Applications within Logistics 4.0

A research conducted on the visions of 3PL service providers

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ABSTRACT,

This study examined which Industrie 4.0 applications are implemented by Third-party Logistics (3PL) providers, in order to improve their value adding services of Warehousing, Transportation, Packaging, Distribution, Loading/unloading and Information services. The fourth industrial revolution with its characteristic elements of Big data, Sensors, the Internet of Things, Cyber-Physical Systems and Machine to machine communication has caused a paradigm shift within the Logistics industry. In this rapidly changing environment, organisations tend to be indecisive on what pathways to follow. To guide these organisations in their decision making, this study was drawn up and answered the question: "What different Logistics 4.0 applications are used in current and future 3PL business activities and what functions are covered?" At the heart of this research lie four emerging technological developments: Blockchain technology, Autonomous Vehicles, Electronic marketplace platforms and 3D Printing. In order to find how these technologies are put into practice and to provide an answer to the research question, a semi structured in-depth interview was conducted with DB Schenker. The study was further complimented with a secondary research on the companies DHL, Kuehne+Nagel, and Panalpina. Outcomes of the research let to five fields in which the four researched 3PL organisations are actively implementing applications. These fields are defined as: Freight brokerage trends enabled by electronic marketplace platforms, Nearshoring and changing production processes due to 3D Printing, Transportation efficiencies through truck platooning and drones, Warehousing and distribution operations due to autonomous vehicles and robots, and the safe and trustful sharing of information throughout all processes due to Blockchain technology. The synergy between these fields leads to large opportunities within the logistics industry and their implementation will mean a large step towards Logistics 4.0.

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Keywords
Industrie 4.0, Logistics 4.0, 3PL, ELM, Truck platooning, Nearshoring, Blockchain, 3D printing, Freight brokerage

9th IBA Bachelor Thesis Conference, July 5th, 2017, Enschede, The Netherlands.

1. INTRODUCTION

1.1 A bachelor thesis providing insights on applications within Logistics 4.0 strategies

In this Bachelor Thesis, a study is conducted, on the different Industrie 4.0 applications applied by logistics companies, in their current and future fulfilment of third party logistic (3PL) services. The emergent rise of Industrie 4.0 innovations is predicted to have a large impact in different divisions of industries and will change the ways in which organisations conduct business. A study conducted by Heng (2014) predicts that Industrie 4.0 is bound to increase the German Gross value with EUR 267 Billion by 2025.

Industrie 4.0 thus counts as a huge transition and is believed to be the fourth industrial revolution. Research on the topic, could lead to great added value and a competitive advantage over laggards.

Former studies have often focused on the implementations of Industrie 4.0 on manufacturing and the creation of 'Smart Factories'. In this study however, the focus lies on another part of the supply chain and looks at how Industrie 4.0 application increase efficiency in logistic services.

The subjects of study are the logistical service providers, within industry jargon also known as 3PL service providers. Neaga et al. (2015) describe these 3PL providers as "an external supplier that performs part or all of the logistics functions of companies (Neaga et al.,2015, p.23) The 3PL adds value to the companies' supply chains by providing Warehousing, Transportation, Packaging, Distribution, Loading/unloading and Information services. (see Figure 1) (Zhou, 2013, p.132)

If a 3PL service provider aims to make its services more efficient, innovations within these six services are needed. This is why, in this study, these six services are used as a framework for the different business processes of 3PL service providers.

This study entitled "Applications within Logistics 4.0" is a qualitative research that will attempt to acquire information on the different applications that are contributing to a better, quicker and more efficient way of conducting logistic services. Information is acquired via a semi-structured in-depth interview conducted with the logistics company 'DB Schenker' and complemented with a secondary literature research on the 3PL service providers: DHL, Kuehne+Nagel, and Panalpina. Through these researches an answer will be provided on the question: "What different Logistics 4.0 applications are used in current and future 3PL business activities and what functions are covered?" By answering this question, the paper serves as a reference for organisations to find what possibilities lie within the fourth industrial revolution and how the biggest global 3PL service providers apply these in their operations.
In this paper, first a theoretical framework is set up, after which the Methodology of the study is elaborated. Then the results are displayed, which give insights in the different kinds of applications that are used by the 3PL organisations. A conclusion and discussion on the basis of these results is drawn up and finally the acknowledgement are stated.

2. THEORETICAL FRAMEWORK

2.1 Background on Industrie 4.0

2.1.1 A fusion of the physical and virtual world in the fourth industrial revolution

Industrie 4.0 is coined as the fourth industrial revolution, hence the '4.0'. To understand this terminology, a brief summarisation on the earlier three revolutions is necessary. The first Industrial revolution was characterised by the introduction of the steam engine, which provided mechanical motion for labour activities and resulted in the transition from hand production to machine production. The second revolution was characterised by the mobilisation of people and information due to improvements of infrastructure facilities as railroads

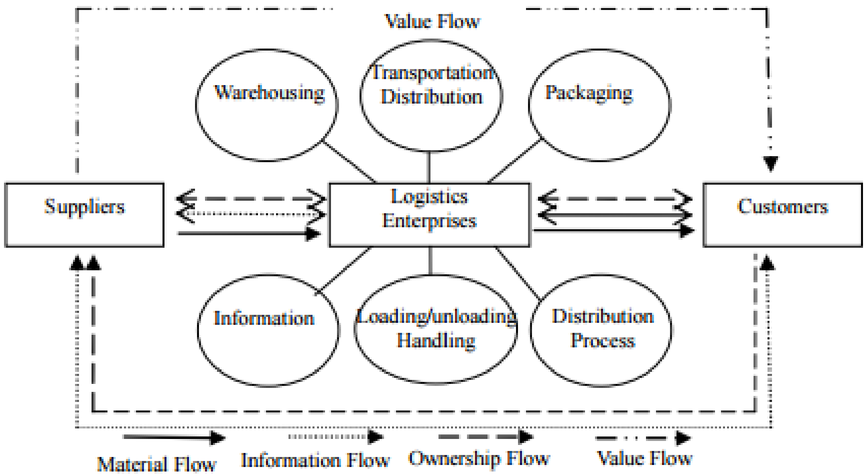

Figure 1. Services within the logistics value chain.

and telephone lines. Technological innovations, as the factory electrification and the development of the production line, enabled mass production. In the Third revolution, the rise of computers and communication systems occurred. Which facilitated a better accessibility of information gathering, processing and analysing. Enabling automated production. (Pentek & Otto, 2015, p.5)

The Fourth Industrial Revolution, in which Industrie 4.0 is settled, builds further on the automation and information technologies of the Third Industrial Revolution. Pentek and Otto (2015) state that in the fourth revolution, the physical and the virtual worlds are combined (or fused) due to the use of Cyber-physical systems, which are able to connect with other systems via machine-to-machine communication through the Internet of things. These Cyber-physical systems are steered via Big data that is obtained through sensors or other data gathering devices. (Pentek & Otto, 2015, p.8)

2.1.2 Big data, Sensors, the Internet of Things, Cyber Physical Systems and Machine to machine communication as the characteristic elements of Industrie 4.0.

Throughout all Industries, Internet of Things is understood to be "the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other)" (Morgan, 2014, para. 3) Following the prediction analysis of Gartner (2015), there will be a global amount of 20.8 billion connected devices by 2020. These devices are steered via the use of Big data, which, besides of the IoT, is also seen as an important development within Industrie 4.0. Via analysis of large data sets, organisations are able to obtain patterns, trends or insights for their business activities. (Swaminathan, 2012; Long, M. 2017, p.33)

The use of this data leads to many benefits. The level of information transparency improves as well as process quality and performance. Predictive analytics are performed on the data sets to calculate resource demands and provide better planning. New or disruptive scenarios are being tested with simulation practices. And cyber physical systems as autonomous vehicles or robots are improved due to data obtained from sensors, which map their direct environment. (Jeske & Grüner 2013 p.6; Witkowski, K.2017a, p.765; Wang et al.2016/6 p.99-100)

In the Logistics industry, where 3PLs manage millions of daily shipments, large amounts of data is obtained via orders transcripts, smart low battery consuming sensors, GPS, RFID tags, weather forecasts or even social media. (Neaga, 2015 p.24). These sensors measure real-world conditions and convert these into digital representation. Often the sensors are installed with a microprocessor, which filters the data and compensates for errors before sharing the data. These kind of sensors are called "Smart Sensors". (PC Magazine Encyclopedia - sensor definition, 2016; PC Magazine Encyclopedia - smart sensor definition, 2016)

In Table 1 an overview is provided on the most commonly used sensor types and their purposes within the logistics industry.

