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D-1.1 REVIEW OF EXISTING LITERATURE AND IDENTIFICATION OF DIGITAL SOLUTIONS

VIRTUA - Digital Transformation - Case Studies for Aviation Safety Standards - Virtualisation

An Agency of the European Union

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SUMMARY

Problem area

Digital technologies are rapidly being integrated into various aspects of the aviation industry, and while they have the potential to enhance safety, productivity, accessibility, and sustainability, they also come with new security and privacy risks. Furthermore, their implementation necessitates significant changes to business models, working processes, standards, and regulations.

In order to keep pace with the changes and advancements in aviation standards, it is imperative to conduct timely and proactive investigations into the application of novel concepts and processes for aviation products, processes, and operations. As the EU Aviation Safety Regulator, EASA is tasked with addressing fundamental questions about how to adapt safety standards in response to the challenges outlined in Flightpath 2050, as well as the introduction of innovative products and processes.

The objective of this project on the implementation of blockchain technologies is to address the potential benefits and constraints (incl. costs) considering the different Stakeholders involved in the management of aircraft parts and components, by investigating different types of blockchains and different use cases for their implementation along the lifecycle of approved parts and components.

In the cases where the benefits are confirmed, the project shall also undertake the assessment of the main changes to be introduced in regulations, standards and working processes as well as the preparation of guidelines and supporting materials for regulatory evolutions and the deployment of the related solutions.

Description of work

The present document is 'D-1.1 Review of existing literature and identification of digital solutions' of "VIRTUA (Digital Transformation – Case Studies for Aviation Safety Standards – Virtualisation)" project (EASA.2022.HVP.01- Horizon Europe Project). It provides an overview of the current regulatory framework of each of the Case Studies under the scope of the project, setting the baseline for the next steps of the project.

Results and Application

The literature review conducted for the VIRTUA project provides a comprehensive overview of the current state and future prospects of digital transformation in the aviation industry, with a particular focus on safety standards. The review highlights the potential benefits of digital technologies, including improved safety, productivity, accessibility, and sustainability.

CONTENTS

ABBREVIATIONS

ACRONYM	DESCRIPTION
A&D	Aerospace & Defense
AIA	Aerospace Industries Association
API	Application Programming Interface
ATA	Air Transport Association (currently known as A4A – Airlines for America)
CAAC	Civil Aviation Administration of China
CFR	Code of Federal Regulations
CNIL	French National Commission for Computing and Liberties
DARPA	Defense Advanced Research Projects Agency
DLT	Distributed Ledger Technology
EASA	European Aviation Safety Agency
EPCIS	GS1 Electronic Product Code Information Services
EU	European Union
FAA	Federal Aviation Administration
GDPR	General Data Protection Regulation
GSBN	Global Shipping Business Network
IAQG	International Aerospace Quality Group
ICAO	International Civil Aviation Organisation
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
MRO	Maintenance, Repair and Operations
MVE	Minimum Viable Environment
OEM	Original Equipment Manufacturer

1. Introduction

The overall objectives related to the review of existing information are to:

- Identify the available scientific literature, industry standards and regulations in relation with the use of blockchain technologies for the management of aircraft parts throughout their lifecycle (deliverable D1.1).

- Identify the digital solutions relevant to the scope of the case study, the available documentation, not only considering aviation but other sectors of application (deliverable D1.1).

The present report shall summarise sub-tasks 1.1 and 1.2:

> **Sub Task 1.1** - Build a long list of relevant standards and regulation covering tender specifications' key areas, and identify industries who initiate this type of study and the chosen approach.
>
> **Sub Task 1.2** - Screening & listing: initial screening of blockchain digital solutions for aviation and relevant other sectors, and assessment of 10 selected blockchain digital solutions according to a structured framework.

1.1 Sub-Task 1.1 Methodology and Key Findings

Sub-Task 1.1: Methodology

We undertook desk research to map out and identify the most up to date information on blockchain publicly backed initiatives from existing studies, reports and websites.
This research activity has been built upon the preliminary analysis carried out for the preparation of the case study, but also on the feedback from the solutions analysed in subtask 1.2, which were able to share interesting sources.

