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Digitalization as a tool to improve export cargo flows at Amsterdam Airport Schiphol

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Contents

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List of tables

List of abbreviations

Abbreviation	Meaning
ACN	Air Cargo Netherlands
AWB	Air waybill
BRU	Brussels Airport
CCS	Cargo community system
CDM	Collaborative decision making
eAWB	Electronic air waybill
FFW	Freight forwarder
GH	Ground handling agent
IATA	International air transport association
ICT	Information and communication technologies
IoT	Internet of things
LAT	Latest acceptance time
PDP	Product delivery problem
RFS	Road feeder services
SCMP	Smart cargo mainport program
SPL	Amsterdam Airport Schiphol
TAS	Truck appointment system
ULD	Unit load device

Throughout this research, several industry terms are used. For the purpose of clarity, these are the definitions and what they describe as defined by Cargo iQ (2019):

- Shipment = Freight + Information
- Freight or Cargo = Physical Freight
- Information = Electronic Data or paper relating to the freight

Abstract

Congestion at Amsterdam Airport Schiphol's landside cargo operation has been a challenge in the air cargo industry for several years. Digitalization may hold the key to alleviate congestion and its adverse effects on the stakeholders involved. In this study, several tools and technologies that can improve export cargo flows were explored. A comprehensive qualitative multimethod approach was employed, comprising an comprehensive literature review and nine stakeholder interviews. Interviews served to investigate the contemporary landscape of digitalization and elicit stakeholders' perspectives, experiences, and insights pertaining to the digitalization of export processes at SPL. Parallels were drawn between landside operations in airports and maritime ports to validate technologies. The research exposed the following major findings:

- Transparent business rules need to be agreed upon between stakeholders;
- Dynamic scheduling and slot management will provide details on available dock capacity at GHs;
- Horizontal collaboration can be expanded to optimize truck load factors and reduce movements;
- Traffic monitoring technology can help trucking companies to better understand real-time traffic information at SPL landside.

Keywords:
Air cargo, digitalization, horizontal collaboration, slot management, business rules

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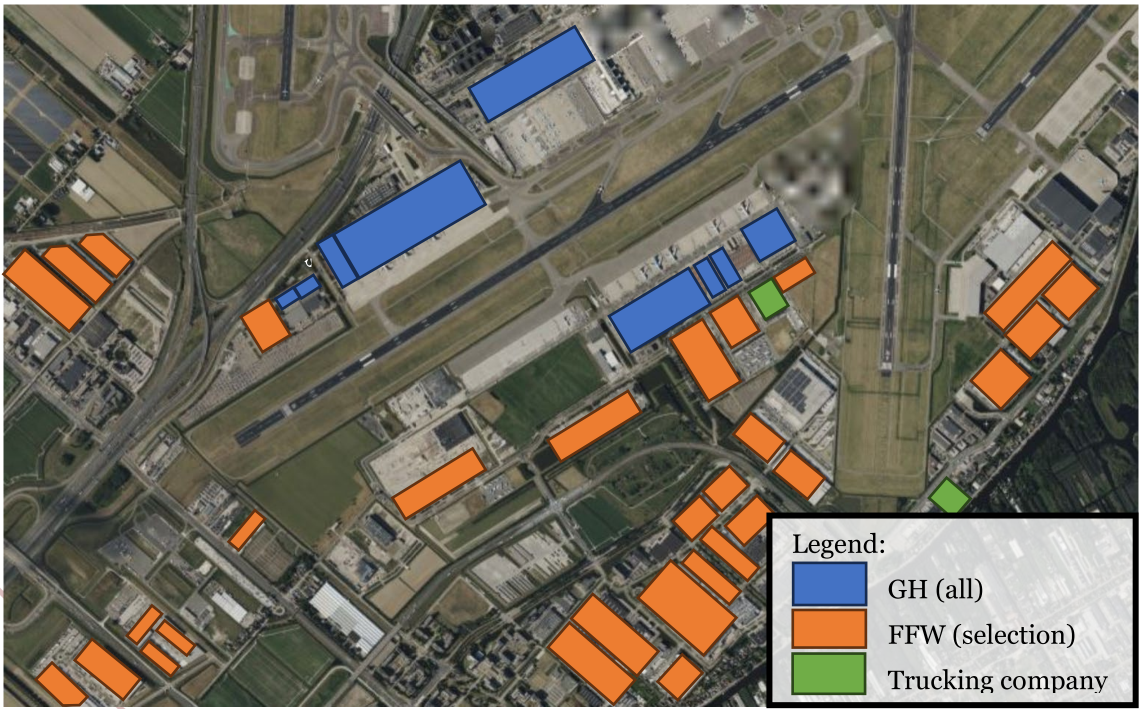
- Diarto Aalders -

1. Introduction

Air cargo is vital for Amsterdam Airport Schiphol (SPL). While air cargo only constitutes 3 percent of all flight movements at the airport, it is responsible for 25% of all jobs at the airport and, therefore, a significant financial contributor to the airport's ecosystem (de Haan & Streng, 2020). Smooth air cargo operations are thus paramount for the airport's attractiveness and competitiveness. Even more since air cargo is generally considered time-sensitive or shipments are booked on flights with low frequencies. One part of the operation in particular deserves attention; landside cargo operations. Landside cargo operations involves the transportation of freight from a second line logistics service provider, a freight forwarder (FFW), and a first line logistics service provider ground handling agent (GH) (Romero-Silva & Mujica Mota, 2022). GH offers logistics services for one or several airlines that operate to and from the airport. SPL has five different GH companies that between them operate from nine distinct warehouses. Figure 1 illustrates the highly diversified positioning of only a selection of stakeholders. Many more FFWs are located in close proximity to the airport, but outside the satellite image.

Figure 1 Satellite view of Amsterdam Airport Schiphol cargo operators (Open source: Bing Maps)



In this environment, the SPL air cargo community continuously faces significant landside supply/demand imbalances as unchoreographed trucks report to the GH warehouses for either delivery or pickup of freight. This leads to congestion and subsequent delays exceeding multiple hours, especially during peak periods like cargo peak season and Fridays (Vrancken, 2020). Coordinating landside operations among airlines, GHs, and FFWs proves challenging due to various factors such as multiple agents involved, unpredictable shipment arrivals, and varying volumes of shipments (Bombelli & Fazi, 2022). Furthermore, in the accountability structure, the airlines are the client of the GHs while in practice the FFW must coordinate activities with the GH, which impairs the communication between GH and FFW. This in turn hurts the transparency and predictability of shipment availability at the handler, complicating the FFW's planning process (Verduijn et al., 2019). SPL exemplifies this complexity with five GHs managing landside freight from around 150 FFWs, further complicated by constrained loading dock resources and personnel (Romero-Silva & Mujica Mota, 2022). Several studies have proposed theoretical models for landside optimization with a focus on horizontal collaboration. Horizontal collaboration involves companies that operate at the same level of the value chain, but usually in different chains. They collaborate by sharing capacity, planning, handling services and possibly even booking services. This kind of collaboration takes place among shippers who produce goods and FFWs or transportation companies who arrange the transport of goods for shippers (Verdonck et al., 2013). Sharing of information between such companies is paramount for horizontal collaboration to be attainable. An overview of available digital technologies that can improve the congestion issues as described above lacks in the existing literature.

Hence, this research aims to explore how digitalization can improve air cargo export flows in an effort to reduce congestion and its adverse effects, as encapsulated by the main question: *"How can digitalization improve export cargo flows at Amsterdam Airport Schiphol?"*.

Like airports, efficient maritime ports rely on cooperation and coordination between privately owned businesses and government agencies, such as customs and other authorities (Inkinen et al., 2019). The port industry is also highly network-centric with a plethora of independent actors engaged in a port-to-port or door-to-door voyage (Raza et al., 2023). Stakeholders show a strong resemblance, with shipping companies for airlines, port authorities/operators for airport operators, and terminal operators for ground handlers, while freight forwarders and trucking companies assume the same role. Landside congestion is commonly cited as one of the biggest challenges in effective port operations (Gurumurthy & Bharthur, 2019; Inkinen et al., 2019; Zhao et al., 2020). Therefore, frequent parallels between these two modalities will be drawn.

The structure of this research is as follows. A comprehensive literature review covers relevant definitions and previous research, spanning air cargo operations at SPL, global contexts, and digitalization in maritime ports. This review culminates in an analysis of the current state-of-the-art application of digitalization within air cargo. Following the literature review, the methodology employed in the study is explained, detailing the research design, data collection methods, sampling, and analytical approaches used. Subsequently, the findings chapter presents empirical outcomes from the stakeholder interviews. A meticulous analysis of the available digital tools and their impact on SPL's landside operations is presented, offering a comprehensive overview of tangible research findings. The concluding chapter integrates insights from the literature review and interview findings. This chapter underscores the study's contributions and outlines practical implications, while also suggesting potential avenues for future research.

2. Literature review

Optimizing the export cargo flow at SPL centers around a problem that is also known as a pickup and delivery problem (PDP). As Savelsbergh and Sol (1995) proposed, a general PDP has a set of routes that must be constructed to satiate transportation requests. There is a fleet of vehicles assigned to operate the routes. Each vehicle has a specific capacity, a designated starting point, and a final destination. The starting point being the FFW while the end point is the GH. Alternatively, Additional complexity arises from to the limited number of loading docks available for unloading trucks at the GH. These docks are capacity-constrained resources (Romero-Silva & Mujica Mota, 2022). Regarding operating capacity, Klein (1960) states that firms have a theoretical capacity which is defined as the output when operating at maximum capacity. In reality, this is not achievable since there will always be factors negatively influencing capacity such as technical or staff issues. At SPL, yet an additional factor is at play. GHs facilitate logistical services for its customer airlines who in turn offer freight capacity to their customers, the FFWs. This means that the GH is not able to directly adjust its capacity based on customer demand. According to a project by TKI Dinalog (2022), containing several research studies, GHs at SPL receive truck deliveries every day of the week, but they are not evenly distributed. As a result, there is congestion during peak hours. While many shipments are delivered just in time, the report found that around 25% of arriving trucks contain at least one shipment that arrives more than 24 hours before it was required.

