



AEROSPACE INFORMATION REPORT

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Opportunities, Challenges, and Requirements
for Use of Blockchain in Unmanned Aircraft Systems
Operating Below 400 Feet Above Ground Level
for Commercial Use

RATIONALE

The number of Unmanned Aircraft Systems (UAS) has been growing over the past few years and will continue to grow at a faster pace in the near future. UAS faces many challenges in certification, airspace management, operations, supply chain, and maintenance. Blockchain—defined as a distributed ledger technology for the enterprise that features immutability, traceability, automation, data privacy, and security—can help address some of these challenges. However, blockchain also has certain drawbacks and it is still not fully mature. Hence, it is essential to study how blockchain can help UAS. This SAE Aerospace Information Report (AIR) presents the current opportunities and challenges of UAS operating at or below 400 feet above ground level (AGL) altitude for commercial use and how blockchain can help meet these challenges. It also provides requirements for developing a blockchain solution for UAS along with the need for the standardization of blockchain-enabled processes.

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1. SCOPE

This SAE Aerospace Information Report (AIR) focuses on opportunities, challenges, and requirements in use of blockchain for Unmanned Aircraft Systems (UAS) operating at and below 400 feet above ground level (AGL) for commercial use. UAS stakeholders like original equipment manufacturers (OEMs), suppliers, operators, owners, regulators, and maintenance repair and overhaul (MRO) providers face many challenges in certification, airspace management, operations, supply chain, and maintenance. Blockchain—defined as a distributed ledger technology that includes enterprise blockchain—can help address some of these challenges. Blockchain technology is evolving and also poses certain concerns in adoption. This AIR provides information on the current UAS challenges and how these challenges can be addressed by deploying blockchain technology along with identified areas of concern when using this technology. The scope of this AIR includes elicitation of key requirements for blockchain in UAS across its life cycle and the need for the standardization of blockchain-enabled processes.

1.1 Purpose

The purpose of this AIR is to present an overview of various life cycle stages of the UAS, key stakeholders, current challenges, and how blockchain can help in meeting some of these challenges while improving processes associated with the UAS industry. Further, this AIR is intended to identify concerns and challenges in utilizing blockchain technology. The purpose is also to define the key requirements and need for standards for blockchain-enabled UAS processes for commercial use.

1.2 Intended Users

This AIR is intended for OEMs, operators, owners, regulators, and users of the UAS blockchain ecosystem. The UAS user community includes designers, data engineers, operators, customers, regulators, and MRO providers. This AIR is also useful for Standards Developing Organizations (SDO).

1.3 How to Use This Document

This AIR is an informational report and provides an overview of opportunities, challenges and requirements in the use of blockchain for UAS operating at or below 400 feet AGL for commercial use. Section 2 presents the available documents and data standards for UAS, as well as abbreviations and definitions referred in this AIR. A brief introduction of UAS and blockchain technologies is discussed in Section 3. A discussion on challenges in the lifecycle management of UAS is provided in Section 4. Requirements for use of blockchain for commercial UAS applications are presented in Section 5. The need for standards for blockchain use in UAS is discussed in Section 6. Finally, conclusions are provided in Section 7.

2. REFERENCES

2.1 Applicable Documents

The following publications are referenced in this document. The latest issue of publications shall apply unless otherwise specified. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications:

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP6823 Electronic Transactions for Aerospace Systems: An Overview

ARP6984 Determination of Cost Benefits from Implementing a Blockchain Solution

Walthall, R., "Unsettled Topics Concerning Adopting Blockchain Technology in Aerospace," *SAE International Edge Research Report*, 2020. ISBN: 9-781-46860-250-0.

2.1.2 Airlines for America (A4A) Publications

Available from Airlines for America (A4A), 1275 Pennsylvania Avenue, NW, Suite 1300, Washington, DC 20004, Tel: 202-626-4000, www.airlines.org.