Below is a detailed list of the sources explored, by typology:

Existing standards and publications related to the **management of airworthiness**

- EASA Regulation
- FAA Regulation
- CAAC Regulation
- ICAO Standards
- IATA Standards
- IAQG (International Aerospace Quality Group) Standards (quality standard setting group for the worldwide supply chain)

Existing standards and publications related to **data management, blockchain, or decentralized ledger technologies**, and official reports and publications from the European Commission and various Member States Governments referring to e-government and blockchain/distributed ledger technologies

- World Economic Forum (*weforum.org/topics/blockchain*)
- EU Blockchain Observatory and Forum (*eublockchainforum.eu*)
- GS1 (*mocdn.gs1.org/standards/blockchain*)
- Aerospace Industries Association (AIA) (*aia-aerospace.org*)
- A4A/ATA Specs (ataebiz.org)
- SAE (*standardsworks.sae.org/*)
- European Union and the CNIL Agency (*cnil.fr/en/home*)
- DARPA (Defense Advanced Research Projects Agency) (*darpa.mil/*)

Research papers and recent publications published by well-recognised authors or specialized consulting services; Online articles from specialized magazines **about blockchain/DLTs**

- IEEE (Institute of Electrical and Electronics Engineers) (*blockchain.ieee.org*)
- K&L Gates
- Universities Research Papers

Various online platforms and **sources** from active consortiums **on blockchain**;

- SITA
- Boston Federal Reserve
- Bank of Canada
- World bank Group
- Chile's Ministry of Energy
- IBM Hyperledger - IBM Food Trust
- We.Trade (inactive consortium)
- A.P. Moller-Maersk & IBM - TradeLens (inactive consortium)
- Mining Industry Blockchain Consortium
- BHP
- Food Standard Agency

Constantly **monitor information** produced **by** the **ongoing implementation project** of an EU blockchain infrastructure.

- European Central Bank

Concerning the study of active blockchain consortia, the following dimensions were covered:

- **Administrative level**: national, regional, local level of a publicly backed blockchain initiative from EU countries but also from other countries across the world;
- **Type of initiatives**: sector coverage and representativeness of the initiative. Giving priority to strictly public initiative but also private initiative delivering public services of particular interest;
- **Governance**: coverage of the blockchain initiative in terms of existing governance arrangements, typology of governance, established processes to ensure a working solution without security issues;

- **Legal and regulatory set-up:** coverage in terms of regulatory and legal compliance and role in the framework;
- **Infrastructure/technology:** technological solution, real value provided by blockchain technology, infrastructure coverage and interoperability of the services provided.

Sub-Task 1.1: Discussion and Key Findings

The main finding from this literature review is that there is, to date, no mention of blockchain and decentralized ledger technology in Aerospace & Defence regulations and public standards, civil and military, within the framework of the sources explored.

The reviewed authoritative existing standards and regulations focuses on the general characteristics required from data collection and management systems as well as functionalities which must be supported; the primacy of "what" must be provided without elaborating on "how" such provision should be secured is potentially generating an agnostic basis for the solution employed; this creates an opportunity for implementation of DLT and Blockchain solutions conditional to demonstrating how the attributes of such solutions are answering the aviation stakeholders' needs.

Indeed, although the sources mention, in the context of airworthiness management and parts traceability management, the use and management of data in digital form, there is no precise definition of these systems, but only global rules on the capabilities that these systems must have.

A particularly good depiction of the required functionalities and attributes which digitally established information systems and data collection systems must comply with is sourced from the Export Administration Regulations (US), the ICAO (International Civil Aviation Organization), the Air Transport Association (ATA), and the European Union Aviation Safety Agency (EASA):

- The Export Administration Regulations specifically define the information systems requirement for data management in Chapter 762.5 - REPRODUCTION OF ORIGINAL RECORDS[1]:

  "*The process must meet all of the following requirements, which are applicable to all systems:*
  (1) The system must be capable of reproducing all records on paper.
  (2) The system must record and be able to reproduce all marks, information, and other characteristics of the original record, including both obverse and reverse sides of paper documents in legible form.
  (3) When displayed on a viewer, monitor, or reproduced on paper, the records must exhibit a high degree of legibility and readability.
  (4) The system must preserve the initial image and record all changes, who made them and when they were made. This information must be stored in such a manner that none of it may be altered once it is initially recorded."

