RE WWay
Research & Education in Inland Waterway Logistics

LOGISTIKUM
viadonau

READER –DEVELOPMENT TRENDS AND INNOVATION IN LOGISTICS – FOCUS ON INLAND NAVIGATION

Summary of relevant sources

Pictures: viadonau in Manual on Danube Navigation (2019), p 79, 106

Contents

1. Market Environment Logistics

1.1 Overview and Status Quo

The transport sector accounts for 25% of greenhouse gas emissions in the EU and this figure is rising. Transport emissions must be reduced by 90% to achieve climate neutrality by 2050. All transport modes will have to contribute to this reduction. Priority must be given to users to give them better access to environmentally friendly mobility alternatives. Multimodal transport has to be promoted to ensure an efficient transport system. A large proportion of the 77% of internal freight traffic currently carried by road should be shifted to rail and inland waterways. Currently, across Europe, approximately 17% of all goods are transported by rail and only 6% of all goods by inland waterways (see Figure 1). Automated and connected multimodal mobility, together with intelligent traffic management systems made possible by digitalisation, will help to reduce environmental pollution, especially in urban areas.[1]

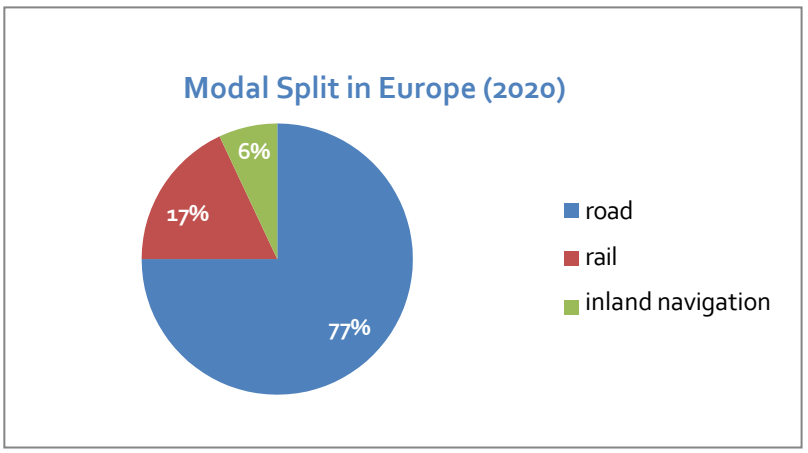

Figure 1: Modal Split in EU-27 (2020) – Source: Eurostat

It is important for national and international trade and economic development that goods are transported safely, quickly and cost-effectively. The rapid increase in consumption and a boom in online trade (increase in smaller consignments) may explain the rapid growth of freight transport within the EU.[2]

Other causes for the changes in the transport and logistics industry are mainly due to the following trends:

- Same Day Delivery - delivery on the day of the order. This trend results in a poorer utilization of delivery vehicles and increased complexity.

[1] Cf. Europäische Kommission: Der europäische Grüne Deal, 2019, P 12f.
[2] Cf. Der Wirtschaftsingenieur, URL: https://www.der-wirtschaftsingenieur.de/index.php/die-7-dimensionen-der-logistik/ [14.05.2020]; Industriemagazin, URL: https://industriemagazin.at/a/fachkraeftemangel-bei-logistikern-wir-sind-kurz-vor-dem-versorgungskollaps [14.05.2020].

- International cooperation and collaboration with the aim of standardising technical and legal conditions in freight transport.
- Artificial intelligence & autonomous logistics - this includes, for example, state-of-the-art warehouse robots, self-propelled delivery vehicles or forklifts.
- Logistics 4.0.: every object is linked to every other object via the network, resulting in connected department stores, intelligent delivery solutions or even smart refrigerators.
- Connectivity: forwarders become strategic partners and must achieve deeper integration into the customer's supply chain. This can lead to decisive cost advantages for shippers.
- Multichannel logistics: a broader positioning and diversification of distribution logistics channels to make logistics processes more stable and reduce supply risks.[3]

1.2 Labour market

Logistics is important worldwide, both as an economic sector and as a field of activity within companies. It enables the division of labour at home and abroad and thus represents a cornerstone of globalisation. Accordingly, logistics is playing an increasingly important role, making a decisive contribution to the economic success and the success of individual companies. Qualified logistics specialists are therefore indispensable. Just like the economic sector, the occupational field has developed rapidly and undergone major changes in recent years, also in the context of increased digitalization. The increasing internationalisation of value chains has led to a change in the job profiles in almost all areas of logistics. Whereas logistics specialists used to be mainly concerned with transport, handling and storage, today they control entire value-added networks. Logistics is much more than just managing the flow of goods and picking containers. Its tasks include the market-oriented, integrated planning, design, processing and control of the entire flow of materials and associated information between companies, suppliers and customers as well as within a company. As the complexity of the tasks increases, so does their attractiveness. The constantly changing requirements of the various markets demand flexible and permanently evolving concepts from logistics. For the responsible employee, process understanding and analytical skills as well as creativity for innovative solutions are essential. Therefore, there is also a demand for highly qualified specialists in logistics, which is also increasing in the future.[4]

