Blockchain in Copenhagen Airport

The Journey Towards Increased Data Sharing and Interoperability

Master's Thesis

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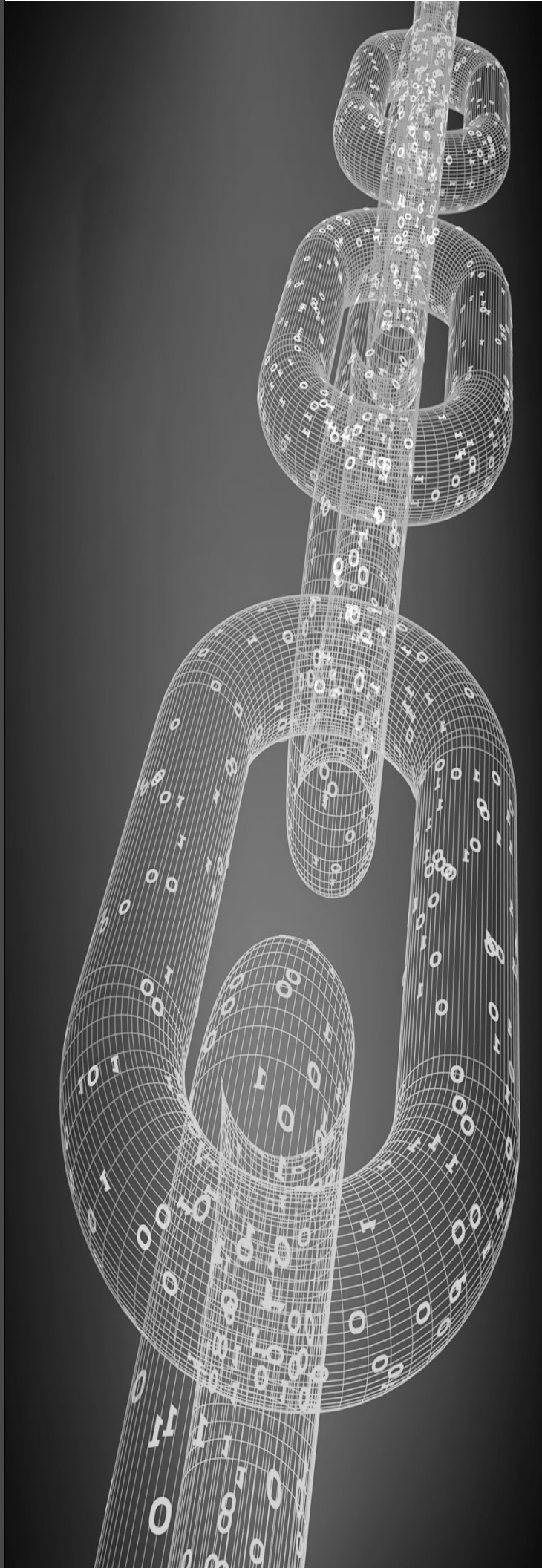

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Abstract

At present, there is limited interoperability and data sharing between Copenhagen Airport, the airlines, and the authorities with regard to the underlying processes for a passenger's journey in the airport. Based on a qualitative typical case, the thesis explores whether blockchain technology can improve data sharing, and what management factors that need to be considered to adopt the technology. From literature, the following four factors are identified: (1) trust, (2) governance, (3) standards, and (4) incentives. Blockchain is a well-suited technology for an airport where different stakeholders need to collect information in a secure manner to allow for optimized resource allocation to improve efficiency of operations and the passenger journey. However, the possibility of adopting blockchain is influenced by the investigated factors. Therefore, all factors need to be considered from a managerial perspective to ensure interoperability, which is paramount prior to the initiation of a blockchain project for data sharing in Copenhagen Airport. Thus, if the stakeholders neglect the concepts, it can constitute interoperability barriers for implementing blockchain-based solutions.

Keywords: Blockchain; data sharing; airport; aviation; enterprise interoperability; trust; governance; standards; incentives.

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1. Introduction

Technology and digitalization are continuously advancing, impacting workplaces and processes (Parviainen et al. 2017). This is also the case in the aviation industry, where Airports Council International (ACI) declared that airports are no longer just the place to facilitate the passenger getting to their destination. Now the airport has shifted into an important gateway and economic machine (ACI, 2020) that seeks to create digital and data-driven airports with the purpose of taking the passenger journey to the next level based on digital solutions (Copenhagen Airports A/S, 2020; Jenkins & Nolan, 2020; Jones, 2019). New technology applications will provide the ecosystem with new opportunities and possibilities to improve the passenger experience by ensuring a seamless travel based on a relaxed, personal and relevant passage through the airport (Copenhagen Airports A/S, 2020; Mullan, 2020). Likewise, technology will provide possibilities to enhance revenue through new business models (Copenhagen Airports A/S, 2020; Beck et al. 2017).

However, the developments and utilization of technology cannot solely ensure progress towards the airport of the future offering seamless travel for the passengers. A key element is interoperability between the actors in the ecosystem which is essential to benefit from implementations of new technology (Hartshorn, 2020). Additionally, a strong focus relies on enhancing data sharing (Copenhagen Airports A/S, 2020), but a prerequisite is the level of existing collaboration between the stakeholders in the particular ecosystem. Moreover, the various stakeholders can be considered interdependent due to one stakeholder's operations allowing the other to operate. Therefore, it could be expected that collaboration is a common focus. However, this is not the case since collaboration and interoperability at present is considered an obstacle for further development of the passenger journey and improvements of operations (International Airport Review, 2019a). The limited data sharing between the stakeholders (International Airport Review, 2019b) is paradoxical as airports aim to become more digital and data-driven (Copenhagen Airports A/S, 2020). Having interoperability can improve operations and ultimately the passenger experience (Hartshorn, 2020; Abdullah, 2015), whereby it needs to be a primary focus to further unlock the potential of data (Copenhagen Airports A/S, 2020).

1.1 Scope of Research

In recent years the blockchain technology has received increasing attention both from scholars and cryptocurrency investors (Hughes et al. 2019). Blockchain facilitates disintermediation where two actors can transact directly with each other through the properties of cryptography and distributed ledger (Lacity, 2018). Hereby, enabling parties who previously would not interact to now participate. There are limited studies focusing on how blockchain can improve operations at the airport and those that exist have primarily focused on the baggage supply-chain (Di Vaio & Varriale, 2020). The thesis will investigate the opportunity and requirements for creating interoperable systems between the primary stakeholders involved in the passenger journey through Copenhagen Airport (CPH Airport). It seeks to understand the possibility of implementing a blockchain-based system, which can facilitate CPH Airport meeting the strategic objective of becoming a more digital and data-driven airport (Copenhagen Airports A/S, 2020). The thesis will focus on CPH Airport because it has won several awards for performance and efficiency (CPH, 2020), illustrating a well-functioning and highly digital airport environment (Copenhagen Airports A/S, 2020). The thesis is based on a typical case to show and understand the prerequisites to embrace blockchain for data sharing between CPH Airport, the airlines, and the local authorities. The three stakeholders have been chosen because they are in charge of the primary checkpoints throughout the passenger's journey in the airport. The passenger's journey is a natural area to focus on because it is based on linear events, and due to the fact that each stakeholder can benefit from receiving information from the other checkpoints. In continuation, a focus will be on how more data sharing can improve the respective stakeholders' operations. The research will emphasize important managerial considerations to be made prior to the adoption of a blockchain-based system.

1.2 Research Question

To enhance data sharing in the airport environment, the thesis will examine preliminary management considerations related to adopting a blockchain solution and how these constitute to the foundation for adoption. Understanding these challenges will lay the foundation to explore the opportunities for implementing blockchain technology. Thus, the focus is to understand what currently limits system interoperability, and how blockchain technology potentially can solve this.

Moreover, it concerns what initial considerations that need to be made in order to embrace a blockchain solution. The master thesis seeks to answer the following question:

What factors constitute the foundation for adopting a blockchain-based system in Copenhagen Airport to enhance data sharing through interoperability?

The research examines blockchain-based systems as the dependent variable that will be influenced by the identified independent variables from the literature review; (1) trust, (2) governance, (3) standards, and (4) incentives. The analysis applies the factors to examine whether they constitute crucial managerial considerations that will impact the possibility of adopting a blockchain-based system. This is related to the ecosystem of CPH Airport, wherefore the analysis initially will examine the stakeholders and the current interoperability between them. Secondly, the analysis will cover how blockchain technology can facilitate the strategic direction of being a data-driven airport through enhanced exchange of information. Thirdly, the thesis focuses on answering what elements need to be embraced upon to ensure that the foundation exists for blockchain technology development and utilization.

1.3 Delimitations

The focus of the thesis is on how blockchain can improve data sharing between the airport, airlines, and authorities. In this regard, the passengers, stores, ground handlers, or other stakeholders' perspective will not be examined as they are responsible for the investigated checkpoints in the passenger journey. On the other hand, they are considered an external factor that is affected by the stakeholders' output.

The research considers the airlines as one segment implying that there will not be distinguished between low-cost-carriers and mainline-carriers. This is because it is expected that the whole segment has an interest in optimizing internal processes and the passenger journey. The thesis will focus exclusively on if/how interoperability and data sharing between the airport, airlines, and authorities covering the passenger's journey can be improved by using blockchain. Lastly, the thesis will solely focus on Copenhagen Airport as a case.

1.4 Thesis Structure

The following section will present in which direction the aviation industry is heading. It will describe the influence and opportunities of digitalization in aviation. Chapter 2 introduces the theoretical background for how to measure enterprise interoperability, an introduction to blockchain, a literature review investigating management considerations when implementing blockchain, and a framework to evaluate when to use blockchain. Chapter 3 covers the thesis' methodology and philosophical research foundation. Chapter 4 describes the case and the involved stakeholders. Chapter 5 contains the analysis and findings of the thesis. This implies a focus on the current interoperability concerns, the identified concepts from the literature review, and an examination of the applicability of blockchain. Chapter 6 presents the discussion of the paper that functions as a continuation to the analysis. It seeks to discuss the analyzed concepts in relation to the previous literature. Moreover, the discussion will contain a focus on barriers and approaches of interoperability. Finally, the section will discuss contributions and implications as well as challenges and limitations. Lastly, chapter 7 to 10 presents the thesis' conclusion, future research, recommendations and reflections on the process.

1.5 Background Information

The following section will provide background information regarding the expected future development of aviation. The background information is applied to shed light on the importance of the research area.

1.5.1 The Future of Aviation

Digitalization is a key trend that is likely to change industries, businesses, and society in a future perspective (Parviainen et al. 2017). Neglecting the development might generate risk in terms of losing market share in highly competitive industries. However, focusing on the digitalization of existing business processes can affect an organization's operations and business model, for instance, by bringing new business opportunities or changing the role of operators within the organization's value chain (Parviainen et al. 2017; Sambamurthy et al. 2003). In this context, Parviainen (2017) distinguishes between three major impacts that may occur by well-executed digitalization of business processes; internal efficiency, external opportunities, and disruptive change. In aviation, the purpose of digital transformation concerns optimizing the internal

efficiency in the ecosystem. Additionally, it concerns enhancing the external opportunities in terms of the passenger experience, which becomes increasingly important due to the development of non-aeronautical revenue (NAR) streams that becomes even more important to ensure airport's financial sustainability (ACI, 2019). International Air Transport Association (IATA) and ACI state in this regard that automation of airport processes is predestined since digital solutions provide passengers with a faster journey from entering the airport to being seated. Ultimately, this is leading to a more frictionless and improved experience for the passengers, which is a vital objective for airports and airlines (IATA, 2019; ACI, 2018). Digitalization and utilization of technology and information are already considered a cruciality in aviation but will also impact the airport processes in a future perspective as it is considered a major contributor to meet the passengers' demands (IATA, 2019).

Based upon a foundation of technology and digitalization IATA has identified 13 major key drivers of change that in the future are expected to impact the industry (IATA, 2018a). The key drivers are later translated into a list of major themes with high relevance in regard to the future of aviation (IATA, 2018a). Based on the focus of the thesis, five specific themes presented in figure 1 has been found appropriate to examine further:

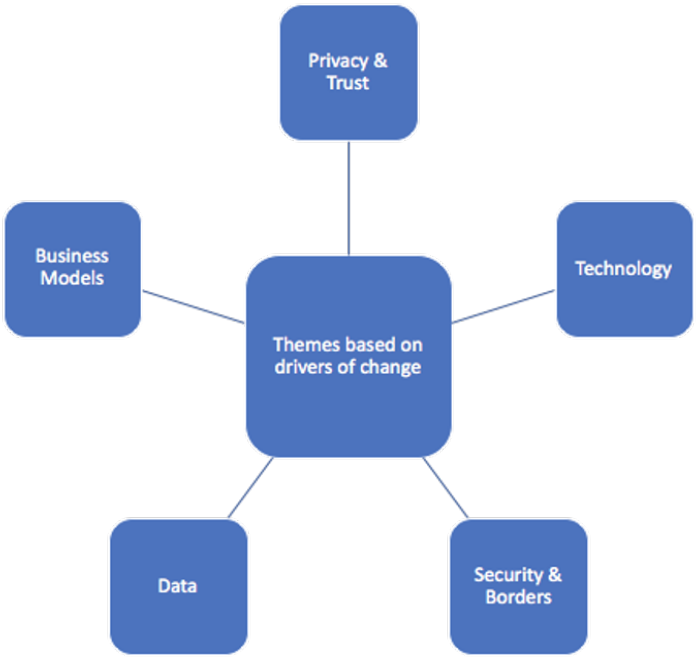

Figure 1 - Themes based on drivers of change. Source: Own work based on IATA (2018a).

In terms of Security & Borders, IATA reckons the importance of a more seamless and automated process of moving goods and people, and the theme will become a crucial aspect of positioning airports in the future (IATA, 2018a). In this context, the introduction of new technologies is recommended to ensure standardized screening and that passenger data is available to the stakeholders in order to streamline security (IATA, 2018a). This is complemented by ACI expecting that more innovative security and border practices will emerge, for instance, automated detection of threats or a queueless screening experience for passengers (ACI, 2018).

Moreover, the ever-growing availability of data is affecting all industries including aviation, which is stated in the following quote: "Advances in big data, predictive analytics, sensor technology, processing power, connectivity, and storage pose significant challenges as well as offering opportunities for businesses and consumers" (IATA, 2018a, p. 12). This will ultimately not only empower organizations and businesses but also the people. This is expected to be realized through open access to information based on shared platforms, but in a more secure manner since the increase in cybercrimes has led to distrust between stakeholders. Hence, the democratization of data will lead to more interoperability which is expected to influence all stakeholders positively. IATA highlights privacy and trust as important factors for the future of aviation. Here, it is stated that a trend exists towards transparency and open data that drives innovation demanded by the travelers. However, it is also causing tensions for the stakeholders in the industry since data sharing with other companies might lead to relinquishing a crucial asset - data - and thereby what might be a competitive advantage (IATA, 2018a). Two future outcomes related to data sharing are considered here. The first consists in that individual persons will be more cautious of sharing data due to the possibility of cybercrimes, wherefore the trust will be lower. The second potential outcome implies that people will give up control of their data in order to obtain economic benefits, convenience, and security (IATA, 2018a). Therefore, it is important for stakeholders of the industry to have a focus on data processing and data management as well as cybersecurity when developing systems.

IATA states that technology improvements - both in-flights and in-airports - will become increasingly automated to improve efficiency and safety (IATA, 2018a). This is supported by ACI

stating the aviation industry has - and will in the future - embrace technologies in order to improve processes, wherefore airports and other stakeholders will utilize technology to deliver traditional services (ACI, 2018). However, the possibility of utilizing an increased number of technologies strongly rely on data sharing and democratization of data. Here, IATA elucidates the importance of collecting and sharing an increasing proportion of data, which can be applied to improve various processes that ultimately provides the passengers with an improved passenger experience (IATA, 2018a). Currently, entities in aviation tend to strive for control of data since it leads to a competitive advantage, which potentially can become an impediment in terms of democratization of data (IATA, 2018a). Therefore, a future key priority consists in building a collaborative community with the purpose of establishing stronger cooperation between the airports and its stakeholders. An increase in interoperability - for instance through data sharing - will ultimately lead to opportunities for applying new technologies to optimize processes and the passenger experience. This is complemented by Hartshorn (2020) stating that "technology will only make airport businesses efficient to a certain degree; it is how the businesses work together that is often overlooked" (p. 1). Thus, the quality of operations and collaborations between stakeholders in the ecosystem of the airport determines the journey of the passenger, and ultimately the passenger experience. This implies a high level of business-to-business (B2B) integrated work and stakeholder management, where high integration across the passenger journey requires data sharing through interorganizational systems. This is complemented by Sabrina Abdullah: "I would like to conclude this article by stating the importance of cross-collaboration management among aviation bodies aiming to deliver a unique passenger experience" (Abdullah, 2015, p. 10). To illustrate the importance of data sharing and cross-collaboration, IATA and ACI launched a new collaborative initiative named New Experience in Travel and Technologies (NEXXT) in 2017. Here, a focus consists in collaborative decision-making, off-airport activities, and advanced processing technology with the goal of "[...] finding potential ways to integrate systems and improve operations in the most secure, effective and sustainable manner for the benefit of passengers and the industry" (IATA, 2017). The collaborative initiative is particularly interesting from a cross-collaboration perspective as IATA represents airlines whereas ACI represents airports. With a greater focus on innovating through collaboration, it is anticipated that in the future a higher degree of collaboration will also be observed in the local airport ecosystems.

1.5.2 Seamless Travel

When embarking on a travel journey in the airport there is high friction and the traveler will encounter multiple interruptions by checkpoints that have to be passed to continue the journey. Airports are continuously working on how to reduce wait time, queues, and decrease the passengers' stress level. This is known as seamless travel where the goal is to remove any process interruption (Manuell, 2017). IATA's annual passenger survey from 2019 showed that passengers are least satisfied with the security and border control processes (see figure 2). Furthermore, it shows that there is still room for improvement in terms of passenger satisfaction for many of the checkpoints the passenger has to go through.

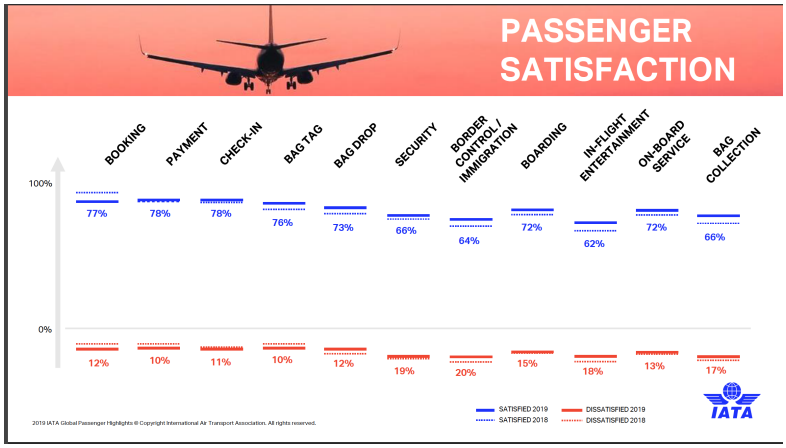

Figure 2 - Passenger Satisfaction Survey. Source: IATA (2020).

Manuell (2017) argues that it is important to acknowledge that each traveler is unique, whereby personalization of the experience is crucial. To be able to personalize the travel experience it is necessary to have the relevant information and use it effectively. Steenbergen (2017) adds that to create a seamless flow, in which the various checks are fluent, involves data sharing and linking information between the stakeholders responsible for that specific checkpoint. Steenbergen (2017) elaborates that: "In the case of a seamless flow, which involves the connecting of the airline, airport and government processes, the data integrity of the participating partners and the passenger must never be compromised". As data is deemed relevant for both personalization and frictionless travel, data privacy and appropriate data management becomes an integral part of the solution. In order to create a seamless travel experience, it is argued that there are three factors that need to be addressed; legal, technical, and governance (it is important that decision-making and changing to

the systems/solution does not stall it) (Steenbergen, 2017). The increased level of data points will allow both airports and airlines to obtain a better understanding of passenger behavior and needs. Furthermore, an expected benefit of more relaxed passengers is that they can have more time to spend on the airside. ACI has estimated that: "[...] an increase in 1% in the global passenger satisfaction (as defined by ASQ survey) generates, on average, NAR growth of 1.5% - i.e. when the passenger perceives an improvement in airport service quality, this results in a more than proportional growth of the airport's NAR" (IATA, 2018b, p. 7). This illustrates the potential revenue gains that can be unlocked by focusing on improving the passenger experience and airport service quality.

The background information illustrates the dire need to improve data sharing as it is expected to improve the efficiency of the stakeholders in the airport. In this regard, there is an opportunity to improve internal operations in the airport ecosystem. Having access to more data can at the same time enable new opportunities for improved personalization, and better knowledge about how much time the passenger spends between each checkpoint in the passenger journey.

2.Literature Background

2.1 Enterprise Interoperability

A company's ability to interoperate is considered a requirement to remain competitive in the complex global market (Tu et al. 2014). The present economic and industrial context cause that enterprise systems need to be continuously restructured in order to respond to the technological evolution and changing market demands (Doumeingts et al. 2008). This is complemented by Chen (2006) stating that a company's interoperable capabilities impact the competitive advantage, and for many it is even a crucial aspect for survival. Thus, organizations must have a focus on enterprise interoperability (Vernadat, 2007).

Enterprise interoperability is often interpreted in diverse ways based on different expectations, which primarily is due to the fact that interoperability can occur in different contexts with varied objectives (Chen, 2006). Institute of Electrical and Electronic Engineers (IEEE) defines interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (IEEE, 1990). Thus, the early definition of interoperability is constrained to information interoperability. The thesis uses Chen (2006) that presented a comprehensive definition of enterprise interoperability: "[…] the ability to (1) communicate and exchange information; (2) use the information exchanged; (3) access to functionally of a third system" (p. 1). Thereby, the academic area of interoperability has evolved from a primary focus on information interoperability to a broader approach coined as enterprise interoperability. Other scholars have found the definition by Chen (2006) useful due to the broad perspective as interoperability can happen at a technical level, a semantic level, and an organizational level (Vernadat, 2007). Moreover, since interoperability is considered a central element to enterprise integration that consists of two standpoints. The first standpoint concerns the connection of IT applications and computer systems as a supportive element in process operations, whereas the second standpoint emphasizes the importance of an organizational focus. This implies the facilitation of information and material flows across the organizational boundaries by connecting heterogeneous functional entities such as information systems, applications, and people. This is with the purpose of improving communication (data exchange at the system level), cooperation (interoperation at the application level), and coordination (organizing processes at a

business level) to make the enterprises function more integrated (Vernadat, 2007). Embracing interoperability implies a focus on more elements that need to be considered when facilitating information flows. It is not sufficient to solely focus on technological elements since the collaborative capabilities need to be present as it concerns information flows across organizational boundaries.

There are various concepts and dimensions to address based on the notion of enterprise interoperability, due to difficulties in measuring whether organization(s) possess interoperable capabilities. Therefore, the development of interoperability measurement became a crucial challenge (Chen et al. 2009). The primary focus is to develop interoperability based on an increase in knowledge and solutions to delimit incompatibilities. Here, a prerequisite consists of identifying which processes and systems that decrease the enterprise's possibilities of becoming more interoperable. The academic field of enterprise interoperability focuses on three categories of barriers; conceptual barriers, technological barriers, and organizational barriers (Chen, 2006; Tu et al. 2004; Guédria et al. 2009).

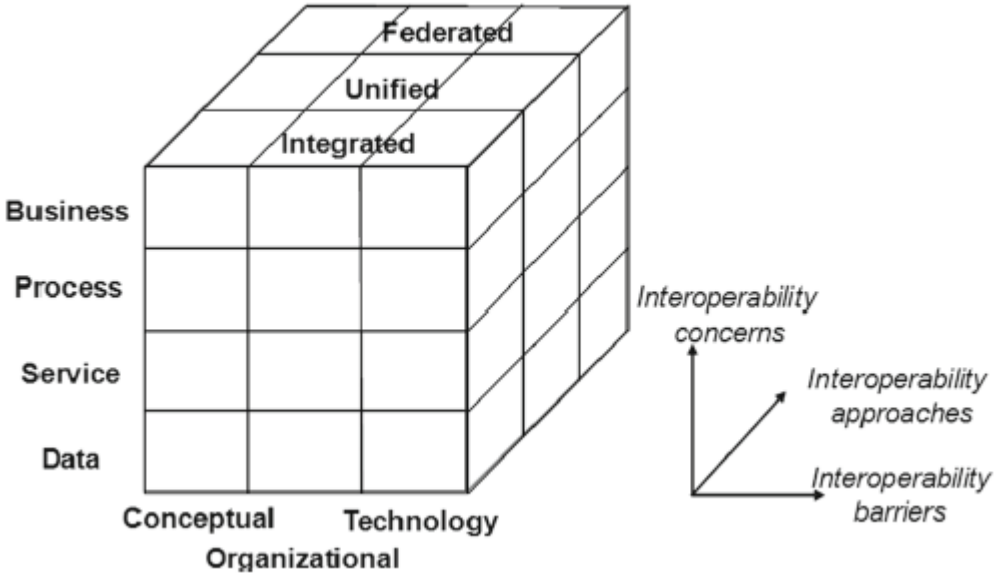

Figure 3 - Interoperability Framework. Source: Tu et al. (2014).