- The ICAO provides guidance for the acceptance of electronic aircraft maintenance records and continuing airworthiness records (III-7-28 and III-7-B of Airworthiness Manual)[2]:

[1] U.S. Department of Commerce (US), EAR (Export Administration Regulations) - Part 762 Recordkeeping, Sub-Part 5 – Reproduction of original records, https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear

[2] ICAO, Airworthiness Manual - Doc 9760, https://aviation-insight.aero/wp-content/uploads/2021/05/ICAO-9760-docs-4thEdition.pdf

"If an electronic system is implemented, it should be ensured that all records are generated, processed, used, stored, and archived following the guidelines set out in Attachment B to this chapter. The software and hardware used should support specific procedures acceptable to the State of Registry with respect to:

a) protection of the records by electronic means against loss, destruction or tampering to the equivalent extent of that provided to paper records;

b) backup of records (e.g., backup system robustness and reliability; timing and frequency of backup completion; segregation from source records; data loss and recovery);

c) user identification, authentication, and authorization to access the records, scope of access, control of access and traceability of all operations concerning any individual record; and

d) security and integrity of the records"

The ICAO also mentions (III-7-28) the following, opening the possibility of using blockchain and other decentralised ledger technologies to better address them:

"Continued airworthiness records should be kept in such a way that they are protected from hazards such as fire, flood, theft, or alteration. Computer backup disks, tapes and other storage mediums should be safely stored in a different location.

Records should be structured or stored in such a way as to facilitate auditing."

- The ATA Specifications are establishing several standards with aviation industry wide acceptance and relevance to information systems design, functionality, and interoperability; examples of such standards are:
  - Spec 42 Aviation Industry Standards for Digital Information Security[3] provides recommendations on standardized methods to achieve the appropriate level of security for an application primarily relying on digital identities but in some cases transitioning from an existing manual process over time to a fully functioning automated digital identity-based solution
  - Spec 2500 – Aircraft Transfer Records[4] provides an industry standard for exchanging Aircraft records in standardized, electronic (XML) formats including records of aircraft components.
  - Spec 2400 – Allowable Configuration Data Exchange Standard[5] is a specification for the exchange of configuration data between Aircraft Operators and Original Equipment Manufacturers (OEMs); it defines part configuration attributes and concepts which integrate engineering product structure with allowable part usage by Function Position installation through the life of an aircraft.
  - Spec 2000 – Authorized Release Certificate[6] (Chapter 16) provides an industry standard for the electronic exchange of the Authorized Release Certificate (e.g., FAA Form 8130-3, EASA Form 1) that declares that an aircraft part has passed certain quality inspections and is approved for service.
- The European Union Aviation Safety Agency (EASA) already issued some regulatory provisions related to Information Technology Systems and their impact on the form of continuing airworthiness records in general and regarding computer-generated signatures and electronic exchange of digital certificates in particular. There is a high degree of complementarity and no conflictual views between ATA Spec 2000,

[3] ATA Spec 42, Aviation Industry Standards for Digital Information Security, https://publications.airlines.org/CommerceProductDetail.aspx?Product=294

[4] ATA Spec 2500, Aircraft Transfer Records, https://publications.airlines.org/CommerceProductDetail.aspx?Product=241

[5] ATA Spec 2400, Allowable Configuration Data Exchange Standard, https://publications.airlines.org/CommerceProductDetail.aspx?Product=307

[6] ATA Spec 2000, Authorized Release Certificate, https://publications.airlines.org/CommerceProductDetail.aspx?Product=280

which defines the format and content of electronic certificates, and the Acceptable Means of Compliance which provide the necessary controls and security measures to ensure the authenticity and integrity of the digital certificates and signatures. Together, these standards provide a comprehensive framework for the electronic records and the electronic exchange of certificates in the aerospace and defense industry.

  - AMC M.A.305(e) Aircraft continuing airworthiness record system is rightfully subtitled INFORMATION TECHNOLOGY (IT) SYSTEMS AND FORM OF RECORDS since the majority of its content specifies what features should be secured by electronic records in order to constitute an acceptable means of addressing the requirements of a continuing airworthiness record system[7]
  - AMC M.A.801(e) Aircraft Certificate of Release to Service (5): This standard defines the requirements for the use of computer-generated signatures and electronic exchange of digital certificates in the context of aircraft certification. The standard outlines the necessary procedures, controls, and security measures to ensure the integrity and authenticity of the digital signatures and certificates[8].
  - AMC to Appendix II to Part-M — Use of the EASA Form 1 for Maintenance: This standard specifies the use of the EASA Form 1 for maintenance of aircraft components and appliances. The standard allows for the use of electronic signatures and digital certificates in the completion of the EASA Form 1[9].
  - Review AMC No 1 to 21.A.163(c): This standard provides guidance on the use of computer-generated signatures and digital certificates in the context of the approval of design changes and repairs for aircraft components and appliances. The standard outlines the necessary controls and security measures to ensure the authenticity and integrity of the digital signatures and certificates[10].