A parallel can be drawn between solving the landside delivery problem and research by Verdonck et al. (2013), who focused on horizontal collaborative logistics from the perspective of road transportation companies. As explained by Verdonck et al. (2013), horizontal collaboration can be distinctly split into two operation approaches: order sharing and capacity sharing. Order sharing encompasses the combining, sharing, or exchanging data on customer requests while the truck fleet of cooperation participants is left unchanged. Increased capacity utilization of trucks is cited as the main improvement of order sharing. Conversely, parties may cooperate horizontally by sharing vehicle capacities rather than sharing customer requests. In cases where alliance partners cannot share private order information, capacity sharing can be a viable alternative to order sharing.

2.1 Definitions

The wide-scale incremental innovation and adoption of technology is commonly referred to as industrial revolutions. Scholars agree upon innovations around the microprocessor at around the 1990's as the big bang of the ICT revolution, marking the start of the third industrial revolution (Taalbi, 2019). Anno 2023, the world has entered the fourth industrial revolution, which according to Heikkilä et al. (2022) means the "intelligent networking of machines and processes for industry with the help of information and communication technology". While airports currently have implemented some industry 2.0 technologies, industry 4.0 will allow for fully connected airport stakeholder with superior proactive/reactive adaptation to real-time operational needs (Kern, 2021). This increase in levels of technological innovation in nearly every business, workplace, and pocket is a process that is known as "digitalization" (Muro et al., 2017). According to Gobble (2018), digitalization refers to the use of digital technology to create and harvest value in new ways. On a similar note, Teubner and Stockhinger (2020) define digitalization as the interplay between digital technologies and social and institutional processes. Continuing that these technologies shape society and economy. Following that definition, Gartner (2023) adds that the outcomes from digitalization can be categorized two-fold. First, digital optimization outcomes that improve existing operations and processes. Second, digital transformation outcomes reinvent the market that is served with new products, services, or business models. Digitalization outcomes are rarely purely optimization or transformation, since most successful strategies include an optimum mix of both initiatives (Gartner, 2023). Despite this fact, this research focuses on the first outcome as it seeks to find optimization of the current processes while acknowledging business transformation initiatives. While digitalization can be seen as an end goal, it is merely a tool to improve businesses and logistics management.

Heikkilä et al. (2022) categorized digital technologies for the application in smart ports into four groups: process technologies, for instance robotics; physical/digital interface technologies, like the Internet of Things (IoT) and dashboards; network technologies, such as cloud computing, blockchain, real-time data sharing, and data-processing technologies boasting predictive analytics and decision-making, such as big data, machine learning and simulation. From these four categories, process technologies will be left out of scope since robotics and automated vehicles are mostly applicable inside warehouses or on private premises and will not be seen on public roads (that make up the landside area) for at least 15 years (Frisoni et al., 2016).

Predictability is defined as "the quality something has when it is possible for you to know in advance that it will happen" (Oxford University Press, n.d.). In the context of air cargo deliveries at GH facilities, it means the act of knowing what, why, when, where, who, and how freight will be delivered (SCMP, 2022). This means knowing details about the shipment's content and quantity, for which flight it is booked (why), when it will arrive, where (potentially a specific warehouse/location/dock), which driver, and which trailer/license plate will bring the shipments.

Jandrić and Ranđelović (2018) explored how digitalization is transforming the world of workers. As companies adopt digital technologies, such as computers and other IT tools, the nature of people's work undergoes a transformation. Moreover, Zaharia and Pietreanu's (2018) work emphasizes how a digital culture will promote transparency, improve stakeholder collaboration, encourage decision-making, and stimulate risk-taking. In turn, this digital culture will significantly impact the airport's operations. Gallardo underpins this, noting that the implementation of a port community system is not merely an IT project, but a change management project (The World Bank, 2020).

2.2 Digitalization areas

As mentioned in section 2.1, digitalization can be clustered into three distinct categories: interface technologies, network technologies, and data-processing technologies.

2.2.1 Interface technology

Physical/digital interface technology, as defined by Culot et al. (2020), entails *"bridging the cyber-space with the reality of machines, products and people at work (i.e., the IoT, cyber-physical systems, and visualization technologies)"* (Culot et al., 2020, p. 8). Several researchers have suggested IoT as a tool to aid in logistical challenges (Egorov et al., 2020; Kern, 2021; Parola et al., 2020). The field of IoT involves combining information processing, communication, and control across a range of transportation systems. This includes vehicles, infrastructure, and the people who use them. It emphasizes the importance of these different aspects working together seamlessly (Nguyen et al., 2023).

IoT technology could have a strong use case in for example traffic monitoring. By using IoT sensors and cameras, traffic patterns such as vehicle speed and the volume of vehicles on the landside area of SPL can be monitored and recorded. This information can then provide real-time information on congestion levels at the different port facilities and allows trucking companies enabling to make more informed decisions on where to go. As a result, businesses can gain valuable real-time insights from their connected devices (Nguyen et al., 2023). Several ports, including Mombasa and Montreal have employed the use of IoT to reduce congestions. Moreover, in the ports of Rotterdam and Hamburg, real-time information exchange and IoT-enabled sensors are providing valuable insights, allowing stakeholders to leverage that data to gain insight into information flow, traffic flow, and cargo flow (Brunila et al., 2021).

2.2.2 Network technology

Gartner (2023) describes several trends of which three can be classified as network technologies. Specifically: data sharing and collaboration, real-time data tracking, and blockchain are proposed for application in (air) port landside optimization by numerous academics (Allied Aviation, 2023; Kuteyi and Winkler, 2022; Parola et al., 2020; Inkinen, 2019; Egorov et al., 2020).

Collaborating with competitors to gain a collaborative competitive edge is a practice known as co-opetition (Brandenburger & Nalebuff, 2020). It requires a long-term view and necessitates a platform to cooperate. Facilitating such platforms for communication at airports is done through

Cargo Community Systems (CCS), also called Airport Community Systems (UNECE, n.d.). Such systems are neutral and open electronic platforms that facilitate information exchange between public and private stakeholders at the airport, in order to improve the competitive position of airport communities. The level of collaboration intensity and depth is closely tied to the operational interlinkage in data management. Responsible coordination can be organized around port communities, which would require a shift from providing only physical infrastructure for material transportation to digitalized management of logistics data that can be shared as needed (Inkinen, 2019). An important consideration of co-opetition is the emotional aspect (Brandenburger & Nalebuff, 2020). There are stakeholders who accept a situation of multiple winners, while others do not feel the same way. Zaheer and Trkman (2017) have shown that a greater willingness to share information within a supply chain leads to improved quality of information sharing with partners in the supply chain. Factors within an organization, such as trust, reciprocity, commitment, and IT infrastructure, can have a positive impact on the willingness to share information. This, in turn, can lead to an improvement in the quality of information sharing (Zaheer & Trkman, 2017).

Blockchain is a decentralized and transparent digital ledger that records and verifies transactions. It enhances collaboration by enabling multiple stakeholders to share and access real-time information securely. This fosters trust, reduces disputes, and enhances accountability as each step in the supply chain is securely recorded (Poleshkina, 2021). The innate nature of blockchain ensures data integrity, facilitating smoother and more efficient cross-organizational cooperation. Ionides et al. (2019) suggest that blockchain may prove beneficial for air cargo. This is supported by a flowchart where preconditions such as lack of trust, complex and evolving requirements, and high transaction volumes are considered. All these conditions apply to the high-complexity environment of air cargo.

2.2.3 Data-processing technology

New opportunities arise with the influx of (new) available data from data-sharing. Data is meaningless without the right context. In context, though, it offers three purposes (Wang & Yan, 2023). Firstly, through descriptive analysis, data serves as input to reflect on what happened. Second, it can be used to monitor operations in real-time (facilitated through network technology). Lastly, it can be used to make estimations for the future in the form of predictive analytics (Wang & Yan, 2023). Prescriptive analytics is a technique that combines descriptive analytics, predictive analytics, and operations research to suggest the best possible decision to maximize business value. The key to prescriptive analytics is identifying potential outcomes or decisions using accurate predictions that incorporate artificial intelligence, operations research, and expert systems (Wang & Yan, 2023). Artificial intelligence (AI) and machine learning are important tools to aid in these complex processes.

2.3 Digitalization at a local level

Air cargo delivery at SPL occurs in diverse ways, depending on clients' size, collaborations, and location(s) (shippers and/or forwarders). Many freight forwarders have their own trucks to pick up and deliver shipments. In the current situation at SPL, three methods for freight delivery exist: dedicated trucking, consolidation by carriers and consolidation by handlers and freight forwarders (Verduijn et al., 2019). Applying horizontal collaboration at SPL was proposed by Ankersmit et al. (2014). Following Ankersmit et al.'s (2014) research the Milkrun-project was initiated. Van Alebeek and Bombelli (2021), proposed a fully integrated five-phase auction-based competition model, a form of order sharing where competition is preserved. They use a combinatorial auction system to exchange transportation requests without disclosing sensitive company information. FFWs submit their requests into a pool, which are then organized into bundles by a central planner and put up for auction. Then, the optimal routing strategy for the fleet is calculated by a central planner who has access to all the collaborating FFWs and transport requests. The model incorporates the GH dock capacity and thereby helps relieve truck congestion similar to slot management technology. A clear improvement in freight forwarder profitability was found while simultaneously decreasing congestion at the ground handlers. Additionally, a reduction in the total distance traveled was detailed, resulting in favorable environmental effects. Limited collaboration disadvantages were found when applying this model. Further research by Bombelli and Fazi (2022) took a slightly different approach, demonstrating a cooperative framework for the most optimal delivery of unit load devices (ULDs) from FFWs to GHs based on capacity sharing. They emphasized the role of an independent IT company to facilitate the central planning of landside logistics, in combination with the auction system described before. Similar to Bombelli and Fazi (2022), and Van Agerbeek and Bombelli (2021), Romero-Silva and Mujica Mota (2022) further analyzed capacity sharing but found contradictory results. Their analysis suggests that the efficiency increase and cost reduction are much less significant than previously found. Continuing, *"Thus, management at SPL … should be aware that operational policies (cooperative or otherwise) might result in opposite results for different performance measurements since we found trade-offs in all the operational policies considered in our experimental design."* (Romero-Silva & Mujica Mota, 2022, p. 13).

Several tools and projects are currently active at SPL which are laid out in the following paragraphs.