Table 1. Sensor types and their purposes

Sensor Type[a,b]	Measurement Purpose
Accelerometer[c]	Acceleration of moving objects
Proximity sensor[d] (RADARs, ultrasonics)	Detecting ranges to nearby objects
LIDARs[e]	Detecting ranges to nearby objects
Temperature, humidity, and barometer sensors	Environmental analysis
RFID[f]	Tag identification
Time-of-Flight cameras[g]	Depth imaging
Vision cameras	Visual analytics Geometric dimensions Physical orientation
Global Positioning system (GPS)	Determining location

[a] Sven and Ortmann. 2013. p.8
[b] Kala, 2016, p.12
[c] "What Is an Accelerometer? - Definition from Techopedia." 2017.
[d] "What Is a Proximity Sensor? - Definition from Techopedia.", 2017.
[e] US Department of Commerce, National Oceanic, and Atmospheric Administration. 2012.
[f] "RFID Definition from PC Magazine Encyclopedia.", 2017.
[g] Hansard et al., 2013.

A third characteristic of the Industrie 4.0 is the use of the earlier mentioned Cyber physical systems. Lee et al. (2015) describe Cyber-Physical Systems (CPS) as "transformative technologies for managing interconnected systems between its physical assets and computational capabilities" (Lee, Bagheri, & Kao, 2015, p.18). Cyber Physical systems therefore have a physical component and a digital component. The digital component analyses, calculates or plans actions and steers the physical component to perform a task. Cyber physical systems are used in all kinds of business activities as moving goods or adjusting machine output.

These Cyber-physical systems do not act on their own, which leads to the fourth characteristic of Industrie 4.0, called Machine-to-machine communication. Due to wireless communication, wherein the systems exchange data (through the internet) the systems are able to collaborate with each other. ("What is Machine-to-Machine – M2M Definition", 2017) With the use of these communications, machines are able to realise synergetic benefits by acting as an integrated collective, which provides optimal solutions for physical actions. Systems are able to interact with each other, bind processing power, or divide tasks.

2.1.3 Four emerging benefits from the use of Industrie 4.0 applications.

Hermann et al. (2016) distinguish Industrie 4.0 applications into four key principles. The first is 'Interoperability between cyber physical systems', which emphasized the collaboration between the different cyber-physical systems via the Internet of Things. The second principle is 'information transparency', which accentuates the large amounts of data that are processed into information and are shared, in order to establish an open and transparent business environment. The third important benefit is described as the ways in which Industrie 4.0 provides 'technical assistance' to humans, by providing the user with systems that are able to assist in the performance of complex tasks within for example production activities. Lastly the fourth principle is described, in which the focus lies on the 'autonomous decision-making' of the cyber-physical systems. Through the increasing quality of transparent information available for these systems, and their improving programming, autonomous decision making by cyber physical systems is becoming more developed. (Hermann, Pentek, & Otto, 2016 p. 3932-3933)

2.1.4 Logistics 4.0

All Industrie 4.0 applications within the logistics industry, fall under the denominator Logistics 4.0. Within logistics, process efficiency is an important indicator. Therefore all Logistics 4.0 applications in a way strive to increase efficiency. This efficiency is obtained by realising the four above mentioned Industrie 4.0 principles on the key logistical services of Warehousing, Transportation, Packaging, Distribution, Loading/unloading and Information services. The innovations in this services are enabled by technological developments. In the next chapters of this theoretical framework, these technological developments are further explained.

2.2 Blockchain Technology

2.2.1 Block Chain technology used for secured open data sharing

Because data is increasing in amount and possible functionalities, it is becoming a valuable asset for logistic companies. (Zyskind, Nathan & Pentland, 2015, p.180) Its value is therefore often explained by companies as a source of a competitive advantage. Baker (2015) explains that organisations tend to hold on to this data and keep it secret. This, however, strikes with the increasing demand for information transparency by customers, who are much more socially and environmentally aware and more often request information about process steps within product supply chains. (Bell et al., 2016, p.5-9)

This information is commonly unknown for the customers. And this is why third parties collect this information and share it, while acting as a data broker. These third parties often act alone, and this leads to the reliability of the shared data being dependent on the incentives of the broker. Shared data is therefore often biased or vulnerable for corruption or other power inequalities, leading to untrusted information sources. (Baker, 2015)

A new way of open data sharing is needed, and is found in 'Blockchain technology'.
Block chain technology was first used for the cyber currency 'Bitcoin'. Through the new technology, two people were able to transact money (data) over the internet, without the need of a bank, acting as an intermediary third party. The technology relies on a system in which all transactions ever made by all members within the system are documented, so that everybody knows how the sharing party has obtained his information. Via this 'chain' each piece of data can be traced back towards its primary source. The data system itself therefore provides the trust. The data in the system is stored in a decentral database, which is controlled by everybody in the system, therefore power inequalities do not exist. (Baker, 2015)

2.2.2 Data sharing between two parties via verified blocks in a block chain

Baker (2015) further explains the working of the Blockchain technology. It starts with two parties (people or systems), who wish to share data. The data send by party A is secured and can be accessed by party B via an encryption key, which is unique and only assigned to the particular interaction (the data sharing between party A and B).
Subsequently the interaction is broadcasted to the block chain network, which verifies if the sharer of the data truly owns the data and if the interaction is legit. (-Dittmar, 2016, p.3) This is performed by checking the 'chain' of earlier interactions, to find proof that the sharing party really has obtained the information and therefore is able to share it. The sharing party could have earlier obtained the data from an earlier interaction with another party. Or he could have uploaded the data himself, making him the primary source. If the sharing party's possession of the data is verified, the interaction is valid, and is than converted into a 'block' and added to the rest of the 'Blockchain'. The interaction is logged and other members of the Blockchain can find that the interaction has occurred. But because the data is encrypted with a key, only the two interacting parties are able to look into the actual data. The next time party B wishes to share the same data with a new party. The system will again verify the whole chain of the data, and will find that party B indeed received the data from the interaction with party A and the data sharing is then again validated. (Baker, 2015)

2.2.3 Practical control on Supply chain activities

The practical difference between the third party broker sharing data and the Blockchain, is that with the former, the receiving party is depending on only one source, validating the information and the request for the data stays secret, resulting in a closed data sharing environment. With the latter however, the data can be traced back through the chain to the actual source. And because every interaction is published, everybody is able to view others requests, resulting in an open data sharing environment. In Appendix B, the schematic outline of the working of a block chain is again demonstrated. (Baker, 2015)

Within logistic supply chains, a customer could request to control the supply chain of a product on the conditions in which it was produced or transported. If all parties are connected to the block chain system, the customer can request the information, which was added by the suppliers, transporters and retailers to its chain, creating a holistic view on all conditions. Because the information is verifiably directly coming from the source, and without mediation of a third party, it therefore serves as a trusted source of information.

The Blockchain technology facilitates a save and open sharing of information, which in the fourth industrial revolution is vital for the control of cyber physical systems. One of the emerging systems is that of Autonomous vehicles, whose technological development is explained in the next chapter.

2.3 Autonomous Vehicles

2.3.1 A transition toward fully autonomous vehicles

Following the predictions, an increase of 57% will occur in the total freight forwarding, between 2010 and 2050. (De Vita et al, 2013, p.39) In order to keep up with this growing capacity demand, new innovative ways of transport are required. One of the key technological innovations on the innovation radar is the use of Autonomous vehicles. Although researchers have predicted the development of driverless, radio-controlled, electric cars since 1939. (Vanderbilt, 2012) Technological developments had not been sufficiently evolved to realise these concepts. In the Industrie 4.0 era, technology has been emerging, which have accelerated the progress. Advances in the fields of smart sensors, processors, integrated systems, data sharing and the Internet of Things have resulted in a charted course from traditional manual driving by humans towards autonomous vehicles, fully steered by computers. (Anderson, et al, 2016, p.2).

