Recommendations for information system developers

Activity: WP 2, Activity 2.3.3

Version: 2

Date: 16 July 2018

Drafted by: Johannes Betz

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

North Sea Baltic Connector of Regions
Interreg Baltic Sea Region Programme 2014–2020

File Version		Editor
1.0 – 1.2	Structure, layout and first content	Betz
1.3 – 1.5	Restructured chapters, final text additions	Betz
1.5	Proofreading	Cailliaux
2	Final adjustments, Executive Summary and Conclusion	Betz

Content

List of Figures

Abbreviations

AIS	Automatic Identification System
CIM	Contrat de transport international ferroviaire des marchandises
C-ITS	Cooperative Intelligent Transport Systems
CMR	Contrat de Transport International de Marchandises par Route
DSM	Digital Single Market
DTLF	Digital Transport and Logistics Forum
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EU	European Union
GSM-R	Global System for Mobile Communications for Railways
ICT	Information and Communication Technologies
IOT	Internet of Things
IIOT	Industrial Internet of Things
IT	Information Technology
ITS	Intelligent Transport Systems
M2M	Machine-to-Machine
MEC	Multi-access Edge Computing
PI	Physical Internet
RIS	River Information System
S2R	Shift2Rail
SERA	Single European Railway Area
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything

Executive Summary

'North Sea Baltic connector of regions' aims to improve the sustainable accessibility to passenger and freight transport in the Eastern Baltic Sea Region. The project takes the EU Trans-European Transport Network Infrastructure Policy implementation to a regional and local level and connects the Core Network Corridor of the North Sea Baltic to the catchment area and access routes in the Eastern Baltic Sea Region. This is done through logistics-, long distance commuter services- and transnational community- and transport branding. The project' outputs will facilitate interoperability and bring a transnational perspective into spatial planning and policymaking. Work package 2 focusses on intermodal logistics aspects and is divided into various sub-work packages that aim to aid increasing interoperability and competitiveness of intermodal transport services.

The Eastern Baltic Sea Region faces low internal and external cohesion and accessibility, but has substantial untapped potential. Accessibility is pivotal in order to unlock growth potential. The transport development in the Eastern Baltic Sea Region is lagging behind as developments are commonly focused on the urban nodes. 'Rail Baltica' will tackle the missing link between the northern and the southern part of the North Sea Baltic Corridor and create cohesion to the region by connecting the existing East-West routes, with traditionally strong volumes of freight, with the new North-South route(s).

This report aims at providing information system developers of logistics stakeholders with an overview of prevailing tools and future trends in the Information Communication Technology (ICT) environment related to transportation and supply chains. Digitalisation has led to a connected world and a more connected economy. The right utilisation of knowledge and tools will succour improving interoperability and interconnectivity and with that competitiveness of logistics services that have become an inherent part of supply chains and with that face increased competition from competing companies and / or transport modes.

The European Commission underlines its desire to create a true single market in Europe through the establishment of a Digital Single Market Strategy that was adopted in 2015. Its' Digital Agenda is one of the seven pillars of the Europe 2020 Strategy in order to generate smart, sustainable and inclusive growth in Europe. The Commission furthermore decided to bring together stakeholders from transport and logistics to create a common vision and to coordinate the implementation and preparation of standards and potential legislative measures. The focus herewith lies on electronic transport documents and interoperable digital information systems. This will help stakeholders from the transport and logistics sector to optimise cargo flows along transport corridors. The European Commission furthermore established a joint-undertaking under Horizon 2020, Shift2Rail, to drive innovation in railway and with that supporting the development of a Single European Railway Area. This will furthermore aid the attractiveness and competitiveness of railway in the long run and also underpin the EU 2020 Strategy of smart, sustainable and inclusive growth in Europe.

There are various documents required in cross-border transportation. E-documents will enable to cut red-tape for all stakeholders involved and improve their power to compete and desireability of the different modes and their combination in intermodal transportation. In terms of advancement - the National Single Window, based on the e-manifest and Directive 2010/65/EU, seems to be the most advanced. The idea is to have a harmonised electronic manifest and only having to submit information once. The desire is to have a true European Single Window in the long run, based on the now implemented national single windows. For rail- and road transportation, there are also efforts to digitalise the paper documents. Issues that are currently being addressed are the recognition of such documents by insurance companies, authorities and courts. This is due to considerations on digital signatures, dangerous goods and different conventions. All these endeavours by the Commission are elements coming together to form and strengthen the desired Single European Transport Area as set out in the relevant Roadmap.

The European Commission moreover established a Cooperative Intelligent Transport Systems Platform in 2014. In line with the establishment of the Shift2Rail joint-undertaking, this platform intends to foster a common vision and enable knowledge exchange. This will help back a harmonised employment of these systems and foster first the digitisation and secondly the digitalisation of transportation processes and documents. A prevailing example of Cooperative Intelligent Transport System development and implementation can be observed in the road sector. The C-Roads Platform is an example where Member States and road operators test these services with the goal of a harmonisation and interoperability across borders. Examples for such services are: emergency vehicle approach-, traffic jam ahead-, slow- or stationary vehicle warning, or green light optimal speed.

All these services are based on communication between vehicles, infrastructure or what is sometimes referred to as ‘everything’. The goal of these services is an increase in safety, but also in automation. The latter enables stakeholders from the logistics sector to increase efficiency and in the long run competitiveness. However, it is also anticipated to make road transport more sustainable due to better capacity utilisation and less congestion on roads. The overall term used for these massive amounts of data exchanged is ‘Big Data’. The utilisation of these data sets has become possible due to the affordability of on-demand network access computing resources – the so called Cloud. The European Commission identified the potential and its’ role within the Commissions Digital Single Market Strategy and therefore initiated a European Cloud Strategy in 2012. The introduction of cloud computing, the Internet of Things and Cooperative Intelligent Transport Systems has increased the amount of data exchanged between devices tremendously and makes handling these data sets in specific data centres complex and difficult. Edge computing tries to bring computation power closer to the edge of a network and with that closer to the data origin. Fog computing takes this a step further and extends or bridges the computation towards the cloud. The cloud can then be utilised to provide further services to stakeholders in what is referred to as Software as a Service. Possible applications for transport stakeholders are the customer relationship management, document sharing or stakeholder collaboration in general. Examples can be found in the ‘Review of ICT solutions supporting intermodal transport sector’ which is also part of the work package 2.3 for which this report is being written.

The competitiveness and sustainability of logistics processes within the supply chain could be improved even further, if a concept discussed by Montreuil would be pursued. It is often referred to as Physical Internet or Logistics 4.0. It is an analogy to the digital Internet and the standard utilised for data transfers. A common standard would allow for interconnectivity and utilisation of the capacity of smart containers in connection with Internet of Things and Cooperative Intelligent Transport Systems. However, the concept can today only be applied to standard shipping containers.

Finally, it has to be underlined that with digitisation and digitalisation underway – these advancements cannot be ignored if transport and logistics stakeholders want to stay abreast with competing companies, new entrants, logistic market platforms, shared economy thinking and increasing substitutability. Competitive advantage can be gained through possible service improvements and product innovation, but also through strategic network- and operational capacity planning, real-time route optimisation and the continuous awareness of new trends and technologies that offer stakeholders the ability to provide a continuously attractive and competitive service portfolio.

1 Introduction

The report ‘Recommendations for information system developers’ is part of the overall work package WP 2.3 ‘ICT solutions for intermodal transport’. The report is part of a series of sub-outputs analysing the Information and Communication Technologies (ICT) landscape and future trends in regards to intermodal transport.

The conglomeration of sub-outputs is finalised in the overall output of 2.3 with the aim to give an overview of ICT requirements, solutions and trends for the intermodal transport chain within the supply chain. The final output seeks to increase knowledge and competence of logisticians – especially in regards to interconnectivity and interoperability improvements in intermodal transport.

This report on recommendations will provide an important aspect needed as the basis for interconnectivity and interoperability improvements. It aims to give a general overview of future trends in the ICT environment related to transport. The digitalisation is moving fast and offers significant potential (European Commission, 2018a). It is therefore important to stay abreast of changes in this area.

This document will outline the growing use and importance of ICT tools and the related technology in supply chains. Supply chains stimulate and facilitate trade (World Economic Forum, 2013) and logistics has become an essential part in the supply chain as digitalisation has led to a connected world and a more connected economy. The use of available information has also affected global collaboration, competition and process optimisation and therefore also the transport chain (OECD, 2002, p.1; BVL International, 2013).

It is important to be aware of state-of-the-art technologies and developments in Information Technology in order to counteract the rising cost pressure of the overall supply chain and those costs related to transportation respectively (BVL International, 2013). However, ICT also offers potential to the visibility along a transport chain and with that accommodates the growing expectations of customers (BVL International, 2013).

The following chapters will look at ICT in supply- and logistics chains, and future trends and will then finish off with recommendations for information system developers or logisticians in the intermodal transport environment.

2 ICT in Supply chains and Logistics

The reports of Activity 2.3.1 and Activity 2.3.2 pay particular attention to tools available for the various parties involved in intermodal transport.

This chapter focuses on different efforts to pave the way for a Digital Single Market and digitisation in transport and logistics. The Digital Single Market (DSM) expresses the European Union's (EU) Commission desire to 'ensure access to online activities for individuals and businesses under conditions of fair competition, consumer and data protection, removing geo-blocking and copyright issues' (European Commission, 2015a). An endeavour of the DSM is the free movement of persons, services and capital – along with fair competition (European Commission, 2015a). With the DSM the EU Commission therefore continues to pursue its goal of a single market, standardisation and removal of bottlenecks in that regard (European Commission, 2018b). Other efforts relevant to supply chains and logistics in general are the Single European Transport Area (European Commission, 2011) and the Single European Railway Area (European Commission, 2012).

The Commission therefore decided in 2015 to set up an expert group that brings together stakeholders from transport and logistics. The aim of the expert group is to create a 'common vision for the future' and to 'coordinate its implementation and the preparation of standards and potential legislative measures' (European Commission, 2015b). Therefore the Digital Transport and Logistics Forum, the DTLF was established, with the focus on enhanced information exchange in the transport and logistics area (European Commission, 2015b). The DTLF currently focuses on two sub-groups. The sub-groups encourage the use of electronic transport documents and advance the development of interoperable digital information systems to optimise cargo flows along transport corridors (Digital Transport and Logistics Forum, no date). There are regular meetings of the sub-groups to discuss progress and activities (European Commission, 2018c). A selection of the various digital information systems already available are outlined in the above mentioned reports. This chapter will focus on examples of the e-documents discussed in the DTLF and transport and logistics sector in order to outline its importance in supply chains and digitisation of transport and logistics in general.

There are different efforts of digital documentation formats and standards, depending on the mode of transport chosen. This chapter aims at providing a general overview of the initiatives or activities in this area only – as this is a rather complex topic and does not serve the purpose of underlining the importance of the future trends in ICT technology for transport and logistics, which will follow this chapter.

2.1 Transport documents and their electronic counterpart

In the maritime sector there is the ‘European Maritime Single Window’ effort. It is based upon the Directive 2010/65/EU (European Commission, 2010a) ‘National Single Window’ implementation and the eManifest initiative (European Commission, 2018d) with the idea of having a harmonised and electronic manifest and the ‘submit once’ principle (UNECE, 2012).

In the road sector the ‘Contrat de Transport International de Marchandises par Route’, more commonly known as CMR (United Nations, 1956) or ‘Contract for the international carriage of goods by road’, regulates various legal issues related to international cargo transport by the road. Each year, approximately 33 million sheets of paper are required for 16.5 million vehicles employed in the transport and logistics sector (Business Europe, 2017a). This underlines the possible benefits of the application of an e-CMR, sometimes also referred to as eCMR - such as: faster administration, higher data accuracy and thus fewer errors and increased transparency and traceability (Kern, 2017). Studies indicate that for the Netherlands alone a cost saving in administration of 180 million Euros per year would be possible if logistics companies would switch from CMR to e-CMR (Business Europe, 2017a).

The railway sector, similar to the road sector, also has a document that regulates various legal aspects related to international cargo transport by rail. The ‘Contrat de transport international ferroviaire des marchandises’, more commonly known as CIM (European Commission, 2018e). Just like the CMR, it is mandatory to provide documents for the cargo of the entire train and therefore the documents are carried with the cargo (European Commission, 2017h). The e-CIM initiative also offers benefits over the paper version in the form of cost efficient and reliable trains through achieved cost- and time savings. The digitalisation in the rail industry is lacking behind other transport sectors. However, the utilisation of the e-CIM, sometimes referred to as eCIM, would foster the digitalisation in the rail industry and push developments in the area of digital maintenance, traffic management and the internal digitalisation of the railway industry itself (Business Europe, 2017a). There are currently some issues with the e-CIM at this stage: not all Member States recognise the e-CIM and digital signatures on e-CIM are not accepted by insurance companies, authorities and courts (Business Europe, 2017a). Furthermore, in the case of transporting dangerous goods, the e-CIM is not accepted in countries such as Germany. Lastly, there is also the issue of different conventions in East and West with e-CIM and SMGS (Evtimov, 2015).

In a best practice example of Samskip and its multimodal operations, it was estimated that with only a digitalisation of 10 per cent, the company could save 165 million Euros per year (European Commission, 2017h). At the Digital Transport days 2017 in Tallinn, a panel discussion discussed electronic documents and what needs to be done to further the progress and development. With the ‘chicken-and-egg’ problem at hand, suggestion was made during the panel discussion to progress with the e-CMR (Port of Hamburg Marketing, 2017). It is currently further developed than the e-CIM. Once the e-CMR works, the experiences made could be used for the progress of the e-CIM establishment (Business Europe, 2017a).

2.2 Intelligent Transport Systems

The digitalisation offers a lot of potential and benefits for the logistics and transport sector. It promotes cost reductions, utilisation of resources and available infrastructure (Digital Transport and Logistics Forum, no date). Intelligent Transport Systems, often referred to as ITS - in a narrower sense, utilise modern ICT tools to enable better sustainability, efficiency and competitiveness. The utilisation of these ICT tools offers great potential to create a genuinely integrated transport system and at the same time support the EU’s ‘Roadmap to a Single European Transport Area’ (European Commission, 2011). The European Parliament therefore has provided the ‘ITS Directive’ as a legal framework. The Directive intends to ease the harmonised employment of ITS across Europe accordingly (European Commission, 2018f).

The activities and endeavours vary in relation to the mode of transport. Whilst the work package 2 transport activities of NSB CoRe very much concentrate on rail and road as mode of transport and in the context of intermodal transport – for sake of completeness and universal applicability in logistics chains, this report shall continue to briefly touch other modes of transport as well. It is also relevant for the overall picture of why these aspects are important in connection to the future trends that will follow this chapter. The EU also regards the ITS Directive as part of their strategy for a Digital Single Market and furthermore wants to utilise these tools for a better transport network management (European Commission, 2018g). The EU thus went a step further, building on the ITS Directive, and created an 'EU Strategy on cooperative, connected and automated mobility' (European Commission, 2018h). The aim is to have a Delegated Act for 'Cooperative Intelligent Transport Systems', or C-ITS, during 2018 (Menzel, 2017).

A C-ITS Platform was launched by the Commission in 2014 as a basis for this undertaking. The intention of the platform was to foster the emergence of a 'common vision' and a platform for exchanging knowledge. Moreover, the platform intended to provide a basis for '…cooperation on technical, legal, organisational, administrative and governing aspects' (European Commission, 2017a). The Platform was run in two phases and the previously mentioned strategy picked up on Day 1 and Day 1.5 services that should be prioritised in the future deployment of C-ITS and rolled out as first steps. Figure 1 below illustrates the identified services list and underlines the fact that many applications of C-ITS at this stage are for vehicles and road transportation (European Commission, 2016a).