- The increasing importance of Information Security as part of achieving the required level of aviation Safety is acknowledged by the recently released Implementing Regulation (EU) 2023/203. The Part-IS[11] relevance to the blockchain use case is recognized and the expected Part-IS associated AMC & GM should constitute an element to consider for any aviation blockchain solution.

The above mentioned EASA regulatory provisions do not represent a barrier to the adoption of blockchain technology, but rather an opportunity for the aerospace and defense industry to leverage the benefits of this technology. By complying with these regulations, the industry can ensure the authenticity and integrity of digital certificates and signatures, which are crucial for the safety and airworthiness of aircraft.

The limited detail about information systems architectures and data management methods does not indicate a required use of centralised databases only and inherently opens the possibility of using blockchain or other Distributed Ledger Technologies (DLTs). However, not all blockchain / DLTs existing solutions on the market meet the criteria set out in these standards, which is why technical evaluation of the fundamental axes of these standards is a necessary step prior to launching any pilot project or initiating global implementation efforts on blockchain/DLT based processes with impact on airworthiness management.

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[7] AMC M.A.305(e) Aircraft continuing airworthiness record system in Annex I (Part-M) of Regulation (EU) No 1321/2014, https://www.easa.europa.eu/en/downloads/95788/en

[8] EASA (EU) - Acceptable Means of Compliance M.A.801(e) Aircraft certificate of release to service (5)

[9] EASA (EU) - Acceptable Means of Compliance to Appendix II to Part-M — Use of the EASA Form 1 for maintenance

[10] EASA (EU) - Review of Acceptable Means of Compliance No 1 to 21.A.163(c)

[11] COMMISSION IMPLEMENTING REGULATION (EU) 2023/203, https://www.easa.europa.eu/en/document-library/regulations/commission-implementing-regulation-eu-2023203

Several white papers and scientific papers on blockchain, applied to Aerospace & Defense use cases, have been published based on blockchain experimentations or consortium working groups of diverse major industry players.

- The Aerospace Industries Association (AIA) confirms, in its Blockchain in Aerospace & Defense Whitepaper[12], that blockchain generates unique value through auditability, automation, security, tamper-evident, cost-effectiveness and decentralisation, the core characteristics of this technology. This whitepaper explains, among other things, the concept of Minimum Viable Environment for blockchain:

  "*Like other platform technologies, blockchain and distributed ledgers gain their success, power, and influence from scale. For blockchain to move beyond contained proofs of concept in A&D, it needs a minimum level of scale, which we call the minimum viable ecosystem (MVE). The MVE is the foundational next step for the progression of blockchain into the A&D ecosystem because it incorporates three crucial aspects of blockchain adoption: breadth, scale, and standards.*"

- SITA, a major player in air transport communications and information technology, is pleading in its MRO Blockchain Services Whitepaper[13] that a blockchain solution would facilitate the seamless tracking, tracing and management of aircraft spare parts. Its conclusion regarding the blockchain solutions is that:

  "It will involve Spec2000 format standards compliance for parts and the maintenance of one source of truth, long-term data integrity and validity from cradle-to-grave. From a business perspective, it will generate trust amongst stakeholders, ready and willing to share data with confidentiality and integrity. Independent automatization reconciliation will guarantee service levels. A reduction in errors will lead to a reduction in direct and indirect costs. Inventory management and operational process efficiencies will be enhanced and maintained."

These publications on blockchain, as applied to industry, make clear that decentralized IT systems meet the data management standards proposed or imposed by the organisations and regulators mentioned earlier in this section.

Major data management standards, applied to blockchain and decentralised databases, are however being discussed outside the Aerospace & Defence industry, by multi-industry public organizations and blockchain editors.