2.3.2 Truck platooning enabled by Cooperative adaptive cruise control technology

In their study on autonomous driving, the OECD describe a truck automation pathway existing out of 5 levels, ranging from: no driving task automation (level 0) to full automation (Level 5). (see Appendix C) (OECD/ITF, 2015, p.23) Due to the complex and hybrid nature of vehicle autonomation, the process is marked by many uncertainties. (Kamali et al., 2016, p.2). In order to let the legislative and social developments keep up with the technological possibilities, the transition is performed in incremental steps. The timing, when fully automated vehicles are available, is still unknown, but due to advances associated with Industrie 4.0, a big step forward is set. One of the key developments in this transition are the concepts of Cooperative adaptive cruise control and truck platooning. Which will be explained in the following paragraph. Autonomous vehicles fully rely on sensors to acquire the data, needed for its automation. In Appendix D a schematic overview is displayed of the different sensor technologies that are installed around a vehicle. Most data is acquired via vision cameras, RADARs, ultrasonics and LIDARs, which enable the vehicle to sense its environment and generate a map. (Kala, 2016a, 12) On the basis of this map, so called motion-planning algorithms decide on what movements the vehicle should make. (Katrakazas, et al. 2015, p. 417-418) These signals are passed through to the ‘advanced driver assistance systems’ that execute the demanded movements of the car. Traditional driver assistance systems are crash warning systems, adaptive cruise control (ACC), lane keeping systems, and self-parking technologies. (Anderson, et al, 2016, p.2).

In addition to the traditional adaptive cruise control, which enables a vehicle to brake or accelerate to keep up a certain vehicle speed, the concept of Cooperative ACC Platooning is introduced. (Gao et al. 2016, p.234) This concept is the precursor on truck platooning, and enables the coupling of a vehicle to its predecessor and keeping a short and safe distance to it, via automated distance control, braking and accelerating. Other functions as steering or throttling are still manually performed by the truck driver. (OECD/ITF, 2015, p.19-20)

Truck platooning builds further on this concept of CACC, but adds support in the other driving function as well. Besides braking and accelerating, the truck is also installed with automated steering and throttling, enabling it to autonomously follow a leading truck within a specific driving lane. Due to this ‘vehicle to vehicle’ (V2V)-communication, trucks are able to drive closely (up to 4.7 meters apart) together in a coordinated formation, forming a road-train or platoon. (Tsugawa et al., 2016, p.68) The first truck in the platoon is controlled manually, and is automatically followed by the following truck(s).

In the logistics sector the two main expenses concerning land transport are fuel and personnel costs. (Schittler, 2003, p.2) Vehicles participating in a platoon experience a decrease in aerodynamic drag force, which leads to reduced energy emission and costs, by 10-15%. Besides that the computer-controlled system has a quicker response time than humans, which increases the road safety. The last advantage of truck platooning is perceived by the driver, who will experience an increase in comfort and convenience, while driving. (Tsugawa et al., 2016, p.68)

2.4 Electronic Marketplace Platforms

2.4.1 Bringing together shippers and carriers via Electronic marketplace platforms

Since the rise of Internet, electronic marketplaces have been developing. These EMs are referred to as “an inter-organizational information system where buyers and sellers can meet to conduct business.” (Kale et al. 2016, p.139) Within the logistics industry, these EMs are referred to as Electronic Logistics Marketplaces (ELMs); (Kale et al., 2016, p.140). For these ELMs yields that they bring together shippers and carriers of transport goods via web-based systems. These systems optimise supply chains, enable customised logistics and improve transportation performance.

Within ELMs a distinction is made between closed ELMs, where partners seek long term commitments, and open ELMs, where short term, money based deals are realised. In this study the focus will lie on the open ELMs, where the organisations of study, use other methods, for finding long term partnerships. (Kale et al., 2016, p.139-141)

2.4.2 Open ELM via machine-to-machine freight matching and negotiations

An Open ELM consists out of open platforms, where any shipper or carrier can access and participate in freight transportation auctions. These auctions are characterised by the many-to-many transactions, (Paché & Colin, 2015, p.5) where the pricing can be both fixed and dynamic. This Open ELM method is often referred to as spot sourcing, where transport services are traded on an ad-hoc basis. Priority lies on pricing and negotiations are held quickly. Spot sourcing is therefore used to trade short term, often small capacities of residual space within cargo compartments. (Kale et al., 2016, p.139-141)

Traditionally, third industrial freight matching negotiations were performed with human interference. Within the Industrie 4.0 era, characterized by developments in the fields of the Internet of Things, Autonomous robots and Machine-to-machine communication, so called cyber negotiations are now possible in these cargo capacity auctions. (Schiele, 2016, p.16-17) In this 100% machine-to-machine real-time freight matching, no human interference is needed. Data needed for negotiations are provided by the organisation's own ERP (Enterprise Resource Planning) or Transport management-systems. (Bolam, 2016, paragraph 5) The data is shared with a negotiation system, which handles the open auctions, and negotiates for best prices with other organisation's negotiation systems via its algorithms, eventually finding the best fitting solution for all parties. As with all machine-to-machine applications, the large processing power of the computers, enables a much larger capacity of negotiating. Resulting in quicker, better and cheaper freight transportation solutions.
(Schiele, 2016, p.16-17)

2.4.3 A win-win method for both shippers and carriers

The open platforms are beneficial for both the shippers and the carriers. Due to the fact that every system is able to join the platform, more competition is created between the bidding systems. Resulting in lower pricing for the shippers. Carriers on the other hand, benefit from the increasing pool of shippers, where they can choose the best fitting solution to fill up their cargo capacity and reduce empty runnings. (Kale et al., 2016, p.140)

Applications as Blockchain technology and Demand prediction, which are also treated in this study, have a facilitating role in these Electronic Marketplace Platforms. The information transparency technologies of Blockchain enable the safe sharing of data, by letting the organisation stay in control of vital organisational data. Customer references are also trustful and unbiased, because the rating system is not managed by a third party, but by all parties in the network.

2.5 3D Printing

2.5.1 An emerging technology with high investment support

When discussing the (future) applications within Logistics 4.0, the rise and impact of 3D printing should not be neglected. 3D Printing is described by Mohr & Khan (2015) as "one of the most disruptive phenomena to impact supply chains and the global logistics industry. " (Mohr & Khan, 2015, p.147) in this decade. 3D Printing (3DP) or Additive Manufacturing (AM) is defined by the American Society for Testing and Materials (ASTM) as: "a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies" (F42 Committee, 2012, p.2)

3D printing thus enables the printing of a product, on the basis of a 3D blueprint. This way of production leads to several benefits, including a reduced time-to-market, reduced waste, improved maintenance processes and costs, reduced inventory and reduced costs of spare parts production.(Thewihsen et al. 2016, p.3)

Several technological developments have been occurring, explaining the large interest in the system. The printers have increased in quality control of outputs and printing speed. Another advancement is the increase in materials and materials providers applicable for 3DP use. The current generation engineers is better educated on the new technology, resulting in a workforce with more knowledge on 3D printing. Due to all these improvements, organisation's management is more interested in 3DP and its possibilities. (Thewihsen et al. 2016, p.3)

Estimations are that 3D printing will reach a global value between $180 billion and $490 billion by 2025. (Chung & Niezgoda, 2016, p.3).An enormous hype is occurring on the new technology, creating a strong push on its applications and development. Gartner investigated the hype and states that: "Many industries have moved beyond leveraging 3DP in experiments and will be approaching an inflection point within the next five years, where executing on 3DP is industrialized into the value chain." (Dizdar et al., 2016, p.11) The hype cycle is shown in Appendix E.

2.5.2 Different production methods due to the 3D printing

Within the framework of Logistics 4.0, where machine-to-machine communication enables cyber-physical components within integrated supply chains, 3D Printing could play a viable role in facilitating increased product to market processes. Linked ERP systems could autonomously demand the printing of a product, which will be quickly made available for the customer. Currently, four scenarios are thinkable in which these cyber-physical 3DP devices could be applied.