Day 1 C-ITS services list

Hazardous location notifications:

- Slow or stationary vehicle(s) & traffic ahead warning;
- Road works warning;
- Weather conditions;
- Emergency brake light;
- Emergency vehicle approaching;
- Other hazards.

Signage applications:

- In-vehicle signage;
- In-vehicle speed limits;
- Signal violation / intersection safety;
- Traffic signal priority request by designated vehicles;
- Green light optimal speed advisory;
- Probe vehicle data;
- Shockwave damping (falls under European Telecommunication Standards Institute (ETSI) category 'local hazard warning').

Day 1.5 C-ITS services list

- Information on fuelling & charging stations for alternative fuel vehicles;
- Vulnerable road user protection;
- On street parking management & information;
- Off street parking information;
- Park & ride information;
- Connected & cooperative navigation into and out of the city (first and last mile, parking, route advice, coordinated traffic lights);
- Traffic information & smart routing.

Figure 1: Day 1 and Day 1.5 C-ITS Services list (European Commission, 2016a)

European Member States and road operators have created a platform for the deployment of C-ITS in this sector called 'C-Roads'. It is a common initiative for trials of C-ITS Day 1 services. All testing is done under consideration of interoperability and across borders. Areas of application in the road sector are: traffic jam warnings, green light optimal speed, in-vehicle signage and notification of hazards such as slow or stationary vehicles (C-Roads, no date). Currently, most ITS progress in logistics is made in the road sector and what is referred to as Vehicle-2-Vehicle-, or V2V communication. These ITS services are sought-after with their potential of better traffic - and thus more efficient transport flows, but also increased safety (European Commission, 2016b).

The concept of Vehicle-to-Infrastructure, or V2I, takes the V2V services a step further and allows to link-up several trucks electronically. The trucks form a platoon, which is why this is often referred to as 'truck platooning' (European Automobile Manufacturers Association, 2017). Whilst this kind of automation is increasingly tested across Europe to progress on the level of automation, legislation still requires a driver (Pillath, 2016). Furthermore, tests are currently mono-brand rather than multi-brand and interoperable platooning (Krosse, 2017).

Public acceptance for these C-ITS related technologies is still limited. There is an increasing effort to raise the awareness amongst the public - not only in terms of safety, but also in privacy related questions (European Commission, 2017b) In order to achieve interoperability in the developments and ensure a step-by-step increase in automation, most tests are carried out using the level categorisation of automated driving established by the Society of Automotive Engineers. The levels are set up in five categories, of which the first three involve humans to monitor the environment. An illustration of the levels of automation can be seen in figure 2 below.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 2: Automation levels according to SAE (Society of Automotive Engineers, no date)

The European Rail Traffic Management System, or ERTMS, is an initiative to provide interoperability through harmonising the control-command systems and signalling across Europe. It is a result from the Global System for Mobile Communications for Railways digital communication standard for internal voice and data communication, often referred to as GSM-R, and the new European Train Control System, or ECTS, as the control-command system standard in Europe (Kapsch CarrierCom, no date). Besides the improvement of cross-border connections, ERTMS offers more safety and more capacity on existing infrastructure (UNIFE, 2013). However, the financing of this undertaking has caused the implementation to fall behind (European Commission, 2017c). There are still a few barriers of interoperability – such as: interaction with legacy systems in Member States, different engineering rules, or different interpretations of the ERTMS rules (European Commission, 2017d). The Fourth Railway Package with its technical pillar introduces important changes. Improved processes will enhance the interoperability and compatibility. These improvements, along with the ERTMS deployment plan, set a new framework for the implementation target dates of 2023 (European Commission, 2017d) and 2030 respectively (European Commission, 2017d). Sixteen ERTMS projects where identified for the North Sea – Baltic Corridor alone (European Commission, 2017e).

Whilst ERTMS is a leading solution for railway signalling and control systems, it does not adequately take advantage of technologies available for Intelligent Transport Systems. To better reap this potential and to drive innovation in the railway sector, the EU went into a joint-undertaking in the form of a public-private partnership. This joint-undertaking is called Shift2Rail (S2R) that provides a platform for cooperation. The research and innovation through the S2R platform back the European Union’s efforts in achieving a Single European Railway Area (SERA). The S2R research activities will for example: commit to cutting costs, increase capacities, and increase reliability and punctuality (European Commission, 2014a). These aspects are covered under ’Innovation Programme 2’, advanced traffic management and control systems that looks at topics such as: communication system, automatic train operation, train integrity, standardised engineering and operational rules, traffic management system and virtual coupling (Shift2Rail, 2017a). Shift2Rail all-together has five Innovation Programmes and several cross-cutting issues that are integrated. An illustration of the research and innovation fields can be found in figure 3 below. Lighthouse projects implemented within S2R and across the various Innovation Programmes are: Roll2Rail, In2Rail, IT2Rail, and Smart-Rail (Shift2Rail, 2017b).

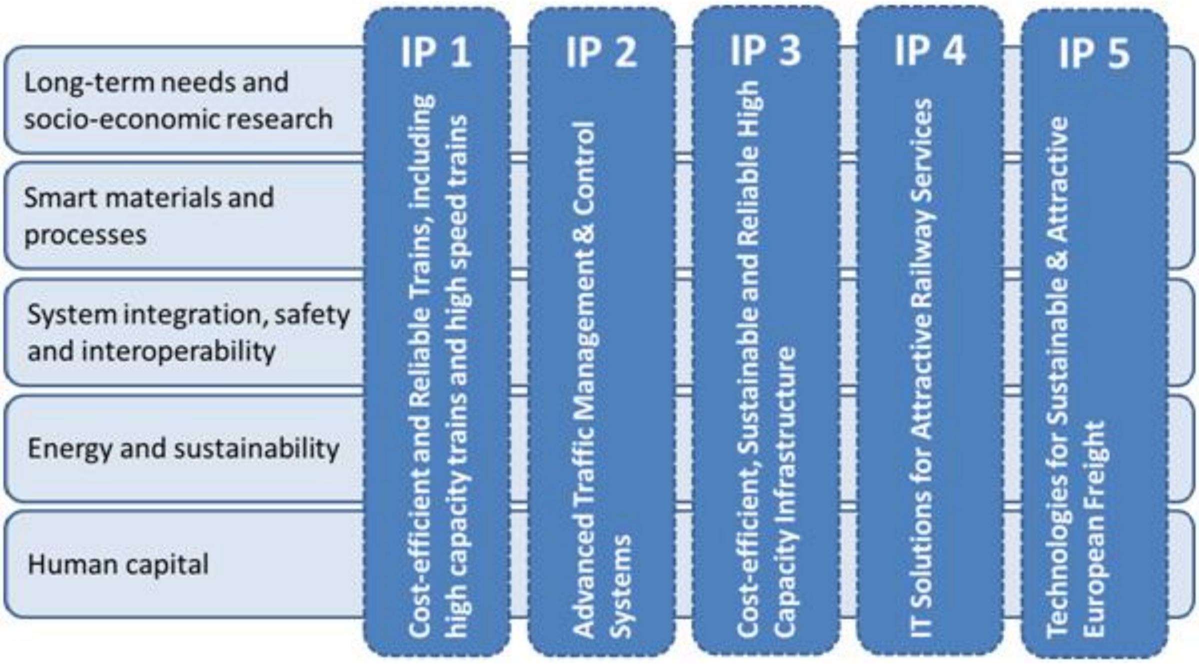

Figure 3: Innovation Programmes S2R (Shift2Rail, 2017c)

ITS solutions can also be found in inland waterway- and ocean shipping. One such example is the use of the Automatic Identification System, the AIS. The system broadcasts relevant information such as: position, speed and course of a ship. Furthermore, the system also allows automatic exchange of information within the proximity of the vessel. There are different needs between inland and maritime shipping. Therefore the River Information System (RIS), was established for the navigation on rivers. The RIS can be used for: fairway- or traffic information, traffic management, waterway charges and harbour dues, information on transport and logistics aspects, or information on law enforcement. Furthermore, the RIS can be used by users such as: authorities, lock operators, terminal operators, skippers, fleet managers and RIS operators (European Commission, 2010b).

3 Future trends related with development of ICT tools technology

ICT has opened up many new opportunities for companies along the supply chain. Not only in terms of new business opportunities, but also in regards to more efficient logistics chains. This chapter will outline some of the most dominant trends in this area. These trends stem from what is often referred to as the ‘fourth industrial revolution’. Industrial revolution went from mechanisation-, mass production-, computerisation and automation-, now to a blending of technologies. The boundaries between the physical elements of the first two steps and the digital element in the third step of industrialisation softened (Schwab, 2016). The four steps in industrial revolution are illustrated in figure 4 below. The following sub-chapters will touch on intermodal logistics related trends that are also briefly touched in the illustration below.

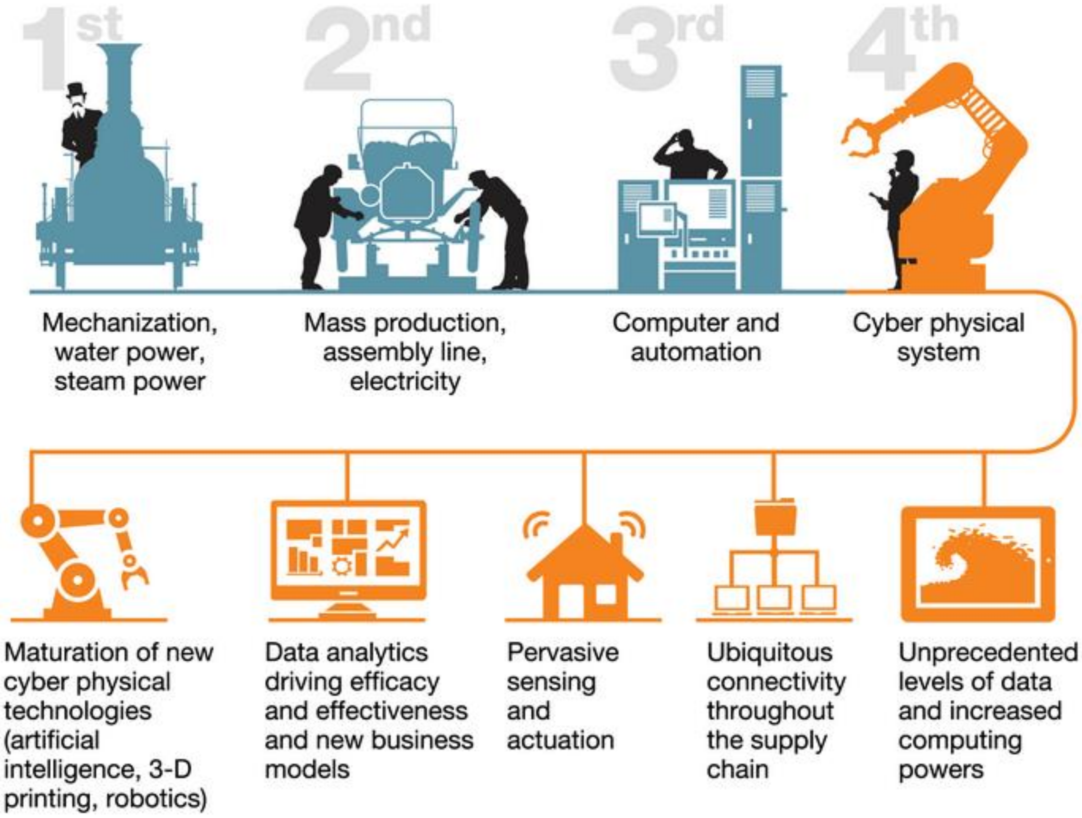

Figure 4: Four stages of industrial revolution (Goenaga et al, 2017)

3.1 Industry 4.0

The term originates from a report for the German Federal Ministry of Education and Research on 'securing the future of German manufacturing industry' (Federal Ministry of Education and Research, 2014; Mapi Foundation, 2015). Industry 4.0 refers to the utilisation of technology for 'smart' factories. The processes of the production include devices that can communicate autonomously amongst another and along the 'value chain'. In other words, computerisation is utilised to monitor the physical processes through a digital copy and makes 'decentralised decisions based on self-organisation mechanisms' (European Parliament, 2016). The fundamental elements of this concept are: interoperability, virtualisation, decentralisation, real-time capability, service orientation and modularity (European Parliament, 2016).

Industry 4.0, or the fourth industrial revolution, utilises technology to create 'Cyber-Physical Production Systems' (Industry-Science Research Alliance, 2013) that utilise ICT along the entire value- and logistics chain of a supply chain. The following sub-chapters will touch the most discussed ICT topics. Due to the twinning of physical- and digital copies of these infrastructures, the boundaries and interaction between some of the below discussed can be blurred. The first two sub-chapters will therefore highlight the differences between the physical and digital aspects of the infrastructure and their communication – and is then followed by various digital ICT tools that support the utilisation of ICT and ITS within the value- and logistics chain and with that also intermodal transport processes.

3.2 Internet of Things and Industrial Internet of Things

The Internet of Things, or IoT, in all brevity - is the connectedness of physical objects and the Internet (Uckelmann et al, 2011). These physical objects are able to sense or act on their immediate surroundings and to communicate amongst each other. On the one hand, the analysis of the generated data from these objects offer potentials for costs savings, efficiency gains, or product and service improvements. On the other hand, with more than 25 billion worldwide connected objects, issues such as interoperability will arise. One very current issue with the Internet is data privacy, safety and security (Davies, 2015). The recent Cambridge Analytica Facebook scandal (Confessore, 2018) has illustrated that achieving parity is difficult and that a consent needs to be found where data may be used in certain frameworks (Davies, 2015). The European Union has established the General Data Protection Regulation (European Commission, 2016c) in 2016, taking effect in May 2018 (Allen and Overy, 2017). For IoT what is more important is the proposal for a 'Regulation on Privacy and Electronic Communication' (European Commission, 2017f). This proposal has much more influence on the development of IoT as it has a more stringent statute on the privacy of electronic communication. This could therefore have a bigger impact on Machine-to-Machine (M2M) communication and functionalism in daily application (Wallace, 2018). An overview of the Internet of Things is given below in figure 5.