The conceptual barriers are associated with syntax and semantics in relation to the exchange of information, which is likely to cause incompatibilities in terms of interoperable efficiency (Chen,

2006). In this regard, syntactic interoperability might be affected as different people, enterprises, or systems operate with different structures in information- and knowledge representation (Chen, 2006). Semantic interoperability has a strong focus on assuring capabilities in consistency, particularly abilities in aggregating, sharing, and synchronizing data across heterogeneous processes or systems (Vernadat, 2007). The purpose is to allow for an unambiguous understanding of information (Chen, 2006), and making sure that systems, enterprises, or communication systems interpret information in a similar way. For many enterprises, this occurs as a complex problem due to the vast amount of information systems and databases (Vernadat, 2007).

Technological barriers embrace the use of information and communication technologies by means of exchanging information. Incompatibilities can, for instance, exist in the respective collaborative enterprises' IT architecture, infrastructure, or platforms. It is often occurring due to a limitation of standards that affects the possibility of heterogeneous computing techniques to exchange information between more systems (Doumeingts et al. 2008). Chen (2006) states that common examples affecting enterprises' interoperability are missing protocols for the exchange of information through the use of computers. Moreover, content barriers are a frequency implying that enterprises apply different methods to represent information. Lastly, an example is barriers in infrastructure, which concerns that collaborative enterprises use different and incompatible middleware platforms (Chen, 2006).

Organizational barriers describe structural and managerial incompatibilities in enterprises that possibly affect the enterprises' abilities to interoperate, which can be anticipated as human factors resulting in incompatibilities (Chen, 2006). In this context, companies that collaborate might have different management techniques and organizational structures, which makes interoperation difficult. Consequently, mapping processes, structures, and responsibilities are considered crucial in order to assure interoperability at an operational level (Chen, 2006). Specific problems related to organizational barriers consist in a definition of responsibilities between two collaborating enterprises, which also relates to authority in relation to specific interoperation processes (Chen, 2006).

The dimension of interoperability concerns defines the various levels where enterprise interoperability occurs, which is based on both an IT and organizational viewpoint (Chen, 2009; Doumeingts et al. 2008). The academic field mentions four particular concerns in which interoperating activities occur - interoperability of data, service, process, and business (Chen, 2006):

- Interoperability of data covers the sharing of information from heterogeneous databases, which implies that it can be localized on various machines with different database management systems and operating systems (Chen, 2006). Daclin et al. (2008) argues that a crucial part of achieving interoperability consists in making different data models and query languages interoperable, which Chen (2006) complements when stating the importance of the ability to exchange non-electronic data and machine transportable data.
- Interoperability of services aims at making various applications function together, which for instance could be databases from two collaborating enterprises (Daclin et al. 2008). This is likely to entail a focus on solving problems within the conceptual barriers, respectively syntactic and semantic differences (Chen, 2006).
- Interoperability of processes focuses on integration processes in a company or between two or more enterprises (Chen, 2006). Based on networked enterprises, Chen (2006) states that it is important to solve the problem of connecting internal processes between enterprises in order to obtain a common process, wherefore the objective is to achieve interoperability through collaborative processes.
- Interoperability of business covers the ability of enterprise management to achieve harmonization in working methods (Daclin et al. 2008). This can be a challenging task as two collaborative enterprises are likely to have different ways of working, cultures, and levels of application of information and communication technologies (Doumeingts et al. 2008). In order to achieve interoperability of business, it is therefore important that the interoperating businesses have shared visions of the collaborating processes, wherefore ambiguity must be limited or eliminated (Chen, 2006). Business integration entails a high focus on achieving harmonization through negotiation and the necessary mappings (Chen, 2006).

Lastly, Chen (2006) defines interoperability approaches as to how units are related and how barriers between these units are removed. He distinguishes between three ways of relating entities for interoperability approaches - federated, unified, and integrated - which can be considered a prerequisite for obtaining interoperability. The federated approach focuses on adjusting and accommodating interoperability should not be forced on the existing methods of work, models, and languages (Tu et al. 2014). Hence, no common standard and format exist (Chen, 2006), which implies that no enterprises in the collaboration impose their methods of work, models, or language. However, it is common that the enterprises map concepts at a semantic level to share ontologies (Doumeingts et al. 2008). Therefore, the federated approach does not assure initial interoperability, wherefore it aims at achieving interoperability in a constant process, where enterprises must adapt and accommodate continuously (Tu et al. 2014).

The unified approach entails a common format and standard of information or data to be shared (Doumeingts et al. 2008). However, this is only at a meta-level whereby it is not an executable entity (Tu et al. 2014), but solely provides a mean for equivalence in semantics. The metamodel can be applied as a mapping-tool between different enterprise's applications and models, and thereby also for translation between the two enterprises' models. Chen (2006) states that the unified approach of interoperability is popular between collaborative enterprises since it is not needed to change the format of the respective systems due to the possibility of mapping these to the neutral meta-format. Utilizing this approach will ultimately result in reduced time, cost, and effort in the implementation compared to the federated approach (Chen, 2006).

The integrated approach implies that a common format exists within all models (Doumeingts et al. 2008), which means that the format must be agreed upon by all interoperable parties in order to align models and follow guidelines when developing new systems (Tu et al. 2014). There is a focus on standardization at the system level, whereas the unified approach focuses on a meta-level. The integrated approach is fitting when developing and implementing new systems, whereas the unified approach might be more appropriate to apply when reengineering existing systems (Chen, 2006). The integrated approach can assure global consistency as the system is developed and implemented with a common format, whereby the interoperability can be considered a purpose and result of the design- and development of the system (Chen, 2006).

2.2 Literature Review

The literature review will initially give an introduction to blockchain technology. Blockchain will be reviewed based on its possibilities for being implemented in the airport, which also consists of a focus on general limitations. Since the adoption of the technology imposes organizational and multi-organizational requirements, the literature review will ultimately focus on important aspects to consider before implementing a blockchain solution.

2.2.1 Literature review process

To identify relevant literature and obtain a better understanding of the technology and its implications a literature review has been conducted (Webster & Watson, 2002). The review is divided into literature search, literature interpretation, and presentation. Both a forward and backward search for blockchain management challenge has been made on the EBSCO and JSTOR databases. Initially the search filtered for basket eight information journals, but due to the fact that it is a relatively new research domain, the search was extended to other journals as well. The reason for the extension was to minimize the amount of relevant literature that has been overlooked. 172 hits were identified, which ultimately led to the selection of 30 relevant articles. Afterwards, all the chosen journals have been gathered in an excel sheet. All the journals were reviewed and based on an inductive approach where relevant concepts were identified. When reviewing the literature, the following four concepts continued to reappear as the major considerations; trust, governance, standards and incentives. In this process, the papers that did not cover these concepts were removed, resulting in using 19 research papers for the literature review. The literature has been arranged in a concept matrix (see table 1) following a concept-driven structure based on Webster & Watson (2002). The following sections will elaborate on each of the concepts to get a more comprehensive understanding of the managerial considerations related to creating the foundation for implementing blockchain.

Title	Author	Year	Trust	Governance	Standards	Incentives
A case study of using blockchain technology in regulatory technology	Gozman et al.	2020		X	X	X
A Ten-Step Decision Path to Determine When to Use Blockchain Technologies	Beck et al.	2019		X		
Addressing Key Challenges to Making Enterprise Blockchain Applications a Reality	Lacity	2018	X	X	X	
Blockchain for the IoT - privacy preserving protection of sensor data	Chanson et al.	2019	X			
Blockchain Research in Information Systems - Current Trends and an Inclusive Future Research Agenda	Rossi et al.	2019	X			X
Building a Blockchain Application that Complies with the EU General Data Protection Regulation	Rieger et al.	2019		X		X
Governance in the Blockchain Economy - A framework and Research agenda	Beck et al.	2018		X		X
How an Enterprise Blockchain Application in the US Pharmaceuticals Supply Chain is Saving Lives	Mattke et al.	2019		X	X	
Management, Governance, and Value Creation in a Blockchain Consortium.	Zavolokina et al.	2020	X	X		X
Delivering Business Value through Enterprise Blockchain Applications	Lacity et al.	2019	X			
The Architecture of Blockchain Organization	Scholz & Stein	2018	X	X		X
How TradeLens Delivers Business Value With Blockchain Technology.	Jensen et al.	2019	X			
Blockchain – The Gateway To Trustfree Cryptographic Transactions	Beck et al.	2016	X			
Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda	Hughes et al.	2019	X	X		X
A systematic literature review of blockchain-based applications: Current status, classification and open issues	Casino et al.	2019	X			
Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA	Queiroz & Wamba	2019	X			
Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review	Seebacher & Schüritz	2017	X		X	
Blockchain and Smart Contracts for Insurance: Is the Technology Mature Enough?	Gatteschi et al.	2018			X	
Blockchain Technology in supply chain management for sustainable performance: Evidence from the airport industry.	Di Vaio & Varriale	2020			X	

Table 1 - Concept Matrix. Source: Own work.

2.2.2 Theoretical foundation of blockchain

Blockchain was formally introduced in 2008 when Satoshi Nakamoto published its white paper on an electronic cash peer-to-peer (P2P) system, where the principal objective was described as: "[...] an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008, p. 1). Essentially blockchain is a distributed ledger technology with a high level of protection against tampering while maintaining to not have a central authority (Rossi et al. 2017). Hereby, blockchain can provide agents who may not trust each other with a single truth (Beck et al. 2018). It is secured by utilizing cryptography and governed with a consensus mechanism. All the transaction information is stored in blocks connected typically through the use of Merkle Trees, which is a technique to hash, pair, rehash until there is only the Merkle Root left. Every block points to the previous block's Merkle Root, hereby creating a chain of blocks (Beck et al. 2018). Beck et al. (2017) argue that blockchain is not only a digital record of events since it has an extra level of logic, namely, smart contracts, which is described as: "(...) programs stored on the blockchain that run as implemented without any risk of downtime, censorship, or fraud" (p. 381). What makes this special is that smart contracts can autonomously executive transactions without the interference of third parties (Beck et al. 2018). Hereby, blockchain becomes an innovative development as it can be used to foster cross-organizational collaboration and workflow:

> "Blockchain solutions allow the organizations involved in the workflow to maintain control over their respective activities but, at the same time, enable them to establish a 'shared and persistent truth' on the state of the workflow at any given time. This truth can act as a point of reference if conflicts need to be resolved at a later point" (Rieger et al. 2019, p. 263).

Furthermore, this has also led to disintermediation where consumers and suppliers engage together directly (Scholz & Stein, 2018). Essentially, blockchain technology can handle who has ownership rights, who can access the data, who can use the data, and who controls the data (Zavolokina et al. 2020).

An important feature of blockchain is the protocol, which defines the technical rules for the system. There is a need for the consensus protocol because the system operates without a central authority, and Rossi et al. (2019) describes its role as: "Consensus protocols address the issue by specifying

how the right to validate new transactions" (p. 1393). There exist different types of blockchain architecture, and they differentiate in regard to what read/write permissions the users have. Public blockchains are readable and writable by everyone, with Bitcoin being the most famous example. They are the most useful when complete decentralization is necessary. On the other hand, private blockchains can only be written by an organization's members. The organization can control who can read and access the information stored on the blockchain. In consortium blockchains different institutions own a set of nodes with which they can control the validation, hereby it can be used to share information among the involved parties (Gatteschi et al. 2018). The other dimension is access to transaction validation where there are two options, respectively permissioned or permissionless (Beck et al. 2017), which will be described further in section 2.3.

The following section will investigate published literature on the following four concepts: trust, governance, standards, and incentives in regard to what role the concepts play in blockchain-based systems.

2.2.3 Concepts related to management considerations

2.2.3.1 Trust

Trust is defined as the confidence in the certainty of future actions. Trust is an integral part of blockchain technology, and blockchain is often highlighted as a solution that enables parties that do not trust each other to operate together on the same platform (Lacity, 2018; Chanson et al. 2019; Casino et al. 2019). Beck et al. (2016) states that the combination of transparency and security makes blockchain a trust-free technology. Trust is driven by the level of transparency, the integrity of data, and the immutability and it is these elements that are integral to create a decentralized network (Seebacher & Schüritz, 2017; Hughes et al. 2019). A range of research papers acknowledge that, once the platform is established, blockchain can bring together parties who do not trust each other (Scholz & Stein, 2018; Zavolokina et al. 2020; Rieger et al. 2019; Di Vaio & Varriale, 2020). However, other researchers have found that when creating a blockchain system it is deemed necessary to first establish mutual trust (Zavolokina et al. 2020; Jensen et al. 2019). Consequently, this becomes paradoxical as trust is needed even for a solution where operations should be in a trustless manner. No system will be entirely trustless as Rossi et al (2019) and Hughes et al. (2019) point out that in 'trust-free' blockchain systems there is still trust in the

system's algorithms to work appropriately to ensure the facilitation of transactions in a secure manner. To overcome this Lacity et al. (2019) points to the fact that mutual trust could be facilitated through non-competing partners. In this regard, blockchain has often become a symbol of disintermediation, but for private blockchain. Rossi et al. (2019) argue that it is unlikely that all trusted third-parties are removed. Queiroz & Wamba (2019) research highlighted that trust does not affect the behavioral intentions to adopt blockchain. The benefit of the technical built-in trust is a decrease in transaction costs (Scholz & Stein, 2018). However, it may lower transaction costs, but the governance costs can possibly increase (Zavolokina et al. 2020).

2.2.3.2 Governance

Governance is defined as a set of rules and processes guiding who and what administrates the created blockchain system. One of the challenges when going from traditional data sharing systems to blockchain-based systems is that it forces the participating actors to be proactive rather than reactive (Gozman et al. 2020). Governance is an integral element in how the system operates and how the actors interact with it. If all parties have the same level of access rights, the parties will be better off using relational databases (Beck et al. 2019). Beck et al. (2018) state that IT governance has three key elements; decision rights, accountability, and incentives. Observing blockchain governance Lacity (2018) identifies three levels of shared governance; (1) democratic where all have equal voting rights, (2) representative where decision-makers are appointed and the benefit to this method is a quicker decision-making process, and (3) regulatory where there is a centralized place of trust. Mattke et al. (2019) recommend setting up a governance system with a benevolent dictator on the platform. Governance can also be viewed from a technical point of view where it is argued that the consensus mechanism has allowed governance to become decentralizable (Rossi et al. 2019; Rieger et al. 2019).

Furthermore, if there are significant investments at an international level in determining governance structures and standards, it can have a positive effect on the level of adoption (Hughes et al. 2019). On the other hand, Zavolokina et al. (2020) and Hughes et al. (2019) clarifies that blockchain provides a variety of new opportunities and challenges in regard to predefining rights, decisions, and the executing codes. Therefore, governance costs appear to be high in decentralized autonomous organizations due to the extensive requirements for smart contracts, coordination

costs, code errors, and later change in conditions or requirements (Beck et al. 2018; Scholz & Stein, 2018).

2.2.3.3 Standards

Standards are defined as agreements on a common format for data structures, accessibility and interfaces (Lacity, 2018). Hence, it is a requirement of how to perform a repeatable task, and can be decided by for example a corporation, an alliance, or a regulatory body (Di Vaio & Varriale, 2020; Mattke et al. 2019). Standardization can be used to foster better data-exchange and can provide the underlying structure for a new value-chain ecosystem (Zavolokina et al. 2020). Standardization of processes among participants can be utilized to improve efficiency. However, it comes with the tradeoff that some may lose their competitive advantage (Gozman et al. 2020). When choosing how to standardize there are three options; (1) create a proprietary system, (2) work with existing standards or (3) join an industry consortium (Lacity, 2018). For IoT solutions, a system can be perceived as neutral when the participating parties are peers, which can lead to quicker acceptance as an industry-standard compared to a centralized system (Chanson et al. 2019). Gatteschi et al. (2018) add that interoperability can be enabled by determining common standards. This is complemented by Rieger et al. (2019) elaborating that when creating GDPR compliant blockchain applications it is necessary to establish standards to ensure the interoperability between the given system and other related blockchain solutions. Hughes et al. (2019) argue that the formalization of blockchain processes and standards will positively impact the level of trust in blockchain solutions. Once a system is deployed, standardization can have a beneficial impact on coordination and productivity capacity while lowering transaction costs (Seebacher & Schüritz, 2017).

2.2.3.4 Incentives

Incentives are defined as the actor's underlying motives, and how the incentives can be aligned. More literature has covered the importance and impact of trust in relation to blockchain. However, trust may not always be a challenge since it sometimes is clashing interests that can cause problems (Rieger et al. 2019). When creating a blockchain platform, it is crucial to ensure that the participants' incentives are aligned (Gozman et al. 2020; Rossi et al. 2019; Zavolokina et al. 2020; Scholz & Stein, 2018). There are many different stakeholders that need to be incentivized, for example, system development and maintenance, users, and token holders (Beck et al. 2018). The

stakeholders need not only to be incentivized to invest financially in the initiative but also to ideally support the development and operation efforts of the systems (Zavolokina et al. 2020). There are multiple ways to incentivize alignment (Rossi et al. 2019); (1) modifying human agent behavior, (2) avoid agent-principal issues of utilization maximization, and (3) ensure a secure consensus mechanism through alignment at the protocol level of the blockchain application. Apart from aligning a variety of stakeholders, it also requires organizations to align their strategy for adopting a blockchain system. Here, known challenges have been both political, cultural, and technological (Hughes et al. 2019).

2.3 Considerations to determine when to use blockchain

Based on the increased focus on blockchain, many have investigated the initial opportunity to use it. However, it can be complicated to evaluate when to use blockchain as there is still a limited number of deployments outside of cryptocurrencies. To support the evaluation, Beck et al. (2019) have created a ten-step framework to determine when to use blockchain. The first seven questions cover whether to use blockchain or not, whereas the last three relate to what type of blockchain system and permission should be used.

Steps	Explanation
1. Need for a shared common database?	It must be thoroughly considered whether a traditional database satisfactorily meets the needs. In that case, Beck et al (2019, p. 102) argue that a traditional database should be used.
2. Multiple parties involved?	The consideration is if the solution requires the functionality offered by a decentralized database. The functionality covers if multiple actors contribute, write, and update data in the system.
3. Do the involved parties have conflicting interests/trust issues?	Blockchain is useful when there are conflicts of interest since it is a trust-free solution once data has been uploaded (Beck et al. 2019, p.104).
4. Parties can/want to avoid a trusted third-party?	Trusted third-party providers are often used when there is limited trust between actors (Beck et al. 2019, p. 106). As argued in the literature review, blockchain

	enables disintermediation through direct peer-to-peer transactions.
5. Rules governing system access differ between participants?	The design of blockchain allows for different access rights in regard to who can read, write, and validate data (Beck et al. 2019, p. 106 - 107).
6. Transacting rules remain largely unchanged?	Once a blockchain system has been deployed it is difficult to make new changes. The inflexibility of the system underlines how indispensable standards are.
7. Need for an objective immutable log?	A core strength of blockchain is immutability as it provides integrity and audibility (Beck et al. 2019, p. 108).
8. Need for public access?	There are two types of access to transactions either public or private. In a public blockchain all nodes are allowed to read the data and propose new transactions, whereas in a private blockchain it is only nodes that have been pre-registered by a central authority that can read and propose new transactions (Beck et al. 2018, p. 1022).
9. Are transactions public?	There are two types of access to transaction validation, permissioned and permissionless. In permissioned blockchain only pre-registered nodes can validate transactions, whereas in permissionless blockchains all nodes can validate a transaction (Beck et al. 2018, p. 1022).
10. Where is consensus determined?	Beck et al. (2019) state that there are three main types of blockchain (p. 114). (1) permissionless public where anyone can read, write and verify transactions, and consensus is determined through either Proof of Work or Proof of Stake. (2) permissioned public where only actors who are trusted and validated can join, and consensus is determined by the actors. (3) permissioned private blockchain, where consensus is determined within the organization.

Table 2 - Ten-step framework to determine when to use blockchain. Source: Beck et al. (2019).

The framework provides a clear decision path for determining the usefulness of blockchain. It is still necessary to be aware of unique conditions because the system configurations will entail both business and design trade-offs (Beck et al. 2019). Therefore, the organizations need to carefully consider if the properties of blockchain meet the organizational requirements for the solution. If a regular database solution can solve the issue it is often an easier and cheaper solution (Beck et al. 2019).

3. Methodology

The following chapter will examine the applied research design and methodology for the thesis and is based on the research onion by Saunders et al. (2015). The methodology chapter will clarify the philosophical research foundation, the approach to theory development, the methodological choices, the research strategy, the time horizon, and ultimately the techniques and procedures for data collection. Moreover, the chapter will contain a quality assessment and ultimately a methodological reflection (Saunders et al. 2015).

3.1 Interpretivism as Philosophical Research Foundation

Research philosophy refers to assumptions and beliefs concerning the development of knowledge (Saunders et al. 2015). This is particularly important to clarify as an initial step in the methodological considerations since the assumptions and beliefs create the foundation of the methodological procedures (Arbnor & Bjerke, 2009), whereby it is important to create a coherent design in the research project. The specific assumption types are ontology and epistemology. Ontology concerns assumptions regarding the nature of reality, whereas epistemology refers to assumptions about knowledge, how to communicate this, and whether it is valid and legitimate. Based on Niglas' (2010), two opposing extremes exist in relation to assumptions which are objectivism and subjectivism. The researchers' assumptions and beliefs are in this regard based on subjectivism due to the belief that the social reality is constructed by the social actor through perceptions and the following actions (Saunders et al. 2015). The ontology consists in realities that are constructed by the individual through actions and social interactions. Here, social actors share meanings and realities resulting in partly shared realities (Saunders et al. 2015). The epistemology focuses on obtaining an in-depth detail of the research area by interacting with various stakeholders to obtain an understanding of their perceptions and realities towards the subject of interest. This is interesting due to the ontology assumption that no single truth exists (Saunders et al. 2015).

Based on the assumptions and beliefs of the nature of reality (ontology) and knowledge (epistemology), the thesis' philosophical research foundation is interpretivism emphasizing that humans possess different social realities. Interpretivism contrasts the positivists' attempt to discover a definite reality of a phenomenon (Saunders et al. 2015). This is based on the argument

that every person has unique and different circumstances that affect the creation and experience of the social reality implying that people perceive a phenomenon in different ways (Saunders et al. 2015). The purpose of interpretive research is to create a new and richer understanding of the context. This is achieved by understanding the subjective meaning of persons, and the combination of more subjective meanings provide the researchers with in-depth detail of the research area (Godkuhl, 2012). That is considered important since the research is investigating blockchain technology in aviation that is considered an immature technology and research area (IATA, 2018c).

3.2 Hermeneutics

Beyond the interpretive philosophical research foundation, the research process has been based on hermeneutics, which is a strand of interpretivism that allows the researchers to obtain a continuously developing understanding of the research area (Saunders et al. 2015). Hermeneutics dates back to ancient Greece focusing on the interpretation of a given message and was developed into a more comprehensive theory and methodology in the eighteenth and nineteenth centuries (Darmer et al. 2010). Ast (1808) presented the formalized hermeneutic circle as "[...] the foundational law of all understanding and law of all understanding and knowledge" (Ast, 1808, p. 178). This interpretation was expanded by Dilthey (1883) arguing that recovering the meaning requires the understanding of human or historical sciences. Later, Heidegger presented the notion "[...] that allows the self-disclosure of the structure of understanding as such" (Mantzavinos, 2020). Next, Gadamer presented a mixture of modification and tradition of hermeneutics based on the opinion that the world is a language rather than a constitutional foundation, which was labeled as the philosophical hermeneutics (Mantzavinos, 2020). Gadamer thereby rejected the notion of a world in itself as different perceptions of the world will be exposed (Arbnor & Bjerke, 2009). Gadamer presented his thought with the following assumption: "This is not a rejection of the importance of methodological concerns, but rather an insistence on the limited role of method and the priority of understanding as a dialogic, practical, situated activity" (Malpas, 2003). Nowadays, more configurations of hermeneutics exist. However, the different thoughts on hermeneutics have the basics in common - specifically the attention towards the role that interpretation plays regarding the individual's choice of actions and view on the nature of reality (Darmer et al. 2010). Thus, the main emphasis in hermeneutics concerns understanding and communication, where the

aim of hermeneutics is to arrive at a common shared vision through the use of language and interaction (Arbnor & Bjerke, 2009). In this respect, an essential characteristic of interpretation in hermeneutics concerns that interoperation does not aim towards an explanation, but rather towards obtaining an understanding of the phenomenon (Darmer et al. 2010). The research aims at understanding how the involved parties understand and perceive the chosen subject from a perspective that is based on the current time and place. The hermeneutical understanding comes from a reconstruction of the investigated object (Mantzavinos, 2020). This reconstruction will allow the researcher to emphasize the subject's understanding. To make this reconstruction it is necessary to observe the subject, and the understanding comes from identifying oneself with the actor's situation. If the researcher does not understand an actor's actions, it is necessary to reconstruct the actor's worldview.