2.5.2.1 Shorter product to market, leading to nearshoring, reduction of freight miles and an increase importance of last mile shipping

In traditional manufacturing companies tended to outsource their production to countries with low labour costs.(Aeb GmbH., n.d., p.6) Due to 3D printing, these organization are able to produce near their consumer market, which is often in the high-wage countries. This 'near shoring' results in the fact that long-distance shipping of goods will be reduced and local 3DP production sites will rise. The focus within Logistics will shift towards "last mile" shipping, and phenomena as End-of-runway services, where logistic companies install special 3DP warehouses next to important airport hubs, in order to realise fast response times will arise. (Aeb GmbH., n.d., p.6-7)

2.5.2.2 Mobile Production facilities

Another possible scenario for the logistics industry is the introduction of mobile production locations. Due to alternative energy and stabilization technologies, containers on current transport vehicles as trucks, trains or planes could be transformed into mobile 3D printing facilities. While on transport, the 3D Printing installation within the container could produce the customized product, demanded by the customer. These mobile production plants are able to produce different kinds of products, if provided with the product's blueprint and materials. Reducing lead times and increasing flexibility and agility. (3YOURMIND, 2016, paragraph 1-10.)

2.5.2.3 Reducement of storage space and warehousing

Organisations are often regulated to provide customers with spare parts for sold products. This leads to a large usage of inventory space of spare parts that are commonly not needed or have a limited shelf life. (Aeb GmbH., n.d., p.9) Due to 3DP these spare parts could now be stored digitally and be printed if needed. This reducing the inventory warehouses significantly. Scenarios are described in which these digital warehouses are managed by logistic service providers, which store the blueprints of spare parts and provide the parts to the customer if needed.(Aeb GmbH., n.d., p.10) These blueprints are often very valuable to the manufacturer and a certain degree of trust is necessary, in order to safely share this information. The earlier mentioned Blockchain technology could therefore be an interesting facilitator.

2.5.2.4 Transport of Raw Materials for 3D Printing

The last scenario associated with 3D printing is the role of 3PL providers in the supply of raw materials, needed to facilitate and 'feed' the 3D printers. (Wimpenny, 2017, paragraph 6) In this scenario, the logistics company handles the new demanded flow of plastics, powder, glue, ceramics, etc. that are demanded by 3DP production locations, private consumers, or other customers using 3D Printing devices. (Attaran, 2017, p.196). This scenario differs not much from traditional raw materials supply chains and is the least innovative regarding Logistics 4.0.

3. METHODOLOGY

3.1 A systematic methodology based on a semi-structured individual depth interview and complemented with a secondary research

Now the concepts of Industrie 4.0 and Logistics 4.0 are explained, and the four emerging technologies of Blockchain Technology, Autonomous vehicles, Electronic marketplace platforms, and 3D Printing are described. Attention will be provided on how different 3PL service providers, apply these technologies in their businesses. In order to conduct a deliberate study on this question, a systematic approach is needed. An elaboration on the outset of the methodology of this study is presented in the following paragraphs.

3.1.1 Data Collection

Because the development of the Industrie 4.0 technologies is still in its earlier stages, the rules and its pathways are not yet predetermined. Scientific empirical proof of best practices is scarce and therefore relying solely on academic writing would result in unreliable outcomes.

3.1.1.1 A semi-structured in-depth interview

In order to establish reliable results, the expertise of globally leading 3PL service providers is consulted. For this kind of business research a qualitative research is suggested by Cooper and Schindler (2014). For this qualitative research, a semi-structured Individual Depth interview is recommended. DB Schenker, an authority in the field of Logistics 4.0, is interviewed to gain information on how they pursue their Logistics 4.0 strategy and the applications they apply. In order to subtract viable information from DB Schenker, the interview is summarized and used as a reference for the choice of the treated applications. In order to limit the bias of wrongful interpretation by the interviewer, the content of the summary is checked by the interviewee afterwards.

3.1.1.2 Complementary secondary research

To not solely depend on one source, three other 3PL service providers (DHL, Kuehne+Nagel & Panalpina,) are consulted on the same question. The secondary research is based on information found in news items, company's homepages, Trend researches, Logistics fora and informative videos. The topic of Industrie 4.0 is rapidly developing and in order to prevent outdated results, the use of recent sources in this study is preferred, therefore mostly sources within the time period of 2013-2017 will be consulted. A viable source of information for the secondary research are quotes of company's employees on the topics. These are the least compromised by interpretations of interviewers or article writers.

3.1 Data samples

In total four companies are researched, and their expertise will enable the successful reflection on the research question. The sample of these four 3PL actors is chosen because of their leading role within global 3PL. DHL, Kuehne+Nagel, and DB Schenker are the top 3 global 3PL providers on the basis of gross revenue. (Armstrong & Associates Inc., 2016) Panalpina, is 12th on the list and forms together with DHL and Kuehne+Nagel the main competitors of DB Schenker.(Zigu, 2017; Global Innovation Manager at DB Schenker, personal communication, 05/2017) All companies have their roots in Germany or Switzerland, and operate in the same region as where Industrie 4.0 is emerging. Therefore these companies possess all characteristics to serve as reliable sources for this study.

3.3 Processing of the results

For each application, its development, operation and its future opportunities are explained. The different applications are then captured in a morphological chart in which one finds: the five value adding services (warehousing, transportations etc.), their complementary technological developments (Blockchain, Autonomous vehicles, ELMs) and the different applications implemented by the four researched companies. On the basis of the results, a conclusion is drawn up and a discussion on the conducted research is established.

3.4 DB Schenker

Now the methodology of this study is defined, a brief introduction on the interviewed company, DB Schenker, is presented. DB Schenker is a globally active logistics and supply chain managing company with a revenue of EUR 15 Billion and a total number of 66,327 employees. (Deutsche Bahn Group., 2015, p.25) Due to their road and rail transportation, DB Schenker has managed to become an important transporter in more than 40 European countries.(Schenker, AG. 2017b., para. 4) Outside of Europe, DB Schenker is active in the transportation of freight through the air or overseas. Schenker AG (2017) describes that in their transport activities, DB Schenker strives to follow a so called Logistics 4.0 strategy, in which investing in digitalization and other automation innovations take priority. In cooperation with the Fraunhofer institute the organisation has realised the DB Schenker Enterprise Lab for Logistics and Digitization, based in Dortmund. In this Enterprise Lab, research is conducted on possible solutions for the handling of logistic solutions like Robots and Automated packaging on the basis of Cyber physical systems and other Industrie 4.0 features.

4. RESULTS

4.1 Companies' activities within the different Logistics 4.0 trends

4.1.1. Freight brokerage trends enabled by electronic marketplace platforms.

During the internet and secondary research two ELM platforms were caught. The Drive4Schenker platform made possible by the collaboration of DB Schenker with UShip, and the Transporeon platform used by Kuehne + Nagel. Both platforms are used to optimize truckloads and to improve transportation performance by bringing shippers and carriers together and participate in spot sourcing activities. A trend of digitizing the entire logistics supply chain is occurring. ("TRANSPOREON International", 2017).

The Drive4Schenker platform is based in the uShip platform, which enables carriers to find, book and manage, Schenker's loads. The platform is based in 19 European countries and should connect all 30000 land transport partners to Schenker's supply chain. ("uShip | Schenker Logistics Nederland", 2017) 5000 full and part loads are offered daily for a fixed price or via an auction. (Schenker AG, 2017a) DB Schenker states that: "Drive4Schenker is a web-based freight brokerage platform. It is a marketplace for full and part loads. And it is for everyone who wants to reduce empty runnings. Capacity, location, prices: Smart searches help you finding exactly the load that you are looking for." (Schenker AG, 2017a para. 2)

The Transporeon platform of Kuehne + Nagel is active as of September 2016. It originated due to a collaboration with the e-logistics network operator 'TRANSPOREON group'. The TRANSPOREON group handles a platform used by 57.000 carriers and 1000 shippers. Dr. Nils Wemhoener, Senior Vice President Operations Overland at Kuehne + Nagel states: "The new process allows optimising truck load factors, reducing operating costs and environmental impact" he thereby concludes that "Using the TRANSPOREON platform will therefore drive efficiencies for our customers and carriers." ("Kuehne + Nagel Introduces TRANSPOREON Platform as Digital Carrier Interface - Aircargobook.com.", 2016, para. 4)

4.1.2 Nearshoring through 3D printing changing production processes

In the research the two leading logistics innovators in 3D printing trends are DHL and Panalpina.

Senior Vice President Strategy, Marketing & Innovation Matthias Heutger and Vice President Innovation and Trend Research, Dr. Markus Kückelhaus of DHL, state: "we identified 3D printing as one of the major disruptive trends to impact the logistics industry in the near future. (Chung, Niezgoda, and Beissmann. 2016 p.1) They therefore share the earlier quoted vision of Mohr & Khan (2015), who claimed the same statement. .