The World Economic Forum has published the Blockchain Deployment Toolkit[14], which aims to provide public organisations and private companies with guidelines and best practices for the deployment of blockchain and other decentralised databases. The content of this guide covers a wide range of topics that can provide

[12] Aerospace Industries Association (AIA), Blockchain in Aerospace & Defense Whitepaper, https://www.aia-aerospace.org/wp-content/uploads/AIA-Blockchain-Whitepaper.pdf

[13] SITA, White Paper Blockchain in Maintenance and MRO, https://www.sita.aero/resources/White-papers/mro-blockchain/

[14] World Economic Forum, Blockchain Deployment Tool Kit, https://widgets.weforum.org/blockchain-toolkit/modules/index.html

significant assistance in airworthiness data management blockchain projects, because the tools in the toolkit aim to cover many scenarios that will arise in a real-life project:

- Consortium Governance
- Digital Identity Management
- Interoperability
- Data Protection
- Data Integrity
- Cybersecurity
- Public and private data structure

This Blockchain Deployment Toolkit allows to explore the most important topics of the project or use case on which an organisation wants to focus, and to find answers and additional content very quickly. The World Economic Forum's guide also addresses issues related to the management of personal data in decentralised databases, which can happen in the context of Digital Identity Management activities, but this guide can be complemented by the work done by the CNIL (French National Commission for Information technology and civil Liberties), which provides concrete guidelines on how to set up such information systems while respecting the GDPR.

Another example of standards to follow is GS1's portfolio, which includes a set of foundational standards, the EPCIS Blockchain Traceability Standards[15], that can be used to structure data that is to be stored in (or referenced by) blockchains. Industry leaders have an opportunity to avoid divergence of internal systems and data formats and to accelerate their adoption of blockchain technologies for enterprise by leveraging the GS1 and ISO open standards EPCIS and CBV, which are global multi-sector standards that enable the exchange of traceability data and serial-level (or item-level) track-and-trace.

To be more specific, EPCIS provides open, standardised interfaces that allow for seamless integration of services in inter-company environments as well as within companies. Standard interfaces are defined in the EPCIS standard to enable visibility event data to be captured and queried using a defined set of service operations and associated data standards, all combined with appropriate security mechanisms that satisfy the needs of user companies. In many or most cases, this will involve the use of one or more decentralized databases of traceability event data, though elements of the approach could be used for direct application-to-application sharing without the use a major, global and decentralized database.

The blockchain offered advantages are scrutinized and a DARPA (Defense Advanced Research Projects Agency) supported recent investigative report[16] highlights unintended centralities in distributed ledgers and identifies several scenarios in which blockchain immutability is called into question not by exploiting cryptographic vulnerabilities but instead by subverting the properties of a blockchain's implementation, networking, or consensus protocol. A subset of a blockchain's participants can garner excessive, centralized control over the entire system.

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[15] GS1, EPCIS Blockchain Traceability Standards, https://ref.gs1.org/standards/epcis/

[16] DARPA funded study by Trail of Bits, Unintended Centralities in Distributed Ledgers – Report, https://assets-global.website-files.com/5fd11235b3950c2c1a3b6df4/62af6c641a672b3329b9a480_Unintended_Centralities_in_Distributed_Ledgers.pdf

To gain perspective on these standards and regulations, an analysis of multiple sources from active consortiums in blockchain, in various industries was carried out to retrieve information that could add content to the literature review. These consortiums concern various industries (Supply Chain, Energy, Environment, Agri-food, Finance), and can be supported by public or private funds.

The most relevant case consists of the consortium set up by the Food Standards Agency[17] in the United Kingdom. The Agency has carried out 3 pilots, on topics related to the management of certificates in the food industry and the traceability of products throughout the supply chain. In these three pilots, 3 decentralized database technologies were tested, providing detailed learning on each of the drivers and the benefits that the solutions used may have offered. The main findings of the Food Standards Agency are:

- The use of blockchains offers real potential benefits to improvements in safety standards and quality of food throughout many value chains. The underlying technology is not a challenge to implement or use and some of the concerns expressed at the time of the pilots have been addressed with continued development of the technology.
- There is no evidence as to significant cost associated with a blockchain solution: it is not blockchain itself that drives cost, but any technology enabled projects may be costly.
- Participation in a blockchain ecosystem should not require organisations to undertake large scale changes in infrastructure. Such changes can be managed by architecting a balance between off-chain and on-chain data so that non blockchain infrastructure can communicate with blockchain ecosystems.
- Technology standards for blockchain are immature, which leads to the following conclusions:
    - Interoperability / translation models needs to be adopted to ensure external systems can interact with the central blockchain with minimal cost of change.
    - Adoption of data standards need to be a pre-requisite
    - Data quality could slow down the adoption of new innovative technologies
- Many of the layers of policy, trust, legal frameworks, process and data definition and ease of interoperability between all participants in any use case are hurdles that need to be decoupled and overcome to ensure that blockchains deliver the promised value to the Food supply chain. The different layers include:
    - Consents and Commitments: Clear a legally robust consent to how data is used, protected, and managed that complies to prevailing standards such as GDPR etc.
    - Keys and Certificates: The receipt of keys and certificates necessary to participate in the value chain with appropriate encryption of data
    - Clear Standards/Data Definitions: A mutually agreed set of definitions for the key data used within the value chain to enable clarity and reduce delays and friction
    - Ease of Interoperability: Interoperability model that supports input of data from multiple types of participant systems using API's and other methods
    - Clear Arbitration in the event of issues: A quick and accurate 'appeal and arbitration' capability that identifies and resolves issues quickly