An essential part of hermeneutics consists in the hermeneutical spiral (figure 4) that is based on the foundation that one cannot interpret a phenomenon independently. This is due to the fact that an interpretation always will be influenced by the interpreter's conceptual world (Darmer et al. 2010).

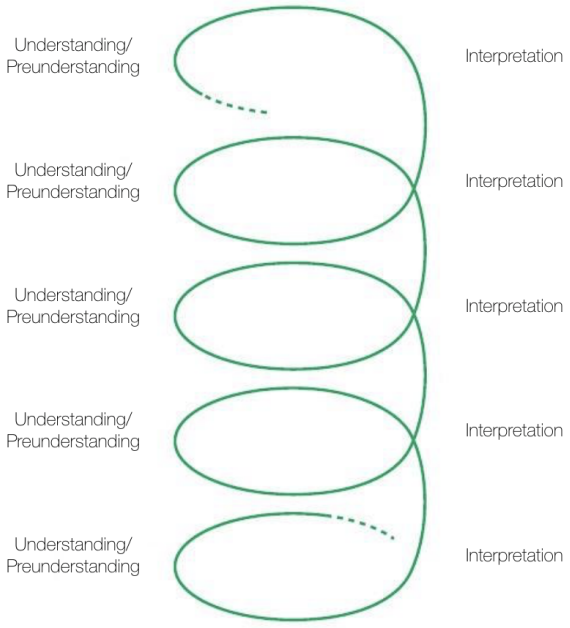

Figure 4 - Hermeneutic Spiral. Source: Own work.

The premise of an understanding consists of a pre-understanding of the phenomenon or subject that is dealt with, which primarily is based on theories, methods, and knowledge obtained from the education regarding blockchain technology. Moreover, a diagnostic pre-understanding exists, which is based on the gathered empirical data and knowledge for the research in the initial process (Arbnor & Bjerke, 2009). This entails secondary data such as publicly available documents from CPH Airport - for instance, the consolidated annual report. Moreover, the diagnostic pre-understanding comes from various whitepapers of organizations and associations in the aviation industry. The diagnostic understanding is contributory to creating a linguistic bridge between the researchers and the actors and will thereby form the basis for dialogue and interaction between the two parties (Arbnor & Bjerke, 2009). Thereby, the pre-understanding will be reconstructed through interaction and dialectic with the ultimate goal of achieving a fusion of horizons and intersubjectivity as the movement of knowledge about the phenomenon will affect the understanding of both parties in the interview. Thereby, a mutual procedural knowledge sharing and opinion formation occur (Fuglsang et al. 2013). The new understanding of the research area will be applied when interacting with new actors, and this implies that the understanding will be further reconstructed (Arbnor & Bjerke, 2009). This is a cornerstone of hermeneutics where the movement in which one obtains a new understanding of a specific phenomenon is considered a continuous process (Fuglsang et al. 2013). For that reason, it is often described as a hermeneutic spiral as the understanding of the object metaphorically appears as a continuous and unfinished process (Fuglsang et al. 2013)

Hermeneutics has been chosen because the investigated phenomenon - blockchain-based systems in airports - is a new technology and the interviewed social actors have varying opinions and levels of knowledge about the phenomenon. Hermeneutics and dialectics are in this regard useful (Arbnor & Bjerke, 2009). The properties of hermeneutics are relevant because the domain is relatively unexplored and constantly developing where limited practical experiences exist. Therefore, it is assumed that people possess different attitudes that are possible to extract through a hermeneutic approach with the purpose to obtain a broad understanding of the researched area.

3.3 Methodological choices

Based on the philosophical research foundation of interpretivism and hermeneutics, the approach to theory development is primarily based on abduction, whereas the methodological choice consists of a qualitative study, which is considered the typical method of interpretivism (Saunders et al. 2015). The following sections will clarify considerations for the methodological choices.

3.3.1 Approach to Theory Development

The approach to theory development concerns more methods for reasoning that reflect different theoretical ideals regarding realization as well as processes to acquire knowledge, wherefore it is closely connected to epistemology (Darmer et al. 2010). Since several approaches to theory development and production of knowledge exist, it is crucial to be clear about the theory initially in the research as a part of the design of the research project (Saunders et al. 2015). Three central methods for reasoning are often portrayed, which are deduction, induction, and abduction (Darmer et al. 2010). The different approaches will be clarified briefly in the following section, which will be followed by arguments for using abduction in the design of the research project.

Deduction is a way of creating knowledge inferring a specific case based on general laws or theory (Arbnor & Bjerke, 2009). The researcher will deduce conclusions about a specific phenomenon based on general hypothesis, laws, or theories (Darmer et al. 2010), implying that the generalizability consists in generalizing from the general to the specific (Saunders et al. 2015). In terms of existing data-use, the deductive approach uses the collected data to evaluate propositions based on theories, and a crucial focus consists of theory falsification or verification (Saunders et al. 2015). Deduction is particularly a sensible approach when the research aims at identifying regularities, which is based on the logic that when premises are true, the conclusion will be likewise (Darmer et al. 2010). The inductive approach is contrasting to deduction in the sense that the creators of knowledge conclude general laws or theories based on specific cases (Arbnor & Bjerke, 2009). The approach is based on empirical conditions that will be used to generate untested conclusions, whereby the generalizability consists of a movement from the specific to the general (Darmer et al. 2010; Saunders et al. 2015). Thus, it is a method in which the investigator attempts to provide knowledge based on a recapitulation of observations (Darmer et al. 2010), whereby the

data collection is applied to explore a specific phenomenon. This allows the researcher to identify themes and patterns in the data (Saunders et al. 2015). Hence, the focus is on the generation of theory. Saunders et al (2015) argue that the strength of induction is the development of an understanding of how humans interpret the social world - and particularly the phenomenon of the research. This is likely to imply an in-depth study of a relatively small sample of subjects in order to achieve the subject's socially constructed viewpoints of the phenomenon, which commonly is based on qualitative data (Saunders et al. 2015). Apart from deduction and induction, a third approach is abduction. Arbnor and Bjerke (2009) describe abduction as a combination of deduction and induction in the sense that it consists of alterations between facts and existing theory, wherefore it moves back and forth between the deductive- and inductive approach. Hence, generalizability is based on interactions between the general and the specific (Saunders et al. 2015). The data collection is initially used to explore a phenomenon and its themes and patterns, which is similar to induction. However, the themes and patterns will subsequently be tested by collecting additional data (Saunders et al. 2015). Abduction can be seen as a criticism of the dimensional and unrealistic approaches of induction and deduction, where the argument consists of researchers coming across unknown or incomprehensible problems that are crucial to investigate for the research. This will be possible based on an abductive approach (Darmer et al. 2010).

The approach of theory development in this thesis is based on abduction leading to the use of elements from deduction and induction (Arbnor & Bjerke, 2009) to provide likely explanations or a qualified guess. This implies that the research is based on prior knowledge from the field of aviation, blockchain, and interoperability, which constitutes a deductive element. Subsequently, the researcher seeks to create new knowledge through a qualified guess in which it is acknowledged that it might not be a universal truth, and this illuminates the inductive element of the research. The abductive approach makes it possible to propose the findings based on a relatively unexplored research area. Since the research area is unexplored and no theories exist yet, it is considered crucial to obtain an in-depth perspective on the research area. Hereby, the inductive element covered the in-depth interviews with the relevant actors. When combining the different viewpoints, it is possible to acquire a more comprehensive understanding of the possibilities and barriers of the research area. This provides the researchers with a foundation based on theory as well as empirical research in order to present qualified guesses. The abductive approach is useful

as the thesis is trying to make qualified guesses regarding what factors constitute the foundation of adopting blockchain. The choice matches the properties of hermeneutics as one is never able to make an absolute truth both only approximations based on the understanding at a given time.

3.3.2 Qualitative Research Method and Interviews

The qualitative study is based on interviews with a wide range of persons related to the aviation industry (see table 3). This allows the researcher to develop an in-depth investigation of blockchain-based systems in aviation as the study progresses by obtaining the social actors' viewpoints. This implies obtaining a more thorough view of the interoperability and the opportunities to implement blockchain in order to improve data sharing between the stakeholders and ultimately their operations. Moreover, an understanding of which barriers that exist in relation to an untroubled implementation. Prior to the interviews, a preliminary understanding of the topic had been established through the literature search. This understanding was subsequently reconstructed based on the interaction and dialogue with the interviewees that clarified their social reality, which has been a continuous process due to the number of interviews. Kvale and Brinkmann (2015) distinguish between two contrasting approaches to conducting an interview that are crucial to consider to ensure coherence between the methodological choices and the philosophical research foundation. Kvale & Brinkmann (2015) uses the analogy of 'the miner' and 'the traveler' to describe the two styles of interviewing:

- 'The miner' emphasizes that the interviewer tries to extract knowledge of the interviewee. The interviewer tries to uncover the truth about a given domain of research, and thereby the interviewee possesses knowledge that must be uncovered by the interviewer (Kvale & Brinkmann, 2015).
- 'The traveler' aims at creating an intriguing story based on conversation. The interviewer primarily requests the interviewee to tell his/her personal story about the research domain. The particular story can be further developed through dialogue, whereby interlaced processes of knowledge construction occur (Kvale & Brinkmann, 2015).

The interviews are based on 'the traveler' approach that is considered coherent with interpretivism and hermeneutics. The intention and expectation of adopting the approach of 'the traveler' consists

in allowing the interviewees to define their respective social construction of the research area. This is assured since the researchers request the interviewee to talk about their viewpoint, and moreover as the researchers deliberately have chosen to create a relatively limited interview script containing more broad and open questions (see appendix A-J for interview transcripts). The semi-structured interviews are thereby done to assure that the researchers obtain the interviewees' unique viewpoint of the research area. The interviews do therefore appear more as a dialogue and construction of knowledge rather than trying to provoke specific answers from the interviewee, which would have been the focus based on the approach of 'the miner' (Kvale & Brinkmann, 2015). The strength of using this technique is that it allows for an open exploration of what the interviewees finds relevant in relation to the dialogue. The limitation can be that the researchers end with having a collection of data, which superficially covers a range of different topics within the given research area.

An interview guide was constructed for each interview. The high-level common themes were: (1) Introduction, (2) passenger journey, (3) present situation, (4) future plans, and (5) ecosystem. The intention of this structure was to establish trust and a common ground by talking about the work the interviewees have done until now, and later going more in-depth with what are the future plans, what can be achieved, and how is the organization equipped to embrace these opportunities. The aim of the interviews is to understand each stakeholder's situation and the possibility of creating a blockchain-based system to improve data sharing. See appendix K for an example of an interview guide.

3.3.2.1 Sampling Criteria

The aim of the sampling process was to get in contact with a wide variety of individuals, which has been reviewed to obtain different angles of the topic. Eisenhardt & Grabner (2008) recommends this approach of identifying interviewees related to the case as it can contribute with a diverse perspective to limit interview biases. In this regard, there have been interviews with individuals coming from different stakeholders and organizations. This has included interviews with individuals representing the same stakeholder, but with different backgrounds ranging from highly technical to non-technical. Likewise, there have been interviews with individuals representing different stakeholders. The reason for having this variety is to get both an

understanding of the different organizational considerations, while also scoping whether it is feasible.

The interviewees have been selected based on a problem/opportunity-oriented selection which implies that all the individuals have some sort of relationship with the inquired research topic (Arbnor & Bjerke, 2009). The contact to the interviewees has been established through either LinkedIn or email independently of each other. However, Sylvain Campeau and Louise Blomberg were recommended by their colleague in the preceding interview.

Interview	Interviewee	Position	Organization	Interview Type	Interview Language	Date & Time
1	Boris Düdder	Associate Professor	University of Copenhagen	Personal	English	24/02-20 16.30-17.00
2	Lars Ingstad Nielsen	Optimization & Passenger Solutions	Copenhagen Airport	Personal	Danish	02/03-20 11.00 -12.00
3	Hasse Jørgensen	Senior Manager Passenger Experience	International Air Transport Association	Teams	Danish	18/03-20 16.00-17.00
4	Jonas Jørgensen	IT Director	Copenhagen Airport	Telephone	Danish	23/03-20 13.30-14.00
5	Louise Blomberg	Technology Office Lead	Copenhagen Airport	Teams	Danish	25/03-20 09.30-10.30
6	Hasham Ahmad	Developer	Freelance	Skype	English	30/03-20 18.00-19.00
7	Sylvain Campeau	Senior Manager Passenger Process & Technology	International Air Transport Association	Teams	English	01/04-20 15.00-16.00
8	IATA Future of Aviation 2035	Industry report	International Air Transport Association	Written	English	N/A
9	Erhan Kilören	Team Leader - Copenhagen Airport	Turkish Airlines	Mail Correspon dence	English	18/04-2020 23.10
10	Sabrina Abdullah	External Lecturer & Independent Consultant	Copenhagen Business School	Teams	Danish	18/04-20 11.45-12.45

Table 3 - List of conducted interviews. Source: Own work.

The initial first step was to establish contact with CPH Airport. Firstly, the researchers went on a guided tour around the airport to understand the fundamentals of how an airport operates, and how the data flows. After the tour, the first interview was conducted with Boris Düdder, who has built multiple blockchain systems and gives lectures on blockchain. The purpose of the interview was to improve the researchers' knowledge about what blockchains technology can be used for and what the potential pitfalls are. Moreover, two interviews have been conducted with people from IATA. Despite the fact that IATA does not have a direct impact on the travel experience at CPH Airport, the association is perceived to have an indirect influence on the direction of the airline industry on a macro level. Moreover, IATA represents the interest of the airlines and speaks on behalf of the airlines in the interviews - hereby giving a more general introduction to what matters for the airlines. Hasse Jørgensen represents the business and passenger experience, whereas Sylvain Campeau represents technical aspects such as the creation of standards and specifications of IT systems.

Three interviews were conducted with people working at CPH Airport. The first was with Lars Ingstad Nielsen who was chosen for the following two reasons. Firstly, he is working with the passenger experience. Thereby he has relevant insights concerning the passenger process and how CPH Airport continuously tries to optimize the passenger journey. Secondly, he is the account manager for the police in the airport, which allowed him to elaborate on the collaboration between CPH Airport and the border control/authorities. The second interview was with the IT Director at CPH Airport, Jonas Jørgensen, that provided the researchers with insights into how decisions are made in CPH Airport and the current priorities. Lastly, Louise Blomberg, Head of the Tech Office, was interviewed. Louise Blomberg works with piloting new technology in the airport and has previously looked into blockchain use-cases in an airport setting. She was able to describe the possibilities and limitations CPH Airport sees in regard to utilizing blockchain.

Moreover, an interview has been conducted with the freelance developer Hasham Ahmad, who has developed multiple blockchain prototypes, for instance, a blockchain-based demo on how airport management can be rethought through the implementation of blockchain. Hasham Ahmad represents a third-party developer, and the interview with him investigated what role the developer has combined with technical feasibility.

The ninth interview functioned as a mail correspondence with Erhan Kilören, Team Leader for Turkish Airlines at CPH Airport. The purpose of the interview was to obtain insights about the airline's objectives, operations, and collaboration with other stakeholders in the ecosystem. Lastly, an interview was conducted with Sabrina Abdullah, External Lecturer at Copenhagen Business School and Independent Consultant. Sabrina Abdullah has knowledge regarding operations, collaboration, and challenges of airports and its ecosystem. Based on these points it was evaluated that her perspectives could add value to the research. The validity of Sabrina Abdullah's answers and affiliation with the thesis will be discussed in the methodology reflections.

3.3.2.2 Interviews

As previously mentioned, the research strategy is based on qualitative interviews (Saunders et al. 2015), where ten persons have been interviewed (see table 3). The interviews have been recorded with the consent of the interviewee and afterwards transcribed (see appendix A-J for transcriptions).

The intention was to conduct as many face-to-face interviews as possible since it would allow the researchers to more thoroughly observe the interviewee throughout the interview. This would have added another aspect to the interviews based on body language and facial expression. However, it was only the two first interviews that were face-to-face. The remaining interviews were conducted electronically via Skype, Teams, or telephone due to the COVID-19 situation. The benefit of doing online interviews was that it did not limit the geographic reach of the study because it became possible to interview the most relevant persons. On one side, it can be argued that online interviews are not able to achieve the same level of interactivity and spontaneous communication that can be obtained when doing face-to-face interviews (Saunders et al. 2015). On the other hand, in some situations, the relative anonymity of online interviews can facilitate more honest answers. For the online interviews, it became more important to establish trust early in the interview so the interviewee would feel comfortable answering the questions. For five of the Skype/Team interviews, the webcam was activated to create a feeling of presence. In all calls, the interviewee was deliberately asked to give consent to the interview being recorded. There were few interviews that contained information that the interviewee wanted 'off the record' which the researchers

complied with to maintain ethics and trust between the two parties. This was additionally done to create an atmosphere where the interviewee felt that they could give more honest answer.

The interviews were conducted in different languages (see table 3). The interview with Lars Ingstad Nielsen, Hasse Jørgensen, Jonas Jørgensen, Louise Blomberg, and Sabrina Abdullah - were conducted in Danish, which is the native language of the interviewees and the researchers. This was chosen to assure that no misunderstandings would occur during the interviews due to language barriers (Saunders et al. 2015). All quotes from the qualitative data have been translated to English when applied in the analysis of the thesis, which has been done rigorously since the researchers are aware that translations may affect the substance of the interviewee's statement. However, in this case, it is not perceived as a limitation as there are detailed references to the specific line numbers for each quote, making it possible to identify the particular quote in the original language in the appendix. Hereby, the reader can quickly read an entire passage in the appendix if desired. Furthermore, it greatly benefits the reading experience to have everything in one language. The gain from allowing interviewees to express themselves in a language in which they feel comfortable has been perceived to outweigh the effects of a later translation.

3.3.2.3 Documents

The interviewees represent different perspectives, and to obtain a more complete understanding, secondary literature and documents have been used as a supplement to the primary data. A typical disadvantage of secondary data is that it may not have been collected for a purpose that matches the specific research (Saunders et al. 2015). Therefore, it is argued that it is necessary to critically evaluate secondary data.

To identify blockchain use-cases, organizations such as SITA (2017) and IATA (2018b) have published white papers based on their vision for a system. The white papers represent a fact-based investigation of what solutions may look like and the vision behind the systems. Here, it is necessary to be aware that there is an agenda behind each of these documents driving the solution that they are promoting.

IATA's 'Future of The Airline Industry 2035' report has been treated as an interview person because it is based on interviews with multiple airline executives. Hereby, it is considered as a relevant interview source to present in an airline perspective in the study. A list of questions was hypothetically answered through quotes in the report. The answers from this interview are useful as it indicates the expected directions the aviation industry is moving towards in the coming years. As valuable as this interview is, it must be acknowledged that the information retrieved has been based on the author's understanding of what is important in relation to the study.

Subsequently to multiple interviews, the interviewees sent us additional material, such as internal presentations on the researched topics, that were used to obtain a more comprehensive understanding of the topic. The documents used in the research are perceived to be relevant as they have all been gathered with the intention to either understand or promote blockchain and improvements to seamless travel. In this sense, the documents are an additional in-depth insight into the interviewees' knowledge foundation on the topic. It is expected that the combination of interviews and documents have equipped the researchers with sufficient information on the researched topic.

3.3.2.4 Coding and Analysis

All the data has been coded through NVivo, which involves labeling units of the qualitative data with a code that summarizes the meaning of the particular data unit (Saunders et al. 2015). The initial coding was based on the preliminary four concepts identified through the literature review and elements relating to blockchain. The initial coding was processed so that additional codes could be added based on the relevance in the data. The approach supports the hermeneutical method as the pre-understanding of the topic is continuously developing. The first coding process used thematic coding. The thematic coding of the transcribed interviews entails that pieces of qualitative data that are important for the further analysis will be easier accessible, wherefore coding is considered an important process for managing the data (Saunders et al. 2015). If a data segment covered several themes, it was coded to all the respective themes. 18 themes were identified from the first coding process (see appendix L).

Both researchers conducted the initial coding independently of each other to avoid influencing the other's perception of what was important. Furthermore, the reason was to ensure that nothing was overlooked in the process. Afterwards, the lists of themes were compared to identify the recurrent elements. The recurrent elements were merged into a final list. Based on this list, a second coding of the interviews was completed using focus coding (Saunders et al. 2015). Here all the codes from the first cycle were compared to the raw data to ensure that they were applicable. Through the coding process, 126 codes were made and the distribution of codes from the interviews can be found in appendix M. An example of codes from the second coding process can be found in appendix N.

3.4 Quality assessment of the collected data

The following section will examine validity and reliability which are considered crucial elements when determining the quality of research (Saunders et al. 2015). The section clarifies how the study satisfies the quality criteria for both validity and reliability.

3.4.1 Validity

Validity concerns the appropriateness of the research, and thereby whether the research is reflected appropriately. Moreover, validity refers to generalizability in relation to the findings of the research (Saunders et al. 2015). Interpretive research might, from a theoretical standpoint, affect the validity of the study due to the fact that it acknowledges that all interviewees possess a unique meaning regarding the research area. A method to ensure validity of a qualitative study based on semi-structured interviews consists of exploring the responses from various angels and test the statements from the other interviewees (Saunders et al. 2015). This was utilized during the interviews, where the researchers had a desire to test statements from the initial interviews in the subsequent interviews, which allowed the researchers to identify recurrent and important elements in relation to blockchain technology in aviation. Another technique that was applied during the interviews was follow-up questions, which assured that the statements were understood fully. Moreover, combining multiple data sources enabled the possibility of comparing data from different sources to ensure accordance with the responses from the interviewees (Darmer et al. 2010). This is closely connected to triangulation that involves the use of more than one source of data and methods of collecting data to ensure authenticity and validity (Saunders et al. 2015).

When conducting a hermeneutic study, the value of applying triangulation consists of obtaining more complexity, depth, and richness to the research (Denzin, 2012). Moreover, validity has been achieved through a careful selection of interviewees based on their credibility and insight into the industry (Darmer et al. 2010), and by ensuring the interviewees cover more angles of the ecosystem in terms of stakeholders (Arbnor & Bjerke, 2009).

3.4.2 Reliability

Reliability refers to the degree to which the methods and the research yield consistent results, and a central element concerns replication. This entails that if a researcher can replicate an earlier research design, and obtain similar findings, the research will be considered reliable (Saunders et al. 2015). The practicability of replication can be considered as contested in a qualitative study based on interpretivism. Therefore, it is acknowledged that when applying interviews as a research method, the results will not always be repeatable as the statements reflect the interviewee's social reality at the specific time of collection based on a complex and dynamic topic (Saunders et al. 2015). Supplementing the interviews with secondary data helps to ensure that a better understanding of the research area is achieved. It is crucial that the interview questions cannot be misunderstood as it will be reflected in the interviewee's social view regarding the research area (Darmer et al. 2010). A level of reliability has arguably also been reached in this study once the interviewees began presenting the same arguments and conclusions on a particular question, and there was a limited level of new knowledge added.

Reliability in a qualitative study can always be questioned because the answers and responses relate to a specific context and the knowledge base at a given time. In case the study had been conducted at an either earlier or later time, it is likely that the results will change slightly due to the rapid change of technology and digitization. To ensure some degree of reliability many interviews have been conducted and the interviewees have been asked similar questions.

3.5 Methodology reflections

The following section will elucidate reflections regarding the research design and the methodological choices for the study. This implies a focus on the trade-off for the given choices and the related interview- and analysis process.