DHL identifies the potential of 3D printing in their trend research, and recognises "its capability to simplify the production of highly complex and customizable products and spare parts."(Chung, Niezgoda, and Beissmann. 2016 p.17) will be the main point of focus. With the use of 3D Printing, DHL seeks to profit from benefits as "greater customization, less waste, and more localized manufacturing and delivery" (Chung, Niezgoda, and Beissmann. 2016 p.24)

As an enabler for 'instant production and distribution'-models (Chung, Niezgoda, and Beissmann. 2016 p.1), 3D Printing can be used in different ways. DHL describes four possible implementations and starts with the use of a 'virtual warehouse'. In which spare parts are not physically stored but only their digital template, which can be produced at customer demand. (Chung, Niezgoda, and Beissmann. 2016 p.18) Resulting in lower inventory costs and no disposal of expired goods.

A second option is to use distribution centers and warehouses as small factories to produce customized products. If logistic companies would collaborate with manufacturers they could offer so called 'postponement services.' Here the final assembly of the product is performed in the distribution center near to the customer.

The last utilization option of 3DP by DHL would be the 'End of runway services' in which 3D printing warehouses are located near important airports. Creating "fast response times and speed to market for time sensitive shipments" (Chung, Niezgoda, and Beissmann. 2016 p.21)

Panalpina recognizes the advantages of nearshoring and sees 3D printing possibilities in the latest stages of the supply chain and focuses on building Logistics Manufacturing Services (LMS) hubs. (Todd, 2017) It states: "As a perfect complement to our Logistics Manufacturing Services (LMS) offering, 3DP is a powerful technology that enables the customization and personalization of your products at the latest possible stage in the supply chain."(Panalpina World Transport, 2017, para. 2) Panalpina refers to the benefits of local 3DP production sites and last mile shipping. The Global Head of Strategy and Innovation Logistics, Andrew Lahy acknowledges this by announcing: "we've opened manufacturing centers around the world, close to local demand." (The Business Debate, 2017, 4:16) Besides that the company has entered into collective research with the Cardiff University exploring the possibilities of 3D printing and looking to identify which product processes can be transformed and what effect these transformation have on supply chains. (DVV Media Group GmbH, 2017)

Panalpina possesses a fully operating 3D printer since December 2015. Their vision is to transform their warehouses into hubs where customized customer products can be produced and shipped within a short time frame. (Panalpina World Transport, 2017, para. 1)

Following Panalpina, these services lead to "Reduced supply chain lead times, Reduced inventory levels, Highly customized products at comparative cost advantage and Increased service levels among other things." (Panalpina World Transport, 2017, para. 4)

4.1.3. Transportation efficiencies due to truck platooning and drones.

Both DB Schenker and DHL perform an interesting role in the advances of autonomous driving and truck platooning. Although much of the research and technological developments are performed by the larger truck producers as MAN, SCANIA or DAIMLER, (Robarts, 2017 para. 4) both 3PL service providers contribute to this research. DB Schenker started a collaboration with MAN on a truck platooning project. Test drives will be performed on the A9 Motorway between Munich and Nuremberg by 2018. (Jentzsch 2017) Ewald Kaiser, Chief Operating Officer Freight at DB Schenker states that "Platooning provides us and our customers with a solution to the demand for completely transparent, as well as faster and more eco-friendly transport processes." (Transportparts.ie. 2015. para. 7)

Besides the benefits of truck platooning Joachim Drees, Chairman of the Executive Boards of MAN SE and MAN Truck & Bus, explains that the deciding factor of the implementation lies on how governments react on its legal implications. "Whether the concept can be realized on a wide scale will depend to a large extent on the legal framework. MAN will offer such a system once the legal setting for it has been created." (Jentzsch. 2017, p. 9)

DHL is also active in the development towards the use of autonomous vehicles.
In their trend report: 'SELF-DRIVING VEHICLES IN LOGISTICS' , Matthias Heutger & Dr. Markus Kückelhaus state the following: "these systems can find the swiftest route to avoid traffic congestion, reduce motoring costs, and minimize environmental impact, achieving an overall experience that's safer and greener for everyone." (Zeiler, Niezgoda, & Chung. 2014, P. 1)
Next to investigating the possibilities on road transport, DHL also focuses on air transport. With the use of autonomous drones or UAV's, delivery goods can be soon generally delivered at difficult reachable places. Tests are already performed with the 'Parcelcopter', which is able to grab onto a package and deliver it at speeds of 70km/h over a distance of 8.3 km. (Palermo, Writer, 2017; Franco, 2017)

4.1.4 Warehousing and distribution operations due to autonomous vehicles and robots.

The smart vehicles that are equipped with sensors are also implemented within warehouses and distribution centers. DB Schenker and DHL use different smart solutions for simplifying the processes around packaging, distribution and monitoring.

DB Schenker, in collaboration with Swisslog, has developed a 'Carry pick solution' within the Arlandastad Logistics Center, near Stockholm. This carry pick system exists of autonomous moving vehicles that are able to find their way across the warehouse via barcodes that are installed into the floor and are able to autonomously search for specific racks, filled with products. The vehicle tunnels under the rack, picks it up and transports it to a working station where the products are handled by for example a central packaging robot. ("Next Generation E-Commerce." 2016.; Swisslog Warehouse & Distribution Solutions WDS. 2016)

Via this system, distribution centers are able to cope with increasing product variability, shorter delivery times and are staying cost efficient. (Swisslog, 2017) Anders Holmberg, the Business Development Manager for DB Schenker in Sweden states: "With more than 60 robots and 1,550 mobile racks, we are able to manage 35,000 different articles, 24/7. And pick up to 40,000 orderlines per day" ("Next Generation E-Commerce.", 2016, para. 4)

In their trend analysis, DHL describes the same carry pick solution, and generalize the concept of autonomous robots into a vision of a distribution center in which, "different types of robots, each with a specific job to perform such as unloading trucks, co-packing, picking orders, checking inventory, or shipping goods" (Niezgoda, 2016, p.26) are deployed. The use of these robots would, following the Trend analysis, eventually lead to "higher productivity and increased quality." (Niezgoda, 2016, p.28) The Robots can be deployed within warehouses, distribution centers, or during the last mile delivery stage.

DHL is already testing a Vision Picking Program in which vision picking technologies support workers via the use of augmented reality glasses to point out which package should be placed where. (van Marle, 2016) "The Vision Picking Program is DHL Supply Chain's first translation of what augmented reality solutions can look like for supply chains." states DHL's Supply Chain chief information officer Markus Voss. (van Marle, 2016, p. 12) The Director of DHL Trend Research Markus Kuckelhaus adds that the Vision Picking Program is not limited to distribution activities but states that: "Glasses could provide visual step-by-step instructions for assembly and repair tasks, and identify quality control issues". (van Marle, 2016, p. 9)

4.1.5 Safe and open information sharing

New innovations in Information sharing techniques, based on the Blockchain technology are not widely applied yet. DB Schenker's innovation research partner, the Fraunhofer institute, has performed research on a network with similar workings as the Blockchain technology. This network is called the 'Industrial Data space' and enables the trusted sharing of data between parties. Hereby data sovereignty, wherein the data owner stays in control of the terms and conditions of how his data is used, is key priority. Other characteristics of the Blockchain technology as the decentral approach, wherein no central supervising authority is established, and wherein trust is ensured by the use of authorization practices performed by certified software, are also found within the Industrial Data space. (Otto et al., 2016, p. 12-15)

Although their research progress does not reach as far as the Fraunhofer Institute, Panalpina also reports to be interested in Blockchain data sharing. Panalpina's Global Head of Strategy and Innovation Logistics, Andrew Lahy states that "We see massive developments in for example Blockchain." (The Business Debate, 2017, 4:45)

Kuehne+Nagel has started a collaboration with BitSE's in order to use the Blockchain technology of 'VeChain' for managing assets. VeChain enables customers to control whether a product is an original or a fake. Luxury goods are installed with a chip that is able to share information about its origin and