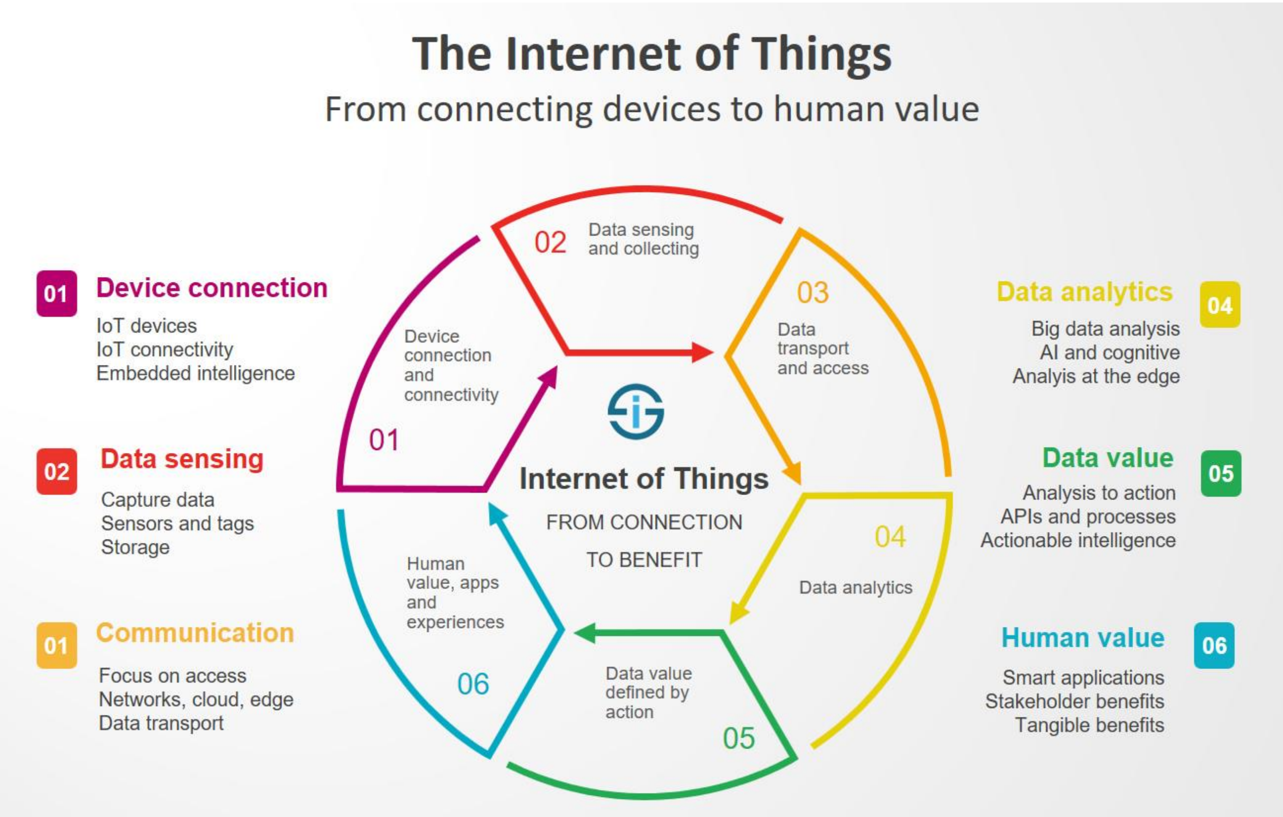

Figure 5: Internet of Things (I-Scoop, no date)

The Industrial Internet of Things, or IIoT, covers IoT in industrial operations (PWC, 2017) and the transmission and administration of critical data and insights (Dudley, 2017). In IIoT industrial objects interact, coordinate data analytics and act to enhance the industrial performance (National Instruments, no date). IIoT, being based on IoT, has the same potentials and issues. IIoT specific however is the necessity to regularly be adjusted in order to stay on par with functionality and maintenance requirements. One specific issue is also the imense need of investments (National Instruments, no date). These investments are possibly offset by earnings from products and services resulting from IIoT, as well as differentiating the products to better stick out from the competition (PWC, 2017). An application example for a more efficient and cost saving application in the transport sector is the Norfolk Southern Railroad case. Capacity was increased through higher speed and rail operation efficiency. The IIoT system integrated railroad logistics with traffic control systems for a better traffic plan. Factors that helped to increase the capacity and efficiency were: train schedules, optimal speed and train movements relative to each other (Intel, 2016).

3.3 Physical Internet

Physical Internet, or PI, is an analogy to the digital Internet and the standard utilised for data transfers (Montreuil et al, 2013). It is based on physical, digital and operational interconnectivity. This offers to adjust the logistics processes and services within the supply chain (Pan et al, 2017). This is therefore sometimes also referred to as 'Logistics 4.0'. However, the concept only works with the standard shipping containers so far, as no standard has been agreed upon outside this transport unit confinement (Montreuil et al, 2013). A common standard could allow for interconnectivity and utilise the capacity of smart containers in connection with IoT (Montreuil, 2011). Sensors and other smart objects powering this capability are increasingly on the agenda of the logistics and transportation industry and they have become much more affordable. The corner stones of this theorem thus constitutes of open cooperation along logistics chains and supply chain interfaces such as: π (PI)-container and π–logistics centres that utilise modern ITS technologies (Maslarić et al, 2016).

Therefore, through the utilisation of the IIoT, the Physical Internet could offer the opportunity of open and shared interconnected logistics activities (Maslarić et al, 2016). The opportunities really just need to be harvested, as the supply chain and the related logistics chain have ample amounts of data at hands (Maslarić et al, 2016). The interconnected activities would increase the efficiency, interoperability and competitiveness of the transport sector as a whole. The EU goal of an analogue and Digital Single Market further underlines the necessity of digitalisation and the potential of the Physical Internet approach. The below figure 6 provides an excellent overview of the PI and what is outlined as a possible roadmap for the implementation of the Physical Internet accordingly.

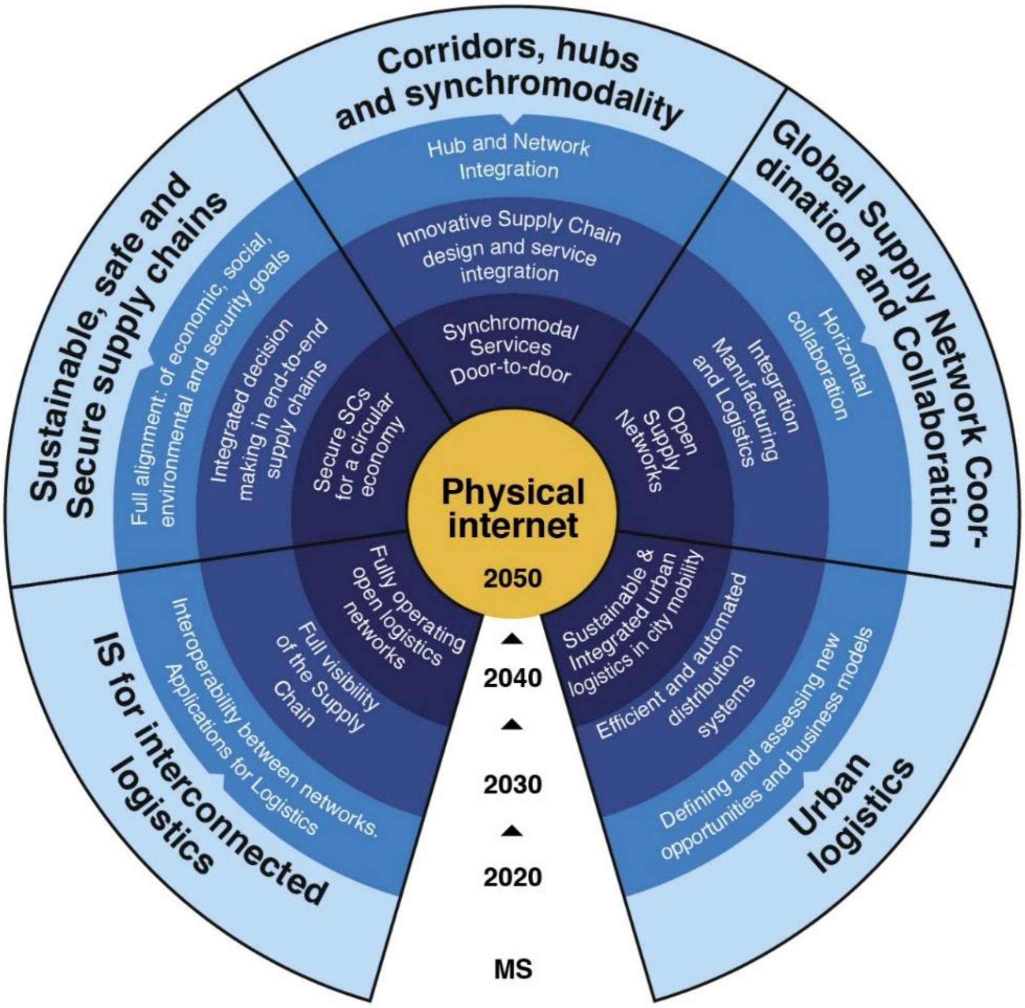

Figure 6: Physical Internet Roadmap (European Technology Platform ALICE, no date)

3.4 Cloud computing

Cloud computing is the convenient provision of 'on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction' (Mell and Grace, 2009). The cloud itself is a physical network of data centers that host many workstations that are interconnected to provide the necessary computing power (Wang et al, 2011). This technology has made it possible for organisations of any size to have affordable access to these computation resources from anywhere in the world and additionally possibly reduce costs on the company owned IT infrastructure. The cloud technology has furthermore enabled a better global collaboration and offering new potential products and services (BSA, 2018). The European Union has identified the potential of Cloud computing and its' role within the Digital Single Market Strategy and therefore initiated a European Cloud Strategy in 2012 (European Commission, 2014b). This chapter will provide an overview of three service models that cloud computing offers the potential for. Chapters 3.4.1 to 3.4.3 will only touch upon these models in a more general perspective, as examples can also be found in report 2.3.2 'Review of the ICT solutions supporting intermodal transport sector'. Before diving into the service models, it should further be pointed out that there are three types of clouds: public, private and hybrid. Public refers to cloud access by anyone connected to the Internet. Private refers to a cloud with access limited to a certain group of people or business affiliates only. The hybrid cloud is a combination of the former two (Huth and Cebula, 2011).

3.4.1 Software as a Service

Software as a Service is a service model based on the provision of a software in the cloud. This allows intermodal transport stakeholders to utilise transport related applications such as customer relationship management, stakeholder collaboration, or document sharing. The main target group is the 'end user' of the software. However, this is valid for various stakeholders in the intermodal transport chain and various software varieties. The stakeholder in other words is provided with an application, middleware, server, storage, data and network through the cloud (Perakovic et al, 2017). The report 2.3.2 'Review of the ICT solutions supporting intermodal transport sector' mentions examples such as load calculators or route planners (NSB CoRe Report 2.3.2, 2018).

3.4.2 Platform as a Service

Platform as a service refers to the model of providing infrastructure in the cloud to deploy applications in a virtualised development or production environment. Through this, intermodal transport software providers are able to develop and set up new intermodal transport applications, for example Software as a Service, without the need to invest in hardware or software (Ezell and Swanson, 2017).

3.4.3 Infrastructure as a Service

This service refers to the lowest layer of cloud services offerings. With Infrastructure as a Service, only the computing power, storage and networking capacities are supplied according to the stakeholders needs (T-Systems, 2014). The Infrastructure as a Service thus is more of a platform on which the stakeholder then can built its cloud presence according to their needs. Figure 7 below illustrates the differences of the three service models of Software-, Platform- and Infrastructure as a Service.

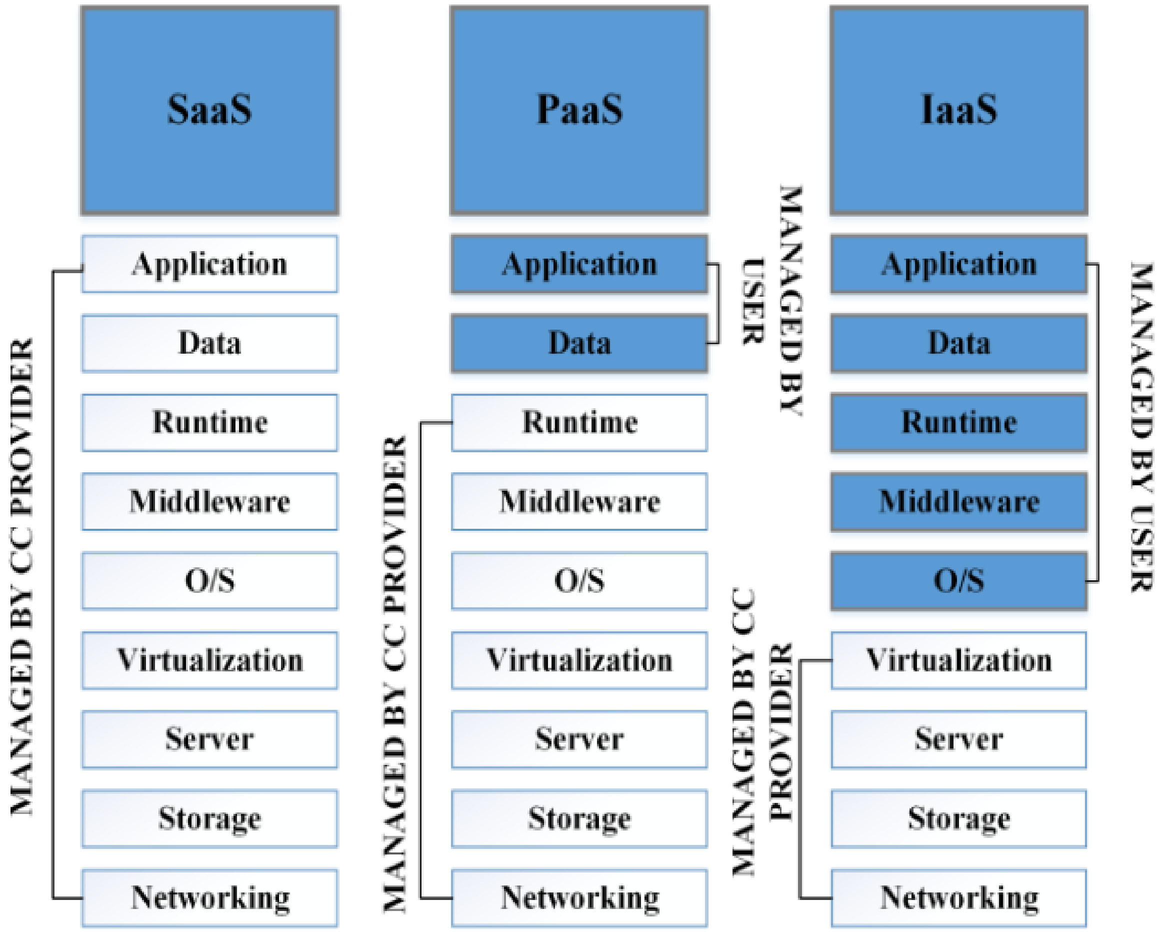

Figure 7: Cloud Computing Models (Perakovic et al, 2017)

3.4.4 Security Considerations of cloud computing

Whilst Cloud computing offers a lot of possibilities, it also has to be pointed out that there are threats. In terms of security and privacy the following broader risks may be considered: loss of governance control, uncertain responsibilities, data protection, authentication and authorisation, vulnerability management, isolation failure, service availability, and compliance and legal risks. From a privacy perspective the personal data regulation also needs to be considered (Cloud Council, 2017). Especially with the ‘General Data Protection Regulation’ that is enforced from May 25th 2018. The most discussed issue from the list is the ownership of the data question. The ‘chicken-and-egg’ issue for interoperability, multimodality and cooperation amongst stakeholders. Data is the new currency. In order for an increased usage of cloud services and all its potentials to the involved stakeholders, it is necessary to specify standards for the applicable levels and scope (European Commission, 2017g). It is ‘the’ discussion found at conferences and other stakeholder meetings in regards to (I)IoT and Big Data.

3.4.5 Edge Computing

With the introduction of cloud computing and the Internet of Things, the amount of data coming from endless numbers of devices has increased tremendously. The concentrated handling of data in a particular data center has therefore become much more complex and difficult. The ulterior motive of edge computing is to bring the computation power closer to the edge of a network and therefore nearer to the data origin. Fog and edge computing appear similar due to the fact that both bring the processing nearer to the source (WinSystems, 2017). Therefore, they are often interchangeably mentioned in literature. However, edge computing takes literally place at the edge of a network. Fog computing on the other hand takes place on the local area network level. Fog computing therefore extends, or bridges, the edge computing towards the cloud. This enables a more focussed data processing and thus higher computation power and transmission speeds for the relevant processes at the respective layer or stage. Figure 8 below illustrates the three different data layers in more detail.