2.3.1 Cargonaut

Cargonaut is a local cargo information facilitator that designed and maintains SPL's CCS and its sub tools. One such tool is eCargo Receipt which optimizes the export delivery process. eLink is a module of eCargo Receipt and provides real time insight in the shipment status as well as the shipment compliancy status for delivery of cargo at the ground handlers (Cargonaut, n.d.). Douven's (2013) showed that while stakeholders were positive and willing to adopt eLink, resistance existed. Especially smaller freight forwarders are not often able to be involved in the development resulting in surprises after implementation adding to resistance. Costs are also cited not to commit to a new IT application. Moreover, according to many freight forwarders, the greatest advantage is the overall overview and that ultimately more and better control of processes is achieved. The 20-25% reduction in lead time and paper savings touted by air cargo branch organization Air Cargo Netherlands (ACN) is not proving to be a decisive factor for the industry. The savings in lead time therefore apply almost exclusively to the transporter, who does not have to wait in line for as long and can continue faster. The freight forwarders do not yet see their interest in this. While Cargonaut has been a player in the local air cargo community for over twenty years, its systems are becoming outdated (Versleijen, 2023). In 2020 Royal Schiphol Group purchased the platform to build "Europe's smartest cargo hub". Three years later, Cargonaut 2.0's new Port Community System is still not live (Versleijen, 2023).

2.3.2 CDM@Airports

CargoHub offers a Collaborative Decision Making (CDM) Trucking platform at SPL, that aims to provide transparent and predictable information on truck movements to GHs and airlines. It also provides capacity and cargo availability details to trucking companies to reduce loading and unloading times (Jeffrey, 2022). A study involving Emirates Airlines, Jan de Rijk, and CargoHub, is trialing Cargo iQ's new road feeder services messaging standards, which aim to close the communication gap between truck drivers, trucking company's head office, and airlines (Cargo iQ, 2022). A planning mechanism like Trucking CDM is designed to minimize lost time and to optimize handling processes in a digital environment (Riege Software, 2020). This ecosystem is connected via a Cross Chain Control Centre, the digital twin of Trucking CDM IT platform (Douven & Lute, 2015). The digital twin of the Trucking CDM platform is a digital solution to a more transparent and honest communication so that every party can make clear and better decisions. Currently, the GH is responsible for coordinating movements, although an independent party could be considered to appoint for coordinating. The advantage that this external party could bring is strengthening the general trust in the cooperation (Douven & Lute,2015).

2.3.3 SCMP

Schiphol's smart cargo mainport program (SCMP) started in 2016 with the aim of making Schiphol the pioneer in sustainable innovation and optimization of the air freight chain. The cargo community, including KLM, ACN, Cargonaut, Schiphol Cargo, Dutch customs , and several universities, has been working on this ambition ever since. Together, the participants want position SPL as a united air cargo community that focusses on optimal landside logistics, digitization of the supply chain and new innovations (Amsterdam Logistics, 2020). The SCMP program is working towards a digital green lane with a digital slot planning tool as outcome (SCMP, 2022). As part of this, digital pre-announcement was introduced in 2021, assuring that the ground handler knows who and what is coming to its vicinity (ACN, 2020). For this, the trucking company links its truck details and desired unloading time to this via Cargonaut's eLink.

Another element of SCMP is the Milkrun initiative at SPL, launched in 2015. Similar to how dairy companies used to operate, Milkrun centers around combining shipments of different FFWs into a single journey to a shared destination. Combining shipments from several forwarders into fewer trucks allows to reduce the number of truck movements while also increasing the load factor of these trucks. To ensure efficient routing and loading for multiple companies, extensive collaboration is necessary at both planning and operational levels. This type of operations stems from applied research into horizontal collaboration at SPL by Ankersmit et al. (2014). Their research shows that besides increased truck efficiency and a reduction of truck movements, smaller forwarding companies gain more frequent transportation opportunities at similar costs. A big drawback of the system is an increase in average shipment throughput time for collaborating companies. Gangsterer and Hartl (2017) identified three streams of research for collaborative vehicle routing: centralized collaborative planning, decentralized planning without auctions, and auction-based decentralized planning. Milkrun can be typified as a decentralized planning without auctions as the GH is responsible for orchestrating the most optimal truck loads. Initially, a small number of GHs and FFWs participated and focused only at import shipments. At the beginning of 2021, the scope was expanded by also including export cargo in the project. Average truck load factor has increased from less than 50 percent to over 90 percent for Milkrun-operated trucks (Schiphol, 2023).

2.4 Global digital framework

The International Air Transport Association (IATA) is the trade association for global aviation, representing 83% of total air traffic (IATA, n.d.). They stipulate industry policy on critical aviation issues for both passenger and cargo transportation. Historically, IATA's Cargo-IMP Standards were used by airlines for cargo interlining since 1975. Later, the application of these standards was expanded to ground handlers and freight forwarders (Hasnain, 2015a). Communicating effectively requires FFWs, airlines, and GHs to exchange standard messages. A significant cargo program was launched in 2005, namely, e-Freight, which is an industry-wide program that aims to build an end-to-end paperless transportation process for air cargo made possible with regulatory framework and electronic message standard, named Cargo-XML (Sauv, 2021). This program aims to achieve several benefits such as increased operation efficiency, costeffectiveness, improved data quality, and, importantly, innovation specified as standardization and digitization.

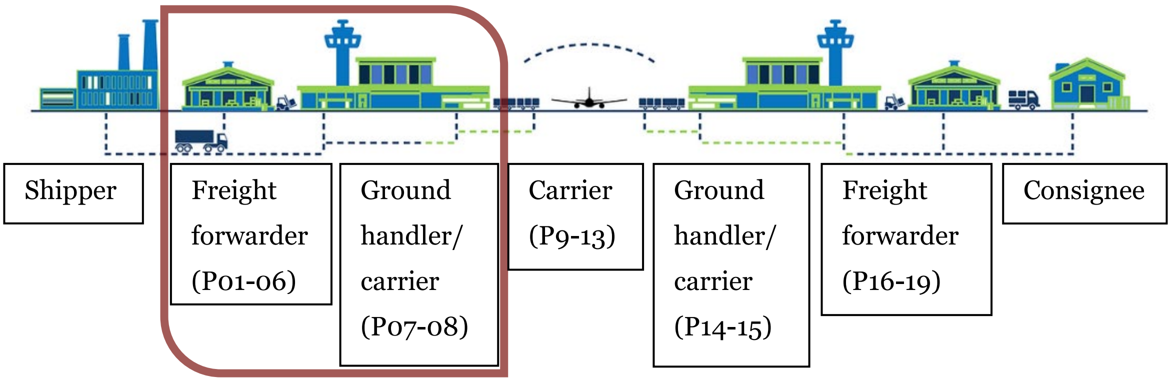
IATA introduced the e-AWB in 2010 with the objective of initiating the digitalization of the air cargo supply chain. Working collaboratively within the cargo supply chain meant digitizing the core industry transport documents, starting with the Air Waybill (AWB). The use of e-AWB as a means to establish the contract of carriage is only possible on feasible trade lanes. In February 2021, the feasible trade lanes represented 67% of the AWBs (Sauv, 2021). This coincides with the achieved global e-AWB penetration rate that between October 2019 and September 2020 averaged at 68.6 percent, with Amsterdam reaching a slightly higher 69.2 percent penetration (IATA, 2020b).

The previously mentioned CCS manages electronic communication within airports among private operators such as airlines, GHs, and FFWs. It also includes hinterland road transporters, importers, exporters, airport authorities, customs, and other relevant authorities. Most Airport Community Systems have their own internal standards, but communicate with other systems or trade communities using specific standards. Specifically, the previously mentioned IATA Cargo-XML standards (Hasnain, 2015b).

2.4.1 Cargo iQ

Cargo iQ, is an IATA-backed global initiative and non-profit organization to establish and supervise a common standard to improve the quality and reliability of operational services in the air cargo supply chain. The Industry Master Operating Plan that they released (Figure 2) outlines the various processes and sub-processes that are commonly involved in planning and transporting air cargo shipments from the shipper to the final consignee (Cargo iQ, 2019). The purpose of the system is to analyze the consistency of shipment planning and execution. A key aspect of the program is the establishment of uniform operational procedures, which are defined and evaluated through specific "milestones" and "route maps" that represent the expected transportation plan (Markill, 2016). By integrating various functions and needs onto a single platform, transportation companies and freight forwarders can gain a more comprehensive understanding of the actual efficiency of their air freight supply chain using a validated approach. This enhanced information can assist carriers, forwarders, and GHs transition to electronic communication methods, such as the electronic airway bill (eAWB).

Figure 2 Air Cargo Industry Master Operating Plan (research scope in red) (adapted from Cargo iQ, 2019)



In the scope of this research, two Cargo iQ processes are relevant. First, the origin activities of the forwarder "*P06 Transfer shipment to carrier domain*", triggering messages/milestones (X)FHL and (X)FWB. This process describes the information sharing of shipment information as presented on the (e)(House) Air Waybill when it is ready to be carried over to the carrier. Then, the origin activities for the carrier "*P07 Receive shipment into carrier domain*", resulting in milestones (X)FOH and (X)RCS. This process describes the arrival and unloading of the goods at the ground handler facilities. Specifically sub-process Pd 7.2 "*Assign Unloading Slot and Position to Delivery Truck*" as this is where the goods first arrive at the ground handler's vicinity. These processes describe the handover of goods and corresponding responsibility between the freight forwarder and carrier (or its subcontracted ground handler).

2.4.2 ONE Record

The previously mentioned e-Freight program has laid the groundworks for the digitalization of the air cargo industry and is now superseded by ONE Record. The IATA ONE Record data model aims to enhance collaboration and attain complete supply chain transparency in the air cargo sector. This is achieved by establishing a consistent approach to exchanging information among various stakeholders in the supply chain, such as shippers, freight forwarders, ground handlers, airlines, and customs authorities. The goal of ONE Record is to create a seamless digital logistics and transport supply chain, where information can be easily and transparently exchanged between all air cargo stakeholders, communities, and digital platforms. The driving force behind ONE Record is the need for the air cargo industry to digitalize and streamline operations, by optimizing data sharing and reducing the use of paper documents (Blaj, 2020). By sharing data more timely and transparently, predictability may improve.