If the research had been based on the positivistic research foundation it would imply reaching one single truth derived from experimentation. In this study, this is considered difficult to achieve due to the fluidity of the research area. Hence, it is challenging to claim that there is a single truth regarding blockchain-based systems in aviation as no practical examples of the specific use-case exist, delimiting the possibility of applying a cause-effect based research. The research would be likely to involve quantitative methods of analysis, which is not considered coherent to the crucial elements of the study involving humans and their individual perception and this is supported by interpretivism and hermeneutics. In case the thesis was based on social constructivism as the research foundation, there would be a stronger emphasis on each interviewee's interpretation and understanding of the phenomenon making it fundamentally opinion-based rather than finding patterns. It will thereby be challenging to present any conclusions, and the findings will be interpreted by the reader independently.

Based on the qualitative interview-based research method, it is stated that the traveler (exploratory) approach is applied. However, there is a risk that the data will be scattered based on the approach as it can be difficult to ensure that the interviewees will talk about the desired topics of the research. The approach of letting the interviewee lead the interview fully is therefore contested, and a semi-structured interview guide is applied to frame the conversation to an extent ensuring the interview also will contain viewpoints regarding the relevant phenomena. Hence, the approach to the interviews is primarily based on the traveler approach but does however also contain limited elements of the miner approach. During the interviews, the researchers did not challenge the interviewees' statements as it was difficult when conducting online interviews. However, the statements from previous interviews were tested during the subsequent interviews allowing the researcher to either obtain another perspective of the specific statement or a validation, which ultimately entails a better understanding of the concepts. Testing whether the previous interpretations and the researchers' interpretation in the subsequent interviews can help ensure that

the study is less prone to suffer from both interview - and researcher bias. By reducing the likelihood of bias, it strengthens the final findings either through verification or falsification of an interpretation. Another relevant reflection regarding the interviews concerns the interviewees selected for the research. The interviewees are chosen based on the organizational scope of the research. Furthermore, interviewing someone from the authorities would have been valuable for the research analysis and outcome, as it would have allowed for a more coherent conclusion.

Reflecting upon the quality assessment hermeneutics assumes that the knowledge about a given concept is based on the individual actor's viewpoint, which is changing continuously. This combined with studying a relatively unexplored and dynamic phenomenon is likely to affect the validity and specifically reliability of the thesis. Hence, social actors will, as time passes, continuously develop their understanding of the phenomenon. Therefore, it can be argued to affect the possibility of replication.

Lastly, a methodological reflection concerns the interview with Sabrina Abdullah due to the role as supervisor that potentially could be biased. However, it was found that Sabrina Abdullah has great insight into the aviation industry, and particularly according to the research area. In order to prevent biased insights, it was the last interview allowing the researchers to obtain a preliminary understanding of the topic and use the interview as a discussion about the topic and to test the preliminary understanding.

4. Case

The ecosystem of Copenhagen Airport compromises a variety of stakeholders ranging from small bakery shops to major airlines. The thesis will focus on CPH Airport, the airlines (as a collective), and the authorities. These have been chosen because they are responsible for nine out of 14 checkpoints in the passenger's journey until take-off (Interview 2, line 46 – 58; Interview 3, line 214 - 216; Interview 4; NEXXT, 2020; IATA, 2018b; World Economic Forum, 2018). Figure 5 visualizes all the steps that the regular passenger goes through prior to take-off.

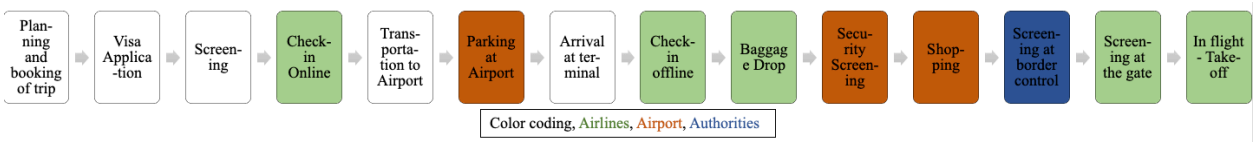

Figure 5 - Steps in the typical passenger journey. The color coding illustrates the owner of the specific checkpoint. Source: Own work

The following chapter will present the primary stakeholders in the passenger journey with a focus on the specific stakeholders' interest and objectives to create a foundation for future elements of the analysis. The chapter will investigate how the stakeholders operate, whether they primarily embrace their own strategy and objectives, or have a holistic perspective on the entire cohesive operation. The descriptions are predominantly based on the collected data and Copenhagen Airport's annual report.

4.1 Copenhagen Airport

CPH Airport is the largest airport in Denmark owned and operated by Copenhagen Airports A/S that also operates Roskilde Airport (Copenhagen Airports A/S, 2020). The airport primarily does business with four customer groups, which are tenants having their own business in the airport, tenants in the tax-free shops of the airport, airlines, and customers. In this regard, more than 1000 companies were in 2019 operating in CPH Airport. The airport served 30.3 million passengers in 2019, which has increased with 18% from 2014 where 25.6 million passengers were served (Copenhagen Airports A/S, 2020). The typical traveler profile in CPH Airport travels for leisure and 73% of all travelers come from the age distribution 15 – 49 (Copenhagen Airports A/S, 2020).

CPH Airport has two main sources of revenue, aeronautical revenue (AR) and non-aeronautical revenue (NAR). AR consists of functions and activities making it possible for airlines to complete the air traffic, whereby it concerns security, check-in, luggage, cargo, boarding and take-off. NAR comes from the facilities and services offered for passengers and others in the airport, which involve property rental, restaurants, shopping centers, hotels, and car parking facilities (Copenhagen Airports A/S, 2020). The AR generated a turnover of 2.4 billion in 2019, whereas the NAR had a turnover of 1.9 billion, and it has traditionally been true that AR is greater than NAR (Copenhagen Airports A/S, 2020). NAR has in general experienced an exponential increase during the last years, which is also the case for CPH Airport (Copenhagen Airports A/S, 2019). From 2018 to 2019 CPH saw the revenue decrease by -2.3% driven by a decrease in AR while NAR has increased (Copenhagen Airports A/S, 2020). Based on a global level of airports, the cost per passenger was $13.59 in 2017, which exceeded the revenue per passenger of $9.95 (Holland, 2019). This clearly illustrates the cruciality of NAR for airports to be financially sustainable. CPH Airport is continuously focusing on optimizing the processes from a passenger perspective, which is also illustrated by the strategic focus areas. CPH Airport's core strategic areas cover elements focusing on sustainability, improving passenger- and retail experience, creating both new revenue streams, a desire to become a more data-driven and digital airport as well as a focus on enhancing the skills to be the 'future airport' (Copenhagen Airports A/S, 2020). More of the objectives relate to the passenger. Firstly, an objective concern maintaining a high level of security which essentially occurs by the security screening. Lars Ingstad Nielsen states that this is particularly important since it is operated by CPH Airport: "It is operated internally. It is a unit of 1100 - 1200 people. They run very independently but are still a department of Copenhagen Airport" (Interview 2, line 46 - 47). Maintaining a high level of security is considered a central element in ensuring a positive passenger experience, which is fundamental for operating the airport.

Lars Ingstad Nielsen argues that currently there can be a tendency to neglect the passenger: "It is important to keep in mind that we [CPH Airport] exist because of the passengers. If there were no passengers, we would not be here. Sometimes people tend to forget that" (Interview 2, line 142 - 145). The statement illuminates that passengers can be perceived as of vital importance for the existence of CPH Airport that needs to meet the passengers demands. The objective of ensuring satisfied passengers and a good retail experience is emphasized by several interviewees. Lars

Ingstad Nielsen states that "Copenhagen Airports most important focus is that our passengers are happy. I see that as a holistic picture. Passengers want to go through the process quickly, and that their requirements are met" (Interview 2, line 442 – 445). This is complemented by Jonas Jørgensen stating that under normal circumstances the primary focus of the airport concerns optimizing the passenger journey - for instance achieved by technological implementations and digitalization - as satisfied passengers are the primary revenue generator (Interview 4, line 42 - 45). Moreover, the airport wants to limit the amount of stress for passengers throughout their journey by improving transparency through information. Louise Blomberg confirms the objective with the following statement: "This is because we know that when passengers are not stressed, they will spend more money. After all, we make most of the revenue through passengers shopping" (Interview 5, line 546 - 549). Hence, the experience of the passenger is crucial for CPH Airport, and every touchpoint creates stress and anxiety (IATA, 2020; Interview 10). The primary focus on ensuring a positive passenger experience, and providing the passengers an efficient process from landside to airside is naturally also based on an economic motivation:

> "One driver consists of getting the passengers through the entire travel value chain quickly. Then they might have time to get something to eat, which will make the commercial department happy [...]. In case the commercial department is happy, it means that we make more money" (Interview 2, line 462 – 464).

CPH Airport focuses on ensuring a positive experience for the passengers with the intention of increasing the NAR. When passengers have more time on the airside, they will spend more money in tax-free, restaurants, and shops (Interview 2, line 452 - 454). The importance of offerings allowing for an increase in NAR is furthermore elucidated with the various expansion initiatives of CPH Airport. In 2018, a 4.000 square meters area opened containing 24 new stores and restaurants (Copenhagen Airports A/S, 2018). Moreover, the airport is currently working on expanding with an 18.000 square meter terminal with the purpose of being able to facilitate 40 million passengers annually. Hence, CPH Airport invests heavily in order to optimize processes for its four customer groups, and this is undoubtedly also with a focus on enhancing the revenues in a future perspective (Copenhagen Airports A/S, 2019).

4.2 Airlines

In Copenhagen, approximately 80 different airlines operate, and these can be divided into low cost-carriers and mainline airlines (Interview 4). Common for most airlines is a focus on revenue, on-time performance, and the passenger experience (Interview 3; Interview 7; Interview 9). The importance of the passenger experiences is specifically highlighted in the conducted interviews with IATA that represents, leads, and serves the airline industry. Hasse Jørgensen states that the primary objective of airlines is to improve the experience of the passengers: "Basically, it is about that airports and airlines want to provide and improve the experience for the customer, which is the passengers. That is the essential focus, and that is what we do" (Interview 3, line 139 - 141). Hence, implying a focus on the offerings for the passengers, which Erhan Kilören complements stating that an objective is to carry passengers to the destination and "[...] while doing so, it is vital to meet passenger's needs and expectations" (Interview 9, line 6). However, it is also stated that airline companies have economic incentives where process optimization shows its importance: "We all know that optimization or an improvement processes, for instance, reduction of a specific process time, will show a result on the bottom line" (Interview 3, line 141 - 143). Hence, there is also an economic perspective that cannot be overlooked because the airline's livelihood and future operation depend on it (Interview 5, line 559). In this regard, the revenue will occur based on savings in relation to improvements in operationalization based on effective turnaround time as well as on-boarding, as a delay of departure is relatively costly for the airline companies because the airline will have to pay additional fees and penalties (Interview 4, line 506 - 508; Interview 5, line 267 - 270). With the exception of low-cost carriers, the passenger experience is absolutely essential, and revenue often serves as a function of it. In the financial crisis 2008, most airlines were under pressure and some even went bankrupt. However, the Asian airlines managed the crisis better than most, and the reason was that they had a high service level (Interview 10, line 487 - 490). A positive travel experience is considered crucial, which ensured that the Asian airlines had customers during the financial crisis. The positive travel experience can in this regard be perceived as an opportunity to do additional business in the future.

Recapitulating, most airlines have several interests that are overlapping with CPH Airport, which is a focus on the passenger experience that will improve by the focus on optimization of processes such as turn-around-time which ultimately leads to on-time departures. Leaving on-time will

prevent an economical fee for delayed departure due to not complying with the slot time and avoid frustrated passengers.

4.3 Authorities

The last major stakeholder of the passenger journey in the airport is the authorities that operate the border control in CPH Airport. The objective of the authorities differentiates from the airport and airlines since the authorities do not have any financial incentive to consider in the operations. The authorities function as a "[...] operating organization with the primary objective of maintaining safety based on assuring that the wrong people do not come in or leave the country" (Interview 2, line 290 - 292). Therefore, the most important objective for the authorities is to assure that the passengers crossing the Schengen-border have been subject to a high-quality check and screening, whereby queue time and process optimization are secondary to the authorities (Interview 2, line 199 - 202). Given the divergent main objectives, the authorities differentiate themselves from the other stakeholders in the airport. This is clarified in the following statement:

> "So, the police still do not work with KPI's. However, they have come so far that they will give a statement of intent. They will aim at a maximum waiting time for passengers of 20 minutes in the border control, but they do not promise anything" (Interview 2, line 233 – 235).

The authorities are therefore operating based on truly different incentives and interest from the other stakeholders, and do not have the same interest in making major investments in process optimization and digitalization, which is exemplified by Hasse Jørgensen's previous working experiences at CPH Airport:

> "I was very involved in the creation of the automated border control at Copenhagen Airport [...]. So, it took from 2004 to 2014, about 10 years, before we actually were running the automated passport control at Copenhagen Airport. So, it takes quite a lot of time to implement these things" (Interview 3, line 342 - 349).

The quote illustrates how time-consuming the process can be when implementing solutions related to the border control and authorities' performance while establishing a partnership for the project between the airport and the authorities. The example illustrates the authorities focus on protecting the country's border rather than limiting queue times. To protect the border the authorities, have several national and international collaborations with interoperable systems to ensure a high-

quality screening process (Interview 2). The requirements of these collaborations may restrict the possibility of collaboration with other stakeholders in the ecosystem.

In conclusion, the stakeholder mapping has illuminated that diverging objectives exist between the authorities and both CPH Airport and the airlines. Here, CPH Airport is focusing on eradicating the misaligning by convincing the stakeholders to observe the value chain holistically with a mutual understanding (Interview 2, line 227 – 229). The objectives, key driver, and key performance indicators (KPI) of the three stakeholders are summarized in the table below:

	CPH Airport	**Airlines**	**Authorities**
Objectives	- Improve passenger experience - Process optimization - Increase revenue - Maintain security	- Improve passenger experience - Process optimization - Increase revenue	- Maintain safety - Quality screening of passengers
Key Driver	- Financial	- Financial	- Non-financial
Use of KPIs	- Limit queue time/ process time	- Leave on time / For process time	- Number of true positive cases identified

Table 4 - Objectives, key drivers and KPI's of the stakeholders. Source: Own work

5. Findings and analysis

The following chapter will present the findings and analysis of the collected data from the interviews. The stakeholder presentation has created the foundation for the following chapter focusing on presenting findings related to interoperability between the stakeholders, the systems, and the possibilities for data sharing. Subsequently, the analysis will investigate how blockchain technology and its properties can contribute to create interoperability and improve data sharing processes between the stakeholders. Afterwards, management considerations in relation to creating a blockchain system will be investigated based on the identified key concepts from the literature review and include new discoveries from the data. The analysis will examine the relationship between interoperability barriers and the concepts. Lastly, it will evaluate the applicability of blockchain and what type of blockchain would be appropriate.

5.1 Interoperability concerns

The purpose of this section is to present findings and analysis for the existing collaboration and interoperability of the three stakeholders. This is accomplished by adopting the interoperability framework by Chen (2006) with the focus on concerns. As previously mentioned, the interoperability concerns clarify four areas in which interoperating activities occur between stakeholders (Chen, 2009; Doumeingts et al. 2008). Prior litterature has shown that collaboration between stakeholders often affects operations and ultimately the passenger experience (Hartshorn, 2020; IATA, 2018d, Abdullah, 2015). When stakeholders demonstrate silo behavior, it will often be reflected in the passenger experience wherefore B2B integration is considered important (Hartshorn, 2020). The section will present findings that reflect the collaboration and interoperability in order to evaluate if it is present and will additionally identify where the stakeholders see the potential for further interoperability. The findings will be concluded by a summarizing table of interoperability of the stakeholders based on the specific concerns.

5.1.1 Business Concern

Business concern focuses on the harmonization of work methods and a shared vision between the stakeholders (Daclin et al. 2018). The stakeholder presentation from chapter 4 showed that divergent objectives are present, as the authorities have no financial objective, whereas both the

airlines and the airport's primary driver is financial. The difference will naturally affect the different stakeholders' focus on process optimization and the commitment towards interoperability. However, because CPH Airport and the airlines have a shared common interest in process optimization and improvements in collaboration (see table 4) it can be argued that there - to some extent - is a shared business vision (Chen, 2006). The authorities deviate from the other two as they lack this vision (Interview 2, line 233 – 235). Therefore, CPH Airport is actively trying to promote the importance of having a shared business vision: "Everybody needs a holistic viewpoint. We work really hard to promote this to the entities that might not be so good at it. It is important that we show consideration for each other, and that we have a common understanding" (Interview 2, line 227 – 229). This is underlined by Sabrina Abdullah who clarifies that, for many years, airports have talked about the concept of collaborative decision-making, but nobody has done anything about it in practice (Interview 10, line 344 - 346). Collaborative decision-making can, therefore, be considered an unsolved business concern that can serve as an obstacle for interoperability. CPH Airport has realized the need to convince the stakeholders to observe the value chain holistically in order to eradicate misalignment (Interview 2, line 233 – 235). The interest in shared business visions is an element that airlines take an active part in promoting to the authorities, which primarily occurs through IATA that represents the interests of the airlines. In this regard, Hasse Jørgensen elaborates that IATA focuses a lot on convincing the authorities not to ignore the holistic operations and the KPIs that possibly can improve operations (Interview 3, line 324 - 326).

Summarizing, it can be argued that some degree of harmonization exists between CPH airport and airlines due to their shared financial objectives. However, the authorities are working based on dissimilar incentives and objectives, which affect the overall harmonization in regard to the business concern (Chen, 2006). Currently, the consequence has been a larger degree of silo behavior by the stakeholders and a lack of collaborative decision-making.

5.1.2 Process Concern

Interoperability of processes focuses on the integration of processes in a company or between two or more enterprises (Chen, 2006). It can be argued that the three stakeholders operate in the same ecosystem and have a crucial stake in the passenger journey as a process. Each stakeholder operates

specific processes in the passenger journey. CPH Airport and the airlines have expressed an interest in making the processes more integrated to improve the passenger experience. Jonas Jørgensen elaborates in this regard that: "[…] we are all interested in giving the passengers a better experience. There is no one in the ecosystem that not will be like that. As long as we maintain and increase revenue together [...]" (Interview 4, line 264 - 266). The statement relies on a financial incentive, whereby the inclination can be challenged from an authority-perspective based on the focus on detecting the maximum number of individuals who cannot legally travel rather than the quality of the passenger's journey (Interview 2, line 196 - 199). However, all the stakeholders are aware that they have a crucial stake in the overall process, and CPH Airport functions in this regard as a primary facilitator for maintaining and improving the process through performance evaluations: "We share it with the process owners in the airport [...]. We share it with everyone that has a stake in the process. They will get a monthly report where they can see their overall performance. But this is also differentiated based on the various airlines" (Interview 2, line 22 - 28). CPH Airport organizes day-to-day meetings with representatives from the other stakeholders that operate in the passenger journey with the focus on evaluating the different processes in the overall passenger journey through the exchange of information. The day-to-day meetings are arranged with the purpose of optimizing and integrating the processes that make up the overall passenger journey process (Interview 2, line 32 - 36). Hence, it can be argued that an interest exists regarding the integration of processes as it will provide value for all the stakeholders. According to Lars Ingstad Nielsen, this is a result of the increasing focus on B2B integration from the perspective of CPH Airport: "During the last 5 - 6 years CPH Airport has realized the importance of getting our stakeholders involved, and to get a strong collaboration with them throughout the process. Back in the days, the stakeholders were involved quite late" (Interview 2, line 107 - 109). For years there has been a development in the collaborative focus, and CPH Airport has realized that further integration of stakeholders is a necessity for assuring integration of processes. CPH Airport provides the framework and foundation for healthy collaboration by involving other stakeholders, which initiates integration of processes with the intention of improving the passenger experience. Similarly, Hartshorn (2020) has emphasized the importance of a higher focus on cross-collaboration and B2B integration. Louise Blomberg presents here the importance of a holistic perspective on the integration of processes: "We try to help the airlines with their turnaround time. Because it is costly as soon as they lose their slot time. Then they will need a new one which entails

an economic loss, as they will have to pay us more money" (Interview 5, line 267 - 270). In this context, it should be underlined that the relationship between CPH Airport and the airlines is dual. There is naturally an integration of processes and thus a partnership in relation to the passenger journey process. Moreover, the two stakeholders are doing business implying that major parts of AR for CPH Airport come from the airlines. The statement illustrates that the integration of processes and collaboration undermines the additional revenue that potentially could be obtained for CPH Airport since sufficient collaboration and integration will be reflected in the passenger experience (Abdullah, 2015). However, the focus on the integration of processes between stakeholders is not only a focus from the CPH Airport. This is also in the interest of the airlines, which is reflected as a strong focus from IATA that has the properties and capabilities to assemble the significant parties and stakeholders in relation to a specific process (Interview 3, line 70 - 73). This is challenged by Sabrina Abdullah stating that the integration of processes between airlines and authorities currently is non-existing, which results in inefficiencies in the stakeholders' operations and in the passenger journey (Interview 10, line 162 - 170).

Summarizing, it can be argued that the integration of processes is present in the ecosystem of CPH Airport. It is primarily facilitated by CPH Airport that has focused on improving the collaboration and integration of processes. More of the interviewees state that all the stakeholders are aware that integration of processes will improve operations and lead to more satisfied passengers. However, the integration of processes between airlines and the authorities is limited, but it contains a huge potential in case it becomes a focal point. A primary obstacle for integration of processes in the ecosystem is the authorities, because of their non-financial objectives and engagements in other ecosystems with strict requirements as highlighted in section 4.3.

5.1.3 Service Concern

The focus of service interoperability is to make various applications function together (Daclin et al. 2008). Based on the interviews and literature, it is clear that historically there has been a lack of service interoperability and collaboration between airports, airlines and the authorities (Interview 1; Interview 4; Interview 5; Interview 6; Hartshorn, 2020; IATA, 2018a). Boris Düdder and Hasham Ahmad argued that this can be due to the fact that the stakeholders tend to demonstrate silo behavior and only optimize their own services. However, the concern is currently experiencing

an increased focus since CPH Airport are working on involving stakeholders to collaborate in the joint ecosystem. It can be argued to be a continuation of the promotion of a shared vision (business concerns) and increased focus on integration of processes (process concern).

One of the areas where CPH Airport has tried to create interoperable applications is the distribution of check-in desks for airlines on landside that currently has been distributed based on a worst-case-scenario (Interview 2, line 305 – 306), implying that it is presumed that the flights are fully booked. However, this is not always the case whereby an incorrect distribution of desks eventually occurs as it is not based on the actual demand for the different airlines. Thus, some airlines might be allocated to many desks while other airlines lack desks to serve the passenger in relation to luggage drop-off and physical check-in. The inconsistent distribution of desks can ultimately lead to congestion and thereby affect the passenger experience. Based on the identification of the problem, CPH Airport has activated initiatives to improve the interoperability of services based on a dynamic desk distribution system that has been created by a third-party developer. The example illustrates CPH Airport's focus on making more applications or systems function together between stakeholders as the dynamic desk distribution will consist of the application for desk-overview from CPH Airport combined with passenger numbers from the database or application of the airline (Interview 2, line 326 – 334). By making the systems interoperable, it will be ensured that the distribution of desks is aligned with the actual needs, which is with the purpose of limiting queue time on the landside. The attempt shows that some willingness exists to collaborate and interoperate between CPH Airport and airlines. The system is however yet to be fully implemented and at the moment it is solely CPH Airport who can modify the information and system. Thereby, the airlines only have visual access to the system (Interview 2, line 339 - 340). Consequently, the service is not fully interoperable at the moment, but it provides a foundation to ensure the system's interoperability in the future. Nevertheless, the intention is that both stakeholders will have similar rights and access in a future context (Interview 2, line 339 – 343).

The previous examples illuminate CPH Airport's interest in collaboration and interoperability between services with stakeholders in the airport in order to improve the passenger experience. However, it is still an interoperability concern that potentially could be improved, for example by a higher collaboration based on a decentralized control system (DCS) between the airlines where

highly detailed data is stored regarding passengers. At the moment, this is not available for CPH Airport (Interview 2, line 392 - 399). This is complemented by Jonas Jørgensen stating that "[...] there are, of course, a lot of interfaces to the airlines as they possess a lot of data. The 80 airlines that we work with know the destination of the passengers when they arrive at the airport. So, there could definitely be a collaboration there" (Interview 4, line 131 - 133). It is thereby acknowledged that a potential exists for increased collaboration and interoperability between CPH Airport and the airlines by developing services, which potentially could lead to new business opportunities. However, the potential is somehow delimited since: "[…] the airlines do not approach us with ideas. They do it for themselves. For example, SAS and their app which provide flight information. It could be interesting if we could coordinate that effort for everyone's purpose" (Interview 4, line 241 - 243). Often when airlines develop a service for the passengers, it is done without involving and integrating other stakeholders, which limits the possibilities of more interoperability. Hence, the airline's approach is in this example conflicting with CPH Airport's desire for more applications functioning together. Arguably, it needs to be CPH Airport who is the facilitator of creating more interoperable solutions (Interview 4, line 274 - 278). The specific desire of more integration of services is furthermore outlined by Louise Blomberg and Jonas Jørgensen stating that CPH Airport is currently working on technology for tracking the passengers. This is with the purpose of integrating with other stakeholders' applications in order to specifically help the airlines with more information about where the passengers are located in the airport. It is an important focus since it is not currently existing, which is elaborated upon by Jonas Jørgensen: "The airlines do not know anything about this, and therefore they call the passengers to come to the gate. Airlines do not know if the passenger is located in the airport. They do not have any information about this" (Interview 4, line 295 - 297). The integration of these services will allow CPH Airport to assist the airlines with on-time departures (Interview 5, 306 - 306). This is complemented by Sabrina Abdullah stating that airlines do not possess information concerning passengers' location, which potentially could be crucial information to assure on-time departure (Interview 10, line 357 - 366).