Table 2. Morphological Chart of all trends and applications

	Services	Freight brokerage	Production	Transportation	Warehousing & Distribution	Information sharing
3PL Providers	*Technologies*	Electronic Marketplace platforms	3D Printing	Autonomous Driving	Autonomous robots	Block Chain Technology
DB Schenker		Drive 4 Schenker		Truck platooning tests with MAN	Carry pick solution	Industrial Data Space
DHL			1.Virtual warehouses 2.Postponement services 3.End of Runway services	Parcelcopter drones	Vision Picking solution	
Panalpina			Hubs for customized production			
Kuehne + Nagel		Transporeon				VeChain asset management
Benefits:		Better pricing for shippers Less empty runnings for carriers.	Near shoring Shorter product to market	1.Fuel reduction 2.Personnel efficiency 3.Increasing road safety	Higher productivity Increased quality	Data sovereignty Safe and open sharing of information.

ownership via the safe Blockchain method. Kuehne+Nagel hereby engage themselves in the battle against fake and stolen goods. ("World's Largest Freight Company to Use Blockchain Tech for Asset Management.", 2016)

5. CONCLUSION

This study attempts to acquire information on the different Industrie 4.0 applications used by 3PL providers. This information is obtained via a semi-structured in-depth interview with DB Schenker and secondary research on the 3PL organizations DHL, Panalpina and Kuehne + Nagel. Five value adding services were identified, which 3PL providers provide their customers: Freight brokerage, Production, Transportation, Warehousing & Distribution, Loading/unloading, Transportation and Information sharing with the customer. On these services, five fields were identified in which companies actively implement applications: Freight brokerage trends enabled by electronic marketplace platforms; Nearshoring through 3D Printing applications; Transportation efficiencies due to truck platooning and drones; Warehousing and distribution operations due to autonomous vehicles and robots; and lastly technologies enabling Safe and open information sharing.

5.1 Freight brokerage trends enabled by electronic marketplace platforms

The companies DB Schenker and Kuehne + Nagel are active within the development of these Freight brokerage solutions. Via the ELM platforms: Drive4Schenker and TRANSPOREON they have created an environment in which shippers and carriers can bid and negotiate on full or part loads. Via this integrated network, these organisations are able to reduce the amount of empty runnings.

5.2 Nearshoring through 3D Printing applications

DHL and Panalpina are active within the development of 3D Printing and its possibilities for Nearshoring activities. They recognize the potential of this technology to improve their spare parts warehousing services, but also strive to influence the production of goods, by creating highly customizable production facilities. DHL distinguishes three pathways: "virtual warehousing, Postponement services and end-of-runway services. Panalpina focuses on creating Logistics Manufacturing Services hubs. For the assistance of manufacturing at the latest stage of the supply chain.

The 3D printing services lead to: "Reduced supply chain lead times, Reduced inventory levels, Highly customized products at comparative cost advantage and Increased service levels among other things."(Panalpina World Transport, 2017, para. 4)

5.3 Transportation efficiencies due to truck platooning and drones

Within the development of Autonomous vehicles and Truck Platooning, the companies DB Schenker and DHL are active. DB Schenker has started a collaboration with MAN to perform test drives of Truck Platoons on the A9 Motorway between Munich and Nuremberg by 2018. Truck platooning contributes to reduced energy and personnel costs and enables a safer and more efficient road environment. DHL has invested in the delivery of packages on difficult reachable places by autonomous Drones. The so called 'Parcel copter' is in its third version and can deliver packages with speeds up to 70 km/h.

5.3 Warehousing and distribution operations due to autonomous vehicles and robots

Within warehousing and distribution services, the organisations DB Schenker and DHL have implemented certain smart solutions that can be implemented for to perform tasks autonomously or to assist warehouse employees. The vision of DHL is that: "different types of robots, each with a specific job to perform such as unloading trucks, co-packing, picking orders, checking inventory, or shipping goods" (Niezgoda, 2016, p.26)

DB Schenker's Carry pick solution mobilizes racks to be brought to a central working station, where the products in the racks can be picked and packaged (by humans or machines). DHL assists their employees with a vision picking solution. This contains a smart glass that is able to scan a barcode of a package and projects in their glasses where it should be positioned on the floor. DHL also strives to implement this technology into assembly or repair activities.

5.4 Safe and open information sharing.

The innovations around Safe data sharing are still in the initial phase. Companies are finding ways to transform Blockchain technology from a cryptocurrency technology to a way of safely sharing all kinds of information. The research partner of DB Schenker, the Fraunhofer Institute has developed an 'Industrial Data Space' and enables the trusted sharing of information between parties is already possible following the characteristics of the Blockchain technology.

Other organisations as Panalpina and Kuehne+Nagel have also shown interests in the technology. Kuehne+Nagel is implementing VeChain in order to provide customers with a safe asset management tool that verifies if a product is an original or fake.

5.5 Overall Logistics 4.0 conclusion

The Industrie 4.0 is coined as the fourth industrial revolution because it would create a paradigm shift in how business is conducted. One finds that the real strength in the use of these technologies lies in their synergetic connectedness. The interwoven culture of the different applications enables their own successful implementation.

Within the logistics industry, a shift is occurring, from 'offshoring' towards closer to market manufacturing (or 'near shoring'). 3D printing is a large enabler of this shift, but is assisted due to the innovations in other fields. The closer to market manufacturing strategy is only profitable if other processes increase in efficiency. Due to autonomous vehicles and robotics, the transport of goods and warehousing and distribution can be handled cheaper. The trucks are also filled at a higher utilization rate due to Electronic marketplace platforms, reducing the amount of empty runnings and again increasing efficiency in transportation. All activities within the supply chain are monitored via smart sensors and stored and shared via open information sharing technologies as Blockchain, leading to information transparency and trust between customers and carriers. The different Industrie 4.0 technologies combined thus result in the success of the industrial shift and this is certainly a given that should be considered when investing in these applications.

6. DISCUSSION

6.1 Limitations

6.1.1 Limited information availability

This study was based on a semi-structured in-depth interview with a Global Innovation Manager at DB Schenker and secondary research on the 3PL organizations DHL, Panalpina and Kuehne + Nagel.

For the interview with DB Schenker yields that the interviewee could have been restrained in what information to provide. This research is therefore almost entirely based on publicly available information. Confidential information is not treated, which could lead to an incomplete reflection of the actual activities of organisations.

During the secondary research on the other 3PL organisations one is dependent on what others have earlier discovered. The concept of Industrie 4.0 is relatively underdeveloped, which leads to less availability in information. The information which is available, is then again recently published and up to date.

6.1.2 Selection of topic and subject

The field of Industrie 4.0 is brought, which limits the amount of aspects that could be handled. The selection of the five technological developments was made on the basis of their interconnected, synergetic character. Other researches on the topic may lead to other results.

Industrie 4.0 is originally a German concept, and Germany houses the Global top 3 3PL service providers (DHL, DB Schenker, Kuehne+Nagel). These organisations apply as strong examples and the study therefore mainly treats the German way of conducting logistics. This does not entail that logistics organisations from other countries or continents do not use aspects of Industrie 4.0 or its applications.

6.2 Further Research

As stated earlier, a selection was made on which content would be studied. This leads to questions that remain unanswered and on which further research could be conducted.

6.2.1 Human-machine co-existence.

During the study on Autonomous vehicles, a conclusion was made that its adaptation does not rely on technological competences, but on how governments develop the legal framework to carry this technology. This topic, together with the question about how non-humanly steered vehicles will be accepted by human road users, is and would be an important subject for further research.

Due to the use of autonomous vehicles and warehousing and distribution robots, traditional job descriptions will also change. An amount of tasks would be filled in by cyber physical systems and jobs as handling machines or planning shifts, which formerly relied on experienced employees, now need less expertise due to smart robots. Further research is needed to find how humans and machines can co-exist within the logistic industry.

6.2.2 Recycling

In this study the focus lies on the upstream of the 3PL material flow, wherein goods flow from supplier to the customer and where 3PL organisations perform the services within this flow. A concept that is not handled in this study is how Industrie 4.0 technologies could assist the downstream of used or expired goods from the customer back to the supplier by means of recycling or reallocation programs.

7. ACKNOWLEDGMENTS

The establishment of this study is made possible with some fortunate assistance. My sincere thanks go out to the Global Innovation manager of DB Schenker for the interesting and helpful interview. My other thanks go out to Prof.dr. Schiele for providing me with inspiration to step into the logistics industry, bringing me in contact with DB Schenker and providing guidance via skype. My third thanks go out to Dr. Vos, who was a helpful contact when information needed clarification.