Spec 42	Aviation Industry Standards for Digital Information Security, Product Code 18044
Spec 2000	Gen 2 Procurement
Spec 2000, Ch. 1	Provisioning
Spec 2000, Ch. 2	Procurement Planning
Spec 2000, Ch. 3-4, 6	Materials Management
Spec 2000, Ch. 7	Repair Order Administration
Spec 2000, Ch. 9	Automated Identification and Data Capture
Spec 2000, Ch. 11	Reliability Data Collection/Exchange
Spec 2000, Ch. 13	Industry Metrics
Spec 2000, Ch. 14	Warranty Claims
Spec 2000, Ch. 16	Authorized Release Certificate
Spec 2000, Ch. 17	Electronic Logbook
Spec 2000, Ch. 18	Electronic Work Package
Spec 2400	Allowable Configuration Data Exchange Standard
Spec 2500	Aircraft Transfer Records

2.1.3 ETSI Publications

Copies of these documents are available online at <https://www.etsi.org/events/17-standards>.

ETSI GR PDL 001 V1.1.1	The landscape of technological standards for distributed ledger technologies
ETSI GR IP6 031	Security aspects of blockchain, IPV6 Network
ETSI GS PDL 005	Permissioned DLT - Proof of concepts framework

2.1.4 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO 22739:2020	Basic Fundamental Terminologies Involved in Blockchain or Distributed Ledger Technologies
ISO/TR 23244:2020	Privacy Protection Consideration in Blockchain/Distributed Ledger Technologies
ISO/TR 23455:2020	Overview of Smart Contract Interaction in Distributed Ledger Technologies and Blockchain

2.1.5 ITU Publications

Available from International Telecommunication Union (ITU), Place des Nations, 1211 Geneva 20 Switzerland, <https://www.itu.int/>.

ITU-T F.571.0	General and Advance Requirements for Distributed Ledger Systems
ITU-T X.1403	Security Guidelines for Decentralized Ledger Technology for Identity Management
ITU-T X.1401	Security Threats for Decentralized Ledger Technology
ITU-T X.1402.0	Security Framework for Distributed Ledger Technologies

2.1.6 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

The FAA and Industry Guide to Product Certification, Third Edition

Air Traffic by the Numbers, https://www.faa.gov/air_traffic/by_the_numbers/

Hobbs, A. and Herwitz, S. (2008). Maintenance Challenges fo Small Unmanned Aircraft Systems - A Human Factors Perspective: An Introductory Handbook. *Federal Aviation Administration*.

2.1.7 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

P2418.4	Standard for the Framework of Distributed Ledger Technology (DLT) Use in Connected and Autonomous Vehicles (CAVs)
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Cui, P., Dixon, J., Guin, U., and Dimase, D. (2019). A Blockchain-Based Framework for Supply Chain Provenance. *IEEE Access* 7, 157113-157125. <https://doi.org/10.1109/ACCESS.2019.2949951>.

2.1.8 Other Publications

ANSI. (2020). Standardization Roadmap for Unmanned Aircraft Systems, Version 2.0. *American National Standards Institute (ANSI) Unmanned Aircraft Systems Standardization Collaborative (UASSC)*. Available at https://share.ansi.org/Shared%20Documents/Standards%20Activities/UASSC/ANSI_UASSC_Roadmap_V2_June_2020.pdf.

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Zeng, Z., Xie, S., Dai, H.-N., Chen, X., and Wang, H. (2018). Blockchain Challenges and Opportunities: A Survey. *Internal Journal of Web and Grid Services* 14(4). <https://doi.org/10.1504/IJWGS.2018.095647>.

2.2 Abbreviations and Definitions

AIR	Aerospace Information Report
AGL	Above Ground Level
ALO	Aircraft Limitation Operation
ANSI	American National Standard Institute
ATA/A4A	Air Transport Association of America (now referred to as Airlines for America or A4A)
ATC	Air Traffic Control
ATM	Aircraft Traffic Management
A/W	Air Worthiness
BiTA	Blockchain in Transport Alliance
BVLOS	Beyond Visual Line of Sight
CAR	Civil Aviation Regulations
CASA	Civil Aviation Safety Authority
C2 Link	Command and Control Link
Chng TC	Changes to Type Certification
DLT	Distributed Ledger Technology
DS	Decentralized System
EASA	European Union Aviation Safety Agency
EEA	Ethereum Enterprise Alliance
ETSI	European Telecommunication Standard Institute
FAA	Federal Aviation Administration
GCS	Ground Control System
HA	Hashing Algorithms
IEEE	Institute of Electronics and Electrical Engineers
IFR	Instrument Flight Rules
IRTF	Internet Research Task Force
ISO	International Standard Organization
ITU	International Telecommunication Union
LAANC	Low Altitude Authorization and Notification Capability
MFTS	Master Flight Test Schedule