[17] Food Standards Agency, Insights and learnings from the Food Standards Agency (FSA) exploring the use of Blockchains, https://www.food.gov.uk/sites/default/files/media/document/fsa-blockchain-first-steps-to-next-steps.pdf

Starting as a private initiative by Maersk and growing into a consortium of over 100 partners in 6 years, the Tradelens blockchain consortium[18] draws similar conclusions. The aim of this blockchain, now inactive) was to ensure the traceability of legal documents and certificates for goods transported in containers by sea, in the form of a distributed register shared between all the players involved in the global maritime trade logistics chains. This consortium was based on the TradeLens platform, developed by Maersk and IBM, through a unique joint venture, managed by a board of directors made up of leaders from across the industry, with the aim of giving a voice to all partners using TradeLens and ensuring that they benefit from the platform for their development and growth.

However, although in 2019 the platform was recording 13 million events and more than 100 000 documents every week (more than half the world's container traffic), collected from more than 100 actors, the platform has not been further adopted in December 2022, Maersk announced that although a viable platform was developed, the need for industry wide collaboration was not achieved. The TradeLens platform itself is now scheduled to wind down operations by the end of Q1-2023. While the Maersk-supported offering is going offline, the industry remains committed to digitalization and analysts are saying there remains a place for blockchain applications.

The Kong Kong-based Global Shipping Business Network (GSBN) emerge as the largest competitor with the support of a range of industry companies. This consortium will have made it possible to explore, through the number and diversity of players involved in it, many aspects linked to the implementation of a blockchain at a global level in a fast-growing sector, the digitisation of which remains very varied depending on the country. These are the key learnings from TradeLens:

- Let legitimacy and political feasibility guide the starting point. Although TradeLens basically aims to digitise 5 critical paper documents, the lack of standards for import/export data management has slowed its adoption. Although TradeLens has been in constant contact with the international maritime trade authorities, universal digital standards have never emerged. Therefore, by the end of 2019, only 3 countries officially allowed the use of TradeLens, while most of other national governments were in testing phase (like China and the US). In some countries, this decision may also have been more political than administrative, removing the acceptance of blockchain-based technologies from the industry authorities.
- The lack of vision on the interoperability of TradeLens with other global supply chain digitalisation solutions has also hindered many actors and governments in its adoption. Moreover, the fact that an API must be developed systematically to connect to the TradeLens platform, at the partner's expense, has also slowed down its adoption. The edition of standards for how the events on the ledger should exchange information with the partners systems could have reduce actors' efforts in connecting.
- Blockchains are decentralized technical solutions to inter-organizational problems. Blockchain technology offers a solution to the trust problem in an inter-organizational context by moving part of the complexity of the problem from the organizational to the technical level. However, Maersk's position as a central player in the development and marketing of TradeLens does not allow it to respond instantly to these trust issues, thus slowing down its adoption.

[18] A.P. Moller-Maersk, IBM, Delivering Business Value with Blockchain: TradeLens, https://www.researchgate.net/publication/345356583_How_TradeLens_Delivers_Business_Value_With_Blockchain_Technology

Another such example is the We.Trade blockchain platform[19]. The circle of blockchain-based trade finance platforms is getting smaller as the We.Trade platform is about to go out of business. The network said growth rates "have not been large enough" to "ensure the sustainability of the business." New investment from existing shareholders would therefore have been necessary to support the company in a new phase of development. However, such an agreement could not be reached, according to We.Trade. Therefore, the company's management decided not to continue the company's activities.
"The closure of We.Trade affects only a very limited number of Unicredit customers, all of whom were informed in time," Hypovereinbank, for example, said in response to a query from DerTreasurer. Alternative solutions have been set up for the few open transactions currently being processed, it added.
We.Trade is a blockchain trade finance solution launched by Deutsche Bank, HSBC, KBC, Natixis, Rabobank, Société Générale and Unicredit, on IBM Blockchain Technology. This was launched in early 2017 with hopes of digitizing foreign trade finance, which is still very much paper-based. Since then, various banking consortia have launched such initiatives. Shortly after We.Trade, the Batavia platform followed, but it merged into We.Trade in the fall of 2018. That year also saw the launch of Marco Polo and Voltron, now called Contour.