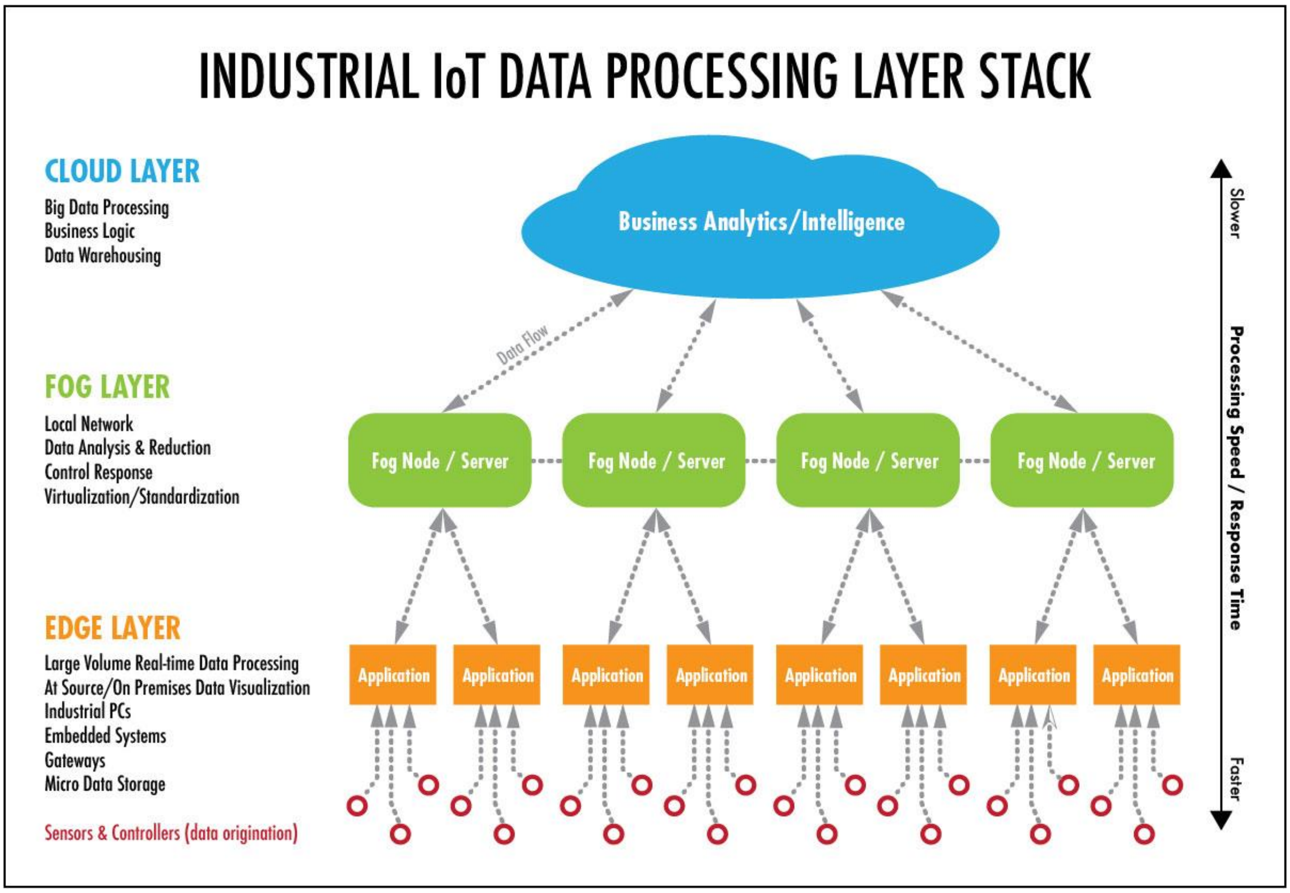

Figure 8: Different data processing layers (WinSystem, 2017)

The distribution of computation power and low latency required for a good service offering can only be achieved in such a way. It is becoming an increasingly important topic when looking at the growing bandwidth requirements by subscribers and devices sharing the bandwidth. In recent years this caused a discussion on net neutrality, which however is not the focus of this document. Figure 9 on busy period bandwidth usage of residential subscribers in the United States does show the variety of applications that share the bandwidth already. The rising opportunities of V2X, V2I, V2V and M2M only increase the need for bandwidth. The industry and governments also therefore increasingly focus on the new communication standards and trials are run accordingly (Hamburg Port Authority, 2018).

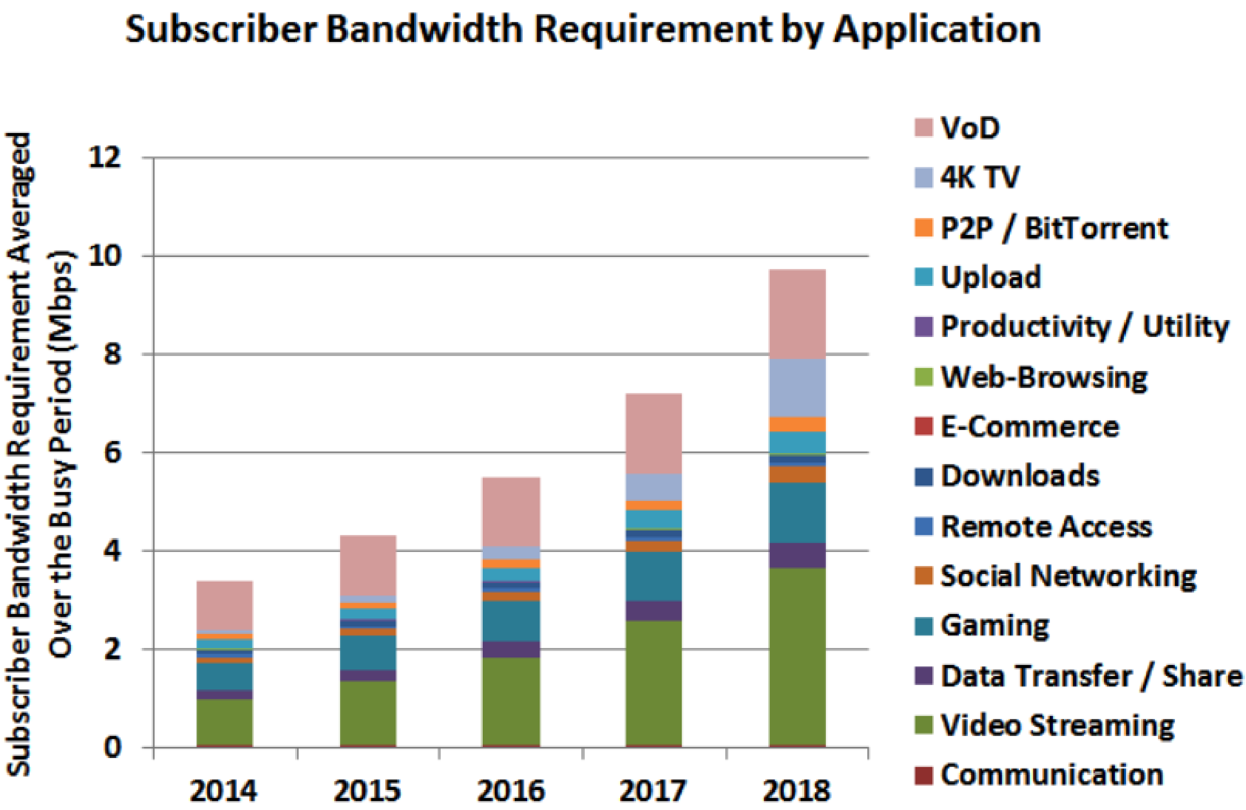

Figure 9: Residential Subscriber Busy Period Bandwidth Requirement by Application (ACG Research, 2015)

The discussed latency issue resulting from increased computation and data packets can be further underlined when looking at the growing trend in Internet of Things: ‘multi-access edge computing’, sometimes also referred to as ‘mobile Edge Computing’ or MEC. This technology is set to play a key role in reducing the network weight from the cloud to mobile edge (Shazadi et al, 2017). Moreover, it is used in various pilots to illustrate possible application fields in the V2X, V2V, V2I and connected and automated driving context. One such test bed was the A9 motorway in Germany (Fraunhofer ESK, 2018). The vehicle-to-everything communication was tested here using the existing infrastructure of a telecommunication company. Another pilot was carried out in Hong Kong and illustrated the use of technology for increased road safety, in this case at intersections with limited vision (Applied Science and Technology Institute, 2017). One other example of use-case testing is the notification of emergency vehicles approaching, using the V2X and MEC technology (Ericsson, 2017). Although these use cases mainly illustrated the aspect of safety, this technology offers much potential for the logistics sector and value added services.

Ericsson pointed out the potential at a high-level conference on European multimodal freight transport in Sofia earlier this year (European Commission, 2018i). Ericsson, being a global shipper and a leading provider of ICT, illustrated that everyone in their supply chain is connected – just not amongst each other. This makes the collection of important information such as track and trace, vehicle status, digitalised documentation and supply chain optimisation rather difficult. Their idea of an ecosystem is illustrated in figure 10 below. Nokia, for that matter, pointed out the business drivers and utilisation possibilities of the 5G standard and MEC. They are: time and energy waste and the need to re-define mobility in the automotive sector – but also the possibility of higher productivity, individualisation as added service and defragmented communication systems in terms of Industry 4.0. MEC and 5G enable: the previously mentioned automated and connected driving, machine-to-machine robot collaboration and autonomous vehicles in warehouses as examples (Dropmann, 2016).

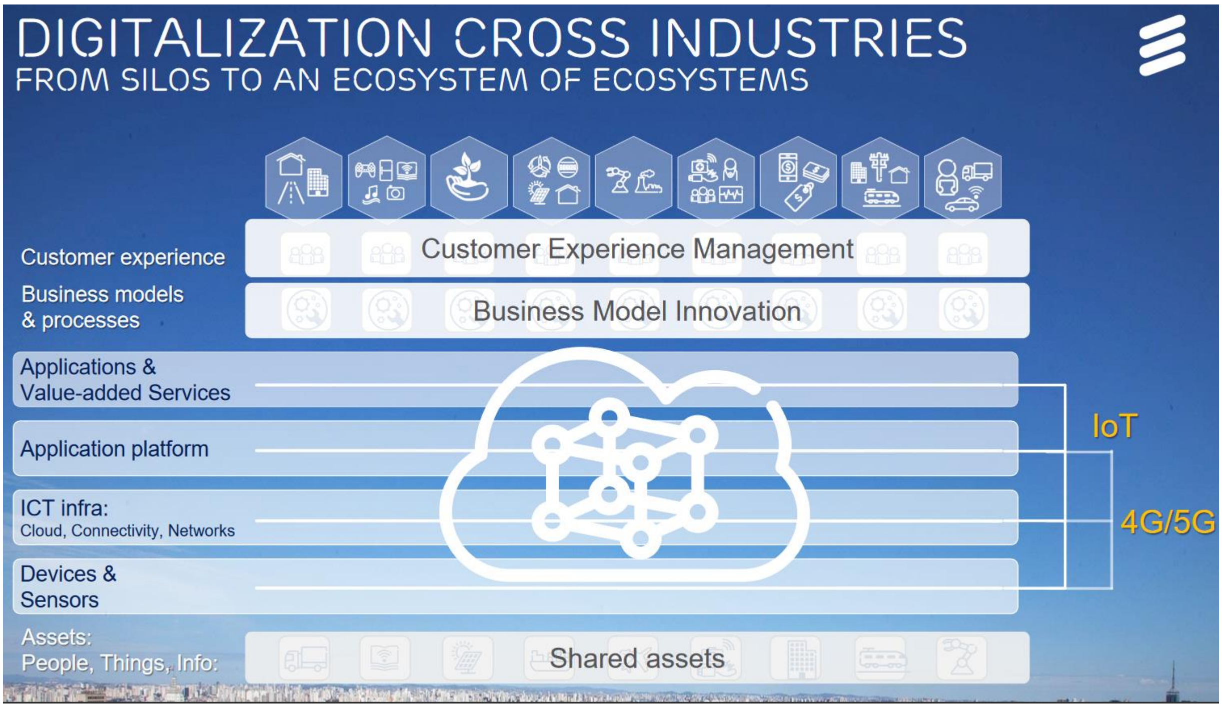

Figure 10: Multi-access edge computing across industries (Isaksson, 2018)

3.4.6 Fog Computing

Fog computing, often also referred to as fogging, is an expansion of the cloud and through that raises the productivity of smart devices through enhanced security and compliance. Fogging platforms: are heterogeneous, increase the efficiency of edge computing, are geographically distributable, can have the form of large scale networks or nodes, support mobility, enable real-time interactions and interoperability (Goswami et al, 2017). The physical devices at the edge of networks providing capacity for services are referred to as fog nodes (Marin-Tordera et al, 2017). With the rise in Internet of Things services and added value generation possible through cloud computing, these fog nodes help to cater for the limitations of cloud computing reflected also in the discussion on edge computing. Furthermore these nodes offer to serve cloud components closer to IoT devices such as sensors, cars, or railways in regards to intermodal transport. Application area examples of fog computing can be smart highways, smart cargo, or connected / autonomous vehicles. There are a number of hindrances for the utilisation of fog computing at this stage: missing edge infrastructure services, lack of standardised hardware, physical security, the complexity in keeping a quality of service, legal and regulatory requirements and no transparency in networks (Bermbach et al, 2017). However, fog- and multi-access edge computing in the supply- and logistics chain is gaining momentum. Furthermore, the European Union with its ‘Digital Single Market Strategy’ also aims for better regulation. The below figure provides an overview of the correlation of cloud- and fog computing.

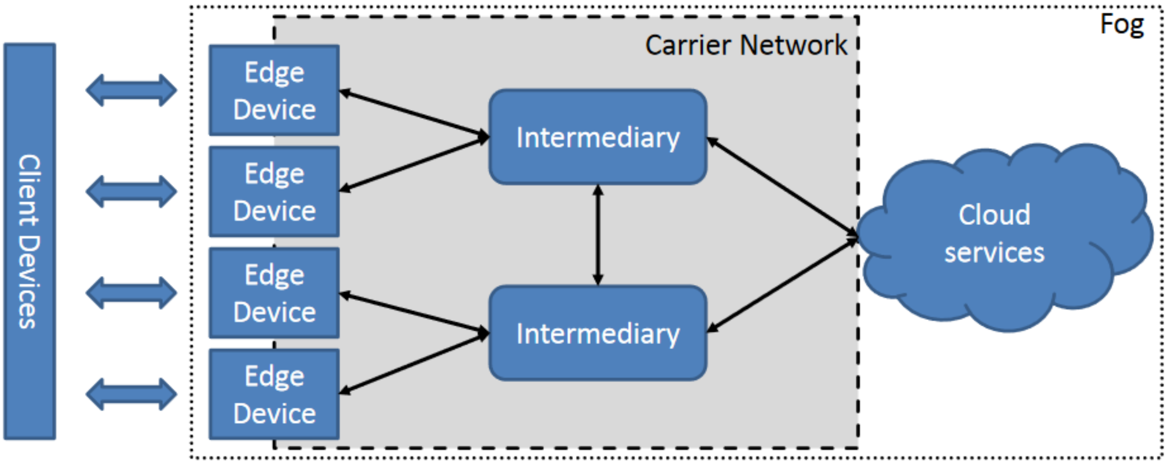

Figure 11: Deployment overview Fog Computing (Bermbach et al, 2017)

With the discussed concepts of Physical Internet and fog computing, the principle of smart cargo becomes a feasible concept. Smart cargo refers to autonomous cargo that uses modern technology to effect the changing of transport systems. The smart cargo is able to react in real-time, make decisions and communicate with other modules in the transport or logistics chain. Smart cargo may even engage autonomously to a given degree (Costa et al, 2016). Smart cargo is then able to use cloud and fog-computing capabilities to make real-time decisions based on environmental-, data driven and knowledge driven considerations and promote inter-cargo communication through collaboration amongst cargo (Costa et al, 2016). This makes transportation one of the biggest potential markets for fog computing. After all, there are some 160 transport related endpoint devices along the logistics chain. The 'OpenFog' project analysis estimated that the market is worth more than USD 3 billion by 2022, considering that there is currently still much potential for data sharing amongst transport assets. The analysis further estimates computing revenue in the transportation market to be at USD $ 132 million in 2018. Therefore the aggregated growth between 2018 and 2022 is estimated to be more than 120 per cent (OpenFog, 2017). Driving forces in the progression of fog computing in transportation are connectivity, telematics and autonomy. Figure 12 below illustrates the real-time awareness of smart cargo.