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APPENDIX

Appendix A

DB Schenker Interview summary

Subject: Applications within Logistics 4.0

Date of interview: 02-05-2017

Interviewee: Global Innovation Manager at DB Schenker

Interviewer: Daan Horenberg

1. In the logistics Industry, there is a transition towards Logistics 4.0, how would you describe the key elements of this concept? Please elaborate.

The transition towards Logistics 4.0 started in 2014, with Deutsche Bahn starting six initiatives: Mobility, Infrastructure, IT, Production, Workplace and Logistics. Around 250 digitization projects were initiated. In this digitization, several areas of development were: Products of the future, Customer interfaces, Optimized Processes, Ethics, Workplace of the future and Data Analytics.

To realise the new innovative technologies, DB Schenker establishes several enablers. Research labs were set up. The current most important lab is: The "DB Schenker Enterprise Lab for Logistics and Digitalization" who started their work in 2015 in Dortmund. Here research is conducted in collaboration with the Fraunhofer institute for material flow and logistics.

Other enablers of research are National & European programs and funding; and customer involvement projects, in which customers are asked to share their needs and demands.

Currently DB Schenker has commissioned a Chief digital officer: 'Markus Sontheimer',. The responsibility of the CDO is divided into three departments: (1) Data analytics, which looks after retrieving value out of data. (2) Digital solution, which develops digital strategies and business models.; and (3) Innovation, which manages innovation requests, idea generation and business rethinking.

2. In what processes of DB Schenker are these applications implemented? (e.g. Planning, Transport Simulation, Order management, Distribution and packaging).

The key digitization areas in which logistic innovation practices are performed are: (1) Digital Workflows, in which operations based on paper are being replaced by digital workflows.; (2) Customer interaction, which acts on changing customer interfaces, due to information transparency and visibility.; (3) Digital platforms, for pooling practices of supply and demand.; (4) E-Commerce; (5) (Big) Data analytics, which investigates new ways of managing data. (6) Asset intelligence, where assets are equipped with smart sensors.;(7) Autonomisation, entities as vehicles will act more autonomously. (8) 3D- printing, where objects could be produced easier via these new technologies.

3. What applications are implemented by DB Schenker to realise the transition towards Logistics 4.0? Please list multiple applications and elaborate on their functionalities.

As a result of the Enterprise lab and the collaboration with Fraunhofer, the following applications are currently in use or are soon to be implemented.

3.1 E-Schenker Services This customer interaction application is implemented for better customer service. By using this website customers are able to advise E-booking, Administration and advanced tracking services.

3.2.Drive4Schenker

In this Digital Platform, small truck companies are deployed to perform deliveries and therefore 'Drive for DB Schenker'. Truck capacities can be directly assigned or auctioned by DB Schenker and the truck companies can bid on them. This mechanism is based on the Uship technology, in which principals find carriers via an online shipping marketplace.

The target of this application is to transform transportation negotiations from a manual process towards a digital process. The main advantage is the increase of information transparency towards the customers and other stakeholders. It shows that DB Schenker does not let favouritism lead their choice in shipping-agents, but the transporter with the cheapest offer gets the deal. The new platform will be implemented in summer 2017.

3.3. Schenker Smartbox

This form of asset intelligence enables to monitor global freight transports not only via GPS but also on parameters as Temperature, Humidity, G-force and vibration. The customer is able to set their parameters in advance, which are then controllable. If a certain value is exceeded, this is documented and available for later inspection. As an example, a customer is cited, for whom DB Schenker transports servers. These are very sensitive devices for which it is crucial to limit the vibration during transport. Via the Smartbox, the customer is able to control how rough the transport has been. The Smartbox also monitors whether the transported good was attempted to be opened. And therefore ensures security.

3.4. Autonomous Driving, Truck Platooning

Developments in the Autonomisation area has been occurring. Truck supplier MAN is researching the possibilities of implementing autonomous driving trucks. As an intermediate step, truck platooning is being developed. This involves a system in which trucks are able to connect to each other via a network, when driving in a column. The first truck in the column is controlled via steering, while the following trucks trail the first truck's moves automatically, enabling automatic braking and acceleration. Via this method truck driving is improved via the enabling of slipstreaming, which decreases fuel consumption drastically.

3.5. Other Applications

3.5.1 Autonomous yard management.

DB Schenker is currently not researching autonomous unloading of trucks. Although there are some ideas of autonomous Yard management, these are not in project yet.

3.5.2 Autonomous coordination of freight exchange between Shipping and the land Transport (truck or train).

The planning process of transport is still mainly performed manually. Digitization could increase coordination possibilities between transshipments, but these are still not in project yet.

4. How many employees work directly with these applications and what are their experiences?

The amount of employees which work with the new applications is difficult to estimate. But in the future, almost all employees will be influenced by digitization technologies. Currently DB Schenker does not test how employees experience the new applications. They see the relevance of this and are planning to test this by next year. The general feedback is that working with the applications is still quite complex.

5. What activities do competitors of DB Schenker pursue in the field of Logistics 4.0?

In the innovation department ,detailed competitor analysis are not performed. However, interesting activities of competitors are:

DHL uses CILLOX, which is a marketplace for online matching of truckloads.

Kuehne + Nagel uses Spacenet an online booking tool to obtain bookings.

Panalpina investigates 3D printing, to realise closer production to the end-consumer market.

6. How is research and development on new applications established? What are DB Schenker's inspirations?

At first, new applications were mainly driven by business. In the Enterprise Lab the first projects were mainly driven by Contract Logistics Another example which has been developed by Contract Logistics is the Carry Pick solution. Other applications are developed internally. The DB Schenker smartbox was implemented as an innovation project within the central innovation department.

Currently new insights are researched via the Enterprise labs, creating a technology push on new innovations. In the Enterprise Lab 7 projects are conducted in 2017 and the contract is based on a 3-years term. Via this collaboration 14 projects have been established.

The partners of Schenker are committed to establish a so called “innovation radar”, this generates new ideas on new technologies, ‘the Internet of things’ is an example of a technology that was deducted via this innovation radar in the past three years.

Besides the activities in the Enterprise Lab, DB Schenker also closely monitors the activities of startups, furthermore the demands of customers, but also governmental influences play a role in deciding which technologies are being researched.. The e-mobility applications were partly a nationally funded research.

7. What technological developments could be interesting for the logistics business?

Technological developments that are very interesting for the logistics industry are Augmented reality & Virtual reality, Artificial Intelligence, 3D printing, (although not actively pursued by DB Schenker), The Internet of things features, Sensor Technologies and Robotics.

8. What new applications are currently developed, could you elaborate more on their features and functionalities.

Decision support systems

Currently experienced warehouse employees conduct the resource planning (e.g. planning of employees capacities) more or less manually . This planning was mainly based on routines and experience. Via a decision support system, DB Schenker is able to simulate, the amount of resources (employees) needed to fulfill a certain demand in capacity. By implementing this solution, the resource planning is backed with quantified evidence, resulting in an increase in resource efficiency. Another benefit of this solution is that the system could be handled by everyone, enabling inexperienced employees to handle the planning and decision making as well. This decision support system is currently piloted on resource planning and could realize estimated savings in the area of 10-15%.

Other currently developing applications are found in the Virtual reality area. DB Schenker is developing an employee trainings application, by which employees are able to be trained in a gamified way, to perform activities that are required by the customer in a virtual warehouse environment.

Virtual Reality is also planned to be applied in the tendering process. Potential customers are provided a virtual tour through the warehouse, providing a clear understanding of DB Schenker’s resources and capabilities.

9. How would you describe the short- and long term transformation of the organizational structure of DB Schenker? What will become your core business? What role will digitization play? What changes in job descriptions will occur?

Due to the digitization practises and innovations changes occur in the business components of DB Schenker. The components are subdivided into two parts, each subjected to a different transformation. The first part, the legacy business of freight forwarding will remain the same in essence. The actual transport of containers and packages will not change, as physical goods are not shippable via the internet.

Furthermore the organisation will experience a large increase in accessible data. DB Schenker should therefore, besides the physical activities, also focus their attention on data analytics and what possibilities arise from this increased volumes of data. This will result into an increase in demand for employees with knowledge in algorithms.

Both the legacy business part as the enabling parts are interdependent. DB Schenker anticipates that both parts stay important in the future way of conducting business in the logistics industry. In order to come along with developments, the changes in efficiency and agility need to occur in the next two years.

10. How would you predict the future of the logistics industry?

The logistic industry is highly dynamic and therefore the future is highly unpredictable. It is therefore essential to invest in change management, which enables flexibility for future developments.