2.4.3 The Digital Airline

In a 2022 white paper by IATA's digital think tank, its 2030 ambition for "The Digital Airline" is outlined (Copart, 2022). In the ambition, nine business dimensions are identified with proposed goals for each. For Data & Technology, an open ecosystem where airlines have a fully optimized, real-time big data infrastructure in place with controlled access to data for third parties is envisioned. Complete and real-time cargo visibility across the end-to-end supply chain using a digital twin should be realized on the end-to-end customer journey front. According to Léopold (2018), no dedicated IATA cargo-focused blockchain initiative exists yet. Data-sharing will the all-encompassing because "*Ultimately, blockchain will affect every aspect of aviation ... Pretty much all the innovation in the industry involves data sharing*" (Newton, 2023, p29). In that same report, a partnership with air cargo giant Kuehne+Nagel is described where blockchain technology is used in the optimization of asset management (Newton, 2023). In a study by Poleshkina (2021), several airlines such as Lufthansa, British Airways, and Cathay Pacific were found to be trialing some form of blockchain in their (cargo) operation. This study created a model that enhances the transparency of the information exchange between all air cargo transportation participants, using blockchain technology. Léopold (2018) identified five areas of blockchain application in aviation: tokenization, provenance, digital ID, certification, and smart contracts. The scope of this research was the entire aviation industry though, meaning not all areas are equally relevant for air cargo. Specifically provenance is suggested as the technology facilitates tracking of the status and location of assets such as cargo reliable a manner as these assets change custody. The change of custody corresponding timing is precisely where this research aims to find more transparency. While information sharing drives costs down, Sahin and Robinson (2004) note that the greatest financial benefit comes from coordinated decision-making. They add that mechanisms between stakeholders are crucial to capitalize on potential savings. Technology serves an important role in this.

In summary, IATA clearly envisions a future where its standards and policies facilitate collaboration. With the introduction of ONE Record, they also aim to be the independent third party serving as a middleman between the stakeholders. While IATA's initiatives push for change on the digital front, Hasnain (2016) notes that digital collaboration with business partners is becoming a necessity throughout the supply chain. This, however, conflicts with the desire for autonomy that the diverse stakeholders in the industry crave.

2.5 Digitalization use-cases

Digitalization adoption varies highly between (air) ports and is strongly related to their size (Brunila et al., 2021). The larger the port, the more resources can be put towards implementing digital development programs and research. The digital green lane as mentioned above aims to provide a two-way solution where delivery times are communicated between GH and the trucking company. One effective way to facilitate communication between trucking companies and terminals for determining truck arrival times is by implementing a truck appointment system (TAS). This system is already being used in maritime terminals, across the globe (Phan & Kim 2015). Congestion gets reduced when trucks only arrive when they can actually be handled by the terminal (Xu et al., 2021). In airports, TAS technology is known as slot management technologies are successfully applied in air cargo, such as seen in Brussels Airport, Liege Airport, Luxembourg Airport, Vienna Airport, London Heathrow, and Dallas Fort-Worth (Nallian, n.d.). Data-processing technology may be used to optimize the use of the slot management system at each GH. Historical data can be used to define required dock and staffing capacity. To further exemplify this, Brussels Airport (BRU) faced similar congestion challenges to SPL and developed its data-sharing platform BRUCloud. BRUcloud is a platform that uses a blockchain for sharing open data within the Brussels cargo community (Ionides et al., 2019). Unlike other cargo community systems, BRUcloud facilitates data sharing in a cloud environment rather than digitizing communication between different parties. This allows the air cargo supply chain stakeholders to work more closely together and function as a network (BRUCloud, n.d.). Within BRUcloud, collaborative apps aim to make the cargo landside process paperless and future-proof (Ionides et al., 2019). In addition, a digital slot booking application in BRUcloud promotes cooperation among freight forwarders, ground handlers, and truckers. This helps to prevent conflicts and bottlenecks that used to result in congestions (Barnett, 2018). BRUcloud is based on Nallian's data-sharing technology. The source retains control over its data and can specify which data fields are shared, with whom, and for what purpose (BRUCloud, n.d.). Currently, Nallian's slot booking and freight consolidation apps are being rolled out in multiple airports around the world such as Liege Airport, Luxembourg Airport, Vienna Airport, London Heathrow, and Dallas Fort-Worth (Nallian, n.d.)

Applying slot management comes with guarantees and risks. Guarantees for a dock and service and risks through possible lack of available slots when needed. In 2023, the Port of Rotterdam has introduced a surcharge on time slots during peak hours to even out peaks of delivery trucks (Rotterdam World Gateway, 2023). According to T. Wang et al. (2020), it is reasonable for container shipping companies to charge more for time-sensitive cargoes than general cargoes, that is, faster delivery services deserve higher freight rates. This argument cannot be made for air cargo as all shipments are time-sensitive.

3. Methodology

This methodology outlines the research approach that was used to answer the question of how the potential of digitalization to improve export cargo flow predictability at SPL. The research focused on identifying digital tools and strategies in air cargo suitable for application at SPL, while drawing parallels with successful digitalization use-cases in maritime ports. The methodology adopted a qualitative research designed to gain an in-depth understanding of stakeholders' perspectives and experiences regarding digitalization's impact on export cargo predictability. This chapter describes the research design and method that were chosen for this study. Additionally, it will explain why this particular method was appropriate. Then, the data collection tool that was used, followed by a summary of the procedures and data analysis. Finally, the chapter will discuss the ethical considerations that were taken into account during the research process.

3.1 Research Design

A qualitative multimethod research approach was used to explore stakeholders' perceptions, experiences, and insights related to digitalization of export flows at SPL. This approach provided a nuanced understanding of the implications of digital tools on improving predictability without relying on quantitative data analytics. Additionally, thorough desk research allowed to gather a comprehensive overview of technology use-cases in both the air cargo industry as well as maritime ports that helped to determine the state-of-the-art of these two industries.

3.2 Data Collection

Primary data collection took place by means of semi-structured interviews with key air cargo stakeholders at SPL. Interviews were guided by a pre-determined set of questions that allowed the interviewees to express their views on the current landside processes, challenges faced, and potential benefits of digitalization. Following the literature review, an interview protocol containing 13 questions was constructed to guide the interviews. The interview protocol was structured and divided into five parts: (I) introduction, (II) digital solutions, (III) challenges, (IV) operationalizing, and (V) specific technologies. Prior to the interviews, all respondents were handed out the interview protocol to enable them to think more deeply about the questions. The instrument was pilot-tested with a manager global operations from a large GH.

The interview questions together with the rationale for their inclusion in this study, backed by references to the literature, are presented in Table 1. The full interview protocol with both English and Dutch questions can be found in Appendix I.

Table 1 Interview protocol with rationale

Question	Rationale
I. Background of stakeholders	
1. Could you provide an overview of your role and responsibilities within your company regarding cargo operations at Schiphol?	Ice breaker and provides a means to verify respondent's involvement in and mandate towards digitalization.
2. How does the unpredictability of export cargo flows affect your company if it does?	The question delves into the impact of unpredictable export cargo flows on the company's operations. By understanding the repercussions of this unpredictability, the company can identify pain points, operational bottlenecks, and potential financial losses. This inquiry recognizes the significance of a smooth cargo flow for business success, emphasizing the need for strategies and digital solutions to mitigate the negative effects of unpredictable cargo movements.
II. Digital solutions	
3. Which digital technologies do you think could be implemented to increase predictability?	Understand which technologies the respondent is aware of and to which degree. This inquiry addresses the vital role of digitalization in optimizing cargo processes and meeting the demands of a globalized supply chain.
4. How could you implement this in your organization?	This question explores the practical strategies for integrating digital tools within the company's operations. Understanding the potential methods for implementation is crucial for assessing feasibility, resource allocation, and the overall impact on streamlining export cargo processes.
III. Challenges	
5. Which challenges do you expect when implementing digital technologies?	Understand which barriers the respondent sees when implementing digital technologies and where By inquiring about anticipated challenges, the question addresses the realistic concerns associated with adopting digital technologies. Recognizing potential hurdles such as technical barriers, change management, and integration issues prepares the company for effective implementation planning.

6. What could you do to alleviate these challenges?	Understand which opportunities or barriers the respondent sees. This question encourages the interviewee to think proactively about mitigation strategies for the challenges identified in the previous question. Addressing these challenges by suggesting solutions or approaches reflects a comprehensive understanding of the implementation process and indicates a forward-looking mindset.
7. How will an increase in predictability benefit your organization?	Quantify and/or qualify the benefits for the stakeholder in question. The question seeks to highlight the direct advantages that improved predictability could bring to the company. Identifying benefits such as enhanced operational efficiency, reduced costs, improved customer satisfaction, and better resource allocation emphasizes the tangible value of embracing digital solutions.
IV. Operationalizing	
8. Which possible challenges do you foresee when operationalizing digital technologies?	This question extends the inquiry into challenges by specifically focusing on hurdles related to the operationalization phase. By addressing challenges unique to this phase, the interviewee can demonstrate a deeper understanding of the complexities involved in integrating digital technologies into day-to-day activities.
9. Who should kickstart these initiatives?	Understanding who the respondent believes should be the initial driver of digital initiatives at SPL. This question reveals insights into organizational dynamics, leadership involvement, and the level of commitment to fostering innovation and change.
V. Specific technologies	
10. How would a dynamic scheduling and slot management technology affect your organization?	Explore the benefits and drawbacks of this technology and sense the respondent's feeling towards this specific technology. This allows to analyze the direct effects on operations, efficiency gains, and resource optimization, while also gauging readiness for embracing such technologies.
11. What are your thoughts on fostering horizontal cooperation among air cargo stakeholders to address landside congestion at Schiphol Airport?	Since horizontal cooperation is not a novel concept at SPL, getting to know the respondent's experiences (through the Milkrun-project). Assessing the willingness to cooperate reflects an understanding of the broader industry landscape and potential solutions beyond the organization's boundaries.

12. What are your thoughts on a third party being made responsible for orchestrating the entire landside operation at Schiphol, considering the different stakeholder requirements/business rules?	This question gauges the interviewee's opinion on outsourcing or entrusting a third party with a critical aspect of operations. The response can reveal attitudes toward risk management, efficiency gains, and the potential benefits or drawbacks of involving external entities.
13. What would be the main reasons for your company to engage or not engage in horizontal cooperation?	By exploring the motivations for engaging in or abstaining from horizontal cooperation, the question delves into strategic considerations, perceived benefits, concerns, and alignment with the company's values and objectives. It offers insights into the interviewee's strategic mindset and decision-making criteria.