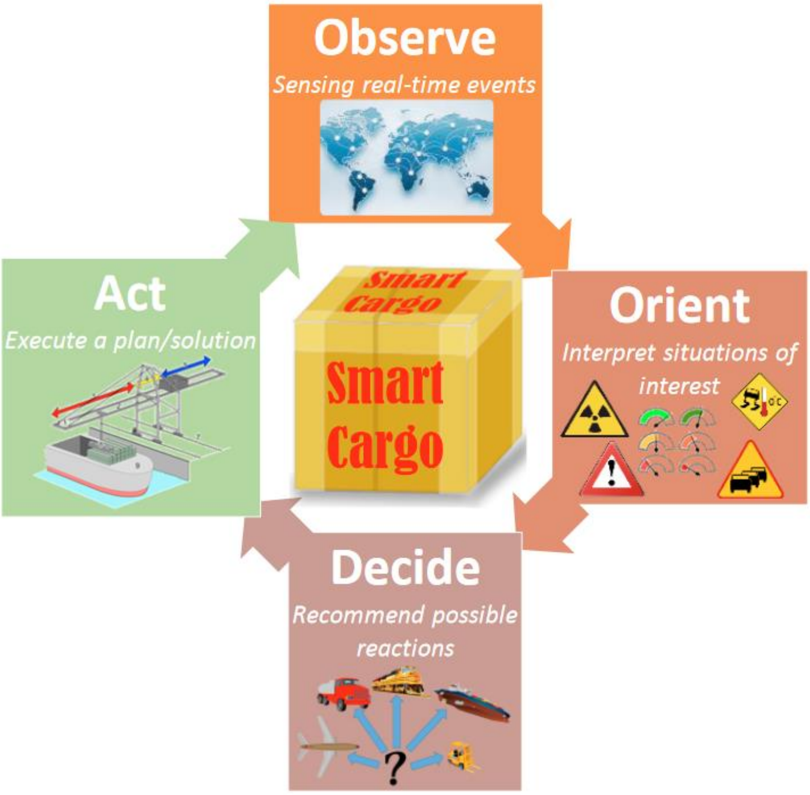

Figure 12: Real-time situational awareness (Costa et al, 2016)

3.5 Big Data

There is no single definition of Big Data. It is also not a new trend. In a wider sense it refers to the vast increase of available data that comes with digitisation. At the end of the 20th century it was a problem due to the then existing information technologies (Kiseleva et al, 2016). Today however the hardware has become inexpensive and the computation power has increased manifold. These massive amounts of data offer new approaches for the generation of added value through the application of today's emerging technologies. There are three defining aspects of Big Data - the three Vs: volume of data, velocity of data and variety of data. The adequate generation and management of such data provides firms with a competitive advantage (Cavanillas et al, 2016).

The potential Big Data market in the transport sector is predicted to be USD 500 billion worldwide according to the OECD. This value is based on estimated time savings, fuel savings and emission reductions (Cavanillas et al, 2016). Furthermore, the three Vs enable intermodal operators and other stakeholders in the supply- and logistics chain to better design the supply chain network. Moreover, the routing and the relevant demand can be determined and optimised through predictive planning using the time-series approach (Bloemhof, 2016). This then helps to reduce costs and boost productivity – and through that increases competitiveness. Other application areas in intermodal transport could be the sensor data of rolling stock and with that - for example its location or condition, type or amount of goods transported (Roland Berger, 2017). Siemens calls their adaption of this concept the ‘Internet of Trains’ (Siemens, no date) and uses 800 data points that are continuously analysed by each locomotive. This then allows Siemens a predictive maintenance approach instead. The diagnostic data can monitor - and through that anticipate component failures that are then repaired before anything can happen (Teradata, 2015). German rail operator DB Cargo commissioned Siemens to equip its locomotives with the ‘TechLOK’ system that uses the Big Data for predictive maintenance (Pieriegud, 2018). Figure 13 below illustrates the potentials of sensors and Big Data in the railway industry.

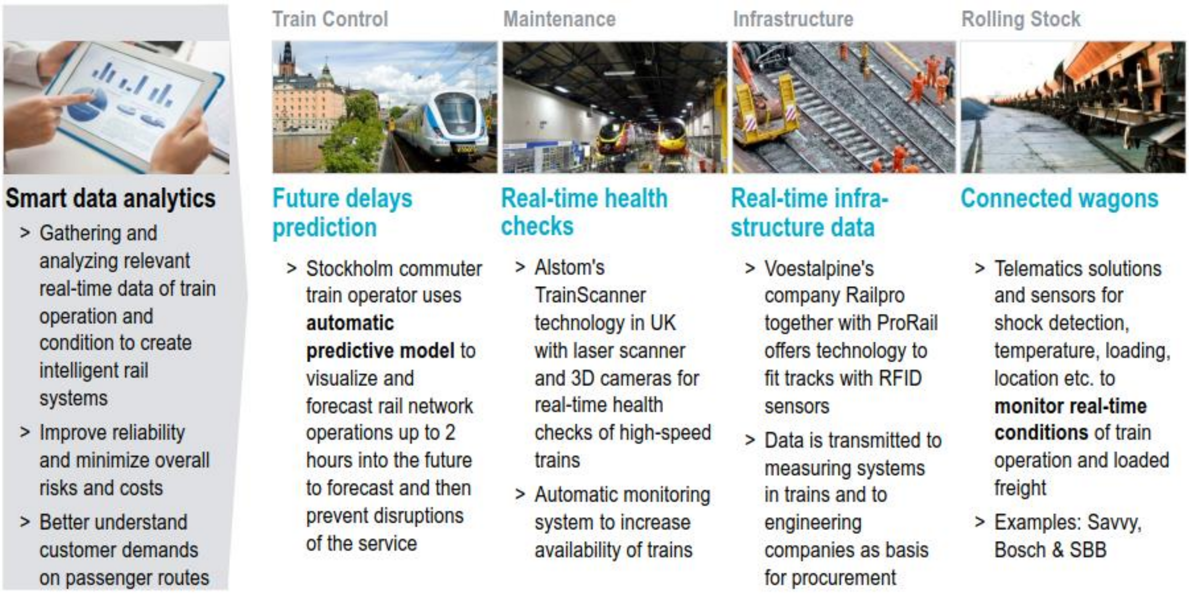

Figure 13: Sensor and big data (Pieriegud, 2018)

The European Commission envisages a ‘common European data space’ that brings stakeholders together from the various Member States, discipline and sector. This data space could then be used to utilise the data to promote new products and services based on these data sets (European Commission, 2018j). Not only would this then enable new business opportunities, but it also aids the interoperability desired for a single market. The European Union established the Shift2Rail joint undertaking, as previously mentioned in the ITS chapter, to drive innovation and to help enable the railway sector to offer value-added services (Pieriegud, 2018). These efforts are supported by ‘Rail Net Europe’, an association of Infrastructure Managers and Allocation Bodies who work together to facilitate international trade and cooperate with the Rail Freight Corridors, offering one-stop shop services in regards to network and corridor questions (Rail Net Europe, 2018). An overview of an ecosystem focused on Big Data and its aspects is provided in figure 14 below.

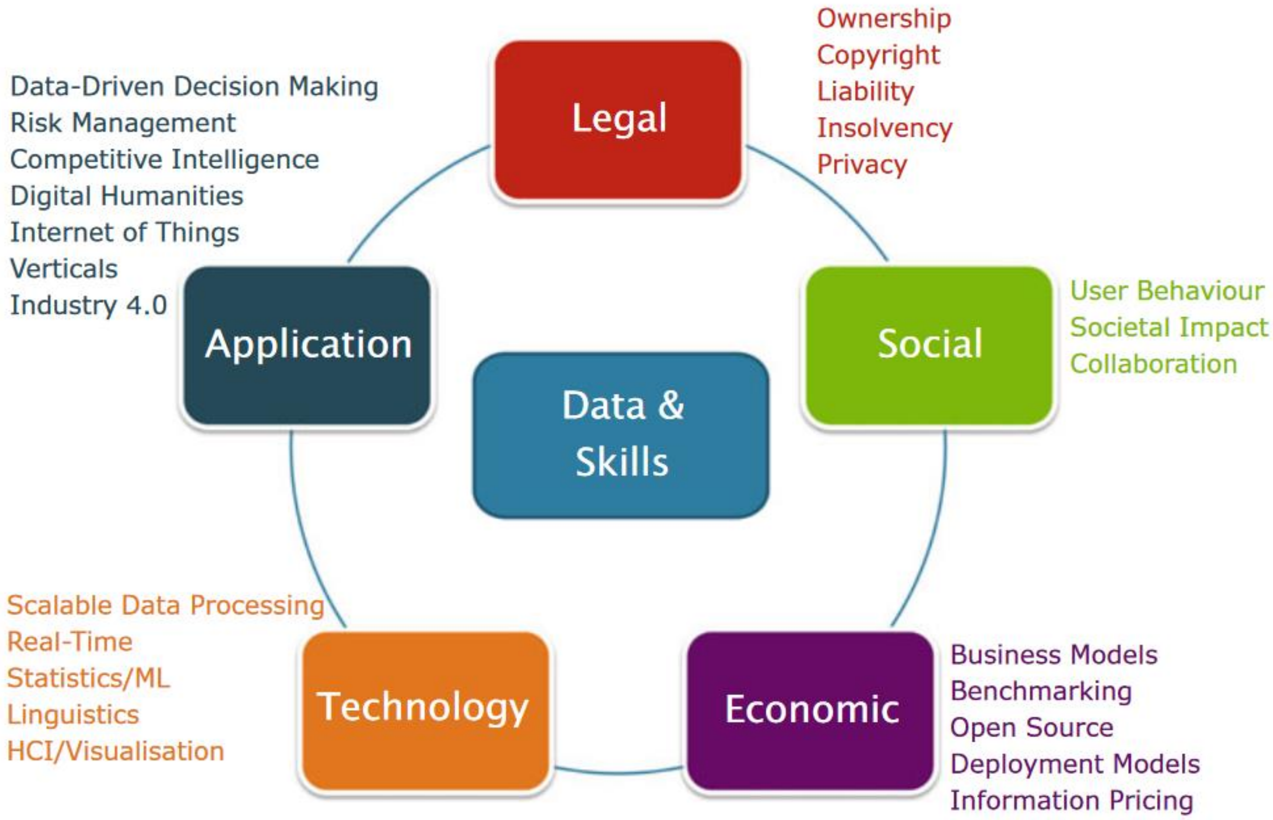

Figure 14: Big Data Value Eco System (Cavanillas et al, 2016; Big Data Value Association, 2015)

The global forwarder DHL published a report on ‘Big Data in Logistics’ (Jeseke et al, 2013) in 2015 to illustrate the utilisation of Big Data in logistics and thus supply- and value chains. The report outlined five aspects through which the application of Big Data could best be illustrated. They are: optimisation, tangible goods and tangible customers, synchronisation with customer business, network of information and global coverage with local presence (Jeseke et al, 2013). In the last-mile of intermodal transportation the available real-time data can for example be used to ensure the best route. The calculation can utilise the data available to consider the best cruise speed and the best route, based upon available information such as traffic or construction works. In turn this then improves the carbon footprint and the transit time. At the same time, the real-time information also enables transparency of the fleet and thus track and trace ability of cargo to the customer. For the intermodal stakeholder on the other hand this transparency enables a better utilisation of capacities on a short-term, but also on a long-term basis when the available information is used to anticipate future relations and occupations of trucks or other aspects such as personnel and infrastructure needed and utilised for the last-mile. Figure 15 below illustrates various aspects of Big Data in logistics.

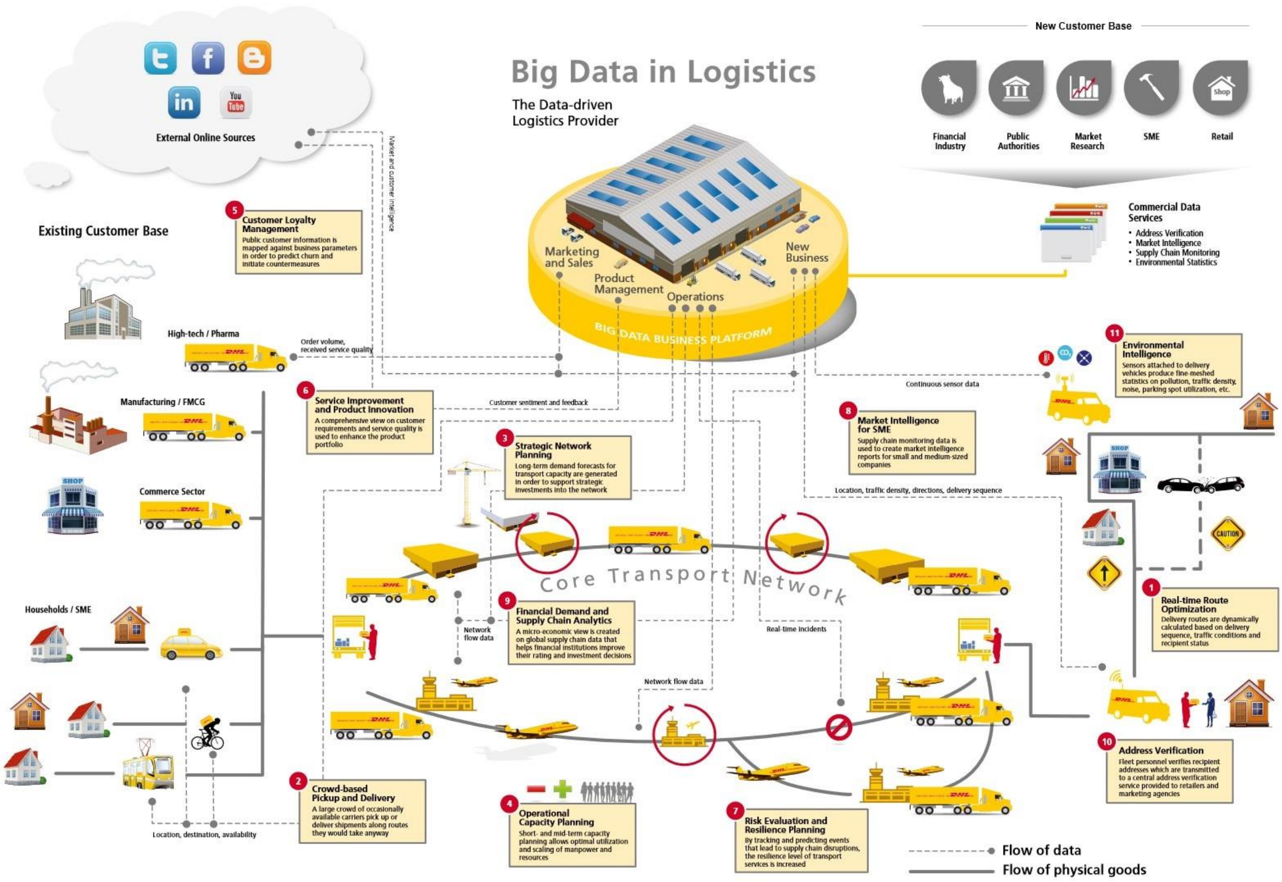

Figure 15: Data-driven Logistics Provider (Jeseke et al, 2013)

3.6 Augmented Reality

Augmented reality refers to the enhancement of real world information with virtual elements. It integrates digitally available information into a real world environment. The technology can be used to provide different stakeholders in the logistics chain with information, without them having to interrupt their daily work. The technology is an inherent part in the automotive industry and their research in connected and automated driving. Examples of applications herein are lane assistance (Glockner et al, 2014), load completeness (Rajamanickam, 2017) or optimised load planning (Glockner et al, 2014).