However, the big breakthrough for these new trade finance platforms has so far failed to materialize. The new providers have hardly progressed beyond individual pilot projects. There are several reasons for this: **For one thing, the digitization of many public authorities is still inadequate. But they need to be integrated into the process. Secondly, there is often a lack of legislation regulating the use of blockchain technology in the foreign trade sector.** This is another reason many companies are still hesitant to use such platforms as We.Trade.

This was also recently confirmed by Contour's head of product Joshua Kroeker to our sister publication FINANCE: "The interest on the part of companies is there, but many are reluctant to be an early adopter, i.e., to join before their bank and counterparties. They still want to wait and see how things develop."

Sub-Task 1.1: Conclusions

The main learning from this literature review is that there is, to date, no mention of blockchain and decentralized ledger technology in Aerospace & Defence regulations and public standards, civil and military, within the framework of the sources explored.

A particularly good depiction of the required functionalities and attributes which digitally established information systems and data collection systems must comply with is sourced from the Export Administration Regulations (US), the ICAO (International Civil Aviation Organization) and the Air Transport Association (ATA). Major data management standards, applied to blockchain and decentralised databases, are however being discussed outside the Aerospace & Defence industry, by multi-industry public organizations and blockchain editors.

Private or public blockchain initiatives, carried out in consortium within an industry and its almost complete value chain, also provide lessons which are major assets for future blockchain prototypes and implementation

[19] We.trade, (paper by Blockdata Tech) - How Blockchain Is Impacting Trade Finance in 2022, https://www.blockdata.tech/blog/general/how-blockchain-is-impacting-trade-finance-in-2022

projects. Such lessons should be filtered through the requirement that any and all functionalities of a blockchain envisaged for aviation implementation should be compatible with EASA regulations.

1.2 Sub Task 1.2 Methodology and Key Findings

Sub-Task 1.2: Methodology

Approximately **10 blockchain solutions,** which are considered relevant for aviation industry and management of airworthiness, were identified. The mapping and assessment of solution apply the following two-step process:

- **Screening & listing**: initial screening of blockchain digital solutions for aviation and relevant other sectors. For the selection of the digital solution, we leveraged from the desk research and from external stakeholders' inputs and suggestions.
- **Assessment**: assessment of the selected solutions according to a structured framework. The selected solutions are assessed according to the assessment framework indicated below.

To perform this task, interviews with the solutions owners or representatives were carried out. In addition, these stakeholders have widely expressed their willingness to be involved in the further development of the project upon request.

A blockchain based digital solution assessment framework is provided below. The following criteria will be used to describe the different initiatives and subsequent digital solutions:

Assessment framework for blockchain digital solution	
Areas of focus	**Examples of question that could be addressed**
Services	• What are the services addressed by the digital solution? • Does the solution deal with them separately or with one single blockchain infrastructure applied to all of them at the same time? • Are these services new or traditional?
Infrastructure	• What is the infrastructural solution set up? Blockchain capacity ○ What kind of blockchain technology is been used? ○ What is the capacity of the used blockchain technology? ○ What capacities had been needed in order to make possible the blockchain application? ○ What is the minimum capacity of the blockchain technology needed to achieve the objectives? Data diffusion ○ How is data propagated? ○ Who receives and sees data? Data storage ○ What type of data is stored on-chain? ○ Where is additional data stored off-chain?