Logistics is slowly making itself attractive to women: Women are still underrepresented in logistics today, but the trend shows that there are now several thousand women working in the various logistics

[3] Cf. Industriemagazin, URL: https://industriemagazin.at/a/fachkraeftemangel-bei-logistikern-wir-sind-kurz-vor-dem-versorgungskollaps [14.05.2020]; Transportlogistic, URL: https://www.transportlogistic.de/de/messe/industry-insights/logistikkonzepte-der-zukunft/ [14.05.2020]; T3, URL: https://t3n.de/magazin/innovative-logistik-trends-onlinehandel-zukunftspaket-238987/ [14.05.2020]; WKO, URL: https://www.wko.at/service/aussenwirtschaft/logistik-branche-struktur-zukunft-trendphtml [14.05.2020].

[4] Cf. Industriemagazin, URL: https://industriemagazin.at/a/fachkraeftemangel-bei-logistikern-wir-sind-kurz-vor-dem-versorgungskollaps [14.05.2020]; Abimagazin, URL: http://doku.iab.de/abi/2011/abi0311_22.pdf [14.05.2020]; Karriere.de, URL: https://www.karriere.de/arbeitsmarkt-logistik-karriere-in-der-container-welt/23040246.html [14.05.2020]; Zentralverband für Spedition und Logistik, URL: https://www.otpat/presseaussendung/OTS_20191129_OTS0158/logistik-branche-als-innovationstreiber-digitalisierung-mehr-chance-als-bedrohung-bild [14.05.2020].

professions and the number is steadily increasing. Many logistics companies already offer flexible working hours, individual part-time work that takes family circumstances into account, and even job sharing is practiced to some extent. Childcare measures are also increasing. An important element in making logistics professions more attractive to women is the opportunity for networking with the help of initiatives such as "Ladies in Logistics" or "Women in Mobility". Positive communication also plays a decisive role. Bosch offers an example of this with its "Working Out Loud" initiative. This initiative sets an example of network-oriented work, which allows women to focus on both personal and professional goals.[5]

1.3 Inland navigation - developments

Inland waterway transport in Europe is mainly concentrated in two countries, the Netherlands and Germany, where almost 70% of the total transport performance of European inland navigation is handled. In general, the Rhine States of the European Union (Belgium, the Netherlands, France and Germany) represent 84% of the total inland waterway transport performance, while the Danube States of the EU (Bulgaria, Croatia, Hungary, Austria, Romania and Slovakia) account for 16.4% of the transport performance on European waterways. The total transport performance of inland navigation in the European Union reached almost 135 billion TKM in 2018..[6] As shown in Figure 2, transport performance in Europe was divided into the following groups of goods:

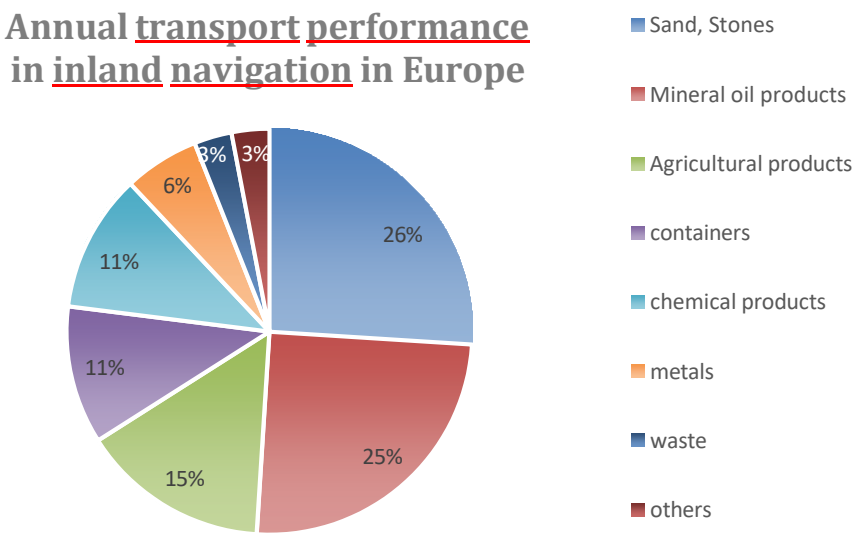

Figure 2: Annual transport performance in inland navigation in Europe – Source: CCNR

[5] Cf. BVL, 2019, URL: https://www.bvl.de/files/1951/1988/2128/Begleitende_Publikation_zur_Session_Maennerdomaene.pdf [14.05.2020]

[6] Cf. Zentralkommission für die Rheinschifffahrt, URL: https://www.ccr-zkr.org/files/documents/om/om19_II_de.pdf [14.05.2020].