Secondary data was collected by means of a comprehensive literature review that explored existing studies, reports, and articles related to digitalization in air cargo. The review covered a range of topics under the digitalization umbrella such as case studies and best practices from other airports. Government reports, airport publications, and industry reports were analyzed to understand the current state of cargo operations at SPL and the initiatives taken towards digitalization, as well as the global developments. Moreover, existing literature on digitalization in maritime ports were examined to identify potential parallels and transferable lessons for SPL.

3.3 Sampling

For this research, relevant publications were found using CataloguePlus which collection includes many well-known publishers, like Emerald, Taylor and Francis, Springer, MDPI, and Elsevier. Rather than predefining a single set of search queries, the applied approach was of an iterative nature. It used multiple combinations of keywords such as *air cargo*, *optimization*, *digitalization*, *digitization*, *landside*, *congestion*, *predictability*, *ports*, *digital transformation*, *workforce*, *horizontal cooperation*, *collaborative logistics*, etc. The keywords were identified through an iterative process, where each search iteration's results were used to enhance and improve the search for better outcomes. For instance, starting with air cargo optimization as a key word combination, it transitioned into horizontal cooperation in air cargo. This approach was decided upon after several trial-and-error attempts. While this process was tedious, it safeguards high-inclusivity of search results. Relying solely on predefined queries could lead to missing relevant work in certain areas, posing a potential risk.

A study was conducted to expose a successful use-case of digitalization in landside cargo operations. The study focused on order sharing at an airport similar to SPL. For this, Brussels Airport was chosen as it provided a worthy reference. While SPL processes around a four-fold of the cargo volumes compared to BRU, around half of BRU's flights are served by a national full-service carrier (FSC) operating a hub-and-spoke model, additional flights are served by a mix of low-cost airline (not contributing to cargo volumes), FSC passenger airlines (transporting limited cargo volumes), and dedicated cargo airlines. Geographically, BRU and AMS are close and are serviced by many of the same stakeholders (CAPA, 2023a; CAPA, 2023b).

The research draws parallels with digitalization strategies implemented in maritime shipping ports. Comparative analysis will highlight similarities and differences in the application of digital tools in improving export cargo predictability, enabling the transfer of best practices from the maritime sector to the aviation industry. Digitalization has proved useful in facing the landside operations challenges in ports. Therefore, analyzing how different ports have reduced congestion, waiting times, and emissions (from idle trucks) through digitalization was deemed a suitable method.

Semi-structured interviews were held with respondents who were selected using convenience and snowball sampling methods. The goal was to ensure fair representation from different stakeholder groups involved in the digitalization of air cargo export flows, thereby capturing diverse perspectives. Stakeholders were identified and included: GH, FFW, trucking companies, and airlines. Two separate companies were selected and interviewed per stakeholder, with the notable exception that one airline performs self-handling, and the focus in the interview was on GH activities, not airline activities (Ground handler 3). Additionally, an IT solution provider was interviewed. A key requirement for the respondents was to have decision-making authority on digitalization strategy or have been involved with digitalization in a project leader role. The full overview of interviewees can be found in Table 2.

Table 2 Interviewees with stakeholder type and role

Interviewee	**Stakeholder**	**Role**	**Appendix**
Person A	Ground handler 1	Director of Operations	II
Person B	Ground handler 2	Assistant Director Cargo Operations	III
Person C	Ground handler 3	Product Manager Digital Operations	IV
Person D	Freight forwarder 1	Export manager	V
Person E	Freight forwarder 2	Head of Airfreight The Netherlands	VI
Person F	Airline 1	Manager Cargo Netherlands & Belgium	VII
Person G	Trucking company 1	Owner and Director	VIII
Person H	Trucking company 2	Owner and Managing Director	IX
Person I	IT solution provider	Implementation Consultant	X

Nine interviews took place, spanning several weeks in August 2023. The interviews were conducted online through Microsoft Teams and lasted between 32 and 57 minutes, averaging 43 minutes. All interviews were conducted in the Dutch language, recorded, and transcribed. Quotes relevant for conclusions were translated into English. Following the interviews, a six-phase thematic analysis as defined by Braun and Clarke (2006) was employed to identify patterns, themes, and recurring ideas related to digitalization's potential to improve cargo flow predictability.

3.4 Data Analysis

Thematic Analysis was used in this study to examine the empirical data that resulted from the interviews. This method of analysis was chosen as it is known as a good qualitative research method that is widely used across a range of epistemologies and research questions (Nowell et al., 2017). The method was used to analyze, organize, describe, and report themes found within the collected dataset (Braun & Clarke, 2006). The nine conducted and recorded interviews provided the source of information for the thematic analysis. MS Teams was used for the interviews and automatically transcribed. A thorough manual verification of the transcription was done afterwards and then meticulously coded in two runs. Key concepts in the transcripts that are important to this research were identified with the aid of coding. The themes and sub-themes were then developed using the codes that emerged from the data as the basis. Finalizing with the names of each theme and sub-theme, writing a description of each theme, and citing examples from the original text to support each description. Based on the findings from the primary data analysis, potential digital tools and technologies applicable to improve export cargo flows at Amsterdam Airport Schiphol and their stimulators and inhibitors were identified. The selection of digital tools was guided by stakeholders' perspectives and experiences shared during the interviews. By conducting thorough desk research, a comprehensive overview of the technology use-cases in both the air cargo industry and maritime ports was gathered. This helped determine the current state-of-the-art in these sectors. The findings were categorized under the themes from the thematic analysis and compared and contrasted with each other. A count was kept of the occurrence per sub-theme, leading to a total theme weight, indicating the respective theme's importance.

In summary, the methodology employed a qualitative approach, including semi-structured interviews with key stakeholders and a comprehensive literature review. Thematic analysis of interviews helped identify digital tools, and comparative analysis with maritime ports provided insights. In the next chapter, the interview's findings are laid out.

4. Findings

4.1 Interview output

Following nine interviews, thematic analysis was used to distill several themes from the interview for further analysis. A total of 103 non-unique codes were identified between the nine interviews. These codes were grouped into 17 sub-themes and five main themes. Table 3 shows all sub-themes, their related main themes and respective weights.

Table 3 Main and sub-themes derived from thematic analysis

Sub-theme	Count	Theme	Theme weight
Just-in-time	2	Flexibility	18
Need for speed	5		
Predictable	4		
Flexibility	7		
Business rules	8	Industry change	42
Change management	6		
Development times	2		
Innovation restrictors	10		
Long introduction lead time	3		
Responsibility	13		
Interface technology	1	Interface technology	1
Financial incentives	4	Network technology	38
Horizontal collaboration	13		
Interconnectivity	8		
Slot management	12		
Autonomous vehicles	1	Physical change	5
Infrastructure	4		

One of the main themes was considered out of scope for this research but was a returning theme nonetheless, highlighting a specific desire or idea from those stakeholder. Specifically, physical change was a common theme and included sub-themes such as the use of autonomous vehicles and infrastructure modifications. These solutions have the potential to reduce congestion whilst they have no relation to digitalization.

4.2 Flexibility

While GHs perceive a high level of unpredictability in export deliveries, FFWs and trucking companies believe the opposite. Four stakeholders agree that air cargo is in fact predictable to a large extend citing that around 80% of all flows are standard with 20% variability. Regarding the unpredictability, respondent E firmly stated *"A lot of people say that air cargo is unpredictable to which I say: that's not true. That's just not true."*. Five of the respondents emphasized that high speed and flexibility is what makes air transport an interesting modality for FFWs and their customers. FFWs work according to latest acceptance time (LAT) which indicates a certain time before departure by when the shipment needs to be delivered to the GH. Both FFWs and trucking companies stated that it is their core-business to consolidate shipments to optimize their movements between their own warehouses and the GHs as much as possible. Only between 60 and 90 minutes before arrived to the GH, the trucking company sends a notification to the GH detailing which shipments are on its way. Opinions differed between how flexible this timeframe is. Respondent H suggested that ideally, this number gets brought up to three to four hours before goods get delivered to the GH. This should provide the GH with more time to guarantee adequate service. Freight forwarder 2 and Ground handler 3 idealized using a just-in-time method for air cargo, where shipments are delivered to the GH premises when they are needed. Other flexibility issues include stakeholders not wanting to give up on flexibility both from an operational perspective and a software procurement perspective. Most respondents believe that adding more time to allow for more efficient consolidation and truck movements is not possible. Freight forwarder 1 specified this further by saying they are not in the position to change their customers' production. A notable exception was Freight forwarder 1, saying that it has the ability to demand from its customers that cargo is made available sooner, potentially with financial stimuli: *"If you say to your customer: listen, we can ship it for € 1 cheaper, but then I want to pick it up on Thursday instead of Friday. Then the customer will take care of that."*.

4.3 Interface technology

Only one of the interviewed stakeholders mentioned any interface technology. Person B mentioned the use of an RFID and a camera-based monitoring system as an option for SPL. It was highlighted that the limitation of such a system that this can only be used reactively and most knowledge gained from such a monitoring system is a repeat of history. Adding *"It is not about how to visualize it. It is about how to break through that pattern of congestion"*.