3.7 Artificial Intelligence

Artificial Intelligence is not a new topic either. John McCarthy came up with this terminology in 1956 when he invited various stakeholders to an interdisciplinary workshop. The workshop was focused on concepts of 'thinking machines' (Marr, 2018). Today, Artificial Intelligence (AI) can be seen more of a system of different technologies that enable machines to enhance the capabilities and through that allow individuals to accomplish more. This enhancement is reached through '…sensing, comprehending, acting and learning' (Accenture, 2017). This then enables intermodal transport stakeholders to utilise the increased productivity of their staff and through that achieve cost savings too. Some of the technologies already mentioned in this report, such as autonomous trucks, are the technologies that allow for the utilisation of AI. It is these areas of automation that currently drive the digitisation and digitalisation of transport.

The interrelation of Artificial Intelligence and Big Data is more and more recognised (Bean, 2018). The necessity of utilising such 'currency' held by many companies can also be observed. Other business areas showed what can happen if new companies can become a threat because they utilise their data to become competitors with a competitive advantage. It is the likes of Amazon, Google or Facebook who have outrun their competition, because they are able to anticipate what their customers want. The same can be expected to be seen in the near future in other business areas. Data is the new currency. It is anticipated that AI and connected autonomous driving will not be the next big thing in passenger cars, but rather in trains and ships. There are already several trials in these areas. In the area of shipping for example, there is the ‘Yara Birkeland’ (Kongsberg Maritime, no date). It is a fully electric and autonomous container ship. Big Data and AI is also already applied in rail transportation. The ‘Internet of Trains’ was already mentioned in a previous chapter for an application example in the railway sector.

The areas of application for AI can best be illustrated with the last mile and transport network. AI can be used to apply calculations on Big Data of past truck transports for example. Using these computations, the AI can aid the transport planner to project the delivery times of shipments of a particular day and customer. These computations also use real-time data and therefore allow immediate adjustments if necessary. Additionally, these computations also allow the analysis of customer demands and therefore allow for adjustments of the tour planning. Therefore not only efficiency gains through updated route plans, but also freight consolidation can be achieved using the AI and Big Data available. This will then enable the transport planner to increase the productivity of the rolling stock and to cut costs for fuel, labour and other factors that could provide the company with a competitive advantage over a challenger of a tender from an industrial company for example (Janardan, 2017). An example of AI application for entire networks is the World Bank’s commitment for an improved multi-modal transport network in the Eastern Corridor of India through the utilisation of Big Data. Hereby the data was used to determine the best location to establish the transport mode change (Quiros, 2016).

The logistics Giant DHL published a report on ‘AI in Logistics’ (Gesing, B., Peterson, S. J. and Michesen, D., 2018) this year and touches the above mentioned examples. However, in relation to the ‘Internet of Trains’ further elaborates the utilisation of Big Data and AI for visual inspections. Damage and wear and tear of rolling stock or assets over time are innate. AI technology and Big Data can facilitate the recognition of damages to the assets. In a next step, the AI and computation power with the available Big Data then enables real-time decision making. Action can then be taken to ensure a correction of the damages or proactive repairs for accident prevention. Figure 16 below illustrates how AI can learn and identify damages on which it then makes decisions.

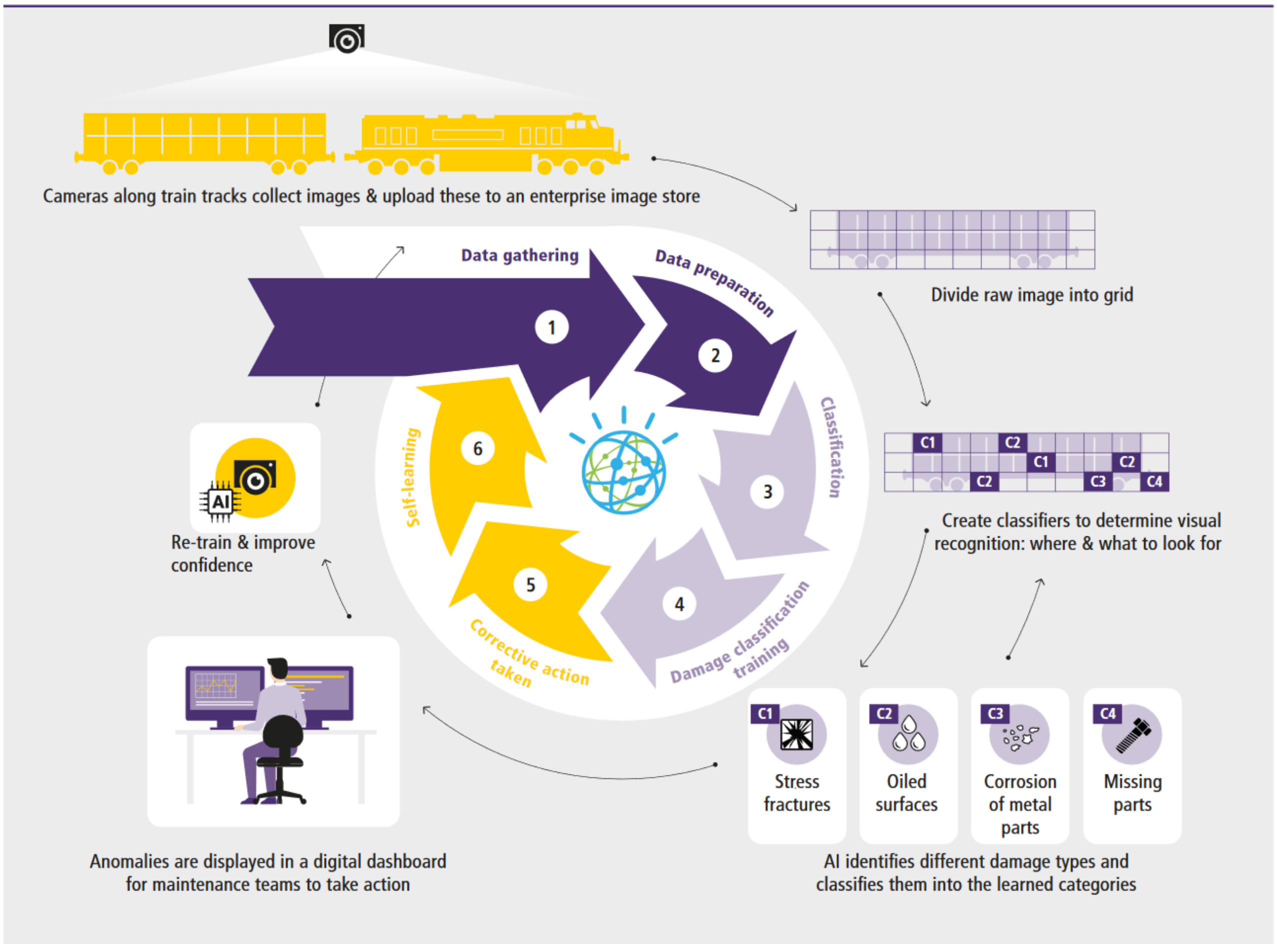

Figure 16: AI visual recognition and inspection enabled maintenance (Gesing et al, 2018)

3.8 Blockchain technology

As mentioned in earlier chapters, there are certain issues that span across the entire supply chain. They are: data visibility, process optimisation and demand management (Godbole, no date). As illustrated in figure 10 of this report by Isaksson, there may be advancement in these areas – but more within their silos. The Blockchain technology is a hot topic currently, as it is envisaged to ease the removal of silo thinking in the logistics field. In a nutshell, a 'Blockchain is a database for storing transactions that is shared among all parties in a network' and 'serves as an (encrypted) ledger for information' (Oude Weernink et al, 2017). This ledger is then amended over peer-to-peer reproduction whenever a transaction occurs. In other words, all stakeholders form a node - and either have the role of a subscriber who can receive, or the role of a publisher who sends transactions to other stakeholder nodes. The data packages are then updated over the ‘chain’ while being transmitted (Gupta, 2017). The peer-to-peer structure is what helps to remove the silos and thus increases productivity and efficiency. Instead of silos, Blockchain enables information exchange. It is for example therefore believed that Blockchain could: ease the paperwork in the logistics chain or operate the Internet of Things (Hackius and Petersen, 2017). Furthermore, the concept could enable ‘smart contracts’ or ‘smart Bill of Lading’ and with that reach a certain degree of automation process (Warner, 2017). An illustration of a before and after is illustrated in figure 17 below.

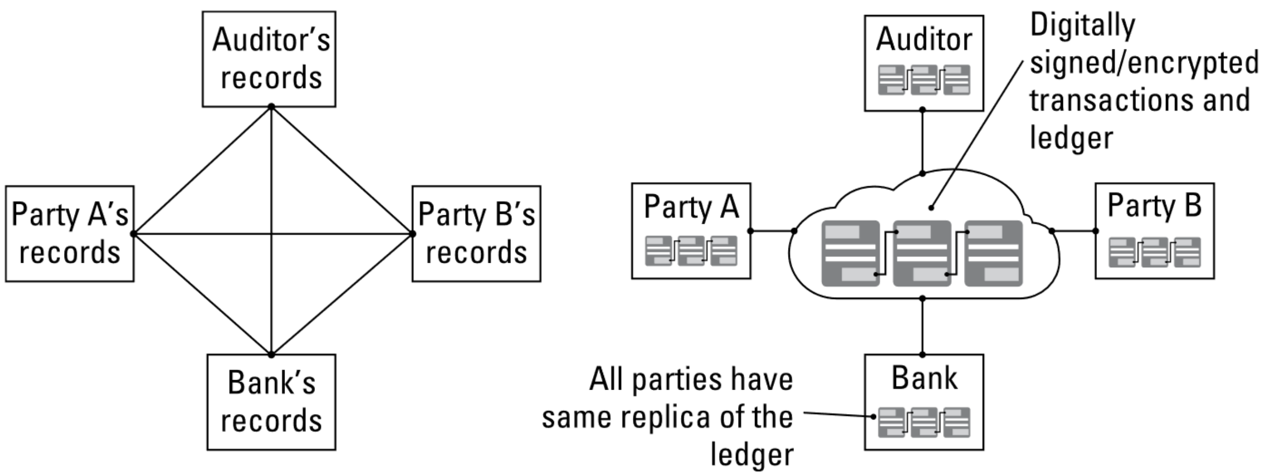

Figure 17: Business Networks before and after blockchain (Gupta, 2017)

Some key characteristics of a Blockchain are: privacy, distributed trust, governance, transparency and security. However, Blockchain also has some concerns and restraints such as: limited block size, high operational costs, environmental impact, immense bandwidth requirements, complexity and usability (Zambrano, 2017).

Examples for the implementation of Blockchain in logistics is ‘SolasVGM’ which is enabling a collaboration between landside stakeholders and provides them with the verified gross mass of containers. Skuchain takes another approach at the supply- and logistics chain by offering collaboration in commerce the possibility to build trust and through that eliminate the need of documents such as the Letter of Credit. An example of smart Bill of Lading application is the Wave application (Oude Weernink et al, 2017). There is a variety of applications of Blockchain that spring up like mushrooms recently. Given some characteristics of a Blockchain, there are however voices about the necessity of this technology in supply- and logistics chains when looking closer at interrelations of stakeholders (Wüst and Gervais, 2017).

Two other aspects of Blockchain as a new technology that are not trivial, are the need for governance and the legal framework. The European Union has recognised this emerging technology and therefore created a 'Blockchain Observatory and Forum' that, for example, monitors developments and addresses emerging issues. The European Union further envisages to develop a common approach for the EU and through that try to improve cross-border services in Europe such as customs (European Commission, 2017h). It remains to be seen how Blockchain, data governance and legal framework will mesh, considering the fact that the technology is based on a shared ledger. The commencement of the General Data Protection law though provides individuals with the ability to demand the amendment or deletion of personal data. The concept of the technology however is based on data shared on a network and that information is only added to the chain, not amended. This feature is what also underlines the authenticity of data stored in the chain (Meyer, 2018).

4 Summary

The digitisation and digitalisation has slowly arrived in the transport sector and the European Union has taken various measures to establish digitisation in the transport sector as well. Examples for these measures are the ‘Digital Single Market’, the ‘Digital Transport and Logistics Forum’, but also the Shift2Rail joint undertaking. They pave the way for e-documents, C-ITS, the ‘Industrial Internet of Things’ - or more transport related the ‘Physical Internet’, but also for Cloud Computing and ‘Big Data’ in the transport and logistics sector.

The digitisation will enable a less paper work and administrative work flow and at the same time increase the transparency along logistics- and supply chains. This process is brought forward by the Digital Transport and Logistics Forum and its sub-groups working on the different transport documents. Digitalisation is supported by the technologies discussed in previous chapters and the various advantages it offers businesses and customers alike. Not only will it increase transparency of cargo movements and information flow, it will also offer businesses new business models to support their existing service offerings. Some of these possible tools are in its infancy still. However, (Kersten et al, 2017, p. 21) illustrates some of the most promising items - which are: predictive analytics, sensor technology and mobile data access for customers. The technology behind this is ‘Big Data’ and the utilisation of Virtual Intelligence for evaluation and processing - and ITS and its components such as V2X communication. Therefore it can be said that the collection and analysis of data and the exchange of data are currently the most relevant topics at hand for information developers from stakeholders in the multimodal transport sector.

Other topics touched in this report are also illustrated. Hoffmann and Ostwalder (2017) have used Porter’s five forces approach to illustrate digital disruptions in service industries. Digital disruption in logistics is only just picking up with a lot of start-ups and examples were pointed out in the report on ‘Best Practices in ICT for logistics’ of Work Package 2.3.2. Whilst the initial costs for the utilisation of digitalisation and digitisation in transport might be relatively high, it is a competitive advantage in the end. Not utilising such tools at hands might result in falling behind and resulting in the loss of business to competitors.

Hoffmann and Ostwalder (2017, p. 4) illustrated the digital disruptions in service industries. In regards to the logistics service providers, Hoffmann and Ostwalder (2017, p. 10) underline the fact that with the rise of digitalisation, the logistics service providers face competition and are under threat from all sides. There are: ‘new entrants’ working on autonomous transport modes, logistics market platforms or vehicle manufacturer platforms that provide network effects and increase the ‘bargaining power of suppliers’, logistics providers are increasingly substitutable through increased competition and the customers become more powerful through the shared economy thinking and opportunities such as ‘cargo sharing platforms’ arising from the new technologies. Hoffmann and Ostwalder (2017, p. 10 ff) go further and name examples for the various areas affecting logistics service providers. To name a few: Daimler Freightliner, DNV GL ReVolt, uShip, Deliv, or Uber Freight.