1.4 Inland navigation – transport routes

The Rhine-Main-Danube corridor has a total length of 3,504 km and connects the port of Rotterdam (Netherlands) with the port of Constanta (Romania) and thus also 15 European countries by inland waterways. If one compares the Danube waterway with the Rhine, it is 2.7 times longer than the Rhine. Nevertheless, in 2017 4.8 times more goods were transported on the Rhine than on the Danube. The transport performance on the Rhine was thus 1.6 times higher than on the Danube in 2017. The limited branching of the Danube waterway allows only a spatially concentrated use, furthermore a longer pre- and post-carriage by road or rail is necessary. As a consequence, inland navigation in the Danube Region generally has a smaller share in the national modal split. However, Danube transport is characterised by longer distances compared to transport performance. The average transport distance on the Danube is about 600 km, while that of the Rhine is only about 200 km. A total of 129 bridges span the Danube from Kelheim to Sulina. Since the bridges allow a maximum of 2-3 layers of container traffic on the Danube, which would be hardly economical, there is practically no container traffic on the Danube. Container transport is mainly operated in the Rhine area. In addition, the Rhine has four main tributaries, which strengthen the role of the Rhine as the most important waterway in Europe. The economic activity and the high population density along the Rhine also support an increased use of this inland waterway as a mode of transport..[7]

2. Development trends at a glance

In general, the transport sector is facing the challenge that the volume of goods will increase strongly in the future - an increase of 50 % is predicted by 2030. At the same time, the road transport mode is already operating at full capacity for the most part, which reinforces the demand for a sustainable, multimodal transport solution. Increasing traffic jams, accidents, hurdles and inefficiencies have also increased the costs of transport, which in turn weakens the competitiveness of road transport in general. In addition, the transport sector is still heavily dependent on oil and is responsible for a large proportion of CO2 emissions.[8] Various trends have emerged to counteract these developments. In particular, the trend towards sustainability is an increasingly relevant aspect for the transport sector in order to reduce its negative impact on the environment in the future. In addition, trends such as innovation and cooperation are an important topic in the transport sector in order to cope with the resource bottleneck with regard to transport infrastructure. In the following, the most important trends from the transport sector are described in more detail and their significance for inland navigation is discussed. In order to select the trends, these were discussed together in the course of an internal expert workshop and their significance for inland navigation was assessed.

2.1 General development trends in logistics

Sustainability: Freight transport can be identified as an environmentally damaging area of logistics. In Europe, greenhouse gas emissions and traffic congestion have been identified as the most serious environmental and sustainability problems in freight transport and logistics. Due to the increasing

[7] Cf. viadonau, 2019, P 20f, 56
[8] Cf. INE, EBU und ESO, 2011, P 4.

volume of transport in Europe and on an international level, this problem will become even more relevant in the future and the need for action is becoming increasingly apparent. Accordingly, the issue of sustainability is becoming increasingly important for freight transport. The catalogue of measures to counteract these developments is relatively large: changed pricing, use of alternative fuels, promotion of a shift to sustainable modes of transport such as rail and inland waterways or the increased use of innovative technologies.[9] From the political side, the modal shift measure in particular is being promoted. As stated in the White Paper 2011, the European Union has set itself the goal of shifting 30% of road freight traffic exceeding a transport distance of 300 km to alternative modes of transport such as rail or inland waterways by 2030. By 2050, this figure should be more than 50%, in order to achieve a long-term reduction of CO2 emissions in the freight transport sector.[10]

Alternative drive technologies or fuels have also been increasingly promoted in recent years. In the road transport sector, a hybrid solution of the following drive systems is conceivable: electric, liquefied natural gas (LNG) and diesel. The greatest potential for electric drive systems is seen in light vehicles[11] The fuel LNG (Liquefied Natural Gas) is an environmentally friendly source of energy and offers the possibility to reduce emissions. This fuel is particularly interesting for inland navigation. The use of LNG could reduce climate-relevant emissions and also generate cost advantages, as the fuel is cheaper than diesel. This would also mean that conversion costs would be amortised relatively quickly.[12] Nevertheless, there are currently no LNG-operated inland waterway vessels in Europe. Only a few pilot operations have already been realised with LNG. In addition, as already mentioned, high investments would be necessary to convert the ships themselves and also the port infrastructure so that the fuel can be stored.[13]

The trend towards sustainability is particularly beneficial for inland navigation, as it is considered a sustainable means of transport and is also regarded as such by the European Commission. Moreover, the waterway mode of transport offers sufficient free capacity to accommodate a modal shift. Accordingly, the trend towards sustainability can be classified as particularly relevant for inland navigation.

Digitalisation: Digitalisation and connectivity and the associated trends Industry 4.0 and the Internet of Things are also currently relevant topics in logistics. Due to the digitalization of society in general and the increasing number of online purchases, the logistics industry is increasingly faced with new challenges. Accordingly, networking of logistics service providers with customers and other relevant players is crucial in order to cope with the increasing transport volume. Even though the technical prerequisites may often already exist or can be implemented relatively quickly, it is still necessary to establish a corresponding basis of trust between the players. Trust is important in order to realize data exchange and to make sure that actors are willing to share all relevant data with the partners and that these data are not misused for their own purposes. Since the willingness to exchange data is often not