4.4 Network technology

Most stakeholders acknowledge further interconnectivity and subsequent data-sharing is possible, potentially through Cargonaut's platform, APIs are extensively used to link GH systems to Cargonaut and sometimes directly to FFWs says Person A. eLink is used by trucking companies to inform GHs that a truck is coming and includes detailed shipment information. As mentioned in the flexibility theme, the timeframe in which this information becomes available to the GH is very short. Both trucking companies and all GHs agreed on this. A single digital portal is seen as desirable by Freight forwarder 1. On the contrary, Ground handler 1 prefers using their own internal systems and then use APIs to link systems. Every single stakeholder sees value in the use slot management to combat congestion. While some see the use of slots as a means to an end, others see it as the "holy grail". Slot times are used at different scales. Ground handler 1 for example uses slots in an informal way by means of email. Ground handler 2 on the other hand is going to transition to a fully slot-managed operation when their new facility opens in 2024. In differing levels, stakeholders are apprehensive to use slots for 100% of the operation. Especially fears regarding the non-availability of slots when an important shipment needs to be delivered is mentioned by both Ground handler 3, Freight forwarder 1, Ground handler 2, and Ground handler 1. Following the fear for lack of slots, financial incentives are mentioned several times to allow for flexibility if the need arises. Respondent H would refuse to pay for regular slots as this should be *"part of the normal service of a GH"*. Horizontal collaboration is a concept known amongst all stakeholders who were interviewed. If not by the theoretical name, then by horizontal collaboration project at SPL: Milkrun. Both Ground handler 2 and Ground handler 3 provide their own import delivery services, not participating in the Milkrun import program. For example, between 50 and 60 percent of Ground handler 2's import shipments are self-delivered to freight forwarders, largely bolstered by high e-commerce volumes. All three GH stakeholders currently participate in the export Milkrun albeit in low volumes. Generally, horizontal collaboration is seen as a positive development. The benefits and savings are acknowledged. However, criticism is given on the scalability of the concept. Citing that aviation is an interesting modality for shippers due to its speed. Building in additional time to optimize deliveries is seen by Freight forwarder 1 as undesirable fearing this will increase shipment lead times. A notable exception to this is Person E who believes an export Milkrun service can be lucrative for all FFWs, especially the smaller players. Both trucking companies highlighted that their companies are already actively engaged in consolidation shipments from forwarders throughout the week. Pickups are combined with return journeys from the hinterland. This, in principle, overlaps with the concept that is Milkrun export. An interesting initiative was highlighted by Trucking company 1 as they currently run a low-tech pilot where they agreed with a GH to have a dedicated dock available 24/7 that is shared amongst three trucking companies. Rather than waiting for a platform to be developed, planners of the respective companies use WhatsApp to agree which company utilizes the dock at what time. Respondent H also notes that while much information is received regarding freight, it still occurs that dimensions are missing or incorrect or that stacking turns out to not be permitted or possible. This affects how well their planners can optimize trucks.

4.5 Industry change

Five out of nine interviewees see a clear role for Schiphol Airport as the airport operator to initiate the next steps in digitalization and trigger an industry change. One such steps could be to set targets for Milkrun participation or slot management implementation. Three stakeholders believe that the local air cargo community can push and achieve change, while Person B believes that agreements regarding delivery times and data sharing is part of the contractual agreement between the airline and its GH. As mentioned above, the benefits of slot management are recognized. Six stakeholders added a desire for strong business rules when using slot management technology. Ground handler 3 specified this by addressing the need for transparent community agreements that don't differ per GH and especially how to prioritize when needed. Such agreements should then be used to hold stakeholders accountable, Person H added, where the role of a single responsible entity comes in. A big shift in mindset is needed to achieve the next steps in digitalization Person E believes. Change management was a recurring subtheme amongst stakeholders with new (internal) company structures stated by Trucking company 1 and Ground handler 1. Development times and costs of collaborative tools are seen as difficult by Ground handler 1 and Ground handler 3. Ground handler 3 addressed the lengthy procurement process that is required by corporate and therefore prefer to do in-house software development. Respondent H on horizontal collaboration made an argument that *"Yes. Theoretically optimizing, consolidating full trucks is something you'd say yes to. Practically it's quite something ... putting certain parties in a position of disadvantage"*, later adding that part of a trucking company's core business is commerce. If freedom is lost there, *"it's simply not interesting for us to engage in"*. Freight forwarder 1 took a similar stance in this, citing the current differing rates for customers. Several critical remarks were made towards the GH that no matter the proposed plans for digitalization, staffing levels need to be sufficient to meet the demand.

5. Discussion and conclusion

This study set out to explore how digitalization can help improve export cargo flows at SPL. The outcomes provide an overview of technologies that can alleviate congestion. A qualitative multimethod study containing an extensive literature review and nine stakeholder interviews exposed the following significant findings:

- Transparent business rules need to be agreed upon between stakeholders;
- Dynamic scheduling and slot management will provide details on available dock capacity at GHs;
- Horizontal collaboration can be expanded to optimize truck load factors and reduce movements ;
- Traffic monitoring technology can help trucking companies to better understand real-time traffic information at SPL landside.

Most surprisingly, it is not technology that forms a stumbling block to kickstart the next step in the digital transformation at SPL, instead, the agreements on how to effectively use technologies between the stakeholders pose the most significant challenge to SPL's air cargo community.

5.1 Transparent business rules

A strong desire for flexibility became apparent during the interviews. Existing fears regarding the loss of flexibility needs to be adequately managed. Tijan et al. (2021) emphasized the necessity to take into account the individual stakeholder preferences when developing integrated community systems. More than 150 local freight forwarders currently operate at SPL, amounting to high variation of preferences. Besides that, the flexibility and the high-speed nature of air cargo and how it affects congestion seems to be largely overlooked in academic sources. While the hypothesis of this research centered around unpredictability, stakeholders believe that, at least for the most part, export flows are in fact predictable. Stating that everybody in the industry knows which days see a peak in deliveries, just not the specifics on a shipment-level. In particular, trucking companies experience that GHs don't have enough staff available and believe that through transparent business rules and agreements, stakeholder can be held accountable. If this was entirely the case, then congestion could be fully solved by increasing GH staff and equipment. Till now, administrative duties have increased for FFWs and trucking companies while the benefits of those efforts have yet to be experienced. Schiphol Airport is seen as the single entity that should be tasked to lead the digital transformation at SPL. This is in line with what was found in other (air) ports like Brussels Airports, Port of Rotterdam, and Port of Mombasa. ACN could gather stakeholder preferences to be used by Schiphol Airport in drafting requirements.

5.2 Dynamic scheduling and slot management

By far the biggest impact can be achieved by implementing slot management technology to regulate air cargo deliveries to the GH facility. Both in maritime ports and airports, this type of technology has lead to a decrease in congestion, shortening delivery times between FFWs and GHs, reducing harmful emissions, and financial savings for trucking companies and their customers. Clear and transparent agreements must be agreed upon to create a fair system that caters to the known and predictable export cargo flows while leaving flexibility in dock capacity for high-priority, or for other reasons late shipments. Details such as minimum required datasets for slot bookings need to be agreed on by all parties. As flexibility is seen as a key selling point for shippers, the desire for flexibility within a rigid scheduling system is necessary. Financial incentives are deemed a good tool to stimulate the use of the fixed and known slots for roughly 80% of flows while retaining a layer of 20% for flexibility. Simultaneously, this can generate an additional source of income for the GH to finance additional flexibility.

5.3 Horizontal collaboration

While horizontal collaboration in itself is not a digital tool, transcending cooperation between stakeholders needs to be facilitated by adequate digital tools. Previous research on this topic have highlighted the potential benefits, although counter arguments for its gains also exist. The sensitivity of this topic is strongly seen by the responses of the trucking companies. Trucking companies already consolidate shipments from FFWs in their warehouses as they are able to combine hinterland journeys to their airport warehouses in a way that cannot be done when using only horizontal collaboration. Despite the air cargo industry's desire to push towards digitalization and the need for sharing data, as suggested by Zaheer and Trkman (2017) there remains a stark difference between FFW stakeholders' willingness to share information. Where DHL is very open to change, Geodis takes a much more hesitant stance towards sharing information or even truck space. Blockchain is frequently proposed in papers to play a role in digitalization. While the technology itself does not have the ability to solve congestion, it can be used in data-sharing platforms where its high data security could be beneficial. Especially reluctant stakeholder that fear exposing sensitive information may be appealed by blockchain's information integrity.

5.4 Traffic monitoring technology

IoT technology could have a strong use case in traffic monitoring at the different GHs. By using IoT sensors and cameras, traffic patterns such as vehicle speed and the volume of vehicles at specific chokepoints on the landside area of SPL can be recorded and monitored. FFWs and trucking companies can use this information to reroute trucks to parts where there is less congestion. While this is a useful tool, its reactive nature makes is more suitable for short-term gains than long-term change as it is not a solution for congestion.

5.5 Relation to other and future studies

Studies on air cargo optimization at SPL mostly focused on import shipments. While this is not an unexpected observation, as the time-pressure of making it to the booked cargo flight is off, it leaves room for export optimization. Research aimed specifically at export took a single concept and explored that into detail. This study served to broaden the literature by addressing available digitalization opportunities. During the investigations, the research scope was limited to local export deliveries. In reality, infrastructure such as landside roads, security gates, docks, and GH staff are shared between local export flows, local import flows, and import and export RFS. The findings as presented here do therefore not display the full complexity of landside operations at SPL. Further studies could explore how (international) RFS export flows can be combined with local cargo deliveries without creating bottlenecks and optimizing freight availability at GH. Moreover, upcoming research could investigate best practices to define business rules for slot management systems. Moving away from management and taking an economics approach to horizontal cooperation could give way for cooperative game theory models to be developed to explore which strategies could best benefit stakeholders involved. A social study into the stakeholder change management and willingness to adapt could disclose methods to help stakeholders deal with digital transformation.

6. Recommendations

For being one of Europe's largest airports, SPL has a very advanced CSS facilitated by Cargonaut and bolsters high integration of FFW, GH, airline, trucking, and customs. Partly due to (inter) national requirements, shipment information is available in a digital format and can be shared easily amongst community members. Still, frequent congestion occurs, leading to financial and ecological losses, not to mention the personal effect this has on employees in the operations. Digitalization has the potential to significantly enhance the predictability of export cargo flows and combat congestion at SPL. The following actions are therefore recommended.

First, Schiphol Airport should rise to the occasion and mandate a strategy for the future digitalization of its local air cargo industry. This strategy should include the use of slot management for export flows at GH facilities. Based on historic data, GHs should determine a nominal and maximum operating capacity on which dock capacity is defined. A clear differentiation must be made between fixed export deliveries and flexible export delivery capacity. Moreover, horizontal collaboration through the Milkrun export concept should be expanded and be made more attractive for smaller FFWs. Also, a short-term installation of traffic monitoring technology to be used by FFWs and trucking companies should provide better insights into where peaks occur and better route optimizing can be achieved. Lastly, Schiphol Airport should define a baseline set of business rules to be used between stakeholders. These can then be used by stakeholders in a way similar to regulation: more stringent is allowed, less stringent is not. Compliance monitoring of stakeholders regarding these business rules by Schiphol Airport is paramount.

