment.

Aircraft maintenance and MRO service providers are most suited to adopt this blockchain architecture in their Information Technology (IT) enabled systems. The industry is highly regulated, vastly interconnected, rigorous documentation and transparency oriented, generating copious transactional data susceptible to breaches in integrity, multi-domain complex processes, all of which require inter-industry and service providers' trust and transparency. The Indian A&D industry champions need to get onto this bandwagon now to remain competitive in the global environment and infuse adequate funding in Research and Development (R&D) for blockchain implementation.

Jakob Schyga, et al. have written an excellent article on the use of the blockchain in an MRO organisation, starting from the initial registration of the aircraft components, the addition of maintenance activities, move and

Aircraft maintenance and MRO service providers are most suited to adopt this blockchain architecture in their Information Technology (IT) enabled systems.

40. "Could Blockchain Help Prove Military Airworthiness?", at <https://www.snclavalin.com/en/beyond-engineering/could-blockchain-help-prove-military-airworthiness#:~:text=Establishing%20a%20framework%20around%20blockchain,savings%20afforded%20by%20adopting%20blockchain>. Accessed on February 28, 2022.

41. n. 23.

ownership changes, smart contract implementation, etc.⁴² The Indian Air Force (IAF) can build on the concept of this article and take the lead in a pilot project for implementation for the Base Repair Depots (BRD) supported new helicopters. Similar pilot projects by Hindustan Aeronautics Limited (HAL) and other collaborators will usher in the technology to the benefit of all participants in the consortium.

The issue of certification and regulation for the airworthiness of the processes and components is necessary in the A&D blockchain. The International Air Transport Association (IATA) agrees that there are substantial benefits with the use of the blockchain in aircraft MRO processes but also acknowledges the associated difficulties.⁴³ Therefore, CEMILAC and DGCA must be roped in early enough in the national A&D blockchain architecture. It is important that they invest in suitably sized projects to gain confidence and scale up aggressively. Cross-certification trust in the military and civil industries will definitely be a spinoff with the blockchain.

Atmanirbhar Bharat in the A&D industry will use electronics embedded hardware from global partners and collaborators. This is also a national security concern as the supply chains are prone to attacks in the firmware and counterfeits being used in the operational platforms.⁴⁴ The global players are using blockchains to closely monitor all iterations in the process and it is but obvious that the Indian industry must keep pace with such implementations not only within the country but be hooked on appropriately with the global chain. Thus, the need to have a national A&D blockchain consortium with appropriate tentacles to hook onto such supply chain blockchains.

42. Jakob Schyga, Johannes Hinckeldeyn and Jochen Kreuzfeldt, "Prototype for a Permissioned Blockchain in Aircraft MRO", in "Artificial Intelligence and Digital Transformation in Supply Chain Management", at <https://www.econstor.eu/bitstream/10419/209382/1/hicl-2019-27-469.pdf>. Accessed on February 28, 2022.

43. H. Goudarzi, J. Martin and S. Warren, "IATA Whitepaper: Blockchain in Aviation, 2018", at <https://www.iata.org/publications/Documents/Blockchain-in-aviation-white-paper.pdf>. Accessed on February 28, 2022.

44. Mike Culhane, "Scientometric Study on Distributed Ledger Technology (Blockchain)", National Research Council (NRC), at https://cradpdf.drdc-rddc.gc.ca/PDFS/unc336/p810132_A1b.pdf. Accessed on February 28, 2022.

On August 25, 2021, the Indian government released the 'Drone Rules, 2021', which have empowered commercial usage of drones in various segments, boosting the drone businesses in India.⁴⁵ The domestic drone manufacture in India is upbeat and indigenisation of the hardware, software and use cases will gradually scale up. The government is already leveraging the drones in various development programmes, like the SVAMITVA (Survey of Villages and Mapping with Improved Technology in Village Areas) Scheme, '*Hara Bhara*', a programme that aims to plant one billion trees by 2030, and more such schemes are in the pipeline.⁴⁶ The private players will enter the market, giving the much-needed muscle to the drone industry to scale up and be self-sustaining. COVID-19 has also been a catalyst for spurring the adoption of drones by private and government agencies in India and the focus remains on being *atmanirbhar*. This is a multi-domain arena which has national security implications as well. Trust in the various constituents of the drones, and authentication of the platforms and their operators all need to be stitched on the A&D blockchain architecture. It may not be as rigorous as that of the military platforms but the crucial elements need to be identified to be participants with the requisite permissions in the consortium. This is an area worth deliberating on by the strategy planners. The blockchain based authentication improves the security and efficiency of authentication,⁴⁷ and local home-grown solutions for use in the civil drone domain and suitably interfaced to the A&D blockchain need to be seriously researched and implemented.