[9] Cf. Institute for Transport Studies, Universität Leeds (UK), 2010, P 7
[10] Cf. Europäische Kommission, 2011, P 10.
[11] Cf. Die Welt, URL: https://www.welt.de/motor/news/article155884171/Nutzfahrzeug-Studie.html
[12] Cf. Pucher et al., 2011, P 1ff
[13] Cf. Borlenghi, et al., 2015, P 21ff.

yet given due to a lack of trust, the attitude of the actors must also be positively influenced in the future.[14]

Innovative transport concepts: Due to the various trends, new transport concepts are constantly being created to meet the changing requirements and to integrate new developments and trends. Multimodal transport in particular has gained in importance. While intermodality is a special form of multimodal transport in which the cargo is transported in the same loading unit (e.g. container), the concept of co-modality uses the most optimal mode of transport or the most optimal combination of modes of transport. The concept of co-modality was defined by the European Commission in 2006, although the concept is hardly known in practice. An important element of co-modality is efficiency, as the aim is to plan and carry out transport operations as efficiently as possible. A further development is the concept of synchromodality, which is a combination of intermodality and co-modality. The idea of this concept, which originated in the Netherlands, is that the customer only defines basic requirements for the transport (e.g. costs and duration of the transport) and that the transport is made efficient and sustainable by a cooperative network of different actors and modes of transport. The cooperative network enables a real time change between the transport modes, which allows to react as quickly as possible to disturbances or other influences. A further development with regard to transport concepts is the Physical Internet, founded by the Canadian Benoit Montreuil. Here, goods are transported like data (e.g. sending an email). The goods or packages are sent independently and with the help of a hub network, the consignment independently searches for the most optimal route to arrive at its destination. The most important requirement for the Physical Internet is an open and transparent logistics network.[15]

Individualization and increasing complexity of logistics: In order to survive in today's competitive environment, many companies have to customize the products and services they offer. This ultimately leads to an increasing complexity of logistics chains and poses a major challenge for logistics and its players.[16] This development is also due to the great importance of e-commerce - especially in the B2C segment. In Austria, the retail trade in particular is characterised by online trading. Studies show that there is an increased demand for higher-value goods, whereby the weight of transport orders is declining. This means that customers demand smaller, individualised goods of higher value.[17] This consumer ordering behavior also influences the logistics processes, which must react flexibly to the changed requirements.[18]

Cooperation: Increasing globalization and thus the growing division of labor in the economy has led many companies to focus on their core competencies. As a result, more and more make-or-buy decisions have to be made and thus global cooperation with other companies has to be established. This has led to the formation of complex company and supplier networks, which in turn result in

[14] Cf. Die Macher, URL: http://n.diemacher.at/1083/logistik-4 [19.05.2020].
[15] Cf. Haider, et al., 2015, P 23f.
[16] Cf. Wittenbrink , 2014, P 23f.
[17] Cf. Holderied, 2005, P 20 .
[18] Cf. Manner-Romberg, Symanczyk, & Miller, 2016, P 4.

increased international flows of goods and commodities, which ultimately lead to increased freight traffic. Therefore, different challenges have arisen for freight transport, such as the increasing ecological demands on freight transport as well as the growing importance of cooperation between the different modes of transport in order to efficiently meet the increased demand for freight transport.[19] A distinction can be made between cooperation between actors at the same level of the logistics chain (horizontal cooperation) and cooperation between actors at subsequent levels of the logistics chain (vertical cooperation).[20]

From the perspective of logistics service providers, different reasons for horizontal or vertical cooperation can be identified. The increasing globalisation and thus the increasing cost pressure (keyword low-wage countries), the high fixed costs in the transport sector and also the deregulation of the transport industry speak in favour of horizontal cooperation. Horizontal cooperation can open up new geographical markets, as international transport services can be offered. In addition, economies of scale can be exploited, allowing existing infrastructure and means of transport to be utilised more efficiently. Finally, cost savings can also be realized. In addition, horizontal cooperations can be used to offer different logistics services, thus addressing different customers and markets. The increasing concentration of companies on their core competencies as well as the increase in competition and thus the growing time pressure in the transport industry speak in favour of vertical cooperation. Through vertical cooperation, specific services can be offered to achieve a competitive advantage. Rationalization gains can also be realized through close integration into the value chain of upstream or downstream players. An advantage for the customer is, for example, the improvement in the reliability of transport demand forecasts through longer-term cooperation.[21]

2.1 Megatrends and freight transport

The following megatrends lead or support the development of new trends in freight transport.

- Safety is an increasingly decisive factor in the transport sector. Security checks at different points in the transport chain are becoming increasingly important. In addition, the various players must ensure that the transport chain is not used for terrorist purposes.
- The consequences of climate change are becoming increasingly visible, making sustainable strategies necessary.

  Some measures have already been taken: emission limits for means of transport such as trucks or increased use of alternative fuels such as liquefied natural gas (LNG).
- The increasing size of cities is leading to bottlenecks in the infrastructure in conurbations and poses a major challenge for logistics service providers. By bundling flows of goods outside the cities (in consolidation centers), the flow of goods into/out of the cities can be optimally designed.
- E-commerce and thus online trade have a significant influence on transport volumes, as the dispatch of goods is a crucial service for customers.