References

ACN. (2020, September). Snellere afhandeling exportvracht op Schiphol met Digitaal Vooraanmelden. ACM. Retrieved August 27, 2023, from https://acn.nl/wp-content/uploads/2020/09/Artikel-Vooraanmelden.pdf

Allied Aviation. (2023, April 10). The future of logistics: Trends to watch for in 2023. Allied Aviation. Retrieved August 6, 2023, from https://www.linkedin.com/pulse/future-logistics-trends-watch-2023-allied-aviation-india/

Amsterdam Logistics. (2020, June 4). het nieuwe gezicht van Smart Cargo Mainport Program Schiphol. Retrieved July 20, 2023, from https://amsterdamlogistics.nl/nieuwe-gezicht-van-smart-cargo-mainport-program-schiphol/

Ankersmit, S., Rezaei, J., & Tavasszy, L. (2014). The potential of horizontal collaboration in airport ground freight services. Journal of Air Transport Management, 40, 169–181. https://doi.org/10.1016/j.jairtraman.2014.07.005

Barnett, C. (2018, November 19). Brussels' strategy offers path for congested air cargo hubs | Journal of Commerce. Retrieved July 21, 2023, from https://www.joc.com/article/brussels-strategy-offers-path-congested-air-cargo-hubs_20181119.html

Blaj, A. (2020). Catch the Wave of Linked Data with ONE Record: Looking beyond the hype for real solutions to real problems. In IATA. Retrieved July 18, 2023, from https://www.iata.org/contentassets/a1b5532e38bf4d6284c4bf4760646d4e/one_record_catch_the_wave_of_linked_data_with_one_record.pdf

Bombelli, A., & Fazi, S. S. (2022). The ground handler dock capacitated pickup and delivery problem with time windows: A collaborative framework for air cargo operations. Transportation Research Part E-logistics and Transportation Review, 159, 102603. https://doi.org/10.1016/j.tre.2022.102603

Brandenburger, A., & Nalebuff, B. (2020, December 15). The rules of co-opetition. Harvard Business Review. Retrieved August 8, 2023, from https://hbr.org/2021/01/the-rules-of-co-opetition

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

BRUCloud. (n.d.). BRUCloud. Retrieved July 21, 2023, from https://brucloud.com/about/brucloud

Brunila, O., Kunnaala-Hyrkki, V., & Inkinen, T. (2021). Hindrances in port digitalization? Identifying problems in adoption and implementation. European Transport Research Review, 13(1). https://doi.org/10.1186/s12544-021-00523-0

CAPA. (2023a). Fast Facts - Amsterdam Airport Schiphol. In CAPA - Centre for Aviation. Retrieved August 3, 2023, from https://centreforaviation.com/data/profiles/airports/amsterdam-schiphol-airport-ams/fast-facts

CAPA. (2023b). Fast Facts - Brussels Airport. In CAPA - Centre for Aviation. Retrieved August 3, 2023, from https://centreforaviation.com/data/profiles/airports/brussels-airport-bru/fast-facts

Cargo iQ. (2019). Air Cargo Industry Master Operating Plan: A description of the air cargo industry transportation business process. In Cargo iQ. Retrieved July 14, 2023, from https://a71bcec4-d0e1-4b94-80d6-695ec0bd0435.filesusr.com/ugd/722a02_e289dc70805f4bd491a467906f728abc.pdf

Cargo iQ. (2022, July 6). Cargo iQ launches pilot to close the road freight visibility gap. Retrieved July 19, 2023, from https://www.cargoiq.org/blank-2/cargo-iq-launches-pilot-to-close-the-road-freight-visibility-gap

Cargonaut. (n.d.). eLink. Retrieved July 18, 2023, from https://cargonaut.nl/elink/

Copart, S. (2022). Digital Think Tank White Paper 2022. In IATA. IATA. Retrieved July 14, 2023, from https://www.iata.org/contentassets/a46387f9bc6b42368c0a72664f6f930f/digital_think-tank_white-paper_2022.pdf

Culot, G., Orzes, G., Sartor, M., & Nassimbeni, G. (2020). The future of manufacturing: A Delphi-based scenario analysis on Industry 4.0. Technological Forecasting and Social Change, 157, 120092. https://doi.org/10.1016/j.techfore.2020.120092

de Haan, F., & Streng, M. (2020). Luchtvrachtmonitor 2018. In Erasmus Centre for Urban, Port and Transport Economics. Retrieved July 11, 2023, from https://acn.nl/wp-content/uploads/2020/03/Luchtvracht-monitor-2018-25MAR2020.pdf

Douven, G. (2013). Inholland studenten doen onderzoek naar gebruik van eLink. CargoHub, 30–31. https://www.academia.edu/9135766/Inholland_Cargohub_magazine_Sep_2013

Douven, G., & Lute, D. (2015). 4C Project Hogeschool Inholland. www.academia.edu. https://www.academia.edu/16157115/4C_Project_Hogeschool_Inholland

Egorov, D. E., Levina, A., Kalyazina, S., Schuur, P., & Gerrits, B. (2020). The challenges of the logistics industry in the era of digital transformation. In Lecture notes in networks and systems (pp. 201–209). https://doi.org/10.1007/978-3-030-64430-7_17

Frisoni, R., Dall'Oglio, A., Nelson, C., Long, J., Vollath, C., Ranghetti, D., & McMinimy, S. (2016). Research for TRAN Committee: Self-piloted Cars : the Future of Road Transport? In European Union (IP/B/TRAN/FWC/2010-006/Lot1/C1/SC11). European Parliament's Committee on Transport and Tourism. https://doi.org/10.2861/685052

Gansterer, M., & Hartl, R. F. (2018). Collaborative vehicle routing: A survey. European Journal of Operational Research, 268(1), 1–12. https://doi.org/10.1016/j.ejor.2017.10.023

Gartner. (2023, June 6). Digital Transformation Strategic Guide | Gartner. Retrieved July 17, 2023, from https://www.gartner.com/en/information-technology/topics/digital-transformation

Gobble, M. M. (2018). Digitalization, Digitization, and Innovation. Research Technology Management, 61(4), 56–59. https://doi.org/10.1080/08956308.2018.1471280

Gurumurthy, A., & Bharthur, D. (2019). Impact of digitalisation in the ports sector. Social Science Research Network. https://doi.org/10.2139/ssrn.3873179

Hasnain, S. T. (2015a). IATA Cargo XML: The new messaging standard modernizing air cargo electronic communications - White paper. In IATA. Retrieved July 17, 2023, from https://www.iata.org/contentassets/04c07dd078df47f6b38600a722282e2b/cargo-xml-standards-white-paper.pdf

Hasnain, S. T. (2015b). Cargo Messaging Standards. In unece.org. Retrieved July 17, 2023, from https://unece.org/fileadmin/DAM/cefact/cf_forums/2015_France/PPTs/T_L__IATA-CargoMessagingStandards.pdf

Hasnain, S. T. (2016). White Paper: Air Cargo Digital Connectivity and Data Exchange Methodologies. In IATA. Retrieved July 17, 2023, from https://www.iata.org/contentassets/bf816cd213164e6e8f832070a82029dc/air-cargo-digital-connectivity.pdf

Heikkilä, J., Saarni, J., & Saurama, A. (2022). Innovation in Smart Ports: Future directions of digitalization in container ports. Journal of Marine Science and Engineering, 10(12), 1925. https://doi.org/10.3390/jmse10121925

IATA. (n.d.). About us. Retrieved July 17, 2023, from https://www.iata.org/en/about/

IATA. (2020). e-AWB international monthly report. In IATA. Retrieved July 17, 2023, from https://www.iata.org/contentassets/4bc75639b37641ba88f2e81e5516a020/e-awb-monthly-report-r17.pdf

Inkinen, T., Helminen, R., & Saarikoski, J. (2019). Port Digitalization with Open Data: Challenges, Opportunities, and Integrations. Journal of Open Innovation, 5(2), 30. https://doi.org/10.3390/joitmc5020030

Ionides, N., Gorelik, A., & Leopold, E. (2019, March 6). Dossier: Blockchain of trust. IATA. Retrieved July 18, 2023, from https://airlines.iata.org/2019/03/06/dossier-blockchain-trust

Jandrić, M., & Ranđelović, S. (2018). Adaptability of the workforce in Europe – changing skills in the digital era. Zbornik Radova Ekonomskog Fakulteta Rijeka, 36(2). https://doi.org/10.18045/zbefri.2018.2.757

Jeffrey, R. (2022, August 3). RFS services grow against challenging economic backdrop - Air Cargo News. Air Cargo News. https://www.aircargonews.net/monthly-exclusive/rfs-services-grow-against-challenging-economic-backdrop/

Kern, J. (2021). The Digital Transformation of Logistics. The Digital Transformation of Logistics (Eds M. Sullivan and J. Kern), 361–403. https://doi.org/10.1002/9781119646495.ch25

Klein, L. R. (1960). Some theoretical issues in the measurement of capacity on JSTOR. Econometrica, 28(2), 272–286.

Kuteyi, D., & Winkler, H. (2022). Logistics challenges in Sub-Saharan Africa and opportunities for digitalization. Sustainability, 14(4), 2399. https://doi.org/10.3390/su14042399

Léopold, E. (2018). Blockchain in Aviation. In Exploring the Fundamentals, Use Cases, and Industry Initiatives. IATA. Retrieved July 14, 2023, from https://www.iata.org/contentassets/2d997082f3c84c7cba001f506edd2c2e/blockchain-in-aviation-white-paper.pdf

Markill, J. (2016, March 16). Descartes Renames Cargo 2000<sup>TM Air Cargo Data Quality Solution to Descartes Cargo iQTM | Descartes. Descartes. Retrieved July 17, 2023, from <span>https://www.descartes.com/resources/blog/descartes-renames-cargo-2000tm-air-cargo-data-quality-solution-descartes-cargo-iq

Muro, M., Liu, S., Whiton, J., & Kulkarni, S. (2017). Digitalization and the American workforce. In brookings.edu. Brookings. Retrieved July 11, 2023, from https://www.brookings.edu/wp-content/uploads/2017/11/mpp_2017nov15_digitalization_full_report.pdf

Nallian. (n.d.). Communities | Nallian. Retrieved July 21, 2023, from https://nallian.com/communities

Newton, G. (2023, June 8). Blockchain – A technology for today. Airlines Magazine, 2, 28–29.