5 Bibliography

Accenture (2017) Why Is Artificial Intelligence Important?. Available at: https://www.accenture.com/t20170628T011725Z__w__/us-en/_acnmedia/PDF-54/Accenture-Artificial-Intelligence-AI-Overview.pdf (Accessed: 18th May 2018)

ACG Research (2015) The Value of Content at the Edge. P. 4. Available at: http://www.edgeconnex.com/wp-content/uploads/2015/05/TheGrowingValueofContentatTheEdge_WP_05.27.15.pdf (Accessed: 17th May 2018)

Allen and Overy (2017) The EU General Data Protection Regulation. P. 2. Available at: http://www.allenovery.com/SiteCollectionDocuments/Radical%20changes%20to%20European%20data%20protection%20legislation.pdf (Accessed: 15th May 2018)

Applied Science and Technology Institute (2017) Comba Telecom and ASTRI demonstrate Mobile Edge Computing System (MEC) with Vehicle-to-Everything (V2X) system prototype at Mobile World Congress 2017 in Barcelona. Available at: https://www.astri.org/news-detail/comba-telecom-and-astri-demonstrate-mobile-edge-computing-system-mec-with-vehicle-to-everything-v2x-system-prototype-at-mobile-world-congress-2017-in-barcelona/ (Accessed: 17th May 2018)

Bean, R. (2018) 'How Big Data and AI Are Driving Business Innovation in 2018', MIT Sloan Management Review, 5 February. Available at: https://sloanreview.mit.edu/article/how-big-data-and-ai-are-driving-business-innovation-in-2018/ (Accessed: 18th May 2018)

Bermbach, D., Pallas, F., Pérez, D., Plebani, P., Anderson, M., Kat, R.I., and Tai, S. (2017). A Research Perspective on Fog Computing. p. 5. 2nd Workshop on IoT Systems Provisioning and Management for Context-Aware Smart Cities (ISYCC 2017). Springer. Available at: http://www.ise.tu-berlin.de/fileadmin/fg308/publications/2017/2017_bermbach_fogvision.pdf (Accessed: 17th May 2018)

Big Data Value Association (2015) European Big Data Value Strategic Research and Innovation Agenda. P. 28. Brussels. Available at: http://www.bdva.eu/sites/default/files/europeanbigdatavaluepartnership_sria__v1_0_final0.pdf (Accessed: 17th May 2018)

Bloemhof, J. (2016) Big Data Analytics in Logistics [Presentation]. P. 5. Available at: https://www.bigdata-alliance.org/wp-content/uploads/2016/06/Smart-Ports-Jacqueline-Bloemhof-WUR-2juni2016.pdf (Accessed: 17th May 2018)

BSA (2018) Moving to the Cloud: A Primer on Cloud Ccomputing. P. 2. Available at: http://www.bsa.org/~/media/Files/StudiesDownload/2018BSA_MovingtotheCloud.pdf (Accessed: 15th May 2018)

Business Europe (2017a) ICT and digital solutions for transport and logistics. Position paper. Brussels. P. 1. Available at: https://www.businesseurope.eu/sites/buseur/files/media/position_papers/internal_market/2017-11-02_ict_and_digital_solutions_for_transport_and_logistics.pdf (Accessed: 15th May 2018)

BVL International (2013) Embracing Global Logistics Complexity to Drive Market Advantage. P. 8. Hamburg: DVV Media Group GmbH. Available at: https://www.bvl.de/misc/filePush.php?id=21777&usg=AOvVaw00a8tEilU (Accessed: 15th May 2018)

Cavanillas, J. M., Curry, E. and Wahlster, W. (2016) New Horizons for a Data-Driven Economy. p. 3. Big Data Public Private Forum. Springer Open. ISBN 978-3-319-21569-3. DOI 10.1007/978-3-319-21569-3. Available at: https://link.springer.com/content/pdf/10.1007%2F978-3-319-21569-3.pdf (Accessed: 17th May 2018)

Cloud Council (2017) Security for Cloud Computing: Ten Steps to Ensure Success. P. 5 ff. Available at: http://www.cloud-council.org/deliverables/CSCC-Security-for-Cloud-Computing-10-Steps-to-Ensure-Success.pdf (Accessed: 17th May 2018)

Confessore, N. (2018) Cambridge Analytica and Facebook: The Scandal and the Fallout So Far. Available at: https://www.nytimes.com/2018/04/04/us/politics/cambridge-analytica-scandal-fallout.html (Accessed: 15th May 2018)

Costa, R. Jardim-Goncalves, R., Figueiras, P., Forcolin, M., Jermol, M. and Stevens, R. (2016) 'Smart Cargo for Multimodal Freight Transport: When "Cloud" becomes "Fog"', IFAC-PapersOnLine, 49 (12), pp. 125. Available at: https://www.sciencedirect.com/science/article/pii/S2405896316308187 (Accessed: 17th May 2018)

C-Roads (no date) C-Roads - the platform of C-ITS deployments in Europe. P. 1. Available at: https://www.c-roads.eu/fileadmin/user_upload/media/Dokumente/c-roads-flyer_2.pdf (Accessed: 15th May 2018)

Davies, R. (2015) The Internet of Things. P. 1. Brussels: European Parliamentary Research Service. PE 557.012. Available at: http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/557012/EPRS_BRI(2015)557012_EN.pdf (Accessed: 15th May 2018)

Digital Transport and Logistics Forum (no date) Presentation. Available at: http://www.dtlf.eu/about-us/presentation (Accessed: 15th May 2018)

Dropmann, U. (2016) 5G Technology Aspects. GSMA/GSA Session: Forward Thinking for Spectrum - Getting Ready for 5G. Nokia. P. 4 f. Bangkok. Available at: https://www.gsma.com/spectrum/wp-content/uploads/2016/11/GSMA-GSA-5G-seminar-5G-technology-Nokia.pdf (Accessed: 17th May 2018)

Dudley, S. (2017) '4 ways to prepare for the Industrial Internet of Things (IIoT)'. IBM Internet of Things blog, 4 August. Available at: https://www.ibm.com/blogs/internet-of-things/iot-iiot-considerations/ (Accessed: 15th August 2018)

Ericsson (2017) Towards 5G Initiative welcomes Qualcomm, shows fast results. Available at: https://www.ericsson.com/en/news/2017/2/towards-5g-initiative-welcomes-qualcomm-shows-fast-results (Accessed: 17th May 2018)

European Automobile Manufacturers Association (2017) What is Platooning. London. Available at: http://www.acea.be/uploads/publications/Platooning_roadmap.pdf (Accessed: 15th May 2018)

European Commission (2010a) 'Reporting formalities for ships arriving in and/ort departing from ports of the Member States', 'Official Journal of the European Union', L283/1. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:283:0001:0010:EN:PDF (Accessed: 15th May 2018)

European Commission (2010b) River Information System. P. 3. Available at: http://www.transport-research.info/sites/default/files/brochure/20110405_145853_15995_Brochure_RIS_web.pdf (Accessed: 15th May 2018)

European Commission (2011) Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system. Brussels. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0144&from=EN (Accessed: 15th May 2018)

European Commission (2012) 'Establishing a single European railway area', 'Official Journal of the European Union', L343/32. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32012L0034 (Accessed 15th May 2018)

European Commission (2014a) Shift2Rail: driving innovation on railways. P. 1. Available at: https://ec.europa.eu/research/press/jti/factsheet_s2r-web.pdf (Accessed: 15th May 2018)

European Commission (2014b) European Cloud Strategy 2012. Available at: https://ec.europa.eu/digital-single-market/en/european-cloud-computing-strategy (Accessed: 15th May 2018)

European Commission (2015a) Shaping the Digital Single Market. Brussels: DG Move. Available at: https://ec.europa.eu/digital-single-market/en/policies/shaping-digital-single-market

European Commission (2015b) Setting up an expert group on Digital Transport and Logistics. Brussels. P. 6 ff. Available at: https://ec.europa.eu/transport/sites/transport/files/media/news/doc/2015-04-15-setting-up-dtlf/com(2015)2259_en.pdf (Accessed: 15th May 2018)

European Commission (2016a) A European strategy on Cooperative Intelligent Transport Systems. P. 6. COM(2016) 766 final. Brussels. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/1_en_act_part1_v5.pdf (Accessed: 15th May 2018)

European Commission (2016b) Cooperative Intelligent Transport Systems. P. 31. Brussels: DG Move. Available at: http://www.transport-research.info/sites/default/files/brochure/TRIP_C-ITS_Report.pdf (Accessed: 15th May 2018)

European Commission (2016c) 'on the protection of natural persons with regard to processing personal data and on the free movement of such data', 'Official Journal of the European Union', L119/1 Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN (Accessed: 15th May 2018)

European Commission (2017a) C-ITS platform phase II. p. 20. Available at: https://ec.europa.eu/transport/sites/transport/files/2017-09-c-its-platform-final-report.pdf (Accessed: 15th May 2018)

European Commission (2017b) Impact Assessment for the provision of cooperative intelligent transport systems. p. 2. Brussels: DG Move. Ares(2017)2592333. Available at: https://ec.europa.eu/info/law/better-regulation/initiative/27517/attachment/090166e5b27cbb2a_en (Accessed: 15th May 2018)

European Commission (2017c) Fact Sheets on ERTMS. P. 2. Available at: https://ec.europa.eu/transport/sites/transport/files/2017-01-05-memo-ertms.pdf (Accessed: 15th May 2018)

European Commission (2017d) Delivering an effective and interoperable European Rail Traffic Management System. p. 4. ff. SWD(2017) 375 final. Brussels. Available at: https://ec.europa.eu/transport/sites/transport/files/swd20170375-ertms-the-way-ahead.pdf (Accessed: 15th May 2018)

European Commission (2017e) Deliverinng TEN-T: Facts and Figures 2017. p. 16. Brussels. Available at: http://www.connectingeu.eu/documents/Delivering_TEN_T.pdf (Accessed: 15th May 2018)

European Commission (2017f) Proposal for a Regulation on Pricacy and Electronic Communications.Brussels: DG Connect. Available at: https://ec.europa.eu/digital-single-market/en/news/proposal-regulation-privacy-and-electronic-communications (Accessed: 15th May 2018)

European Commission (2017g) The Digital Single Market Strategy and ist R&I component [Presentation]. Energy Info Days. Brussels: DG Connect. P.5 . Available at: https://ec.europa.eu/easme/sites/easme-site/files/h2020_energy_info_days_transforming_the_energy_sector_through_digitalisation_presentations.pdf (Accessed: 17th May 2018)

European Commission (2017h) Electronic Transport Documents [Presentation]. Digital Transport Days. Tallinn. 8th - 10th November. European Commission.

European Commission (2018a) Digitalisation of Transport and Logistics and the Digital Transport and Logistics Forum. Brussels: DG Move. Available at: https://ec.europa.eu/transport/themes/logistics-and-multimodal-transport/digitalisation-transport-and-logistics-and-digital-transport-and_en (Accessed: 15 th May 2018)

European Commission (2018b) The European Single Market. Brussels. Available at: https://ec.europa.eu/growth/single-market_en (Accessed: 15th May 2018)

European Commission (2018c) Digital Transport and Logistics Forum. Brussels. Available at: http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3280&Lang=EN (Accessed: 15th May 2018)

European Commission (2018d) European Maritime Single Window environment. Brussels. DG Move. Available at: https://ec.europa.eu/transport/modes/maritime/digital-services/e-maritime_en (Accessed: 15th May 2018)

European Commission (2018e) Council Decision on the Convention concerning International Carriage by Rail. Brussels. COM(2018) 63 final. 2018/0026 (NLE). Available at: https://ec.europa.eu/transparency/regdoc/rep/1/2018/EN/COM-2018-63-F1-EN-MAIN-PART-1.PDF (Accessed: 15th May 2018)

European Commission (2018f) Intelligent Transport Systems: Action Plan and Directive. Brussels: DG Move. Available at: https://ec.europa.eu/transport/themes/its/road/action_plan_en (Accessed: 15th May 2018)

European Commission (2018g) Intelligent Transpot Systems: Innovating for the transport of the future. Brussels: DG Move. Available at: https://ec.europa.eu/transport/themes/its_en (Accessed: 15th May 2018)

European Commission (2018h) An EU strategy on cooperative, connected and automated mobility. Brussels. Available at: http://europa.eu/rapid/press-release_MEMO-16-3933_en.htm (Accessed: 15th May 2018)

European Commission (2018i) High-level Conference on European Multimodal Freight Transport - for Better Transport Connectivity. Brussels. 20 March. Available at: https://ec.europa.eu/transport/themes/logistics/events/high-level-conference-european-multimodal-freight-transport_en (Accessed: 17th May 2018)

European Commission (2018j) Elements of the European data economy strategy. Brussels. Available at: https://ec.europa.eu/digital-single-market/en/towards-thriving-data-driven-economy (Accessed: 17th May 2018)

European Parliament (2016) Industry 4.0. p. 20. Brussels: DG Internal Policies. Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf (Accessed: 15th May 2018)

European Technology Platform Alice (no date) Physical Internet Roadmap 2050. Available at: http://www.etp-logistics.eu/wp-content/uploads/etpalice/Road_map_Alice_PIE.jpg (Accessed: 15th May 2018)

Evtimov, E. (2015) Common consignment note as way forward for legal challenges in international railway transport [Presentation]. p. 9. International Rail Transport Committee. UNESCAP. Bangkok. Available at: http://www.unescap.org/sites/default/files/CIT%20-%20Common%20consignment%20note.pdf (Accessed: 15th May 2018)

Ezell, S. and Swanson, B. (2017) How Cloud Computing Enables Modern Manufacturing. American Enterprise Institute. Information and Innovation Foundation. P. 2. Available at: http://www2.itif.org/2017-cloud-computing-enables-manufacturing.pdf (Accessed: 17th May 2018)

Federal Ministry of Education and Research (2014) The new High-Tech Strategy Innovations for Germany. Berlin: Federal Ministry of Education and Research - Division Innovation Policy Issues. Available at: https://www.bmbf.de/pub/HTS_Broschuere_eng.pdf (Accessed: 15th May 2018)

Fraunhofer ESK (2018) Deutsche Telekom, Fraunhofer ESK, Hexagon and Nokia complete tests of automated driving technology on A9 Digital Test Track. p. 2. Available at: https://www.esk.fraunhofer.de/content/dam/esk/dokumente/PM18_03_Teststrecke_A9_en.pdf (Accessed: 17th May 2018)

Gesing, B., Peterson, S. J. and Michelsen, D. (2018) Artificial Intelligence in Logistics. Troisdorf: DHL Customer Solutions and Innovation. Available at: https://www.logistics.dhl/content/dam/dhl/global/core/documents/pdf/glo-ai-in-logistics-white-paper.pdf (Accessed: 18th May 2018)

Glockner, H., Jannek, K., Mahn, J. and Theis, B. (2014) Augmented Reality in Logistics. P. 16. Troisdorf: DHL Customer Solutions and Innovations. Available at: http://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/csi_augmented_reality_report_290414.pdf (Accessed: 17th May 2018)

Godbole, S. (no date) How Blockchain can transform Global Trade Supply Chains [Presentation]. Available at: http://www.unescap.org/sites/default/files/3_IBM%20Blockchain.pdf (Accessed: 18th May 2018)

Goenaga, M., Radtke, P., Speicher, K. and Westinner R. (2017) 'Ops 4.0: Fueling the next 20 percent productivity rise with digital analytics', McKinsey & Company. Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Operations/Our%20Insights/Ops%204%200%20Fueling%20the%20next%2020%20percent%20productivity%20rise%20with%20digital%20analytics/SVGZ_Ops_4_Fueling_productivity_ex2.ashx (Accessed: 15th May 2018)

Goswami, D., Chakraborty, A., Das, P. and Gupta A. (2017) 'Fog Computing Application for Smart IOT Devices in Agile Business Enterprises', Global Journal of e-Business and Knowledge Management, Vol. 8-13, No 1, pp. 1-8. Available at: https://techtalkdotorg.files.wordpress.com/2018/03/fog-computing-application-for-smart-iot-devices-in-agile-business-enterprises_dipanjan-goswami.pdf (Accessed: 17th May 2018)

Gupta, M. (2017) Blockchain for Dummies. IBM Limited Edition. Hoboken: John Wiley and Sons. ISBN: 978-1-119-37123-6. Available at: https://public.dhe.ibm.com/common/ssi/ecm/xi/en/xim12354usen/XIM12354USEN.PDF (Accessed: 18th May 2018)

Hackius, N. and Petersen, M. (2017) 'Blcokchain in Logistics and Supply Chain: Trick or Treat?', Digitalization in Supply Chain Management and Logistics. Proceedings of the Hamburg International Conference of Logistics (HICL) - 23. Available at: https://tubdok.tub.tuhh.de/bitstream/11420/1447/1/petersen_hackius_blockchain_in_scm_and_logistics_hicl_2017.pdf (Accessed: 18th May 2018)