[19] Cf. Holderied, 2005, P 20
[20] Cf. Pfohl, 2004, P 141
[21] Cf. Claus, 2015, P 23ff

- Increasing digitalization, for example, can minimize transport distances. Access to 3D printers means that spare parts can be produced where the customer needs them, making long transport routes from the manufacturer obsolete.
- Most means of transport are already equipped with technical interfaces, which enables communication between them. This creates a mobile world in which transports can be coordinated via smart phones, for example. So you can be notified on your mobile phone, for example, when a parcel is delivered and can open the door for the parcel service.[22]

3.2. New technologies

The vision of the "Internet of Things" offers a future-oriented approach for the logistics industry. In a concrete context, it describes the autonomous transport of goods and merchandise through internal and external networks. Analogous to the flow of digital information on the Internet, logistical objects find their own paths in the "Internet of Things", whereby they flexibly decide on the most favourable route of onward transport at nodes, depending on the conditions prevailing there, and request the necessary resources. Logistics 4.0 or the use of Physical Internet and Big Data to further optimise the flow of goods and increase the efficiency of the use of resources and the design of processes. Whereas transport and supply chains in the past were mostly closed processes and systems of fixed defined participants, Logistics 4.0 gives the option of developing open networks from these, which can be used to achieve the best possible use of capacities and optimised process control through modularisation and interface management to and between loads and load carriers. 3D printing is also bringing about major changes for the "traditional" supply chain. The product in demand could be printed directly at the customer's site. In principle, the use of the process gradually shifts the production location towards the place of use. This results above all in a reduction of long transport flows (near sourcing), intermediate storage and buffering. For logistics service providers, the use of 3D printing means on the one hand the elimination of transport revenues. On the other hand, however, there are new business areas in which logistics service providers can establish themselves, such as supporting customers in integrating 3D printing into existing value-added networks or specialising in digital warehousing.[23]

3.3 New business models

New innovative business models are putting increasing pressure on a whole range of established companies in a wide variety of industries. This also applies to the logistics industry, where all types of transport relationships (B2B, B2C and C2C) are affected by change. The main causes identified for the development of new, innovative business models Changes in the transport and logistics industry, current development trends and new technologies. These points are discussed in more detail on the following pages.[24]

[22] Cf. Lehmacher, 2015, P 9-15.
[23] Cf. WKO, URL: https://www.wko.at/branchen/ooe/transport-verkehr/spedition-logistik/1---4.0-Branchenleitfaden-WKOOe-Fachgruppe.pdf [14.05.2020]
[24] Cf. Bearingpoint, URL: https://www.bearingpoint.com/de-de/ueber-uns/pressemitteilungen-und-medienberichte/pressemitteilungen/digitale-plattformkonzepte-pr/ [14.05.2020].

3. 4 drivers fort he development of innovations

3.1. Driver 1: Sustainability

In terms of specific energy consumption, inland navigation can be considered the most effective and therefore the most environmentally friendly mode of transport. The inland vessel can transport a tonne of cargo almost four times as far as a truck for the same energy consumption.[25]

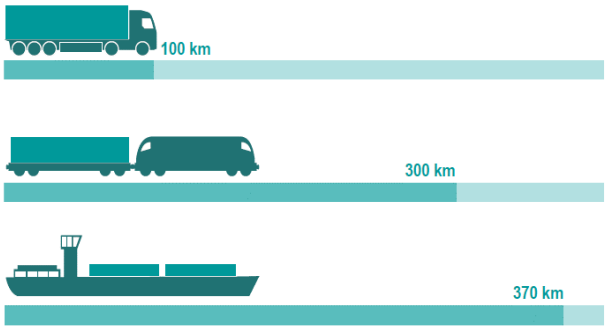

Figure 3: Specific Energy Consumption – source: viadonau

The external costs, i.e. those costs resulting from climate gases, air pollutants, accidents and noise, are also lowest for inland navigation. In particular, CO2 emissions are comparatively low, which means that inland navigation can make a contribution to achieving the European Union's climate objectives.[26]

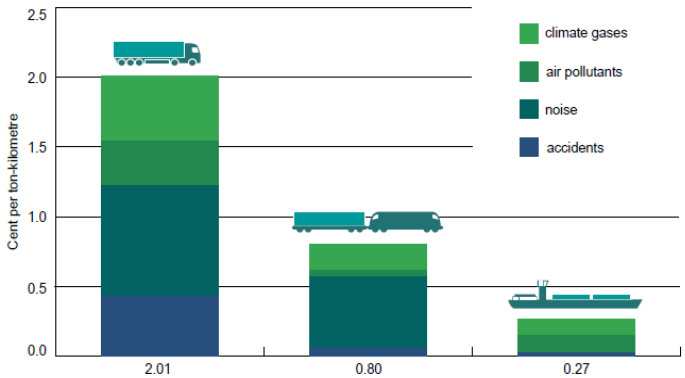

Figure 4: External costs– Source: PLANCO Consulting & Bundesanstalt für Gewässerkunde 2007

Compared with other modes of transport, inland waterway transport offers a significantly larger transport capacity per transport unit and thus is able to make an important contribution to relieving the burden on road and rail. To illustrate the mass capacity of inland navigation: An inland vessel with 4 lighters (7,000 net tonnes) can transport as much as 175 rail wagons or 280 trucks. This corresponds to a convoy of lorries of about 20 km on the motorway! An increase in goods transport on the Danube therefore means a significant reducing congestion, noise, pollution and accidents on the road and relieving the burden on rail.[27]

[25] Cf. viadonau, 2019, P18.
[26] Cf. viadonau, 2019, P18.
[27] Cf. viadonau, 2019, P19.