Nguyen, H. P., Nguyen, P. Q. P., Nguyen, D. K. P., Bui, V. D., & Nguyen, D. T. (2023). Application of IoT technologies in Seaport Management. JOIV : International Journal on Informatics Visualization, 7(1), 228. https://doi.org/10.30630/joiv.7.1.1697

Nowell, L., Norris, J. M., White, D., & Moules, N. J. (2017). Thematic analysis. International Journal of Qualitative Methods, 16(1), 160940691773384. https://doi.org/10.1177/1609406917733847

Oxford University Press. (n.d.). Definition of predictability. In Oxford Advanced Learner's Dictionary. Retrieved July 24, 2023, from https://www.oxfordlearnersdictionaries.com/definition/english/predictability

Parola, F., Satta, G., Buratti, N., & Vitellaro, F. (2020). Digital technologies and business opportunities for logistics centres in maritime supply chains. Maritime Policy & Management, 48(4), 461–477. https://doi.org/10.1080/03088839.2020.1802784

Phan, M., & Kim, K. H. (2015). Negotiating truck arrival times among trucking companies and a container terminal. Transportation Research Part E-logistics and Transportation Review, 75, 132–144. https://doi.org/10.1016/j.tre.2015.01.004

Poleshkina, I. (2021). Blockchain in air cargo: challenges of new World. MATEC Web of Conferences, 341, 00021. https://doi.org/10.1051/matecconf/202134100021

Raza, Z., Woxenius, J., Vural, C. A., & Lind, M. (2023). Digital transformation of maritime logistics: Exploring trends in the liner shipping segment. Computers in Industry, 145, 103811. https://doi.org/10.1016/j.compind.2022.103811

Riege Software. (2020, December 15). Riege Software joins CargoHub Trucking CDM platform [Press release]. https://www.riege.com/s/hzlhcumouogt/

Romero-Silva, R., & Mujica Mota, M. (2022). Trade-offs in the landside operations of air cargo hubs: Horizontal cooperation and shipment consolidation policies considering capacitated nodes. Journal of Air Transport Management, 103. https://doi.org/10.1016/j.jairtraman.2022.102253

Rotterdam World Gateway. (2023, March 27). Surcharge on time slots during peak hours. www.rwg.nl. Retrieved September 2, 2023, from https://www.rwg.nl/en/news/639

Sahin, F., & Robinson, E. P. (2004). Information sharing and coordination in make-to-order supply chains. Journal of Operations Management, 23(6), 579–598. https://doi.org/10.1016/j.jom.2004.08.007

Sauv, D. (2021). IATA & the story of the electronic Air Waybill (e-AWB). In IATA. Retrieved July 18, 2023, from https://uncitral.un.org/sites/uncitral.un.org/files/media-documents/uncitral/en/Webinardematerializationnegotiabletransportdocuments/presentations/david_sauv.pdf

Savelsbergh, M., & Sol, M. (1995). The general pickup and delivery problem. Transportation Science, 29(1), 17–29. https://doi.org/10.1287/trsc.29.1.17

Schiphol. (2023, June 30). Milkrun: een duurzamer vrachtproces. Retrieved August 21, 2023, from https://www.schiphol.nl/nl/schiphol-group/blog/milkrun-een-duurzamer-vrachtproces-dankzij-de-melkboer/

SCMP. (2022). SCMP Digital [PDF].

Taalbi, J. (2018). Origins and pathways of innovation in the third industrial revolution1. Industrial and Corporate Change. https://doi.org/10.1093/icc/dty053

Teubner, R. A., & Stockhinger, J. (2020). Literature review: Understanding information systems strategy in the digital age. Journal of Strategic Information Systems, 29(4), 101642. https://doi.org/10.1016/j.jsis.2020.101642

The World Bank. (2020). Accelerating Digitalization: Critical Actions to Strengthen the Resilience of the Maritime Supply Chain. In The World Bank - Mobility and Transport Connectivity Series.

Tijan, E., Jović, M., Panjako, A., & Žgaljić, D. (2021). The role of Port Authority in port governance and Port community system implementation. Sustainability, 13(5), 2795. https://doi.org/10.3390/su13052795

TKI Dinalog. (2022). Predictive analytics and collaborative planning in air cargo logistics: PRACTICAL. In TKI Dinalog.

UNECE. (n.d.). Airport community systems. United Nations Economic Commission for Europe. Retrieved August 3, 2023, from https://tfig.unece.org/contents/airport-community-systems.htm

van Alebeek, S., & Bombelli, A. (2021). Auction-based coopetition in the landside air cargo supply chain. Journal of Supply Chain Management Science, 2, 3–18. https://doi.org/10.18757/jscms.2021.5781

Verdonck, L., Caris, A., Ramaekers, K., & Janssens, G. K. (2013). Collaborative Logistics from the Perspective of Road Transportation Companies. Transport Reviews, 33(6), 700–719. https://doi.org/10.1080/01441647.2013.853706

Verduijn, T., Vunderink, S., Bombelli, A., Tavasszy, L., Van Damme, D., Romero-Silva, R., & Mota, M. M. (2019). Smartest Connected Cargo Airport Schiphol: Onderzoek naar innovaties die de logistieke prestaties van luchtvrachtketens op Schiphol versterken. Publicatiereeks HvA Faculteit Techniek, 15, 9789492644190. https://research.hva.nl/files/6282785/HvA_SCCAS_definitief.pdf

Versleijen, J. (2023, February 23). Schiphol krijgt nieuw IT-vrachtplatform maar niet van de grond. Nieuwsblad Transport. Retrieved July 18, 2023, from https://www.nt.nl/luchtvracht/2023/02/23/schiphol-worstelt-met-bouw-nieuw-it-vrachtplatform-cargonaut-2-0/

Vrancken, R. E. M. (2020). Optimizing the freight handling in the air cargo handling chain: the concept of drop and collect [Master thesis]. Eindhoven University of Technology.

Wang, S., & Yan, R. (2023). Fundamental challenge and solution methods in prescriptive analytics for freight transportation. Transportation Research Part E: Logistics and Transportation Review, 169, 102966. https://doi.org/10.1016/j.tre.2022.102966

Wang, T., Tian, X., & Wang, Y. (2020). Container slot allocation and dynamic pricing of time-sensitive cargoes considering port congestion and uncertain demand. Transportation Research Part E-logistics and Transportation Review, 144, 102149. https://doi.org/10.1016/j.tre.2020.102149

Xu, B., Liu, X., Yang, Y., Li, J., & Postolache, O. (2021). Optimization for a Multi-Constraint truck appointment system considering morning and evening peak congestion. Sustainability, 13(3), 1181. https://doi.org/10.3390/su13031181

Zaharia, S., & Pietreanu, C. V. (2018). Challenges in airport digital transformation. Transportation Research Procedia, 35, 90–99. https://doi.org/10.1016/j.trpro.2018.12.016

Zaheer, N., & Trkman, P. (2017). An information sharing theory perspective on willingness to share information in supply chains. The International Journal of Logistics Management, 28(2), 417–443. https://doi.org/10.1108/ijlm-09-2015-0158

Appendices

Further appendices containing interview transcrips can be found in the separate appendices document:

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Appendix I. Interview protocol

English version

I. Background of stakeholders

1. Could you provide an overview of your role and responsibilities within your company regarding cargo operations at Schiphol?
2. How does the unpredictability of export cargo flows affect your company if it does?

II. Digital solutions

3. Which digital technologies do you think could be implemented to increase predictability?
4. How could you implement this in your organization?

III. Challenges

5. Which challenges do you expect when implementing digital technologies?
6. What could you do to alleviate these challenges?
7. How will an increase in predictability benefit your organization?

IV. Operationalizing

8. Which possible challenges do you foresee when operationalizing digital technologies?
9. Who should kickstart these initiatives?

V. Specific technologies

Please read the following definitions:

Dynamic scheduling and slot management technology *center around a collaborative application that enables the cargo community's ground handlers, freight forwarders, and trucking companies to better coordinate their freight handling processes.*

Horizontal collaboration *involves companies operating at the same value chain level but usually in different chains. For example, trucking companies A and B operate at the same value chain level while serving different freight forwarders. They collaborate by sharing capacity, planning, handling services, and possibly even booking services.*

10. How would a dynamic scheduling and slot management technology affect your organization?
11. What are your thoughts on fostering horizontal cooperation among air cargo stakeholders to address landside congestion at Schiphol Airport?
12. What are your thoughts on a third party being made responsible for orchestrating the entire landside operation at Schiphol, considering the different stakeholder requirements/business rules?
13. What would be the main reasons for your company to engage or not engage in horizontal cooperation?

Dutch version

I. Achtergrond van stakeholders

1. Kan je iets vertellen over jouw rol en verantwoordelijkheden binnen jouw werkgever met betrekking tot de vrachtoperatie op Schiphol?
2. Welke invloed heeft de onvoorspelbaarheid van export op uw bedrijf indien dit het geval is?

II. Digitale oplossingen

3. Welke digitale technologieën kunnen volgens jou worden geïmplementeerd om voorspelbaarheid te vergroten?
4. Hoe zou je dit in je organisatie kunnen implementeren?

III. Uitdagingen

5. Welke uitdagingen verwacht je bij de implementatie van digitale technologieën?
6. Wat zou je kunnen doen om deze uitdagingen te verlichten?
7. Hoe komt een vergrote voorspelbaarheid jouw organisatie ten goede?

IV. Operationalisering

8. Welke mogelijke uitdagingen of obstakels voorzie je bij het operationaliseren van digitale technologieën?
9. Wie moet deze initiatieven initiëren?

V. Specifieke technologieën

Lees de volgende definities:

Dynamic scheduling and slot management technology *draait om een samenwerkingstoepassing die de grond afhandelaars, expediteurs en truckers van de vrachtgemeenschap in staat stelt hun vrachtafhandelingsprocessen beter te coördineren.*

Horizontal collaboration *gaat het om bedrijven die op hetzelfde waardeketenniveau opereren, maar meestal in verschillende ketens. Vrachtwagenbedrijven A en B werken bijvoorbeeld op hetzelfde waardeketenniveau en bedienen verschillende expediteurs. Ze werken samen door capaciteit te delen, te plannen, diensten af te handelen en mogelijk zelfs diensten te boeken.*

10. Hoe zou dynamic scheduling and slot management uw organisatie beïnvloeden?

11. Hoe denk je over het bevorderen van horizontale samenwerking tussen stakeholders in de luchtvracht om de congestie aan landzijde op Schiphol aan te pakken?
12. Als een derde partij verantwoordelijk wordt gemaakt voor het organiseren van de gehele landside operatie op Schiphol, rekening houdend met de verschillende stakeholder requirements/business rules, wat zou je daar van vinden?
13. Wat zijn de belangrijkste redenen voor uw bedrijf om al dan niet horizontaal samen te werken?