MOBI	Mobility Open Blockchain Initiative
MRO	Maintenance Repair and Overhaul
MSL	Mean Sea Level
MTOW	Maximum Takeoff Weight
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PC	Production Certificate
PMA	Parts Manufacturing Approval
POC	Proof of Concept
POH	Pilot Operation Handbook
PoA	Proof of Authority
PoW	Proof of Work
PoS	Proof of Stake
PoET	Proof of Elapsed Time
P2P	Peer to Peer
Prov A/W	Provisional Airworthiness
Prod TC	Production Type Certification
Prov TC	Provisional Type Certification
PSP	Partnership safety plan
SSP	Supplemental Service Providers
STC	Supplemental Type Certificate
TC	Type Certificate
TIR	Type Inspection Report
TSOA	Technical Standard Orders Authorization
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UTM	Unmanned Traffic Management
VFR	Visual Flight Rules
W3C	World Wide Web Consortium

3. INTRODUCTION

Unmanned Aircraft Systems (UAS) are increasingly being used for various commercial applications related to security, surveillance, disaster management, logistics, asset health management, and many more. Rapidly growing operations of UAS require frequent and high volume data logging, data security, trusted and automated operations. The challenge is in managing them across various stakeholders of UAS. This involves monitoring and managing a large and complex network of UAS which necessitates the use of many advanced technologies. Blockchain is one such technology that can help address many of these challenges related to data security, data traceability, and transparency. This AIR presents key challenges associated with the development at deployment of UAS and related to certification, airspace management, operations, digital supply chain management, and maintenance. Further, it provides a perspective on how blockchain can be used to meet these challenges. The requirements for the implementation of blockchain in UAS applications have been presented. The available literature and standards were studied and possible gaps in the implementations of blockchain for UAS have been identified.

3.1 UAS Overview

UAS includes the unmanned aircraft, command, and control (C2 Link) and communications. The UAV is the aerial unit monitored and when required controlled by a remote pilot. Generally, the UAV is categorized based on several criteria that includes Maximum Take-off Weight (MTOW), size, operation, range, autonomy, etc. The general classification of UAVs is remotely piloted aircraft systems and autonomous aircraft systems. UAV is monitored and controlled by the pilot from a ground control station (GCS). Figure 1 provides details of the communication mechanisms in UAS.

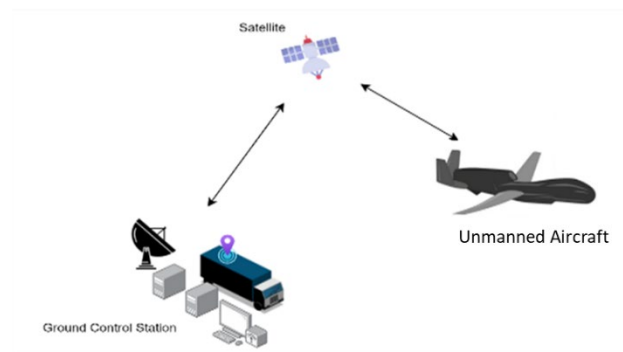


Figure 1A - Communication through satellite

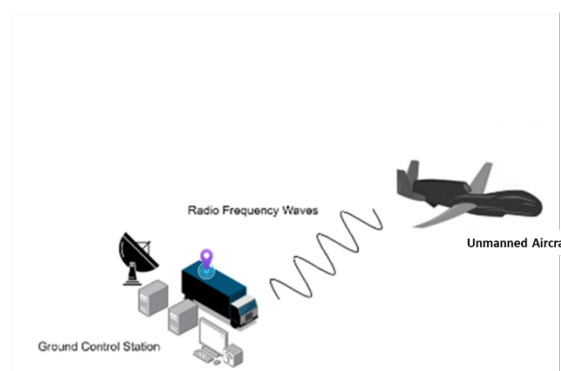


Figure 1B - Direct communication

Figure 1 - Unmanned aircraft system