	Technological consensus rules ○ How is consensus reached? ○ About what is consensus reached? ○ Who is involved in the process? About smart contract functionality ○ Does the system support smart contracts? ○ What layer supports this functionality? • What are the infrastructural requirements for the success of the solution implementation? • How could the solution benefit from, interact with or contribute to a blockchain infrastructure at EU level? • What is level of risk in term of cybersecurity? And more globally any other operational & technical risks associated with the solution?
Cost	• What is the pricing model of the solution? • What are the associated costs (direct/indirect)? • What is the cost of implementation? What is the maintenance cost?
Governance	• What is the governance set up of the solution? ○ Is there a gatekeeper? ○ Who is it? ○ What is its role? (Access control, permissions management, terms and conditions, software maintenance and updates, dispute resolution, setting terms for asset issuance/tokenisation) • Who is responsible for the blockchain solution? • Does the vendor maintain any roles, and which ones? • What are the governance requirements for the success of the solutions implementation? • How would the governance model support an effective management of information security risks across functional chains (particularly for those risks that may have an impact on safety, respectively during the phases of Production, Operation, CAMO, Maintenance, etc)?
Interoperability	• What is the degree of flexibility and interoperability of this solution? • Is it possible to connect it to other separated ledgers? Could it be applied to other public services? ○ If so, what are the requirements (in terms of infrastructure setup, governance, and technology features)? Could it be applied to other public bodies? ○ If so, what are the requirements (in terms of infrastructure setup, governance, and technology features)? Could it be applied to other administrative levels (local/regional/national/European)? ○ If so, what are the requirements (in terms of infrastructure setup, governance, regulatory framework and technology features)? • If the solution already provides a degree of interoperability, what are the requirements for its success? ○ Is there a need for technical standardisation? • What is the level of possible reversibility in case the client wants to change the solution?
Regulatory framework	• Are there any features of the legal/policy framework that have been crucial to the existence of the solution? ○ Is there any regulatory set-up that had been essential to the existence of the solution? ○ Are there any blockchain standards that had been essential to the existence of the solution?

	○ Are there any industry standards that had been essential to the existence of the solution? • How GDPR in embarked by design?
Sustainability	• What is the CSR impact of the solution ○ What is the carbon footprint impact of the solution? ○ How does it help to have positive impact on society? ○ How does it help to have a better governance?
Scalability	• Is it extendable at other administrative levels (local/national/regional/EU level)? ○ If so, what are the requirements (in terms of infrastructure setup, governance, regulatory framework, and technology features)? • Is it extendable at EU level? Return of the financial investment ○ What was the level of investment (financial resources) needed to carry out the solution? ○ Who provided the funds? ○ Was this source the only one available or there were other funding organisations? ○ Was the investment paid back? After how much time?
Replicability	• Is this solution replicable elsewhere or its existence is totally related to its particular context?

The following solutions were identified, contacted, and showed great interest in the project. The different points of the assessment framework were presented and discussed to better understand their solution and the use cases addressed.

- Block Aero (*block.aero/*)
- Sky Republic (*skyrepublic.com*)
- SkyThread (*skythread.aero/*)
- Tilkal (*tilkal.com*)
- TrustFlight (*trustflight.com/*)
- Aerotrax (*aerotrax.com/*)
- Blockaviation (*blockaviation.com/*)
- Neurochain (*neurochaintech.io/*)
- SITA Flightchain (*sita.aero/*)
- VeriTX (veritx.com)

Other blockchain editors addressing the use case studied have showed interest to join the initiative, in which case the deliverable will be amended accordingly.

Sub-Task 1.2: Discussion and Key Findings

The number of blockchain solutions on the market addressing the current case study are few in numbers and the solutions identified above represent most of this ecosystem of vendors.

Although the main objective of these solutions remains the same, confirming that this blockchain use case in the Aerospace industry is relevant, these vendors have major differences in the scope of the parts addressed, the actors involved and the possible additional services that the solution can provide.

There are also major differences in the infrastructures put in place to meet these needs, showing that there is not one blockchain technology but multiple ways of using decentralized ledger technologies.

2. Next Steps

The upcoming deliverable (D-1.2 Case study work plan, incl. analysis method shall encompass all the listed resources and industry trends on hand and will entail the identification of the scope for the case study (Who, What, Where When and Why) to define the requirements and use case scenarios for the project. In addition, desk research on each identified scenario shall be performed to determine the current best practices.

For the execution of the case study, interviews shall be conducted to collect expert opinions about the barriers and effectiveness of the implementation of Blockchain, as well as providing in-depth information on the technical architecture that the selected blockchain solutions are proposing. The degree in which such solutions are compatible with the already documented EASA regulatory relevant material will be explored during the interviews.

Finally, a detailed execution plan will be developed through the profiling of different stakeholders based on the previously performed interviews, schedules bottom-up investigations or design thinking workshops to help stakeholders to make strategic decisions on which use cases needs to be analysed.

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