Summarizing, it can be argued that especially CPH Airport has a strong focus on integration of applications and services with the purpose of optimizing processes and the passenger experience. This is exemplified by the current development of a dynamic desk distribution where it is intended that more applications will interoperate. Furthermore, the interviewees from CPH Airport have

expressed that this is a focal point and that they are actively trying to facilitate service interoperability. The airlines are to some extent also interested in increased interoperability of services as it can affect the passenger experience. However, it is found that airlines mainly develop their own applications without involving and integrating the other stakeholders, which ultimately affect the interoperability of services.

5.1.4 Data Concern

Interoperability of data is essential for enterprise interoperability and collaboration nowadays. The data concern reflects the ability to exchange non-electronic data as well as machine transportable data, and the utilization of the data that is exchanged (Chen, 2006). Data interoperability occurs when stakeholders exchange data and information, which for instance can happen through processes or services, wherefore it is argued that the concerns to some extent are interrelated (Chen, 2006). The interview with Boris Düdder provided complementing thoughts to Chen's (2006) argument about data interoperability often appears as a fundamental obstacle for ensuring interoperability between two actors:

> "In particular you see that you have a lot of silos in companies. People do that for certain purposes because it is their kingdom essentially. They would, or fear to lose power if they now share this data to integrate. And that is of course for a lot of other scenarios a problem. So how do you make sure and clear to them that you don't lose power essentially by sharing information?" (Interview 1, line 250 – 254).

The statement illustrates a dilemma today, regarding the protectiveness and value of data. Hasham Ahmad elaborates on the same argument when asked about whether data sharing, in general, is considered sufficient between organizations, where he argues that data sharing is limited which is "[…] kind of expected because everything is siloed and protected […]" (Interview 6, line 67 - 68). A general problem for data sharing consists of organizations that tend to adopt a silo behavior and a protectionism mindset since it is assumed that sharing data is equal to giving up control and thereby power (Interview 1; Interview 6). In this context, the fear of yielding power is presumably the current limiting factor for interoperability of the services that were identified in the previous section. Boris Düdder elaborates on this viewpoint regarding interoperability of data and data sharing in the specific use-case. The interviewee argues that in a comprehensive data-collaborative perspective between the stakeholders the quality of data has a huge impact on data integration

(Interview 1, line 335 – 336). The argument concerns the importance of ensuring a high data-quality, and this is essential if the data is to be stored in a distributed database between the stakeholders.

Related to the level of data sharing at CPH Airport, Lars Ingstad Nielsen mentions that his teams' operations entail daily sharing of data with the other stakeholders (interview 2, line 508). The complexity of this specific data can, however, be challenged as it primarily consists of key figures in relation to the KPIs, wherefore the data sharing from heterogeneous databases in this example occurs through daily mails (Interview 2, line 155 – 160). Nevertheless, Lars Ingstad Nielsen is aware that the extent of data sharing is insufficient when looking at the overall picture, which is considered an obstacle for further optimizing more operations. It is here stated that "we need data from everybody. This is what we are struggling with right now. But the more we can gather, the more agile an operation we can have. And that is precisely in everyone's interests" (Interview 2, line 501 - 503). The current limitation in data sharing is complemented by Jonas Jørgensen, who however sees possibilities for new ways of increasing the revenue if the data sharing problem is solved (Interview 4, line 138 - 148). Hasse Jørgensen from IATA does additionally elaborate on data sharing as a current obstacle for interoperability, and the interviewee underlines the uncertainty about ownership of data if it has been shared (Interview 3, line 194 - 197). Sabrina Abdullah shares this viewpoint on how data sharing currently affects interoperability and collaboration: "I do not think it will be open data sharing. Right now it is very closed. Then it will be a radical change [...]. It is a very sensitive and competitive environment they have. They cannot even tell you have many passengers they have on board, so why would they tell you something else?" (Interview 10, line 177 - 180). Hence, data sharing is currently an obstacle as the stakeholders keep the data to themselves entailing no data sharing.

Based on the interviews, a pattern has been identified reflecting that the authorities and the border control in the passenger journey process are perceived as a primary limitation for ensuring data-interoperability. Lars Ingstad Nielsen clarifies that he often meets the obstacle in his daily work routine: "They are naturally always critical in this regard. And typically, they will need to involve the national police behind closed doors where they figure out if it is something they want or not" (Interview 2, line 278 - 280). Louise Blomberg elaborates further on the border control and data

sharing, and a potential reason for the authorities' mindset leading to a limitation in data interoperability concerns the complexity and sensitivity of the data possessed by the authorities. This implies that GDPR needs to be considered which leads to a major challenge (Interview 5, line 244 - 246). Hence, the authorities are vigilant with data sharing as it implies a risk due to exposing sensitive data. This can potentially lead to a scandal, which is something all stakeholders try to avoid - and it is particularly not in the interest of the authorities (Interview 5 line 281 - 283; Interview 2, line 288 - 290). Therefore, it is stated that the data sharing between CPH Airport and the authorities are limited at present time, where Louise Blomberg states similarly to Lars Ingstad Nielsen that the primary data sharing consists of key indicators for waiting time at the passport control (Interview 5, 290 - 203). However, Louise Blomberg elaborates that CPH Airport has a desire to share more data with all stakeholders (Interview 5, line 343 - 345) which implies that CPH Airport likewise obtains more data in order to improve processes and the passenger experience, which for instance could be trough new offerings.

Hasse Jørgensen further emphasizes that data interoperability is not just a restriction between the CPH Airport and the authorities but also in the operations between CPH Airport and the airlines:

> "It is not only regulators that have doubt about data. It is also a concern for the various stakeholders. Airlines will not share data with airports, and airports are not willing to share information with airlines. So, it will be great to develop a platform with a high level of data security" (Interview 3, line 49 - 54).

This is complemented by Sabrina Abdullah, who emphasizes that due to the limited data sharing, it is only the airlines that have information on the passengers in the airport (Interview 10). In this regard, it is stated as an active choice as "[...] airlines do not want to share data with the airport" (Interview 10, line 407 - 408). Thus, it is not just framed as a matter of uncertainty, but as an active choice from the stakeholders to not share the majority of the data, which can be related to the previous statement regarding data sharing implies giving up control. According to Sabrina Abdullah this is a primary challenge that relies on distrust between the airlines and CPH Airport, whereas the data sharing problem for the authorities consists of a non-financial incentive (Interview 10, line 423 - 425). Based on the findings from section 5.1.2 that reflects a limited integration of processes between authorities and airlines, it can be argued that it is affected by the non-existing data sharing between the two stakeholders. Sabrina Abdullah uncovers that data

sharing will lead to a higher degree of integration of processes and ultimately to an improved passenger journey (Interview 10). Data sharing is, in this context, considered beneficial for both stakeholders. Airlines would be able to improve operations based on information regarding whether the passenger has been through the border control, whereas the border control would be able to do likewise based on information regarding passenger numbers from the airlines in order to allocate the right amount of resources in terms of staff (Interview 10, line 162 - 170). Hence, there is a need to adopt a holistic view with a mindset focusing on "[...] how can we help others along the way, and how can we help them to do their work more effectively? This could be through data sharing" (Interview 10, line 260 - 262). Hasse Jørgensen does in this relation state the importance of the stakeholders needs clarification and agreement of which data to share in relation to optimize specific processes. Currently, this is not clear wherefore IATA allocates many resources to elucidate the obstacle (Interview 3, line 59 - 62). The opinion is further clarified by Hasse Jørgensen, stating the importance of standards for communication (Interview 3). Moreover, IATA is focusing on creating the fundamental standards in order to improve communication, data sharing, and data interoperability, which is expected to be reflected on the passenger journey.

Summarizing, the interviews elucidated different opinions regarding whether data sharing occurs and if data interoperability exists to a sufficient extent between the stakeholders. The viewpoints are influenced by the interviewees' area of work, the complexity of data in this relation, and by the interviewee's perception of data sharing. However, the majority of the interviewees clarify that the data interoperability and sharing of information at the current stage is limited, which is a delimiting factor for further collaboration. It is assumed to affect the possibility of creating operations and services to increase revenues as well as improving the underlying processes related to the passenger journey. The section additionally states that a limitation especially consists of the authority's willingness to share data is restricted due to regulatory elements. However, the data sharing between the stakeholders with financial incentives are additionally limited which can be caused by a fear of giving up control as well as distrust between the stakeholders. Moreover, it is due to uncertainties regarding semantic interoperability which concerns how to handle and represent information and data. Therefore, the major associations in aviation are currently allocating lots of resources to create standards with the purpose of promoting data sharing in a future context.

Table 5 recaps the findings of collaboration and interoperability of the four concerns. The table does additionally present an evaluation of the level of interoperability in the specific concerns and an evaluation of the interoperability focus of the three stakeholders. Here, the evaluation distinguishes between three magnitudes of interoperability focus and interoperability level, respectively low, medium, and high. The ratings are assigned based on the presented findings in the four concerns.

	Copenhagen Airport	Airlines	Authorities	Clarification	Interoperability level
Business Concern	Financial Incentive. Optimization. Passenger Experience.	Financial incentive. On-Time Departure. Passenger Experience.	Non-financial incentive. Maintain Security. Check & Screening.	Shared interests between Copenhagen Airport and the authorities whereas the authorities differ, which ultimately affect the harmonization of business interoperability.	Medium
Process Concern	High focus on process integration. Facilitates process integration through meetings with stakeholders.	Moderate focus on process integration. Willingness to follow, but not to encourage.	Limited focus on process integration. Operates relatively independent.	CPH Airport functions as facilitator for more integration of processes. The airlines are somewhat interested if value is identified. Authorities are not interested due to divergent objectives.	Low
Service Concern	Increasing focus on integration of services and applications. Developing new systems based on application integration where stakeholders are involved.	Low focus on integration of services and applications. Developing independently instead of involving stakeholders.	Limited focus on integration of services and applications. Non-financial incentive entails no interest in new business opportunities.	Increasing focus by CPH Airport where airlines affiliate if operated by CPH Airport. However, airlines tend to develop without a holistic view which entails other stakeholders are not involved. Currently not relevant for authorities to due divergent incentives.	Low
Data Concern	Moderate focus on data sharing. Data sharing of key indicators. Interest in data sharing between stakeholders due to the potential of new business opportunities as well as improved operations.	Limited focus on data sharing. Possess a vast amount of data that however is not shared among stakeholders. Interested in data from airport and authorities to ensure on-time departure.	Limited focus on data sharing. Possess useful data for other stakeholders that is not shared due to divergent objectives and regulations. Interested in passenger numbers from airlines for staffing.	All stakeholders identify a potential in obtaining more data in order to optimize operations. However, data sharing does not occur due to mistrust between the stakeholders, and moreover since the possessed data is considered a competitive advantage in which data sharing leads to a fear of giving up control. Lack of a holistic view.	Low
Interoperability Focus	Medium	Medium/Low	Low		

Table 5 - Overview of Interoperability Concerns. Source: Own work.

5.2 Enhancement of data- and information-sharing

The previous sections examined interoperability concerns and it is found that a general consensus between the interviewees exists in regard to the respective stakeholders possessing data that the other stakeholders can benefit from in their operations. Additionally, it is identified that data sharing is currently limited, which restricts the possibilities for further improvement of operations and the passenger experience (Interview 2; Interview 3; Interview 4; Interview 5; Interview 6; Interview 10). This section will illuminate examples of how the different stakeholders can gain value and thereby improve operations based on information that other stakeholders possess.

Despite the fact that the airlines possess a vast amount of data (Interview 2; Interview 10), a lack of information is still a limiting factor for an on-time departure. Airlines are currently unaware of the location of the passengers during the passenger journey (Interview 10). What makes the passenger journey special, is the fact that it is based on a linear flow of events where the passenger has to go through the checkpoints in a specific order. This means that a data point can be collected for each stage the passenger passes through. At the same time, it is the three different stakeholders who are the owner of the information at the different stages (see figure 6). By creating a distributed event ledger that stores all the relevant information each stakeholder's operation could benefit and be improved. For example, the airlines have a desire to obtain information when passengers cross the different touchpoints of the passenger journey. This could, for instance, be information from CPH Airport when a passenger is crossing the security screening, or from the authorities when the passenger crosses the border control. In that sense, the airlines will be more informed about the passengers' location which can be helpful for on-time departure (Interview 10). Due to increased information, the airlines can send notifications to the passengers informing them that it is time to go to the gate in order to be able to board the flight. If the passenger's location implies that it will be impossible to onboard the flight in time, it will be possible to remove the luggage before it would severely damage on-time performance and departure (Interview 5; Interview 10). This information can also prove useful for CPH Airport as it will be possible to identify how much time passengers spent within each of the different stages in the airport. An improved information flow can ensure heightened transparency both for the airlines but also for the passenger knowing how much time they need to reach the designated gate. Ultimately, if it can increase the level of

transparency, it is assumed to positively impact stress level for passengers. As shown in section 1.5.2 a decrease in stress levels can strengthen NAR. Additionally, CPH Airport has a desire to receive passenger-related data from airlines to obtain knowledge regarding passenger preferences that will create the possibility to focus on personalization in which the individual passenger will receive tailored offerings in the airport in order to improve the passenger experience. The passenger-related data will also allow CPH Airport to invent new business models to make the passenger experience even better - for instance through supporting the rest of the passenger journey by providing assistance with car-rental or booking of taxi or hotel at the passengers' destination (Interview 4; Interview 10).

The authorities have expressed a desire for obtaining information and data from particularly the airlines. As previously mentioned, information regarding the passenger numbers from the airlines will provide an information basis for optimizing operations based on a more correct allocation of resources in terms of staffing based on the actual demands (Interview 5; Interview 10). A reduction of border control congestions is also expected to be reflected in the satisfaction level of the passenger experience.

The data shows that the stakeholders have an interest in information and data that is possessed by other stakeholders. Hence, enhanced data sharing will improve operations for the stakeholders since previously inaccessible information in that sense will be possible to utilize. This will likewise affect the passenger experience positively (Hartshorn, 2020; Interview 10; Abdullah, 2015). The interviews have shown that improvements in data sharing will enhance the efficiency of more operations. An increase in data sharing is also considered a necessity if the intention is to continuously provide more seamless travel for the passengers as well as meeting the previously mentioned strategic objective of CPH Airport.

Several interviewees stated that the creation of a data exchange platform is particularly interesting, as it could change the way that the companies operate and enable them to tailor the operation more to a specific time (Interview 5, line 346 - 351; Interview 3, line 53 - 55). What this means is that data could be commoditized. In the same sense being able to move data and push information around the ecosystem can both improve the stakeholders' operation and the passenger experience.

This will also lead to more informed passengers which ultimately entails an enhanced overview of possibilities based on the time. Moreover, improvements in information to passengers will reduce the stress level (Interview 10), which is important as "the analyzes show that a higher stress level will lead to decreased passenger consumption. Stressed passengers will go straight to the gate [...]" (Interview 10, line 76 - 79). This does not add any value to the airport since it is a business that relies on revenue from sales (section 4.1). It is assumed that if passengers are sitting at the gate, they will not spend any money and consequently the airport cannot profit. In this sense, the additional information can be utilized to create a better experience through increased transparency and information sharing hereby reducing the information asymmetry. From a technical perspective, improving data sharing as well as commoditizing data will most likely require a shared/distributed database system (Interview 6). The examples provide a basis for creating a system that brings together multiple stakeholders to enhance trust and data sharing with the potential to ultimately lead to a better experience for the passengers (Interview 2; Interview 10; Abdullah, 2015; Hartshorn, 2020). Inspired by the interviews, figure 6 has been created to illustrate examples of who and where the respective stakeholders can benefit from the information shared at each of the checkpoints that they operate.

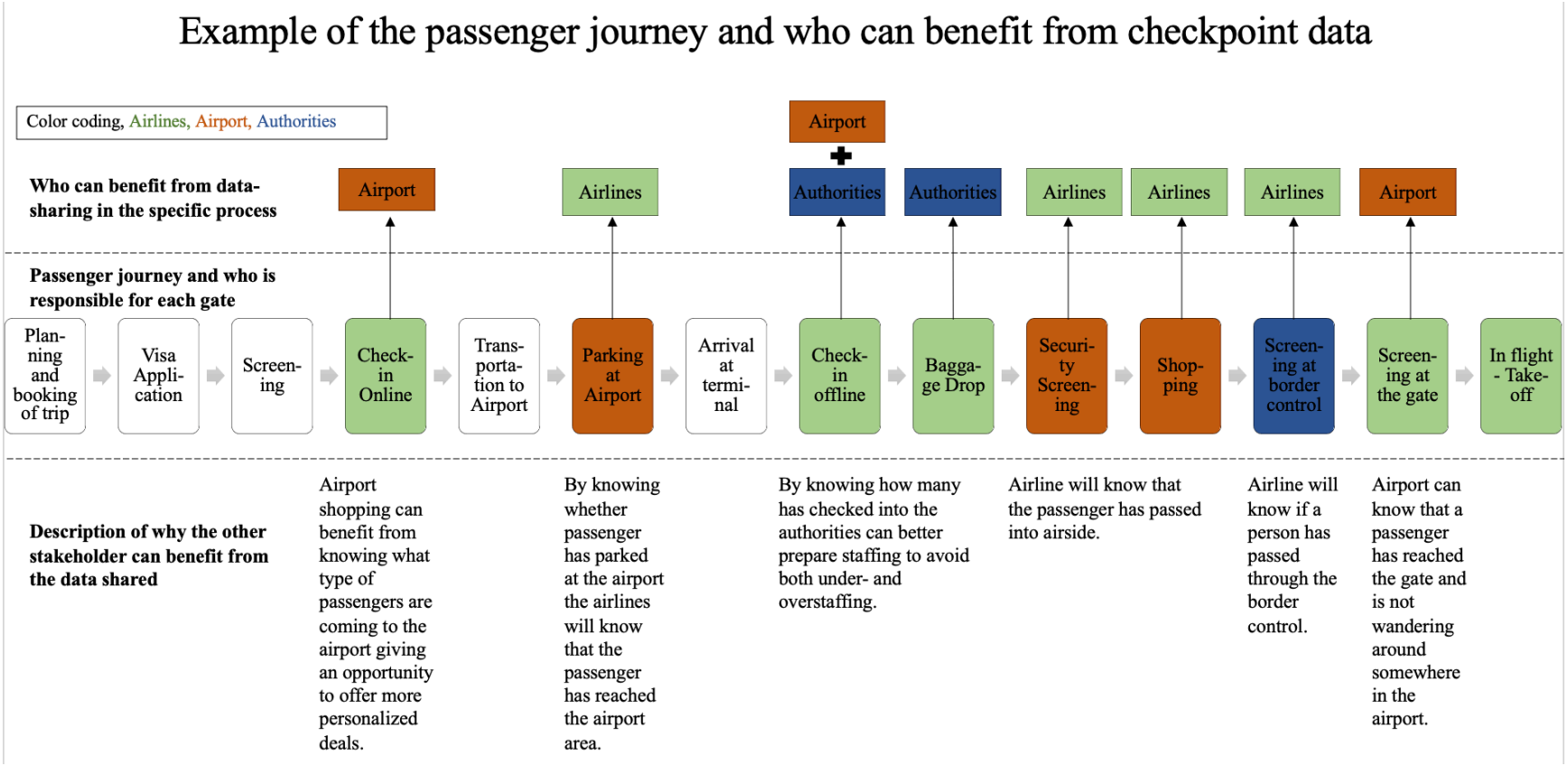

Figure 6 - Overview of ideas to where stakeholder can benefit from data at a given checkpoint in the passenger journey. Source: Own work

In this context, the following sections seek to clarify whether blockchain technology can support and facilitate data sharing contemporary with solving some of the investigated challenges for future development between stakeholders such as mistrust and fear of giving up control.

5.3 The Potential of Blockchain Technology in CPH Airport

The previous sections illustrated that the involved stakeholders do not share data in spite of agreeing that data sharing most likely will optimize operations for all stakeholders, which will be reflected positively on the passenger journey. The section seeks to examine how blockchain technology and its properties can facilitate and enable data sharing between the stakeholders.

5.3.1 Why can blockchain solve these concerns?

Based on the interviews, it is clear that data is considered a valuable resource wherefore the stakeholders are facing a dilemma as mistrust exists between them, which is reflected on the currently limited data sharing (Interview 1; Interview 4; Interview 5; Interview 6; Interview 8; Interview 10). In continuation, the paramount perception of data sharing by the stakeholders involves giving up control (Interview 1; Interview 3 Interview 6) and a fear consisting of potential data leaks which implies that the stakeholders will lose competitive advantage (Interview 2; Interview 7; Interview 8).

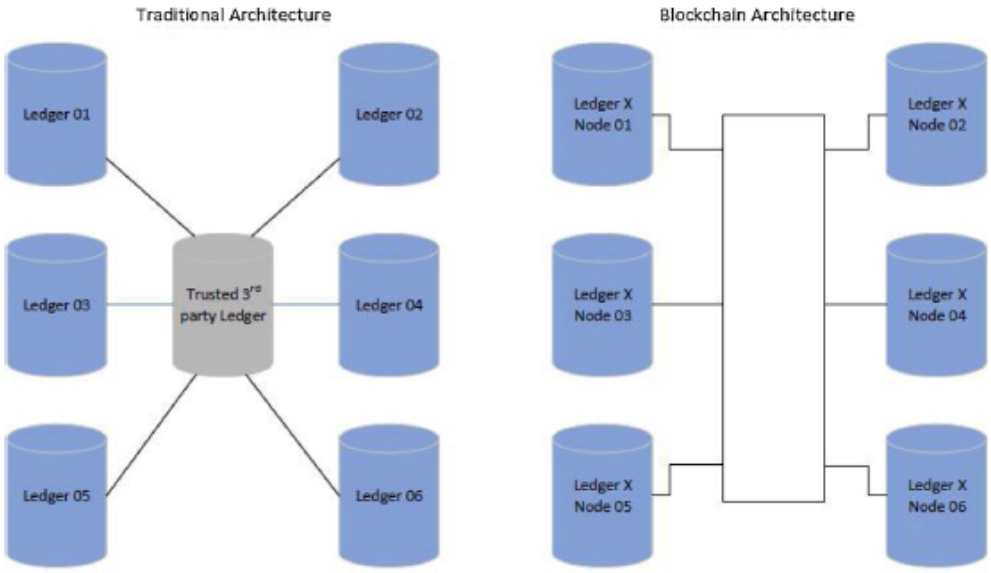

Figure 7 - Illustration of traditional and blockchain architecture. Source: Hughes et al. (2019).