45. "Drones Rules, 2021 dated 25 August 2021", at <https://www.civilaviation.gov.in/en/ministry-documents/rules>. Accessed on February 28, 2022.

46. "Indian Drone Industry Reaching the Skies, IBEF, Knowledge Centre, October 12, 2021", at <https://www.ibef.org/blogs/indian-drone-industry-reaching-the-skies>. Accessed on February 28, 2022.

47. "Lightweight Blockchain Assisted Secure Routing of Swarm UAS Networking". Jian Wang Yongxin Liu Shuteng Niu Houbing Song, *Computer Communications*, vol. 165, January 1, 2021, pp. 131-140, at https://www.sciencedirect.com/science/article/abs/pii/S0140366420319885?dgcid=rss_sd_all. Accessed on February 28, 2022.

The blockchain will particularly offer digital traceability and enhance the efficiency and quality of business processes, including the collaborative supply chain partners processes. Companies not ready to change will face existential threats.

CONCLUSION

Blockchain technology will transform the functioning of B2B, G2C, G2G, B2G services by revamping the existing processes in many domains which will bring in efficiency. Similarly, the private companies are also studying the blockchain to add value to their service delivery systems with 56 per cent of Indian businesses embracing blockchain technology as a part of their core business.⁴⁸ As per the *Niti Aayog* strategy, various government organisations and other stakeholders will work in harmony to implement use cases in a

coordinated and interoperable architecture in the country. The application of blockchain technology will encourage innovation in various spheres through federalisation of processes by removing third parties and, thus, propelling India into a digital leap forward.⁴⁹ The aerospace domain is embracing digitisation, big data, analytics, predictive modelling, robotics, cloud and blockchain to create value. The A&D industry across the globe is burdened with managing paper records or hard databases to fulfil regulatory compliance as it switches organisational boundaries.⁵⁰ The blockchain will particularly offer digital traceability and enhance the efficiency and quality of business processes, including the collaborative supply chain partners processes. Companies not ready to change will face existential threats. Capable cross-functional teams need to consider the

48. "The Rise of Blockchain in India and its Future" Latest News by, *Analytics Insight*, February 14, 2022, at <https://www.analyticsinsight.net/the-rise-of-blockchain-in-india-and-its-future/#:~:text=As%20per%20a%20report%20by,trillion%20contribution%20to%20India's%20GDP>. Accessed on March 7, 2022.

49. Teena Jain Kaushal, "How Blockchain Will Help India Take a Digital Leap", *Business Today*, February 20, 2022, at <https://www.businesstoday.in/magazine/30th-anniversary-special/story/how-blockchain-will-help-india-take-a-digital-leap-321692-2022-02-07>. Accessed on March 7, 2022.

50. "Blockchain in Aerospace and Defense", Deloitte Perspectives, at <https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/blockchain-in-aerospace-and-defense.html>. Accessed on March 7, 2022.

blockchain and make commercial dividend out of deploying it and latter sustained adoption.⁵¹ India is embarking on its most ambitious indigenous military aviation project to build the Advanced Medium Combat Aircraft (AMCA) with advanced stealth features as well as 'super cruise' capabilities. Production of fifth-generation jets is extremely complex and expensive. This is bound to create a competitive and collaborative aviation ecosystem that has to be nurtured and regulated for efficiency right from its inception. The trust and transparency in the aviation consortium of designers, developers, manufacturers, after

sale support and MRO participants is essential for the *atmanirbhar* fighter in India. The federated and consortium approach of blockchain implementation needs to be a strategic imperative in the Indian A&D industry. The Indian A&D industry champions need to invest in the technology in line with global trends and embrace its implementation in a staggered but aggressive manner. The government could give impetus through the *Niti Aayog* strategy by including the A&D industry in its blockchain use cases and hooking onto the national architecture.

The federated and consortium approach of blockchain implementation needs to be a strategic imperative in the Indian A&D industry. The Indian A&D industry champions need to invest in the technology in line with global trends and embrace its implementation in a staggered but aggressive manner.

51. Anvita Pillai, "Digital Transformation: Nice-to-Have to Must-for-Survival", at https://www.bosch-softwaretechnologies.com/media/images/company/media_articles/cover_story_ad_apr-may_2021.pdf. Accessed on March 7, 2022.