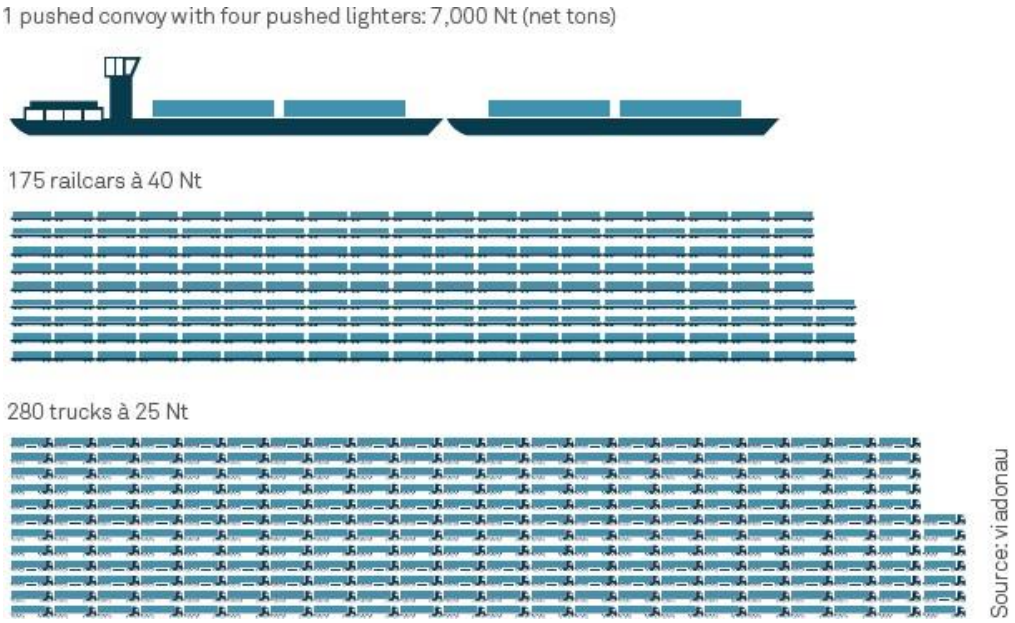

Figure 5: Mass efficiency - source: viadonau

Infrastructure costs consist of the costs of constructing and maintaining transport infrastructure. As natural infrastructure is usually available in the case of inland waterways, infrastructure costs and land consumption are correspondingly low. Detailed relevant comparisons with land transport modes are available from Germany: According to these, the infrastructure costs per tonne-kilometre are around four times higher for rail or road than for waterways. According to current cost estimates for infrastructure projects in the riparian countries, the improvement of the entire infrastructure of the Danube waterway, which is almost 2,415 km long, would amount to a total of EUR 1.2 billion. This corresponds roughly to the costs incurred for the construction of about 50 km of road or rail infrastructure.[28]

As mentioned above, the modal shift in favour of sustainable transport modes such as rail and inland waterways can be limited by several factors.

Accessibility can be described as the first and most important factor: if we refer to the topography of Europe, some countries have access to a wide inland waterway system, while others do not. For this reason, countries like the Netherlands, Romania and Bulgaria have a higher share of inland waterways in the modal split than countries like Latvia or Lithuania. Another aspect of accessibility is that transport by rail or inland waterways requires terminals, which makes transhipment possible. Transhipment facilities are particularly needed for the pre- and post-transport, which in most cases takes place by road. Another limiting factor is the transport distance: as transhipments lead to additional transhipment costs for rail and inland waterway transport, a long transport distance is necessary for rail or inland waterway transport to be profitable. Therefore, equal transport distances are required

[28] Cf. viadonau, 2019, P20.

depending on the product and the market, so that inland waterway or rail can compete with road transport. The characteristics of the products shipped may also influence the choice of transport mode. While products of high value and low volume are preferably transported by truck, products of low value and high volume should be considered for transport by inland waterway vessels or trains. This leads us to the next limiting factor: the use of new technologies, is in most cases not yet commercially feasible in inland navigation. The last limiting factor can be the delivery time: For short delivery times, such as the 24-hour service, other modes of transport are currently not competitive with road transport. Therefore inland navigation is mainly used for transport with longer delivery times.[29]