The main properties of blockchain distributed ledger technology is the enablement of more transparency and control combined with cryptography to ensure a higher level of security (Gatteschi et al. 2018; Beck et al. 2018; Di Vaio & Varriale, 2020). Hasham Ahmad and Sabrina Abdullah complement that the properties of cryptography are valuable since each stakeholder holds potential information that others can benefit from (Interview 6, line 291 – 297; Interview 10, line 455 - 459). It is stated that the major benefit of blockchain is the cryptographic audit and known identities, where data is immutable and mistakes can be traced (Gatteschi et al. 2018, p. 5). However, Boris Düdder argues that choosing certain properties implies a trade-off, for instance, that the price for increased scalability is a loss in trust (Interview 1, line 127 – 130). Nonetheless, these can be attractive properties to facilitate information sharing between the involved stakeholders. The properties combined with the irreversibility of records can potentially enable a degree of data sharing between the airport's stakeholders. Similarly, Lacity (2018) argues that blockchain is applicable to use when participants do not want to rely on trusted third-parties and security trumps performance. Figure 7 illustrate how the distributed nature allows stakeholders to be connected direct without any trust third-party. According to several researchers, blockchain will enable a redesigning of stakeholder relationships, where the consensus mechanism enables an understanding of who has what and who has done what in a distributed linear event log (Queiroz & Wamba, 2019; Di Vaio & Varriale, 2020). Lastly, blockchain can provide proof of transaction verification ensuring that the stakeholders know how the data has moved and to who (Mattke et al. 2019). Since the amount of data is rapidly increasing CPH Airport has expressed an interest in sharing more data with other parties in the ecosystem. An additional challenge to the previously highlighted concerns is that sharing data through their data warehouse would not be safe (Interview 5, line 344 - 349). Blockchain can make data sharing more secure due to its cryptographic properties. Furthermore, it allows the users to better control and track who uses the data. Hereby, data can be treated as a commodity that can be traded between the stakeholders. The airlines possess information that could improve CPH Airports operation and indirectly the passenger experience. Louise Blomberg presents a specific example of the opportunity related to enhanced data sharing: "We only know the occupancy rate. We would like to know the real numbers of passengers who are coming and how many they have in business and economy [...]. We have SAS fast-track and there is also security there" (Interview 5, line 344 - 355). If Copenhagen Airport knew the distribution of passengers, they would be able to move security between the regular- and

fast-track security in real-time, and this will lead to a decrease in queue time. The creation of an interoperable blockchain system will allow data to flow in a controlled procedure between the designated stakeholders. Blockchain allows users to record digital facts, but it cannot be considered simply as a record as smart contracts can be utilized to prevent and respond to technological disruptions like fraud (Buterin, 2014; Di Vaio & Varriale, 2020). This is done by applying the business logic to enforce rules based on conditional statements, which are either partially or fully enforced when the conditions are met (Gatteschi et al. 2018, p. 4 - 5).

Summarizing, there are more properties of blockchain technology that are considered useful and appropriate for enabling data sharing. That is particularly the irreversibility of records (Hughes et al. 2019; Casino et al. 2019), improved transparency and control (Gatteschi et al. 2018; Beck et al. 2018), proof of transaction verification (Mattke et al. 2019), the consensus mechanism and linear event log (Beck et al. 2018), cryptography (Beck et al. 2018; Hughes et al. 2019) and ultimately clarification of ownership (Zavolokina et al. 2020). Based on this, blockchain can be considered a useful technology to improve data sharing between the stakeholders. However, this might be different in practice considering the stakeholder's divergent objectives, which will be analyzed in the following section by considering how the identified concepts affect the use of blockchain technology.

5.4 Management considerations related to creating the foundation for implementing blockchain

The section investigates how the primary data meets the identified blockchain concepts from the literature related to initial requirements and essential considerations when creating a blockchain system.

5.4.1 Trust

The literature review illustrated the paradoxical dilemma regarding trust. Blockchain is proclaimed to be an excellent solution for facilitating transactions and information sharing between parties who do not trust each other (Chanson et al. 2019). However, other researchers have shown that establishing a blockchain system between multiple actors requires initial trust (Zavolokina et al. 2020; Jensen et al. 2019). This section will examine the level of trust between the stakeholders.

Section 5.1 illuminated the conflict of interest between the stakeholders and a need for privacy are major contributors to limited trust and data sharing at the moment (Interview 3).

The stakeholders are afraid of losing power by sharing their data, indicating a low level of trust in regard to something that can be perceived as valuable for the entire ecosystem. Furthermore, Sabrina Abdullah states that: “It is the challenge that there is mistrust between the airlines and the airport. But the authorities. That is an entirely different entity, they don't care about money” (Interview 10, line 423 - 425). The airport setting can be described as a highly complex setting due to the number of stakeholders with varying objectives and the number of ongoing processes that has to work at any given time (table 4). Considering the level of complexity, there are arguably multiple degrees of trust and distrust which concern systems, collaboration, and passengers (Interview 3; Interview 5). However, Sabrina Abdullah argues that it is important to build a system where everyone creates value: “We need a technology that can get these people to collaborate so that all can create value” (Interview 10, line 457 - 459). Therefore, blockchain can potentially serve as a link to promote more collaboration between the stakeholders, which Hughes et al. (2019) additionally clarify by stating that blockchain technology contains properties that replace trust in humans with verifications and trust in technology and the affiliated protocols.

However, it is important to consider that blockchain technology contains trade-offs when choosing between the properties. For instance, one of the prices of improving trust in the system is a limited possibility of scalability (Interview 1). Another apprehension with regard to improving data sharing is data privacy. Moving towards data sharing will require a change in relationship between the stakeholders and the level of trust. IATA’s future of the airline industry presents an argument to why stakeholders are cautious in regard to sharing data: “The trend towards open data and radical transparency on one hand (to drive innovation or as demanded by consumers) may cause tensions, for example when companies want to protect secrets to maintain a competitive edge” (Interview 8, line 126 – 128). Managing this trade-off becomes a crucial part of how the company will perform in tomorrow’s world. At the moment it is difficult to predict the direction, but regardless it is unavoidably that data and management will play a critical role (Interview 8, line 78 – 94).

The next consideration related to trust and data sharing is whether delegating the operation of the system to a third-party operator would be tolerated. The need for trusted third-parties is a big dilemma as it entails advantages and disadvantages to involve a third-party provider. The greatest advantage of having a trusted third-party is that the party can operate more independently and avoid some degree of politics (Interview 3). However, the downside of having a trusted third-party is that the involved stakeholders become highly dependent on the third-party provider operating the system appropriately without taking advantage of the system ownership. If it becomes a monopoly, it will allow the third-party operator to charge a high price for the service and the airlines are locked-in. In case the airlines want to break free, the consequences can be severe, Hasse Jørgensen explains a specific dilemma:

> "There has just been a case where Finnair did not want to pay what they think is a high price per transaction in the USA. SITA responded by saying then we close the service. The result was that Finnair didn't show up in 70% of the searches" (Interview 4, line 229 – 236).

The use of a third-party might result in a monopoly situation that can lead to disadvantages for the stakeholders due to a lock-in mechanism. Due to the fact that Finnair refused to pay, they lost access to SITA's 70% market share. The long-term consequences of losing access to that part of the market would be catastrophic. The lock-in mechanism will occur once all the structural agreements have been obliged to and resources are invested in the solution, whereby it becomes more expensive to abandon the collaboration (Shapiro et al. 1998). However, operating the system without a third-party can lead to increased resource costs associated with the initial negotiation for the system, attracting the talent to operate the system, and finally operating the system which is computationally expensive (Hughes et al. 2019) Hence, this will become a trade-off in terms of giving away control or taking on the burden of operation. Given the nature of the envisioned system, it is expected that if data is commoditized the stakeholders cannot afford a situation like the one between Finnair and SITA.

Summarizing, there is a lower level of trust between the stakeholders when it comes to data sharing because of the privacy and control concerns. It is perceived that blockchain could be utilized to mitigate some of this in a shared system (Interview 10; Hughes et al. 2019). However, Zavolokina et al. (2020) and Jensen et al. (2019) highlights the importance of initial trust prior to creating the

blockchain system. Based on this, it is expected that trust will most likely serve as a major challenge in the initial part of creating the envisioned new system. The next section will investigate how the use of governance can be utilized in the preparation of the system.

5.4.2 Governance

The literature review indicated that there are high requirements for the governance structure in a blockchain system. Due to the fact that a blockchain-based system is irreversible, it is particularly challenging and costly to make changes to the system after the system has been sent into production affecting the flexibility (Beck et al. 2018; Hughes et al. 2018; Interview 1, line 366 – 374). Therefore, almost everything has to be agreed upon before developing the system, which is complemented by Boris Düdder:

> "This means that you will have to include a lot of people from complementary fields in order to achieve all that. Without having this overview, how will you do that? […]. So how do you find a team that is truly productive in that? A team that does not stumble for every problem that is on the path" (Interview 1, line 367 – 371).

The extra requirements in terms of upfront capabilities can be a constraint as it is generally acknowledged that when starting a new project many of the integral and initial decisions have a major outcome on the end results, and these decisions are typically made on a limited knowledge base (Kreiner & Christensen, 2002). As previously argued, the stakeholders have different objectives, and therefore it is assumed that each will have different requirements to the levels of data granularity in the system which will affect the governance model (Interview 2; Interview 5). When transitioning into becoming a smart airport the need for having a decentralized decision-making process increases, because otherwise, everyone will wait until a decision is made. This will slow down progress. In the same sense, Sabrina Abdullah argues that there is a need for changing the decision-making hierarchy and move towards more decentralization:

> "If the airport tells the airlines and other entities that they will make the decisions, then it will go faster. They can make decisions so they can move quicker. When talking about IT-governance it is decentralized. Each department makes its own decision. The airport is a platform where those who meet obviously have to talk together and collaborate" (Interview 10, line 210 - 217).

By ensuring more decentralization, the relevant actors from each stakeholder will be able to make sufficient decisions to improve the operations and collaboration. The authorities have strict data governance requirements in terms of access-rights and levels of information. Here, they evaluate what type of data that will be shared, with whom, and the likelihood of the data being misused or shared with third-parties (Interview 2). Lars Ingstad Nielsen describes how CPH Airport collaborates with the authorities based on the specific governance regarding data sharing: "It is always critical when working with an authority like the police who at all costs must avoid any leaks. But we are collaborating with the police and comparing because we are a trusted partner" (Interview 2, line 261 - 265). Given the authorities' rigorous requirements to approve data sharing, it is expected that different rules for governing the system access differ between the participants. The authorities' current governance process is expected to increase the time it takes to make a decision. For small scale internal testing Louise Blomberg argues that CPH Airport has created a decision-making model that is agile and allows them to quickly test new technology without having to go through multiple layers of approval (Interview 5). The authorities' rigorous approval model can be seen as a contrast to CPH Airport's rather agile model. When creating the joint system, it is a requirement that both governance processes can be embraced, which potentially depict a challenge of blockchain technology in the ecosystem.

Given the nature of the stakeholders, there are more alternative governance methods that could be applied based on the recommendations of Lacity (2018). Firstly, it could be based on a democratic method where all have equal voting rights. Secondly, it is possible to apply a representative governance method implying that decision-makers are appointed to improve the speed of the decision-making process. The second solution corresponds to Mattke et al's. (2019) point on choosing a benevolent dictator. This will be discussed in section 6.2.

Summarily, it is argued that there are several important considerations to be made in terms of the governance structure. These decisions will be made at an early point and have a major impact on the outcome of the system, and it will additionally be hard to change due to the irreversibility of blockchain. It is expected that the cost associated with making all of those decisions will be high both financially, timely, and in terms of the needed capabilities. Moreover, the major challenge in

terms of governance concerns the contrasting models for approval. The following section will examine the role of standards to create a common ground.

5.4.3 Standards

Related to governance, the literature review illuminated a need for standards when developing the system (Hughes et al. 2019) with the purpose of delimiting the need for making changes to the system when it is deployed since it can become a costly and difficult task (Section 2.2.3.3). Moreover, trust will be positively influenced by developing and adapting standards (Hughes et al. 2019). Louise Blomberg argues that standards are crucial in the airport setting as "when you create a technical solution it needs to use a standard that is open, so everyone can communicate together with each other" (Interview 5, line 515 - 516). IATA complements the need for standards to ensure the ability to communicate (Interview 3; Interview 8). When creating a system, Boris Düdder argues that each organization sets its unique mark on what the system may look like:

> "Yes, it takes time. As always with this kind of organization committees. Like negotiation and in particular one important point is you know Conway's law. So essentially what we do is that we also encode culture. Conway's law is about our organization leaving an imprint on our products. Particular on software as we do" (Interview 1, line 274 – 277).

Standards are crucial when there is a desire to create a system that the majority can benefit from, as they can agree on a standard where everyone will know the required specifications to adopt it. According to Jonas Jørgensen, there are 80 different airlines associated with CPH Airport (Interview 4, line 191) which pose a challenge since it is a high number of entities that need to agree upon a standard. When creating a system, it is necessary to ensure syntactic and semantic interoperability of data for all the entities (Chen, 2006) to reduce the likelihood that configurations need to be made at a later point. Making changes to blockchain systems once it has been deployed is argued to be a costly endeavor (Interview 1; Beck et al. 2018; Scholz & Stein, 2018). Therefore, it is also argued that large scale implementations are not likely to be made until standards have been created (Interview 3). Arguably, due to the nature of the data in the system and the authority's regulations, it is expected that there will be complex and evolving requirements to what the system can do (Interview 3; Interview 5; Interview 7). IATA reports the need for utilizing data in a secure and standardized manner: "At an industry level, airlines need to make the case for their ownership of data, including efforts to standardize data (where appropriate), mechanisms for gathering and

sharing data safely for both commercial and operational purposes (including disruption management and passenger communications)" (Interview 8, line 103 – 106). The reason why standards are created is due to the inflexibility of the current systems, especially when it comes to collaboration between multiple stakeholders (Interview 6). On the other hand, both the literature review and Boris Düdder argue that through blockchain systems there will actually be increased coordination cost due to the nature of how blockchain operates (Interview 1; Beck et al. 2018; Scholz & Stein, 2018).

Another consideration involves which stakeholder shall initiate and bear the initial costs of facilitating the discussion for setting a standard. It is natural that the driving forces behind the initiative are international organizations, for example IATA or ACI because they can engage with all airports (Interview 5). These associations have the reach to implement standards on a global basis and a higher likelihood of engaging the involved stakeholders, which ultimately will increase the possibilities for stakeholders adopting these standards. In this regard, Sylvain Campeau argues that if a decision is fast-tracked it will take between 8 - 12 months for IATA in collaboration with the involved stakeholders to determine a standard (Interview 7, line 369 - 399). For better or worse, choosing a standard can be perceived as another lock-in mechanism: "No because still if you now decide on a system you have a kind of lock-in situation. So, it is not so easy to switch to another system, to port your data and everything else" (Interview 1, line 293 – 295). It is necessary to carefully consider the impact of the choice and what consequences it can have in the future. Lacity (2018) presents three options in regard to working with standards related to blockchain systems. Relating to the argumentation made by the individuals it leans toward the third option of joining an industry consortium, in this case, it could be IATA or SITA.

When focusing on improving data sharing across the passenger journey, it is expected that it needs to oblige to GDPR and other governmental compliance requirements because the data is sensitive. Therefore, ensuring that the authorities are involved in the creation of a standard can help to prevent unexpected surprises later on. According to Hasse Jørgensen, the first step is to invite the authorities to participate from the beginning of the process. Similar to the findings in section 5.4.2, it is expected that involving the government will be a resource-intensive task that requires patience (Interview 3). On the other hand, "it also requires that you are willing to take a chance in the

planning process in regard to time and economy [...]" (Interview 3, line 47 - 49). Due to the authorities' requirements, it is expected that the initial preparation for creating the system will require a substantial resource investment, both in terms of time and eventually also financially. Louise Blomberg supports this by stating: "But as soon as you need to involve the police, more data will be involved that are highly sensitive. Then GDPR comes into play. I think this is where you will see the biggest challenge" (Interview 5, line 244 - 246). Hereby, it is not the technology that becomes a limiting factor, but instead the need to comply with a list of strict requirements. Contrary, Boris Düdder argues that through the use of zero-knowledge proofs it is possible to create a blockchain-based system that is GDPR compliant. However, this involves trade-offs that need to be evaluated:

> "So, making that GDPR compliant, for example with the right to be forgotten. How do you do that? For a system that is immutable. That is not completely easy. And in particular when you don't want to sacrifice the positive things that you get. That you have for example integrity. How do you make that without the integrity part of the system suffers" (Interview 1, line 198 - 202).

Hence, the data requirements can be overcome, but it will come at the price of something else in the system. Therefore, there are important considerations related to choosing standards and ensuring that the system will remain compliant with changing legislation. Sabrina Abdullah presents a practical perspective as to why there is a need for standards in the airport: "But I think that you should create standards in the airport, so you do not do things differently" (Interview 10, line 240 - 241). Hereby, standards will additionally imply more similar work procedures for entities which will be reflected in the interoperability of the systems.

Summarizing, this section has illustrated some of the considerations related to standardization and how it may impact the stakeholders. Standards hold an important role in ensuring interconnectivity between the actors. Before any standards have been made in regard to blockchain, it is unlikely that any large-scale implementations of the blockchain systems will be seen. Therefore, it currently poses a challenge for the possibility of implementing blockchain. The following section will examine how the diverging interest can be aligned to improve data sharing.

5.4.4 Incentives

Incentivizing and aligning stakeholders is highlighted as an important feature in the literature review (Beck et al. 2018). As previously mentioned, there are differences between the stakeholders in terms of operations and objectives (Chapter 4). This section will investigate the need for incentivizing each actor's behavior with the needs of the system.

Looking at CPH Airport, Jonas Jørgensen argues that CPH Airport is interested in testing blockchain, but that it has not yet been possible to find any use-cases that provide sufficient business value. Therefore, uncertainty exists in relation to where to initiate a blockchain implementation (Interview 4):

> "But this is the interaction - there are approximately 80 airlines and stores in the airport. Everyone needs a piece of the pie and that can cause problems [...]. What exactly do we want to offer the traveler depending on who we are interacting with? And how we interact with them?" (Interview 4, line 190 - 194).

The big question is how to start and with whom - especially if there are major requirements for the governance and standardization procedures. Bringing everyone to the table and hearing what each individual viewpoint will require a substantial number of resources. Furthermore, Louise Blomberg elaborates that the collaboration between all the links in the value chain might be a problem for using blockchain, as a test of the system will require the airlines, the authorities, the security, and the data department to be incentivized. This is a high number of stakeholders that might pose a challenge (Interview 5). Moreover "there might be fearful people thinking that they cannot put their data into the system" (Interview 5, line 178 - 179). It will become a challenge to align all the stakeholders to ensure cohesion. However, Louise Blomberg is convinced that it is not impossible to align the stakeholders in regard to the creation of a blockchain-based system: "We can incentivize airlines and police if we can provide a system that works, and if we have secured the things that there is uncertainty about - especially GDPR. I actually think that the attitude of the passengers should be the primary focus" (Interview 5, line 465 - 468). The quote sheds another light on the issue and emphasizes the role of the passenger based on the transparency of data usage. This is additionally supported by IATA stating that there are two considerations to be made:

> "There is an opportunity for airlines if they are able to develop the range and quality of their services to customers using the data they hold while demonstrating that they are secure guardians of passengers' confidential information. An industry-wide commitment to privacy may avoid the need for regulators to intervene in this area" (Interview 8, line 161 – 165).

However, blockchain technology is considered a practical solution for increasing the transparency of data-usage (Beck et al. 2018), wherefore it can become useful to mitigate a potential challenge regarding uncertainties from a passenger perspective.

When implementing a blockchain system, it is crucial that it is not only one stakeholder that commits to the project, but all involved need to participate and come along. At the same time, it has to be considered how to secure a commitment from all the involved stakeholders in order to prevent actors from acting in their best self-interest because that could potentially harm the system. To some extent, the consensus mechanism can be utilized to ensure such alignment (Rossi et al. 2019). The next element becomes the ownership and control of the system, because when data is flowing between all stakeholders who is the natural owner of the system? Hasse Jørgensen points out that he sees the ownership structure as one of the major barriers for the future success of the system: "Some point to regulators who should deliver the fundamental architecture. But that is not necessarily a good idea that they are in charge. Because we have different interests" (Interview 3, line 209 - 211). Hereby, it can be argued that it is necessary to consider, which ownership structure will limit the agent-principal issue of utilization maximization. In this regard it seems unlikely that the authorities will take primary ownership of the system due to their non-financial objectives and the fact that they only control and push data from one checkpoint in the passenger journey (see figure 5 and 6).

Another finding related to the ownership structure is the importance of understanding the entire ecosystem. The airport's ecosystem covers a wide range of actors from small shops to major airlines. Therefore, the entire ecosystem must be involved and collaborate to ensure that the platform will function efficiently, which for instance can be facilitated through technologies such as blockchain to ensure collaboration between the stakeholders as well as value for everybody. This will moreover lead to "[...] the benefit of becoming proactive rather than reactive as we are

today" (Interview 10, line 460 - 463). Being proactive can further help improve the operations as it can be a technique to lower the number of unforeseen events in the airport. Interestingly, Jonas Jørgensen argues that it is not the technical elements that are the most complicated, but instead the intricate relationships and lack of collaboration between the stakeholders (Interview 4, line 187 - 195). Related to incentives, there are some needs to understand how the ecosystem should be involved to maximize the benefit and collaboration. Predicting who to engage on the journey is not an easy task but a necessary one.

First aligning the various stakeholders will become integral and later incentivizing them to actively participate in developing the system. Due to the fact that CPH Airport owns the physical space, the interviews showed that it is expected that they can bring the stakeholders together. It appears that the introduction of such a solution is not grounded by the level of trust between the organizations. It is to a higher degree based on key personnel and organization with a sufficient level of knowledge being able to bring the stakeholders to the table and drive forward a solution.
Apart from the four concepts identified in the literature review, two additional management considerations related to the usefulness of blockchain systems were identified through the interviews, which will be examined in the coming two sections.

5.4.5 Limited knowledge

Based on the interviews, an additional finding has been identified which is limited technical knowledge that ultimately leads to incompatibilities. According to Boris Düdder, it implies that people do not possess the required knowledge regarding blockchain technology and its essential properties:

> "The second barrier is knowledge. Skilled workforce is necessary. That is essentially a big problem [...], a lot of people do not understand what (security) properties to get from blockchain. [...] they will say they use blockchain, and that they are secure and do not have to care about anything" (Interview 1, line 227 – 230).

However, Boris Düdder explains that the lack of a skilled workforce is reckoned as a problem for blockchain technology implementation based on a general viewpoint. Therefore, it is not only considered a barrier in the aviation industry, but likewise in many other industries (Interview 1). Hasham Ahmad does likewise highlight the limited knowledge as an incompatibility that restricts

the development of the blockchain technology in the airport setting: “But I think that there is so much lack of understanding about how this works. Because it is sort of noise that nobody can see how simple it is” (Interview 6, line 433 – 435). Hence, Hasham Ahmad has been developing a prototype of an airport management software solution based on blockchain technology and smart contracts in order to illuminate blockchain technology and the appertaining properties´ potential in the ecosystem of airports. This showcase has been well received by the audience, which includes IATA that found the demo interesting (Interview 6, line 233 - 234). Nonetheless, statements from Sylvain Campeau illustrates a consensus that the limited knowledge constitutes a limitation for blockchain technology in the aviation industry:

> “[…] I think one of the challenges concerns that you have technical people with a good understanding of it. But on the business side, there is a grasp of what blockchain is and can do for them [...]. It is a challenge for a lot of people" (Interview 7, line 42 - 45).

Based on the statement from Sylvain Campeau, limited knowledge is particularly centered around people in the ecosystem with a business function. This will ultimately lead to incompatibilities in relation to identify use-cases in which blockchain technology can provide business value (Interview 7). This opinion is supported by Jonas Jørgensen stating that the technology undoubtedly will be utilized in a future context, but that it has not been possible to identify where the technology can provide business value (Interview 4). The limited knowledge about blockchain becomes evident in the interviews with Lars Ingstad Nielsen and Louise Blomberg where it is argued that the stakeholders feel like they are giving data away. The strength of blockchain is that data can be pushed to the system and remain more secure compared to traditional alternatives. Hasham Ahmad argues that due to the encryption it is essentially more secure and it can be better controlled who can access the information:

> “Yeah, that is a misunderstanding, because they are probably thinking that the blockchain is public data. It doesn’t take much to kind of think that if the data you put on our chain is encrypted, then it’s not free, it’s private. And you can sell the key to unlock that data is totally, you know, it’s not given away” (Interview 6, line 291 - 294).

The quote illustrates the properties that blockchain offers which is challenging the viewpoint presented in some of the other interviewees’ statements. It highlights how easily data can be secured through the use of blockchain and how it is possible to control who has access. Arguably,

a change of mindset becomes necessary to see the opportunities and understand how processes and collaborations can be rethought.

Summarizing, it can be argued that a consensus exists that limited knowledge regarding blockchain technology is present, which ultimately makes it hard to identify specific use-cases that can provide business value. Hence, knowledge regarding the technology is currently considered an incompatibility restricting the possibility of utilizing blockchain technology as a distributed database. It is expected that this may serve as a limiting factor in regard to initializing any projects. The next section will examine the challenge of perceiving the potential business value of blockchain.

5.4.6 Business value

Another discovery identified from the interviews has been the importance of perceived business value. Multiple interviews have shown that an important metric in regard to investing in a blockchain system concerns the expected value of the investment compared to the associated opportunity costs. When evaluating projects, it is often defined based on a mindset of 'what's in it for me'. Therefore, CPH Airport often makes the initial investment to start new projects. Lars Ingstad Nielsen describes why CPH Airport is willing to make these investments in the following way:

> "When we come to our stakeholders and want to work on a process where they do not have to invest money but time. Then they say that it sounds exciting, but we don't have any money can you help us? So sometimes we have an interest in wanting to help our stakeholders, because it can also help our own processes" (Interview 2, line 65 - 70).