In the future it becomes crucial, who is controlling the customer interface. Digitization of the customer interface results into changing customer communications. An important capability is instant quotation, that are able to provide the price of a service to the customer right away. This is very different from how it traditionally occurred. Changes in the customer interface are mainly speeded up by start-ups, which invent new possibilities regularly due to their expertise in digitization.

In future logistics the horizontal collaborations with partners will increase as well. Better integration between supply chains will result in an increase in efficiency,. Although the integrated ecosystem view advocated by Silicon Valley states that this horizontal collaboration also could occur between competitors, this deviates from the view of German organisations. Due to a lot of industrial companies in Germany collaboration happens a lot vertically with suppliers and customers ,

In order to better control your data and with whom you share it, Fraunhofer developed the Industrial data space. This system enables you to securely transfer your data and stay guaranteed of ownership. Large organisations as Bosch & BMW are also part of this intiative. Based on use cases the Industrial Data Space will be developed with all member organizations.

Appendix B

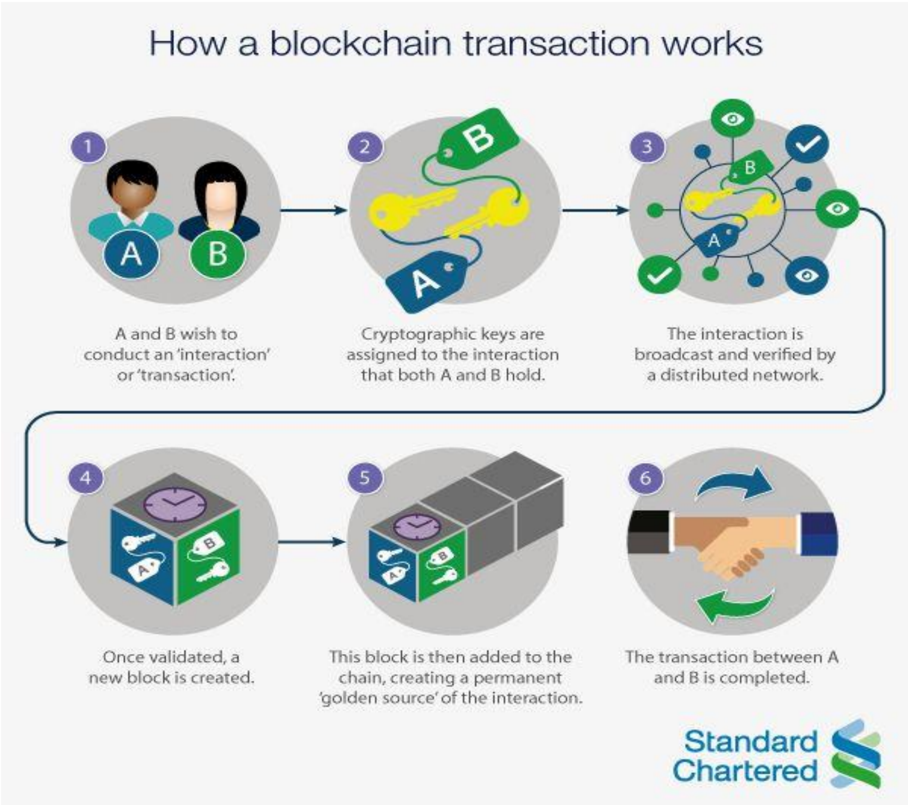


Figure 2. The principles of Blockchain transactions (Andreasyan, 2016.)

Appendix C

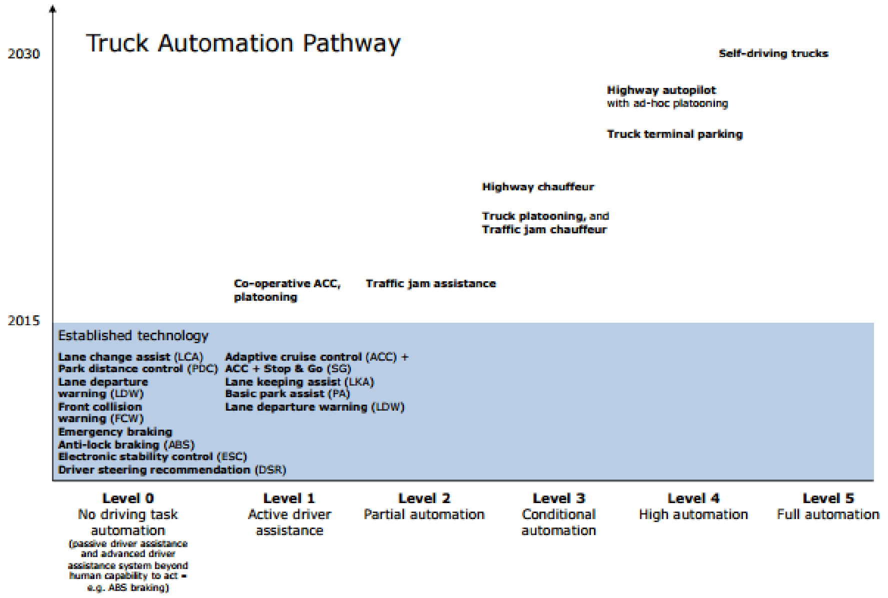
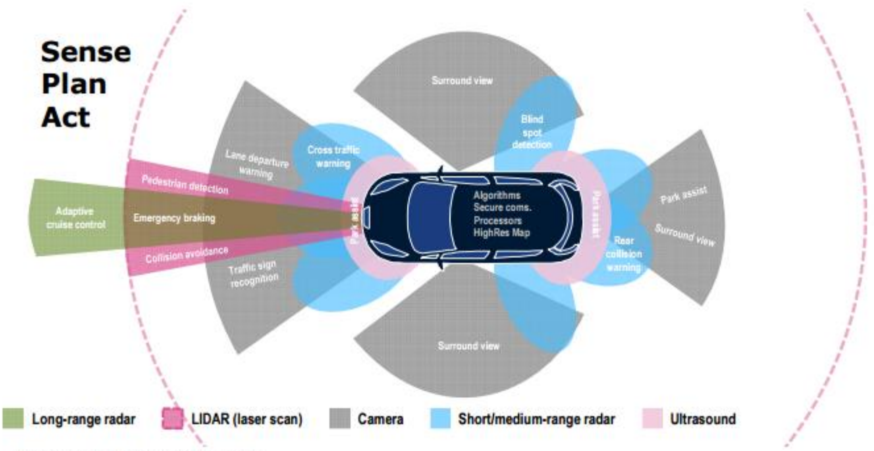


Figure 3. Truck automation pathway from human to fully automated driving (OECD/ITF, 2015, p.23)

Appendix D



Source: Adapted from (Parrish, 2015).

Figure 4. Sensing technologies within autonomous vehicles (OECD/ITF, 2015, p.11)

Appendix E

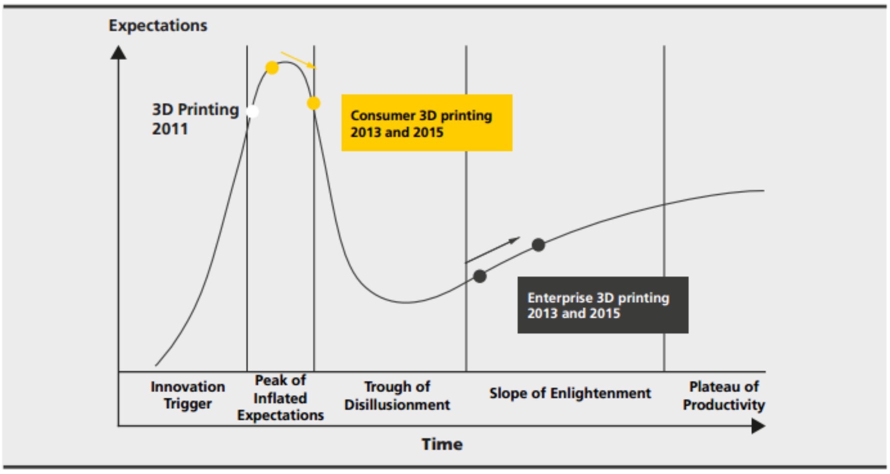


Figure 5. Gartner hype cycle (Chung, Niezgoda, and Beissmann, 2016. p.4)