As mentioned above, a shift to sustainable modes of transport is necessary. EU policy therefore tries to promote a shift to such modes of transport through a variety of measures. The European Commission's 2011 White Paper "Roadmap to a Single European Transport Area - Towards a competitive and resource-efficient transport system" presented the EU's vision for transport in the future. This White Paper contains proposals for action by the EU to make transport more sustainable in the future. As rail and inland waterways are recognised as sustainable modes of transport, a modal shift towards these modes of transport should also take place. The aim is to shift 30% of road traffic exceeding 300 km to rail or inland waterways by 2030. By 2050, the figure should be 50 %.[30]

3.1.1 Excursus: Alternative fuel LNG

LNG or liquefied natural gas is natural gas that is cooled to at least -162 °C, which is 600 times less than unprocessed natural gap This is also the main advantage in connection with transport! In addition to being used as a fuel for inland waterway vessels and trucks, LNG can also be used for industrial processes in gas form. The companies RAG, Ennshafen OÖ GmbH and IVECO Austria opened Austria's first filling station for LNG (Liquefied Natural Gas) in Ennshafen in Upper Austria on 26 September 2017 as part of the LNG Future Forum. There are already two bunker stations on the Rhine within the framework of inland navigation - in the port of Rotterdam and the port of Amsterdam. These are truck-to-ship bunker stations, which means that the truck is connected to the ship that refuels it. Norway and other Scandinavian countries can be seen as pioneers for LNG. In 2009 there were already 336 ships in the LNG tanker fleet worldwide.[31]

3.2. Driver 2: Digitalisation and Connectivity

Digitalisation, connectivity and the associated trends Industry 4.0 and the Internet of Things are also currently relevant topics in logistics. Logistics 4.0 is an extension of the underlying idea of an Internet of Things. Due to the digitalization of society in general and the increasing number of online purchases,

[29] Cf. ACEA, URL: https://www.acea.be/uploads/publications/SAG_17.pdf P10 [14.05.2020]; Eurostat, URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics_-_modal_split [14.05.2020].
[30] Cf. Europäische Kommission, 2011, P 3ff.
[31] Cf. Quelle: Youtube, URL: https://www.youtube.com/watch?v=WyZTuzUzR68 [14.05.2020]; LNG Masterplan, URL: http://www.lngmasterplan.eu/images/D_111__Status_Quo__Trend_Analysis__Danube_and_Italy_v2.1_FINAL_2015-3-12.pdf, P24; Aymelek, URL: https://www.researchgate.net/profile/Murat_Aymelek/publication/274379729_Challenges_and_opportunities_for_LNG_as_a_ship_fuel_source_and_an_application_to_bunkering_network_optimisation/links/55e5bf9f08aecb1a7ccd4ab6.pdf P768 [14.05.2020].

the logistics industry is increasingly faced with new challenges. Accordingly, networking of logistics service providers with customers and other relevant players is crucial in order to cope with the increasing volume of transport. Even though the technical prerequisites may often already exist or can be implemented relatively quickly, it is still necessary to establish a corresponding basis of trust between the players. Trust is important in order to realize data exchange and to make sure that actors are willing to share all relevant data with the partners and that these data are not misused for their own purposes. Since the willingness to exchange data is often not yet given due to a lack of trust, the attitude of the actors must also be positively influenced in the future. In addition, the use of (partly) autonomous vehicles (e.g. in platooning) can, for example, make better or more efficient use of the transport infrastructure.[32]

Connectivity - Automated driving: Digitalisation has made innovative solutions available to further optimize freight traffic on the roads. Platooning is one of the concepts that can revolutionize transport on highways. In this process, several trucks are electronically connected to each other to communicate in real time. The vehicles are arranged in a convoy, allowing the lead vehicle to transfer its driving behaviour to the others. This enables the convoy to perform manoeuvres such as acceleration and braking synchronously for all vehicles. This technology enables trucks to drive behind each other without danger at a distance of a few metres and to reduce their air resistance considerably. In addition, automated systems enable the vehicles to react more proactively to traffic situations and topographical conditions, thus saving further fuel. Platooning achieves a significant increase in efficiency in the overall platoon, which significantly reduces CO2 emissions. In addition, the available traffic space is better used and the traffic flow is optimized. The more vehicles have the technology, the more effectively platooning contributes to the optimization of freight traffic. The aim is to develop a system that is independent of manufacturers in order to ensure even more flexible application possibilities.[33]

Many land-based transport systems are already state of the art in terms of autonomous vehicles. There are several examples of automated subways, self-propelled intralogistic vehicles or driverless transport systems (AGV) at modern container terminals. In modern aviation, too, there are very diverse approaches to autonomous control concepts. Consequently, autonomy is also seen as an opportunity for maritime transport to meet the challenges of competitiveness, safety and sustainability. This includes advanced decision support systems that offer the possibility to operate ships remotely under semi- or fully automated control. For inland navigation, the trend of autonomous vehicles is not as relevant in the near future as for example for road transport, as the hazard potential is still predominant for inland navigation. Nevertheless, an open data management offers the actors of inland

[32] Cf. VDA, URL: https://www.vda.de/de/themen/innovation-und-technik/automatisiertes-fahren/platooning.html [14.05.2020]; Die Macher, URL: http://n.diemacher.at/1083/logistik-4 [14.05.2020]; Kauder, Hasselfeldt, & Oppermann, 2016, P 1f; Bundesvereinigung Logistik (BVL) e. V., Digitalisierung in der Logistik P 20, URL: https://www.bvl.de/positionspapier-digitalisierung [14.05.2020].