Each stakeholder considers the potential value-add and the opportunity costs of investing in a blockchain system versus other improvements. The interesting element is that, as the previous section showed, there may be a limited knowledge on what blockchain is and can do. The question is then how do you perceive the value-add if the knowledge is limited. Furthermore, Lars Ingstad Nielsen describes CPH Airport's approach to innovation and implementation of new technologies in the following way:

> "As I said earlier, we are rarely first-movers. Actually, very seldom. Sometimes, but we mainly compare with the airports that we benchmark against and say what exciting things

> they have done. Is there anything where we would jump on the ride? The advantage of this is that then many of the early problems have been fixed" (Interview 2, line 89 - 93).

In this sense, CPH Airport can be seen as a traditional large corporation that needs to see a proof-of-concept to avoid taking on moonshot projects that are too risky or that could compromise their operation. The view that the airline industry is rarely known as being first-movers on adopting new technology is supported by IATA: "The airline industry appears to react to new technology rather than lead the way" (Interview 8, line 131). The major challenge is that the airport stakeholders are considered rather risk-averse and are not regularly first movers on adopting new technology, whereby the stakeholders are not ready to bet on immature technology due to the unpredictability of which direction the future is heading. This might also be the case with blockchain in aviation. Therefore, it can be questioned how willing CPH Airport is to adopt this technology at the present time. As previously mentioned, Jonas Jørgensen states that CPH Airport does not currently see any use-case where blockchain technology will add sufficient value (Interview 4). On several occasions, CPH Airport has been one of the first to make new commercial and operational initiatives, for example, loyalty programs, digital wayfinding, and their app (Interview 5). However, Louise Blomberg argues that this is changing:

> "Without criticizing too much I think we have lost sight and cannot follow along in regard to how fast people have suddenly come onboard. Instead, we have concentrated on other things we are good at. We are really good at the operational aspects. But I think that in the past two years we have made a comeback" (Interview 5, line 402 – 406).

Therefore, there may be a possibility that the airport would be willing to experiment with this new technology, as mentioned in the previous section the prerequisite is however whether they perceive the technology to add enough value to their operations in the future. Moreover, Hasham Ahmad argues that it is quite straightforward to set up a demo-solution once the stakeholders are on board: "Like I mentioned before the technology itself can be done quite easily [...]. It still needs a lot of investment and integration. But this is not where the challenge falls, right? Because the technology is there right now to be able to do this easily" (Interview 7, line 227 - 230). There may be an opportunity for the airport stakeholders to experiment with blockchain technology despite the fact that there have not been many practical examples yet. However, section 5.4.5 and this section has shown that there is a need for employees who have the relevant skills and can emphasize the potential business value of the blockchain to both their own organization and the other

stakeholders. On the other hand, Jonas Jørgensen argues that there is a potential for blockchain in the airport in the future as it can enable more data sharing and new revenue streams for CPH Airport: “But we are aware that it is in these interfaces that we should use blockchain. Blockchain is definitely a technology we will use in the airport. I’m not in doubt about that” (Interview 4, line 285 - 287). Hence, it will be possible to provide additional value through new value chains and business models. This is supported by Hughes et al. (2019) stating that when blockchain technology is implemented a side effect might occur implying that the increased awareness of the technology will lead to the development of new applications.

Summarizing due to the limited knowledge about what blockchain can do the perceived value-add of blockchain systems is low at the moment. This serves as a major barrier to moving towards the creation of a new shared system. However, the technical people of CPH Airport (Interview 4; Interview 5) acknowledge the possibilities with blockchain for creating additional business value since data can become a commodity. Hence, it is a matter of finding the right areas in which the blockchain proof-of-concept can be initiated, which poses an immediate challenge in the ecosystem.

Sections 5.4 have illuminated managerial considerations that need to be embraced in order to utilize a blockchain-based system for data sharing. In case the considerations are neglected prior to development of the system, it is likely that it will lead to significant obstacles for using the system efficiently. In fact, a neglected focus on the concepts will potentially lead to what Chen (2006) coined as interoperability barriers, which is the focus of the following section.

5.5 Relationship between concepts and interoperability barriers

Chen (2006) highlights three types of barriers in the interoperability framework; conceptual barriers, organizational barriers, and technological barriers. The following section will categorize which type of barrier each of the concepts is related to. An overview of the classification can be found in table 6.

Trust is an element connecting the different stakeholders, and it is something intangible and latent between the different stakeholders. In this sense, the concept of trust - or even mistrust - can be

perceived as a structural incompatibility that underlies the organizational barrier (Chen, 2006). The governance concept illustrated challenges in regard to the governance model of a blockchain-based system, which likewise can be emphasized as an element of the organizational barrier as it concerns different processes, structures, and requirements (Chen, 2006). In the same sense, having misaligned incentives can be perceived as a managerial incompatibility. Thereby, it relates to the organizational barrier (Chen, 2006). The limited knowledge currently constitutes an obstacle to developing and utilizing blockchain technology (Interview 1; Interview 6; Interview 7), and it can be argued that the concept serves as another organizational barrier as it concerns human factors leading to incompatibilities (Chen, 2006). Consequently, the business value is also perceived as an organizational barrier, since if the key personnel does not see the value compared to the opportunity cost it is not likely that a system will be created. The last identified and examined concept is standards that are considered crucial for efficient data exchange. In the same sense, Chen (2006) clarifies the importance of existing syntax and semantics in relation to the exchange of data, which is an element of the conceptual barrier of the framework. Thus, it is crucial that standards are agreed upon to ensure an unambiguous understanding of the data to create a transparency that allows each stakeholder to set up their systems to receive the correct data interface (Chen, 2006).

Ultimately, the framework consists of the technological barrier embracing the use of information and communication technologies to exchange information and data (Chen, 2006). Throughout the analysis, it is illuminated that the interviewees from particularly CPH Airport are confident that the technology and the appertaining development is not the problem. However, no fully functional systems or technologies are currently existing in the ecosystem for exchanging information on a large scale, which implies that it is not possible for the interviewees to rely on practical experiences with the development.

	Conceptual Barrier	Organizational Barrier	Technological Barrier
Trust		X	
Governance		X	
Standard	X		
Incentives		X	
Limited knowledge		X	
Business value		X	

Table 6 - Relation between identified concepts and interoperability barriers. Source: Own work.

The previous sections have shown that if there is a focus on the management consideration there could be a potential value in creating a shared blockchain system to improve data sharing. On the contrary, if the focus on the concepts are neglected by the ecosystem, it is expected to constitute what Chen (2006) frames as interoperability barriers. The interrelation of the barriers will be discussed in 6.7. The following section will scrutinize what type of blockchain that would be recommendable for this particular situation given the characteristics highlighted in the previous sections of the analysis.

5.6 Evaluation of the possibility to use blockchain in Copenhagen Airport

Based on Beck et al's. (2019) ten-step framework it is argued that the previous section has answered the first six questions and have indirectly shown that theoretically there is a potential for developing a blockchain system. The answers are summarized in the table below. The following sections will seek to answer the last four questions and examine what type of blockchain system and permission would be applicable.

Steps	Explanation
1. Need for a shared common database?	Yes, each stakeholder has information that can benefit another's operation (Section 5.3.1)
2. Multiple parties involved?	Airport, Airlines, and Authorities (Chapter 4).
3. Involved parties have conflicting interests/trust issues?	Currently, there are conflicting interests due to privacy concerns and fear of losing competitive advantage (Section 5.4.1).
4. Parties can/want to avoid a trusted third party?	The information to be shared in the system can have some degree of privacy concern. Additionally, when working with sensitive data the trusted third-party can become very powerful (Section 5.4.1).
5. Rules governing system access differ between participants?	The stakeholders will have different access rights depending on which touchpoint it covers (Section 5.4.2 to 5.4.4).
6. Transacting rules remain largely unchanged	Once a standard has been created, it can be expected that there will be limited changes. However, regulations and particularly the authorities can force changes (Section 5.4.2 and 5.4.3).
7. Need for an objective immutable log?	To allow all stakeholders to benefit, it is expected that there will be a need for an immutable log. The log can be used to understand who has had ownership, responsibility for the passenger and information at any given process and time.
8. Need for public access?	Due to the sensitivity of the data, there is not a need for public access.
9. Are transactions public?	No. It is expected that the recommended solution is a private blockchain.
10. Where is consensus determined?	By suggesting a private blockchain solution the only option is to have a permissioned based solution.

Table 7 - Answers to the ten-step framework. Source: Own work.

5.6.1 Immutable log

The section will investigate if there is a need for an immutable log when evaluating the relevancy of using blockchain for sharing data as illustrated in figure 6. If data is commoditized, an immutable log can facilitate transparency over the developments and moments of data in the system, and who has owned the data at various timestamps. Hasham Ahmad elaborates on how commoditization can be used to change the existing business model:

> "If it means selling data, the great thing about blockchain is that you can send value (representative value) with data. So, if you request data from an airport, then there could be a fee attached to that. So, the airline can make money and the airport can be more efficient. So that's in everyone's interests to have that relationship" (Interview 6, line 201 - 204).

In this regard, it could be valuable to have an immutable log because it would allow for entirely new methods of working with data that stakeholders did not have access to before. By the nature of having the property immutability it will allow for better audibility in the system because it will allow the stakeholders to monitor where each block is pointing. Hasse Jørgensen highlights a challenge in regard to having shared systems: "Another major challenge that is unsolved concerns what happens when the system does not work? What is the contingency plan? What is the back-up plan when the systems are not running? When you cannot exchange data between the various parties" (Interview 3, line 275 - 278). Having back-up plans and solutions available is essentially, and as a method of protecting the data could be to have an immutable log. Ultimately, as Beck et al. (2019) argues having an immutable log is a technique to embed audibility and integrity. The literature review showed that there are limitations to this as well, exemplified through limited scalability and storage constraints. Illustrating that there can be a need for an immutable log.

5.6.2 Public access

This section will examine whether there is a need for public access to the system. It is argued that only the investigated stakeholders should be able to access the system. If it is expanded, it could potentially scare away the stakeholders who are more cautious. The strength of having a system with public access is that it would be easier to grant other actors (who are not one of the three stakeholders) temporary access-rights to limited information in the system. Furthermore, IATA argues that data is highly valuable to operations: "The trend towards open data and radical

transparency on one hand (to drive innovation or as demanded by consumers) may cause tensions, for example when companies want to protect secrets to maintain a competitive edge" (Interview 8, line 126 – 128). It is expected that the created system should prevent this by default in order to be able to bring aboard all the relevant stakeholders. It is therefore argued that there is no need for any public access.

5.6.3 Public transactions

The section will examine the necessity for having public transactions. Under the assumption that the stakeholder participants are held constant, it is presumed that there is not a need for the transactions to be publicly displayed. A common misconception is that when data is pushed to a public blockchain it is given away. On the other hand, it is argued that due to the encryption it is still protected. Compared with a private blockchain Hasham Ahmad clarifies that:

> "The encryption makes that and adds value to that. I mean, you can take a public chain, which has total visibility, but just encrypt the data on it. And if that network that you're sharing with people is private, then of course you don't have the threat of public access. But even if they did, to break the encryption is nearly impossible" (Interview 6, line 294 - 297).

The idea is to keep the information encrypted and controlled in a manner so other parties who have been granted access can retrieve the information. The important notion is to understand that cryptography to a great extent solves this problem:

> "Yeah, if someone says we're giving away the data free, then just encrypt it and solve the keys. It is that simple. And it's more secure than the current system, because now if it is leaked to the public, there's no threat of leak. So, your security protocol is less about securing the flow of data and more about securing the keys" (Interview 6, line 302 - 305).

Additionally, it is possible to create an even more complex security combination by adding multi-factor signatures or keys that expire. It is argued that even though cryptography can secure the data, it is still recommended to create a private system where it is only available to be viewed by the involved parties. Since it is argued that there is limited need for transactions being public.

5.6.4 Determining consensus

The section will investigate where consensus should be determined. The data published in the system is of high value and has to comply with relevant regulations (Interview 5; Interview 7). It is expected that there will need to be control of who can access and retrieve information. In section 5.6.2 and 5.6.3 it was argued that there is not a need for public access whereby a private solution should be used. After having determined access to transactions, the next thing is the transaction validation access. Given the fact that a private solution has been recommended according to the framework, there is only one application validation, which is permissioned. Hereby, the consortium of stakeholders will become the gatekeepers in terms of participation. However, Dinh et al. (2017) have shown that the private blockchain technologies are not ready for mass adoption and argue that it will take some time before they are ready to replace the existing systems. The current lack of scalability serves as a barrier for quick implementation of the technology, however, it does not decrease the long-term potential of the technology and the opportunities it brings forth.

Section 5.6 showed that, based on Beck's ten-step framework, there is a potential to use blockchain for improving the data sharing along the passenger journey between CPH Airport, the airlines, and the authorities.

6. Discussion

The findings and analysis have provided a range of insights on the challenges and potential for implementing blockchain-based solutions in CPH Airport. The following chapter will discuss the findings and compare it with previous literature to understand the possibilities and challenges for developing blockchain-based systems for the ecosystem. Afterwards, the barriers for interoperability will be discussed and the interoperability approach for the stakeholders in order to utilize such a system. Additionally, the thesis' contribution to literature will be discussed and lastly challenges and limitations to the study will be discussed.

6.1 Trust

The data shows that there is a low level of trust between the stakeholders. The common perception found in the data was that giving up data can result in losing a competitive advantage. Arguably, there is a high sense of ownership and protectionism as the data is considered essential. The previous literature showed that the properties of blockchain allows for better control and transparency of data when creating systems that involve multiple actors (Gatteschi et al. 2018; Rossi et al. 2019). The transparency from the blockchain and the ability to easily trace data movements can help foster a positive attitude towards the utilization and data sharing in the ecosystem. It is important to note that the involved parties will not give away data, contrary they will only share the relevant information and control who can access the information through the use of public and private keys. Similarly, they will only receive the data that is relevant for their operation. As an example, the airlines will solely receive data regarding whether the passenger has crossed the border control or has been detained - the data will not involve a reason but simply just the information making it possible to track the location of the passenger. Another perspective is the fact that previous literature has shown that cross-collaboration and data sharing can potentially transform companies and provide even more value (Parviainen et al. 2017; Sambamurthy et al. 2003). Moreover, previous literature has shown that blockchain can be used to bring together partners who do not trust each other to make transactions without any intermediaries (Scholz & Stein, 2018; Zavolokina et al. 2020; Rieger et al. 2019; Di Vaio & Varriale, 2020). However, as other researchers are arguing, the stakeholders need to have some degree of trust before they are willing to commit to a project (Zavolokina et al. 2020; Jensen et al. 2019). In the case of creating

a solution in an airport setting, it is expected that there will be a need for trust prior to engaging in the development phase. Conceivably, the lack of trust combined with the projected resource costs serves as a limiting factor. Rossi et al. (2019) argue that it is unlikely that all trusted third-parties are removed. In this regard, the findings showed that there is a dilemma between having a third-party operating the system or taking on the burden of developing and operating the system by themselves. Similar to Zavolokina et al. (2020), the findings have shown that transaction costs potentially can be lowered, however, developing and operating costs would most likely then grow significantly. These costs become a substitution of potential increased costs for a higher freedom and control of the system. The stakeholders will be forced to make a difficult prioritization on which priorities will be emphasized and consequently which will be neglected. Another consideration is what exactly is trust? How does one measure the level of trust and its influence? In this thesis, trust has been analyzed as a result of action, or lack of action, based on the interviewees' responses and confidence in the certainty of future actions. In the same sense, Queiroz & Wamba (2019) showed that trust does not affect the intent to adopt blockchain. However, as it can be seen from the findings, it is perceived that trust plays a big role in currently preventing any data sharing, as the data is valuable and sensitive. Several interviewees argue it will be harmful if data gets into the wrong hands.

6.2 Governance

The findings showed that there are increased requirements to the governance structure due to the fact that there are multiple parties participating in the system and due to the irreversible nature of the system. Mattke et al. (2019) recommends choosing a benevolent dictator to manage the system's operations. The advantage of this solution is that the decision-making process can become agile and that there are clear control structures. The disadvantage is that smaller actors may be hesitant to join the initiative as they will most likely be forced to participate on other's premises. Additionally, the analysis highlighted challenges with having a centralized place of trust operating independently from the stakeholders. When applying Lacity (2018) governance structures to the ecosystem there are two relevant shared governance forms, namely democratic and representative. The findings showed that when the authorities and sensitive data are involved, regardless of the security measures protecting, it often slows down the processes significantly as there are multiple layers of approval which the requests have to go through. In the same sense

assuming that all 80 airlines are onboard and aligned can make things rather complicated. Therefore, having an entirely democratic system could significantly slow down the decision-making process. On the other hand, democratic governance is the solution that most likely will ensure that all the actors who are involved are heard throughout the decision-making process. Representative governance can reinforce a quicker decision-making process, but as with the democratic form there are also limitations to this governance structure. The limitation here is that if there are only a few representatives for the airlines it can easily become highly political and perhaps even scare some of the airlines away from the solution - if they feel that they would not have a say or impact. This can lead to alienation of the less influential actors. In the interviews, it became clear that SAS has a larger presence than any other airline in CPH Airport (Interview 2; Interview 10), whereby it is likely that SAS would have a greater influence under the representative governance model.

6.3 Standards

Standardization helps ensure a limited number of changes to the system, and that it is clear how the data structures look, creating the foundation for semantic interoperability. The use of standards can also support that stakeholders live up to regulations in regard to for example personal data management. The findings showed that the actors with the network and capabilities to create these standards are the established international organizations who already collaborate with several organizations, such as IATA, ACI or SITA. Due to their existing partnerships it is believed that they will be able to bring the various stakeholders to the table to negotiate. There is a threat that if standards are determined locally, there will later be created global standards implying that it is likely the system using the local proprietary standards will have to be changed. A challenge is whether it makes sense to establish any standards in CPH Airport before the standards have been agreed upon internationally, as there is the threat that if they set out different requirements it will be complicated and expensive to reconfigure the system at a later point (Beck et al. 2018; Scholz & Stein, 2018). It can be assumed that the uncertainty regarding standards at present causes local ecosystems to be locked into a waiting position in regard to developing blockchain-based solutions as local implementation based on non-global standards can cause long-term financial losses.

Seebacher & Schüritz (2017) argued that standardization can have a beneficial impact on coordination and productivity capacity while lowering transaction costs. On the other hand, the findings showed that by choosing a standard the organization will experience a higher degree of lock-in to the particular system and data structure if the system has been configured to accommodate these specifications. It becomes a trade-off between the expected gain from lower coordination cost and improved interoperability versus the costs of relying on a specific system. At an industry level, airlines need to make the case for their ownership of data, including efforts to standardize data (where appropriate), mechanisms for gathering and sharing data safely for both commercial and operational purposes. Throughout the thesis, the importance of standards and creating a common format has been regarded as useful when creating the blockchain. However, Gozman et al. (2020) argue that creating standards can result in a loss of competitive advantage. This can serve as a limiting factor for some stakeholders who will have to invest significant resources to accommodate a standard. For the solution investigated in this thesis, it is not expected that it will lead to great losses since it will require limited adjustments to the existing systems. Instead, it is assumed that there can be a benefit to operational performance and passenger satisfaction levels due to the higher level of transparency and communication possibilities.

6.4 Incentives

The analysis has shown that the stakeholders have varying objectives, and therefore a relevant question is how to align stakeholders with highly varying objectives? The findings showed that when creating a standard, IATA typically invites all the relevant stakeholders to the table and hears what they have to say. By engaging everyone in the project it is more likely that the individual stakeholders to a higher degree feel an ownership of the project. On the other hand, in risky development projects, stakeholders can be hesitant to initiate because who will bear the economic burden? Thereby, it becomes inevitable to have someone champion the project in the early stages and once it is running onboarding of the remaining stakeholders will occur. The big debate is then how do you balance the trade-off between bearing the initial costs of developing the system versus later being able to earn back the benefits of the system. Multiple interviewees argued that CPH Airport should be the initial primary owner since they own the physical infrastructure, and it was perceived that CPH Airport has a higher probability of being able to bring all the stakeholders together - just like the previous example with IATA. However, it will also mean that they will have

to bear the initial development costs of the project. In previous co-development projects, CPH Airport has taken the same role where they have provided significant resources in the early stages - Lars Ingstad Nielsen gave the example of how CPH Airport funded all the houses that border control sits in to ensure that this area was upgraded (Interview 2). Zavolokina et al. (2020) has emphasized the importance of incentivizing the parties to engage in the project both financially and operationally. It is found that governance is a challenge due to the diverging stakeholder interests, decision-models and requirements regarding regulations (Interview 2). The particular challenge that can occur will probably arise due to a misalignment of operations and a lack of holistic viewpoints from the stakeholders of the ecosystem, which illuminate that the concepts can be considered interrelated in the sense that the concepts potentially can affect each other. When working on incentivizing the involved stakeholders, it becomes important to explain the holistic operation, where everyone plays an important role and understands how a joint solution may benefit them. By understanding the holistic operation and by the creation of a joint system it could potentially mitigate the challenge related to the agent-principal dilemma presented by Rossi et al. (2019). If the stakeholders are able to achieve this perspective and data sharing can be improved, it is expected that it can lead to positive spillover effects on unrelated areas of the stakeholders' operation. For example, if the airport can offer greater personalization through the information they have gained, it is expected to benefit NAR. Furthermore, how can a large ecosystem become actively engaged in the project?

Besides the four concepts identified through the literature review, two additional concepts were added through the data coding and analysis. This is because the concepts were present through the majority of the interviews and added value to understanding the likelihood of adopting blockchain-based systems.

6.5 Limited knowledge

One of the first things that became apparent from the data was that the level of knowledge regarding blockchain and its possibilities varied greatly. The knowledge gap indicates a need for someone conveying and mitigating these possibilities. The challenge with blockchain is that it requires a redesign of how processes function since it is irreversible once it has been deployed. Hereby, the fundamental understanding of how to work with dataflows has to be reconsidered as

organizations have to be more stringent in terms of how they manage and publish data. The question is how much knowledge is sufficient to understand what blockchain is? Is it required to know how to program a system? It is difficult to answer these questions, but having a general idea about what the properties of the blockchain technology offer will provide the basis for determining where it can be used.

Another challenge in terms of knowledge is that digitization entails a vast amount of opportunities, so how can actors navigate all the information and identify the key opportunities and trends? How can organizations scope the potential? Two options are either through partnering with industry specialists or acquiring the needed capabilities. What can be seen in other cases is that organizations and associations have typically partnered with industry specialists such as R3 (Corda) or IBM (Hyperledger). By partnering with industry specialists, one has access to individuals with domain knowledge about blockchain and combines it with the individuals from the ecosystem who have the practical expertise. Another possibility is to hire employees with the needed experience and knowledge about implementing blockchain solutions. However, at the moment these employees can be considered scarce and expensive as there are few with relevant experience.

6.6 Business Value

Throughout the interviews, it became clear that an important evaluation metric was how much business value blockchain will provide when weighing the opportunity costs of not incentivizing other projects - often projects where the perceived value is higher due to lower complexity were preferred. From the interviews with employees from CPH Airport it became clear that Copenhagen Airport is already one of the best operating airports with some of the lowest average queue times (Interview 2; Interview 4; Interview 5). A challenge highlighted by Louise Blomberg is the fact it is found problematic to improve an already well-functioning operation at the risk of perhaps weakening the performance (for a period). Another possible explanation is simply if they feel that operation is so good that it cannot be improved unless it will require major fundamental changes. Hereby, there is a chance that CPH Airport is satisfied with status-quo and the current well-functioning operations which entails that they are not looking forward to new investment in this area and instead invest in other areas of the operation. However, it seems unlikely that this would

be the case as Jonas Jørgensen argued that he was most excited about testing the potential and opportunities with facial biometrics and what use-cases there could be in the airport (Interview 4). It is assumed that there are multiple factors causing the low perceived value of blockchain systems. Firstly, it could be the employees' limited knowledge. Secondly, CPH Airport is not described as a first-mover, and it could be that the lack of proofs-of-concept is serving as a limiting factor compared with other technologies with a higher likelihood of success and/or lower required investment that can be initiated. For example, both CPH Airport and IATA are investigating the opportunities related to utilizing biometrics to remove friction in the passenger journey (Interview 3; Interview 4; Interview 5; Interview 7). Furthermore, with the advent of COVID-19 Jonas Jørgensen argued that all the innovation projects had been set on hold (Interview 4). Once operations resume, it is unlikely that they will begin with major projects that will be resource-intensive. There are other projects that were perceived as easier to complete with a satisfactory result, due to the fact that they do not require cross-collaboration and data sharing between different stakeholders. For example, CPH Airport's projects could be run through the Tech Office offering a rather agile development process, allowing them to do resource-light pilot projects to test the feasibility of a project and technology. Furthermore, if it were to take many years to set all the standards and develop a blockchain solution, it is possible that an alternative database solution will be created that can solve the challenge and can be easier to implement.