Hamburg Port Authority (2018) New Communication Standard: 5G Industrial Environment Trial Platform Launched in the Port of Hamburg. Available at: https://www.hamburg-port-authority.de/en/press-latest-news/new-communication-standard-5g-industrial-environment-trial-platform-launched-in-the-port-of-hamburg/ (Accessed: 17th May 2018)

Hoffmann, E. and Osterwalder, F. (2017) 'Third-Party Logistics Providers in the Digital Age: Towards a New Competitive Arena?', Logistics, 1(2), 9. ISSN 2305-6290. Available at: https://doi.org/10.3390/logistics1020009 (Accessed: 17th May 2018)

Huth, A. and Cebula J. (2011) The Basics of Cloud Computing. P. 2. Available at: https://www.us-cert.gov/sites/default/files/publications/CloudComputingHuthCebula.pdf (Accessed: 15th May 2018)

Industry-Science Research Alliance (2013) Recommendations for implementing the strategic initiative INDUSTRIE 4.0. p. 14. Available at: http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_report__Industrie_4.0_accessible.pdf (Accessed: 15th May 2018)

Intel (2016) 'Enabling the Industrial Internet of Things'. P. 7. Available at: https://www.intel.com/content/dam/www/public/us/en/documents/articles/enabling-industrial-iot-paper.pdf (Accessed: 15th May 2018)

Isaksson, O. (2018) Towards a Sustainable and Integrated European Multimodal Transport System. p. 8. High-Level Conference on European Multimodal Freight Transport. Sofia. Available at: https://ec.europa.eu/transport/sites/transport/files/high-level-conference-european-multimodal-freight-transport-session-1-olle-isaksson.pdf (Accessed: 17th May 2018)

I-Scoop (no date) The Internet of Things (IoT) - essential IoT business guide. Available at: https://www.i-scoop.eu/internet-of-things-guide/ (Accessed: 15th May 2018)

Janardan, M. (2017) 'Moving the goalposts: AI and logistics', Infosysinsights: Tech Talk, 5, pp. 34-39. Available at: https://www.infosys.com/insights/insights-editions/Documents/a-future-with-purposeful-ai.pdf (Accessed: 18th May 2018)

Jeseke, M., Grüner, M. and Weiß, F. (2013) Big Data in Logistics. Troisdorf: DHL Customer Solutions and Innovations. Available at: https://www.detecon.com/ch/ch/files/dhl-detecon_big_data_whitepaper.pdf (Accessed: 17th May 2018)

Kapsch CarrierCom (no date) European Railway Management System - ERTMS. P. 3. Available at: http://www.climateactionprogramme.org/images/uploads/documents/European_Railway_Traffic_Management_System.pdf (Accessed: 15th May 2018)

Kern, D. (2017) e-CMR: Digitalising consignment notes [Presentation]. P. 10. Available at: http://www.smartmobilityworld.net/wp-content/uploads/2017/11/KERN.pdf (Accessed: 15th May 2018).

Kersten, W., Seiter, M., von See, B., Hackius, N. and Maurer, T. (2017) Trends and Strategies in Logistics and Supply Chain Management - Digital Transformation Opportunities. BVL International. Bremen: DVV Media Group. ISBN: 978-3-87154-608-2. Available at: https://logistiktrends.bvl.de/en/system/files/t16/2017/Trends%20and%20Strategies%20in%20Logistics%20and%20Supply%20Chain%20Management%20%E2%80%93%20Digital%20Transformation%20Opportunities%20Kersten%20von%20See%20Hackius%20Maurer.pdf (Accessed: 17th May 2018)

Kiseleva, T., Palali, A. and Straathof, B. (2016) Do national borders slow down knowledge diffusion within new technological fields? The Case of Big Data in Europe. CPB Discussion Paper 330. p. 4. The Hague: CPB Netherlands Bureau for Economic Policy Analysis. ISBN: 978-90-5833-737-5. Available at: https://www.cpb.nl/sites/default/files/omnidownload/CPB-Discussion-Paper-330-Do-national-borders-slow-down-knowledge-diffusion.pdf (Accessed: 17th May 2018)

Kongsberg Maritime (no date) Autonomous Shipping. Available at: https://www.km.kongsberg.com/ks/web/nokbg0240.nsf/AllWeb/597733F8A1B8C640C12580AC0049C134?OpenDocument (Accessed: 18th May 2018)

Krosse, B. (2017) Multi-brand Truck Platooning [Presentation]. P. 4. Available at: http://erticonetwork.com/wp-content/uploads/2017/03/Bastiaan-Krosse-Multi-brand-truck-platooning-March-21-Brussels.pdf (Accessed: 15th May 2018)

MAPI Foundation (2015) The Internet of Things: Industrie 4.0 vs. The Industrial Internet.Available at: https://mapifoundation.org/economic/2015/7/23/the-internet-of-things-industrie-40-vs-the-industrial-internet (Accessed: 15th May 2018)

Marin-Tordera, E., Masip, X., García-Almiñana, J., Jukan, A., Ren, G.-J. and & Zhu, J. (2017) 'Do we all really know what a Fog Node is? Current trends towards an open definition'. Computer Communications. p. 3. DOI: 10.1016/j.comcom.2017.05.013. Available at: https://upcommons.upc.edu/bitstream/handle/2117/108773/What_is_a_fog_node-com_com_R1_last.pdf (Accessed: 17th May 2018)

Marr, B. (2018) The Key Definitions of Artificial Intelligence (AI) That Explain ist Importance. Forbes. Available at: https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/#2e4815684f5d (Accessed: 18th May 2018)

Maslarić, M., Nikoličić, N. and Mirčetić, F. (2016) 'Logistics Response to the Industry 4.0: the Physical Internet', Open Engineering, 6, pp. 511 - 517. DOI 10.1515/eng-2016-0073. Available at: https://www.degruyter.com/downloadpdf/j/eng.2016.6.issue-1/eng-2016-0073/eng-2016-0073.pdf (Accessed: 15th May 2018)

Mell, P. and Grance, T. (2009) 'The Nist Definition of Cloud Computing'. Available at: https://www.nist.gov/sites/default/files/documents/itl/cloud/cloud-def-v15.pdf (Accessed: 15th May 2018)

Menzel, G. (2017) Cooperative, connected and Automated Mobility [Presentation]. p. 4. Available at: https://hypermotion-frankfurt.messefrankfurt.com/content/dam/messefrankfurt-redaktion/hypermotion/2017/events/presentation/its-gerhard-menzel.pdf (Accessed: 15th May 2018)

Meyer, D. (2018) 'Blcokchain technology is on a collision course with EU privacy law', The Privacy Advisor, 27 February. International Association of Privacy Professionals. Available at: https://iapp.org/news/a/blockchain-technology-is-on-a-collision-course-with-eu-privacy-law/ (Accessed: 18th May 2018)

Montreuil, B. (2011) 'Towards a Physical Internet: Meeting the Global Logistics Sustainability Grand Challenge'. CIRRELT. Available at: https://www.scl.gatech.edu/sites/default/files/downloads/towardsphysicalinternet-benoitmontreuil.pdf (Accessed: 15th May 2018)

Montreuil, B., Meller, R. D., Thivierge, C. and Montreuil Z. (2013) 'Functional Design of Physical Internet Facilities: A unimodal road-based crossdocking hub', CIRRELT-2013-15, FSA-2013-003. P. 1. Available at: https://www.cirrelt.ca/DocumentsTravail/CIRRELT-FSA-2013-15.pdf (Accessed: 15th May 2018)

National Instruments (no date) 'The Industrial Internet of Things'. P. 8. Available at: http://www.ni.com/pdf/company/en/Trend_Watch_IIOT.pdf (Accessed: 15th May 2018)

NSB CoRe Report 2.3.2 (2018). Best Practices of ICT for Intermodal Transport. Chapter 3.1.1. and 3.1.2. Interreg Baltic Sea Region Programme Project North Sea Baltic Connector of Regions - NSB CoRe. ILIM.

OECD (2002) OECD Science, Technolgy and Industry Outlook. P. 1. Paris: OECD Publishing Service. Available at: http://www.oecd.org/science/inno/2762979.pdf (Accessed: 15th May 2018)

OpenFog (2017) Size and Impact of Fog Computing Market. P. 11 ff. 451 Research. Available at: https://www.openfogconsortium.org/wp-content/uploads/451-Research-report-on-5-year-Market-Sizing-of-Fog-Oct-2017.pdf (Accessed: 17th May 2018)

Oude Weernink, M. , van den Engh, W., Francisconi, M. and Thorborg, F. (2017) The Blockchain Potential for Port Logistics. Whitepaper. Springer. Available at: http://smart-port.nl/wp-content/uploads/2017/06/Bijlage-6_White-Paper-Blockchain.pdf (Accessed: 18th May 2018)

Pan, S., Ballot, E., Huang, G. Q. and Montreuil, B. (2017) Physical Internet and interconnected logistics services: research and applications', International Journal of Production Research, 55:9, pp. 2603-2609. DOI: 10.1080/00207543.2017.1302620. Available at: https://doi.org/10.1080/00207543.2017.1302620 (Accessed: 15th May 2018)

Perakovic, D., Perisa, M. and Sente, R. E. (2017)'New Challenges of ICT usage in Transport and Logistics', 6th International Conference Transport and Logistics, Niš, 25.-26. May. p. 13. Available at: https://bib.irb.hr/datoteka/877936.NEW_CHALLENGES_OF_ICT_USAGE_IN_TRANSPORT_AND_LOGISTICS.pdf (Accessed: 15th May 2018)

Pieriegud, J. (2018) Digital Transport of Raiways. P. 31. ISBN: 978-83-950826-0-3. Available at: https://shift2rail.org/wp-content/uploads/2018/04/DIGITAL_TRANSFORMATION_RAILWAYS_2018_web.pdf (Accessed: 17th May 2018)

Pillath, S. (2016) Automated vehicles in the EU. P. 7. Brussels: European Parliamentary Research Service. PE 573.902. Available at: http://www.europarl.europa.eu/RegData/etudes/BRIE/2016/573902/EPRS_BRI(2016)573902_EN.pdf (Accessed: 15th May 2018)

Port of Hamburg Marketing (2017). Digital Transport Days minutes. Unpublished.

PWC (2017) 'Monetizing the Industrial Internet of Things'. P. 1. Available at: https://www.mapi.net/system/files/attachments/files/Monetizing%20the%20Industrial%20IoT_1.pdf (Accessed: 15th May 2018)

Quiros, T. P. (2016) 'Unlocking Multi-modal Transport using Big Data: India's Eastern Corner', Transport for Development Blog, 11 February. World Bank Group. Available at: http://blogs.worldbank.org/transport/unlocking-multi-modal-transport-using-big-data-india-s-eastern-corridor (Accessed: 18th May 2018)

Rail Net Europe (2018) Rail Net Europe. Available at: http://www.rne.eu (Accessed: 17th May 2018)

Rajamanickam, V. (2017) How augmented reality is revolutionizing the freight industry. Available at: https://www.freightwaves.com/news/2017/11/10/how-augmented-reality-is-revolutionizing-the-freight-industry (Accessed: 17th May 2018)

Roland Berger (2017) Rail Supply Digitization [Presentation]. P. 13. Available at: https://www.rolandberger.com/publications/publication_pdf/roland_berger_rail_supply_digitization_20170118.pdf (Accessed: 17th May 2018)

Schwab, K. (2016) The Fourth Indsutrial Revolution: what it means, how to respond. World Economic Forum. Geneva. Available at: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond (Accessed: 15th May 2018)

Shazadi, S., Iqbal, M., Dagiuklas, T. and Qayyum, Z. U. (2017) 'Multi-access edge computing: open issues, challenges and future perspectives', Journal of Cloud Computing: Advances, Systems and Applications, 6(30), p. 4. DOI: 10.1186/s13677-017-0097-9. Available at: https://link.springer.com/content/pdf/10.1186%2Fs13677-017-0097-9.pdf (Accessed: 17th May 2018)

Shift2Rail (2017a) Innovation Programme 2: Advanced Traffic Managemtn and Control Systems. Available at: https://shift2rail.org/research-development/ip2/ (Accessed: 15th May 2018)

Shift2Rail (2017b) R & I Projects. Available at: https://shift2rail.org/projects/ (Accessed: 15th May 2018)

Shift2Rail (2017c) Innovation Programmes [illustration]. Available at: https://www.shift2rail.org/wp-content/uploads/2013/09/IPs.jpg (Accessed: 15th May 2018)

Siemens (no date) Internet of Trains. Available at: http://news.usa.siemens.biz/sites/siemensusa.newshq.businesswire.com/files/press_release/file/Siemens_DigitalRail_Infographic.pdf (Accessed: 17th May 2018)

Society of Automotive Engineers (no date) Automated Driving: Levels of Automation - International standard J3016. p. 2. Available at: https://www.smmt.co.uk/wp-content/uploads/sites/2/automated_driving.pdf (Accessed: 15th May 2018)

Teradata (2015) The Internet of Trains. Available at: http://assets.teradata.com/resourceCenter/downloads/CaseStudies/EB8903.pdf (Accessed: 17th May 2018)

T-Systems (2014) Cloud Brokerage: Multi-Cloud Strategies Made Easy. P. 16. Available at: https://www.t-systems.com/blob/77586/618f3b7c563b7e2a56c40c029ffeea58/DL_WP_Cloud_Brokerage.pdf (Accessed: 17th May 2018)

Uckelmann, D., Harrison, M. and Michahelles, F. (2011) Architecting the Internet of Things. P. 8. Berlin: Springer.

UNECE (2012) Single Window for Trade. Brussels: United Nations Economic Commission for Europe. Available at: http://tfig.unece.org/contents/single-window-for-trade.htm (Accessed: 15th May 2018)

UNIFE (2013) The European Rail Traffic Management System: In brief. Available at: http://www.ertms.net/?page_id=40 (Accessed: May 15th 2018)

United Nations (1956) Convention on the Contract for the International Carriage of Goods by Road (CMR). Geneva. Available at: https://treaties.un.org/doc/Treaties/1961/07/19610702%2001-56%20AM/Ch_XI_B_11.pdf (Accessed: 15th May 2018)

Wallace, N. (2018) EU e-privacy proposal risks breaking 'Internet of Things'. Available at: https://euobserver.com/digital/141302 (Accessed: 15th May 2018)

Wang, L., Ranjan, R., Chen J., Benatallah, B. (2011) Cloud Computing: Methodology, Systems, and Applications. P. 3. Borca Raton: CRC Press Taylor and Francis. ISBN 9781439856413

Warner, M. (2017) 'Introduction To Blockchain Technology and Uses for Shipping', Blockchain for Shipping and Logistics, 21 November. Available at: https://www.hkmw.hk/pdf/publication/blockchain-shipping-and-logistics-presentation-sli.pdf (Accessed: 18th May 2018)

WinSystems (2017) Cloud, Fog and Edge Computing - What's the difference? Available at: https://www.winsystems.com/cloud-fog-and-edge-computing-whats-the-difference/ (Accessed: 17th May 2018)

World Economic Forum (2013) Outlook on the Logistics and Supply Chain Industry 2013. p. 8. Geneva. Available at: http://www3.weforum.org/docs/WEF_GAC_LogisticsSupplyChainSystems_Outlook_2013.pdf (Accessed: 15th May 2018)

Wüst, K. and Gervais, A. (2017) Do you need a Blockchain? International Association for Cryptologic Research. Available at: https://eprint.iacr.org/2017/375.pdf (Accessed: 18th May 2018)

Zambrano, R. (2017) Unpacking the disruptive potential of blockchain technolgy for human development. White Paper. 2017. Ottawa: International Development Research Centre. Available at: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/56662/IDL-56662.pdf (Accessed: 18th May 2018)