A major consideration, which has briefly been touched upon, is whether a blockchain solution would provide more value than e.g. developing centralized databases with APIs, a hashgraph solution, or something entirely third? Hasham Ahmad argues that it is improved cryptography that serves as the key to unlock data sharing and cross-collaboration regardless of blockchain (Interview 6). However, the strength of blockchain is that cryptography automatically comes as a built-in part of the system (Interview 6). This does not exclude other alternative solutions that can add the cryptography on top to ensure a secure connection.

The question is what that actually leads to low perceived value? It could be the limited knowledge regarding blockchain and its properties, the perception that other solutions exist, or that the resource costs are too high due to the various barriers. These barriers and their impact will be discussed in the following sections.

6.7 Interoperability barriers

Based on table 6 from the analysis that provides an overview of how the identified concepts impact the barriers from the interoperability framework. The findings have shown that the framework's distinction between the primary barrier - conceptual - and secondary barriers - organizational and technological - can be questioned. Hence, the framework can be considered dependent on the specific situation and the current interoperability of the belonging ecosystem that is researched. Chen (2006) states that the conceptual barrier will be affected by the remaining barriers. The argument is complemented by the findings of the thesis illuminating that the organizational barrier needs to be solved, for instance through a shared vision, collaboration, and alignment of incentives, in order to assure that a common format can be agreed upon. Likewise, the analysis has shown that for blockchain technology applied to facilitate data-exchange a prerequisite is to ensure syntax- and semantic interoperability to cope with the conceptual barrier.

However, the findings and analysis challenge the perception that the conceptual barrier should be considered the primary barrier whereas the organizational- and technological barrier are contemplated as additional barriers. Firstly, it is found that it will be a challenge to adopt and utilize a blockchain-based system if the organizational elements are not functioning. For example, based on distrust between stakeholders, divergent objectives, and interests in relation to the governance of the system. These elements will influence the possibility of developing and utilizing the technology, wherefore it can be argued that if an organizational barrier exists it will presumably also affect the possibility of utilizing the blockchain-based system. Thus, it might occur that the organizational barrier leads to limitations in terms of adopting the technology.

Secondly, the purpose of the technology is to enable data exchange between the stakeholders of the ecosystem. In case semantic- and syntax interoperability is not ensured, for instance through standards, it will influence the purpose of effortless data exchange negatively. A lack of a common format of data will imply that it will be necessary to accommodate data continuously which is a resource-intensive process that undermines the purpose of the blockchain-based system. In that sense, it can be argued that the technological barrier not only influences the conceptual barrier, but the presence of a conceptual barrier will limit the possibilities of utilizing the technology.

Thirdly, the analysis presents that standards - and a common format for data - potentially will lead to enhanced data sharing, which ultimately entails that the stakeholders will obtain a new understanding of the other stakeholders. It will be possible to create interoperable data exchanges that can improve processes in a way that has not been possible prior to an interoperable solution have been created between the stakeholders. At present time with no sharing of data, this can be perceived as a limiting factor for organizational interoperability. Likewise, it can be argued that when the conceptual barrier exists, it will lead to elements that might facilitate an organizational barrier. This is based on the argument that due to the limitation of data sharing, the respective stakeholders do not possess the necessary information about other stakeholders' operations to ensure structural alignment in operations and processes centered about the passenger journey.

In this case, it is found that barriers should not be considered primary and secondary, but rather as equally important due to the interdependence. It is not solely the organizational- and technological barrier that influence the conceptual barrier, but it can be argued that the barriers are interdependent in the sense that the barriers will affect each other. The conceptual barrier will therefore also pose challenges for the technological element and the organizational area. Likewise, the organizational barrier will imply some challenges for utilizing information and communication technologies. Therefore, the framework needs to be thought upon based on the particular situation of an ecosystem that strives for more interoperability.

6.8 Interoperability approaches

The interoperability framework distinguishes between three approaches that are specific ways to create interoperability between entities (Chen, 2006). The section will discuss which approach(es) that currently exist in the ecosystem and if this is the most suitable based on a blockchain-based system for data sharing. As previously mentioned, the integrated approach entails a common format for all models in the ecosystem implying global consistency and coherence exists, whereas the unified approach likewise has a common format, but on a meta-level, allowing for mapping between models and applications. Lastly, the federated approach implies that no common format exists at all, whereby establishment of interoperability occurs when the stakeholders adjust continuously (Chen 2006; Doumeingts et al. 2008; Tu et al. 2014). The findings have shown that limited exchange of data is occurring currently. The data that is shared is done through e-mail or

printouts indicating that the current procedure is closely related to the federated approach of the interoperability framework. Hence, the format of the shared data is not necessarily useful when received where readjustment has to be made to be able to utilize the data. This illuminates not only a challenge for interoperability (Chen, 2006) but clarifies that the stakeholders tend to focus on the individual operations.

The federated approach is not considered relevant for a blockchain system that enables data sharing, since the different formats will limit the opportunity to utilize the exchanged data. Assuring a common format is a necessity, which likewise is illuminated in the findings about the role of standards. Thus, it can be argued that an integrated approach between stakeholders of the ecosystem will be the most efficient as it will make sure that the shared data actually can be applied in operations whereby it is not necessary to use resources later in the process to accommodate the data. Interoperability can be obtained without interfacing efforts by adapting to an integrated approach. In case a blockchain-based system is developed, it is fitting to make sure that an integrated approach exists since it will provide assurance that the interfacing solutions can efficiently connect to the system. However, ensuring that all stakeholders adapt to an integrated approach based on a common format might be unrealistic, and this will also be the case in the studied ecosystem. Firstly, border control can be considered a part of another ecosystem - the Danish police and international collaborations such as Interpol (Interview 2). It is there assumed that an integrated approach occurs consisting of a common format, which ensures that data can be utilized and exchanged between the entities in that ecosystem. Therefore, it is unrealistic to expect that the border control will adapt to another common format - and an integrated approach - in the ecosystem of CPH Airport. The fact that the border control has divergent objectives and incentives will additionally pose a challenge for the possibility of the border control adapting to the common standard due to discrepancies. Secondly, the airlines are not solely operating in CPH Airport which similarly poses a challenge for realizing an integrated approach. A particular airline in CPH Airport can also be perceived as an entity of a larger ecosystem because the airline operates in many locations and it is assumed that their systems have been configured to facilitate operations all over the world. Furthermore, many airlines are part of an alliance such as One World or Star Alliance with whom they share certain information as well (Interview 10). Therefore, it can be argued that it will entail obstacles for airlines to adopt a common format in the ecosystem of Copenhagen

Airport. On the other hand, the analysis found that there might be a potential of incentivizing the airlines through enhanced operations which ultimately leads to improvements in the passenger experience. Hence, a common format between CPH Airport and the airlines can potentially occur if business value can be elucidated. CPH Airport is interested in ensuring an integrated approach between the stakeholders of the system as it will enable data sharing, which ultimately will be reflected in an improved passenger experience as well as a possibility of developing new business models.

Due to divergent objectives and the fact that border control and airlines operate in other ecosystems is expected to constitute an obstacle for ensuring an integrated approach in the ecosystem. This implies a common format in which the exchanged data can be utilized once it is received. However, a possibility is to convince the border control to adopt the unified approach implying a common format on a meta-level. This will allow the stakeholders to map the data-models in which the accommodating-process will be significantly resource-intensive compared to an integrated approach. Despite the increased cost, the unified approach may be the best solution because a fully integrated approach in the ecosystem is not possible since the airlines and authorities participate in other ecosystems apart from Copenhagen Airport.

6.9 Contribution & Implications

The following sections will discuss the generalizability of the findings, the contribution to literature and practice.

6.9.1 Generalizing based on a case study

Case studies offer the ability to go into depth with an investigated phenomenon but when investigating something specific there is a question related to the general applicability of the findings. Flyvbjerg (2006) highlights that context-dependent knowledge and a strategic case choice can make case studies generalizable. He continues to argue that the most important element for science is the ability to accumulate knowledge. In this regard, cases are equally valuable compared with other types of studies and can be highly useful in making new scientific discoveries (Flyvbjerg, 2006, p. 227). Walton (1992) proceeds to argue that the best theories are likely to come from case studies (p. 129). Case studies are particularly good at falsification through rigorous

testing (Flyvbjerg, 2006, p. 227 - 228). Furthermore, Yin (1994) argues that case studies can be seen as a distinct project and can highlight the real-world context in which the phenomenon is occurring. Additionally, Eisenhardt & Grabner (2007) emphasizes that even though case-studies are often perceived as subjective, well-designed studies are often objective because of the researcher's closeness to the data and true representation of it (p. 25). A common misconception is that cases should be representative of the population, this can be resolved through theoretical sampling (Eisenhardt & Grabner, 2007. p. 27). Based on these points it is argued that the knowledge created from the specific case can be useful in a larger context as it illustrates important considerations to be made when evaluating the usefulness of blockchain and whether it is applicable in airports. The following sections will discuss the thesis' contribution to literature and practice.

6.9.2 Contribution to literature

There are multiple contributions to the literature. Firstly, the thesis has shown the importance of acquiring the right knowledge in order to properly assess the potential of the technology and related its business value in given situations. Secondly, it sheds light on a new perspective related to enterprise interoperability and the relatedness of the three areas. Chen (2006) highlighted conceptual barriers as the primary whereas the technological- and organizational barrier are considered as secondary barriers. Here, it is argued that the technological barrier and the organizational barrier influence the conceptual barrier. However, this thesis illuminates a new view regarding the interoperability barriers in the sense that interdependence between the barriers is found. This means that they should be considered of equal importance in this particular use-case, which contradicts Chen (2006) distinguishing between primary and secondary barriers.

The limited knowledge and perceived business value of blockchain solutions should be taken into account to understand why actors and ecosystems may be hesitant to adopt blockchain-based solutions even though it could, in theory, provide additional value to their operation. Until now, blockchain has been down prioritized due to low perceived business value compared with large opportunity costs of improving other areas of operations. CPH Airport has the capabilities to bring together the different stakeholders and would be an appropriate champion of the project in the beginning.

Lastly, the thesis provides a glance at the need for taking a holistic perspective in regard to the operation, as the stakeholders' current approach is primarily concentrated on their own objectives and deliverables.

6.9.3 Contribution and implications to Practice

Besides the literature contributions, the findings have implications for practice as well. Airport ecosystems wishing to create more data sharing through integrated database solutions should take these implications into consideration prior to a project in order to scope the feasibility of their setup and potential challenges.

The findings illustrate some of the considerations and challenges that other airports can face and will have to consider if they want to implement blockchain and seek to improve data sharing between the actors in the ecosystem. Hereby, the findings of the thesis can better prepare airports and its stakeholders to examine and evaluate the potential of implementing blockchain, as the thesis investigates how blockchain can be used to improve operations that can have positive effects on the passenger experience and internal operations. The thesis highlights the opportunities to redesign the existing processes to improve operations through increased data sharing. In this regard, the distributed ledger with a linear event log can create transparency of the movements in a passenger journey and be used to quickly identify potential bottlenecks related to queue times.

There has been a prevalent opinion that the stakeholders do not want to share data due to the feeling of giving it away. The blockchain's property of cryptography prevents giving away data. Contrary, it gives more control of who can access and use the data. Furthermore, the thesis illustrates some of the challenges in regard to data sharing that are faced in an airport, and hopefully it can spark imagination to how these challenges can be solved. Moreover, it illustrates how data can be utilized in a different way to advance new business models, for example, new data can enable more personalization. Additionally, two types of governance structures are recommended, which of the two that should be chosen depends on the number of stakeholders and how fast the decision-making process should be.

Currently, there is a challenge since standards have not been decided upon yet, either first movers will create local solutions for their ecosystem at the risk of later global standards being decided upon. Otherwise, the ecosystem will have to wait with the creation of a blockchain-based system until a standard is agreed upon. From the interviews with Sylvain Campeau from IATA, it became clear that they are not actively working on creating standards related to blockchain, but if it becomes relevant it is possible to fast-track the creation of these standards in 8 - 12 months.

6.10 Challenges & Limitations

Despite the results found in this thesis, it is acknowledged that there are challenges and limitations in the study, which the following section will elaborate upon.

One element the study neglects is the connectivity between already existing systems both internally and potentially also between stakeholders. These systems are already designed and have accumulated legacy debt, which means that it may not be easy to make changes to them even if standards are created. For example, it is mentioned that border control (the authorities) screen up against 12 systems already, creating yet another system to interact with and require substantial work (Interview 10). Due to the lack of interviews with individuals from the authorities and airlines, the thesis is based on an overweight of interviews with individuals for CPH Airport and how their systems/processes are working. In this regard, Conway's law states that any system created mirrors an organization's communication structures. As each stakeholder is different, it is expected that their systems look completely different. Therefore, there are important considerations to be made in regard to pre-existing systems and infrastructure that is not covered in this study.

Furthermore, the study has focused on blockchain as the solution for a distributed ledger, but that does not mean that this is the only technology to enhance data sharing and improve operations. There might be other approaches that potentially could solve the same problem and create interoperability without the use of blockchain technology (for example traditional databases, APIs, or other solutions). Through the interviews, it was also stated multiple times that technology is not the biggest challenge and that it can be overcome. However, it is necessary to also critically reflect

on what blockchain can do and cannot. For example, it still has challenges with scalability (Dinh et al. 2017).

The airlines have been treated as one joint that is assembled under IATA. The statements covered in the thesis are applicable for the broad interests of the airlines as a collective stakeholder. However, it is expected that even though many airlines appear to be similar on the surface each organization is unique and there can be vast differences in operations and what is perceived as important. In this regard, there may be specific cases where the findings are not relevant to the same degree.

The study focuses on the three primary stakeholders related to the passenger journey in order to understand how data sharing can be improved between them. The airport ecosystem is larger than these three and there are several other stakeholders that have not been taken into consideration in the study. For example, it is not known if/how other stakeholders like the passengers and ground handlers may affect the system or how they can potentially benefit from the creation of a blockchain-based system.

Another element that can serve as a challenge for implementation is the fact that the passengers own the data and airlines are not allowed to share the data without consent depending on the sensitivity. The passenger may as well serve as the final obstacle, however, this has not been considered in the thesis (Interview 5, line 461 - 468).

An additional limitation is the fact that the only interview representing the authorities' perspective is Lars Ingstad Nielsen who is CPH Airport's account manager to the authorities. Otherwise, it is based on the other interviewees' perception of how the authorities operate. It would provide value to the research in case it was possible to obtain information from the authorities regarding what they perceive as the biggest opportunities, what they think blockchain can do, and if they would be interested in creating interoperable systems to improve data sharing. The results would have become more robust if the authorities had been more involved as it would have added an extra dimension to the thesis. Originally, an interview was planned with the head of border control, but due to COVID-19 the interview was canceled. Lastly, as part of the research project, a field trip to

the World Blockchain Expo was planned along with several interviews at the conference. Unfortunately, the trip was also canceled due to COVID-19, which consequently led to a major missed opportunity to learn about blockchain and aviation.

7. Conclusion

Today there is limited interoperability and data sharing between the main stakeholders in the passenger journey through Copenhagen Airport. Improving the interoperability between the stakeholders can entail a better foundation for allocating resources internally and improve efficiency of operations. The thesis strives to uncover how blockchain technology can help facilitate data sharing between the main stakeholders in the passenger journey based on the following research question:

> **What factors constitute the foundation for adopting a blockchain-based system in Copenhagen Airport to enhance data sharing through interoperability?**

To answer the research question, a typical case study has been conducted based on the three stakeholders; CPH Airport, airlines, and authorities. Four concerns were identified and used to understand the interoperability between the stakeholders; business, process, service, and data. It was found that the divergent objectives and incentives from the stakeholders affect the stakeholders' ability to interoperate. The analysis of the business concern clarified that there is shared interest between CPH Airport and the airlines, whereas the authorities are focused on non-financial objectives. Based on the process concern and the service concern, the analysis illuminated that CPH Airport is the primary stakeholder that focuses on the integration of processes and services. However, airlines are willing to adapt in cases where value is proven. The data concern found that there is limited data sharing in the ecosystem despite the fact that the stakeholders agree that other entities possess data that potentially can add value to their operations and the passenger journey. The analysis of the four concerns has shown that there is limited interoperability at present, but that there is an opportunity to improve the level of interoperability and data sharing.

Subsequently, the analysis investigated how blockchain technology and its properties can enable interoperability and facilitate data sharing between the stakeholders. The research presented managerial consideration in relation to establishing a foundation for the creation of blockchain-based systems. In this regard, key concepts identified in the literature review were applied and combined with the new discoveries from the primary data resulting in the following six concepts; trust, governance, standards, incentives, limited knowledge and business value.

Firstly, it was found that limited trust serves as a limitation in data sharing and interoperability in the ecosystem. Blockchain technology can bring parties together where there is limited trust. However, to create a project focused on improving data sharing, a degree of trust between the stakeholders is needed. It is concluded that a mutual connection based on a degree of trust needs to exist as the foundation for adopting a blockchain-based system, but once the system is operating, trust will not be a primary consideration. Secondly, the analysis illuminates that the stakeholders face difficult decisions regarding governance of the system. The choice of governance structure will have an impact on the participation of the ecosystem. In this regard, it is found that both representative- or democratic governance structure is applicable in the ecosystem. However, both governance models imply trade-offs that will benefit certain stakeholders, meanwhile other stakeholders will be limited. Thirdly, it is found that standards are a fundamental factor as it ensures a known common format that allows for easier interfacing opportunities. The standards will have to be created at an international level to establish a foundation for adopting blockchain technology because the airlines operate in many locations and the authorities screens up against several domestic and international systems. It is found that the absence of standards currently limits progress regarding blockchain in Copenhagen Airport. Fourthly, the analysis concludes that CPH Airport has the capabilities to bring together all the stakeholders and align their incentives to create a structure for the project where the stakeholders are engaged both in the financial and operational aspects of the solution. Two additional factors were identified that constitute a challenge to the adoption. The limited knowledge about blockchain technology is currently functioning as a delimiting factor for adopting the technology. This has resulted in lower perceived business value relative to the requirements of other projects and technologies.

With the increased focus on becoming more data-driven, blockchain offers an opportunity to achieve this goal. The thesis has shown that blockchain enables the stakeholders to access data that has been inaccessible until now. The extra data can allow the stakeholders to improve current operations and the passenger journey through a fundamental change and real-time adjustment of the operations, which also leads to the creation of new opportunities. However, to improve interoperability there are several major decisions that need to be considered as they will impact the

entire creation process. If the concepts are neglected, they will constitute interoperability barriers rather than the foundation for using blockchain.

7.1 Future Research

The thesis has led to several contributions both in literature and practice. However, there are still many unanswered questions worth exploring. For example, the role of standards was highlighted and the reason to create interoperability for inflexible systems was shown. In this regard, it could be investigated how interfacing solutions can be constructed to integrate pre-existing systems or with other blockchain applications.

The thesis focused on how blockchain could be used to improve data sharing, and what factors constitute the foundation for adopting the technology. However, other alternatives to blockchain are available. For example, hashgraph or, as Hasham Ahmad suggested, applying cryptography extensively on top of existing technologies (Baird, 2016; Interview 6). Therefore, for future research, it could be relevant to make a comparison of the properties offered by the different technologies that can facilitate data sharing. This entails an investigation of solutions that would be the most relevant in this ecosystem. Investigating whether these solutions could offer an easier and cheaper alternative to constructing the system using blockchain technology.

Additionally, the thesis has focused on the organizational dimensions that need to be considered to create an interoperable data sharing solution through blockchain. For future studies, it could be interesting to investigate the technological requirements and barriers related to creating the system. For instance, whether the system can facilitate an adequate amount of transactions per second, and if it can be scaled sufficiently to embrace all the stakeholders.

The passenger has not been a focus in this study. As they have to give consent to the airlines sharing their data, it will be relevant to study the passenger's perception of sharing data in the airport ecosystem and whether their attitudes are equivalent to sharing data online.

Moreover, the study has focused on the CPH Airport, the stakeholders, and the passenger journey. A natural next step is to investigate whether it is the same considerations that are present in airports located in other regions and hereby to test the generalizability of the finding.

The study found six concepts that need to be considered to ensure a foundation for adopting blockchain technology. However, these concepts are uncovered through an explorative interview process based on a conceptual approach. Creating a prototype in CPH Airport will be the natural next step. When working in-depth on the prototype, it is like that additional concepts impacting the implementation possibility can occur. Furthermore, it will allow researchers to test the findings and conclusions from this thesis in a changed setting. For example, the thesis emphasizes the dilemma regarding governance and initial ownership of the blockchain-based system. In this regard, future research could examine which governance model provides the most value in an ecosystem that involves entities that also operate and needs to have interoperability to several other ecosystems.

7.2 Recommendations

Blockchain is hyped as revolutionary and there is undoubtedly a potential in the technology, but it is also important to be realistic about what problems it can solve and what it cannot. The great thing about blockchain is that cryptography and consensus mechanism offers means to bring together parties who do not trust each other. The stakeholders must be prepared that embarking on a blockchain journey will be both exciting and demanding. There are many considerations that need to be made prior to the developments. It will require many different capabilities ranging from legal to understanding the processes and the data involved to technical expertise. We recommend initiating projects to explore the needed standards to create interoperability in order to be able to create a foundation for adopting blockchain. Furthermore, we perceive that the cost of developing standards and blockchain systems outweigh the loss of competitive advantage due to the improved operations available from increased data sharing. Based on Beck et al. (2018) we recommend choosing a proven private permissioned blockchain architecture for the solution. Given that the three stakeholders do not have the technical capabilities related to creating the blockchain system, it is recommended that they partner with industry experts instead of acquiring skills. There are two reasons for this recommendation. Firstly, it can give access to an expertise level that will most

likely not be available through hiring. Secondly, acquiring the capabilities needed may take a longer time than establishing a partnership. The downside with choosing to partner can be the fear of giving up control and relying on a third-party provider. In this particular case, we recommend choosing a representative governance structure because it will make it easier in the pilot testing phase. Furthermore, it can improve decision-making and once the system is functioning additional airlines can slowly be onboarded to the system. However, since they are not involved in the early stages it is argued that these stakeholders have less say in the development of the system (in the beginning). The ideal interoperability approach is fully integrated, but because both the airlines and authorities have to interoperate into multiple ecosystems it is recommended that the stakeholders adopt a unified approach. The unified approach entails that a common format is decided upon at a meta-level, which can help ensure a more efficient data sharing process. Looking at the figure 6 it is recommended that the first project initiated is to experiment with creating a blockchain prototype system to push data regarding who has checked into the security area. Hereby, the airline can know if a passenger has reached the airport in case the person has checked in from home. The reason for choosing this step is because it is one of the simpler processes that involve the boarding pass which is automatically scanned. Furthermore, it is one of the processes owned by CPH Airport, and it was concluded that they will have to take the lead of the project if they want to ensure that the project will be initiated.

8 Reflections on the process

An intention with this thesis has been to elucidate the value a blockchain system can give to the ecosystem of Copenhagen Airport. Hence, it is hoped that the stakeholders will consider the findings in order to create a foundation for more interoperability, data sharing, and improved operations.

The entire process has been a great opportunity to learn how to conduct a larger study and go in-depth with a new topic of interest. Hereby, we have obtained a better understanding of the hermeneutical process because each interview provided us with new insights from people with different backgrounds. This meant that we slowly started to obtain a more thorough understanding of the processes, and the focuses and priorities for the different people coming from different areas. We truly felt the impact of the chosen philosophical research foundation as the project has been an explorative and iterative process. Due to the escalation of COVID-19, the project became even more iterative as we had to reconfigure our scope and who we would be able to interview. As mentioned, the plan was to participate in a major blockchain conference, but unfortunately the trip got cancelled. Our aim with attending the conference was to gain access to the newest knowledge about the research area and technology that is still young and unexplored, and to meet with the main experts in the field. Instead, we had to figure out who to contact, and we were forced to reevaluate our approach and what data we would be able to collect. This meant an endless series of emailing and we will be forever grateful to the people that took the time to help us.

Furthermore, going into depth with blockchain to learn how to differentiate between what is the hype around the technology and what it can actually do, has been a fascinating journey. Undoubtedly, blockchain is a promising technology. However, there are management and organizational considerations that need to be solved upfront. It is expected that it will require substantial investments both economically and timewise to create applications that include several organizations.

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