[33] Cf. VDA, URL: https://www.vda.de/de/themen/innovation-und-technik/automatisiertes-fahren/platooning.html [14.05.2020].

navigation such as shipping companies or forwarding agents the possibility to get a quick overview of the transport flows. This way, enormous efficiency advantages can be realised even in individual processes such as smuggling through automated registration and payment. Furthermore, a rapid exchange of information allows transport processes such as transhipment and pre- and post-carriage to be optimally planned to avoid cost-intensive waiting times. Especially in ports with container handling, digitalisation is already a very present topic, as the handling of the many containers and their transhipment would hardly be possible without the use of electronic data processing. The trend towards digitalisation is already being lived out in the port of Hamburg, for example, although there is still potential for expansion. However, in order to be able to take advantage of this trend in the future in the area of inland navigation, high investments must be made in equipment and in training and further education, the security of a digital network must be ensured and international standards must be introduced.[34]

3.1.2 Excursus: Pioneer: „smartPORT " - Hamburg

The port of Hamburg is a pioneer in the field of digitalisation in connection with inland navigation. The aim of the pioneer "smart PORT Logistics" is to optimise land transport due to limited road capacity. smart PORT logistics combines economic and ecological aspects in three sub-areas: Traffic flows, infrastructure and flow of goods. An intermodal port traffic centre for shipping, rail and road traffic forms the basis for linking the traffic flows. Intelligent networking is a prerequisite for smooth and efficient traffic in the port of Hamburg and ultimately also for the flow of goods. Optimum data acquisition and rapid information exchange enable logistics companies, forwarders and agents to select the most efficient mode of transport for their operations. A cloud-based IT platform provided by SAP is used to network all transport and logistics partners so that all relevant information (e.g. information on specific route sections) is transmitted. By monitoring truck movements using GPS, alternative routes can be recommended in real time and waiting times caused by traffic jams, for example, can be avoided. In addition, a control instrument shows the route in and out of the port and at the same time takes into account current traffic movements. Furthermore, the smartPORT has a virtual container depot that helps to avoid journeys with empty containers. A shore-side power supply from renewable energies for cruise ships will considerably reduce the environmental impact in Hamburg. Intelligent points of the port railway are equipped with sensors that transmit data in real time to a central IT system, thus providing information on their condition, enabling maintenance to be carried out in good time and thus reducing or eliminating downtimes[35]

3.1.3 Excursus: River Information Services (RIS)

High-quality cost- and time-saving transport services and the provision of electronic information have become a key success factor. To enable inland navigation to meet these needs, an information and management service, River Information Services (RIS), has been generated in Europe. RIS are able to

[34] Cf. Projekt Munin, http://www.unmanned-ship.org/munin/about/the-autonomus-ship/ [14.05.2020]; Youtube, URL: https://www.youtube.com/watch?v=Z5cTxSjjEXI [14.05.2020]; Projekt NOVIMAR, URL: https://www.researchgate.net/publication/330359084_Platooning_auf_Wasserstrassen__Erste_Ergebnisse_aus_dem_Projekt_NOVIMAR [14.05.2020]

[35] Cf. Hafen Hamburg, URL: https://www.hamburg-port-authority.de/de/hpa-360/smartport/ [14.05.2020].

support both freight transport and passenger navigation on waterways. RIS improves traffic safety, economic efficiency, reliability and transport planning. The basic idea is that RIS data are used to provide information bases to support traffic and transport-related tasks. RIS are of great value for the entire European inland navigation. Through RIS the latest advances in logistics on waterways can be used. Furthermore, reliably planned offers can be developed. RIS are a decisive factor in the development of the European inland navigation space.[36]

3.3.Driver 3: Individualisation and increasing complexity in logistics

In order to survive in the current competitive environment, many companies have to customize the products and services they offer. In addition, customers are demanding ever shorter delivery times. Ultimately, this leads to an increasing complexity of logistics chains and poses a major challenge for logistics and its players. This development is also due to the great importance of e-commerce - especially in the B2C sector. In Austria, the retail trade in particular is characterised by online trading. Gross annual sales in Internet retailing amounted to approximately EUR 3.8 billion in 2018, which corresponds to 5.02% of the total retail volume. Studies show that there is an increased demand for higher-value goods, whereby the weight of transport orders is declining. This means that there is a demand from customers for smaller, individualised goods of higher value. For the providers and players in logistics, this development in turn means new requirements in terms of speed, punctuality, flexibility and quality of the service offered in order to guarantee value. This consumer ordering behaviour also influences the logistics processes, which must react flexibly to the changed requirements. This development is also reflected in the increasing importance of CEP transport.[37]

Inland navigation is also affected by the trend towards individualisation and the increasing complexity of transport processes, as increasingly individual transport services reduce the possibilities of transport bundling. This in turn is a trend which is disadvantageous for inland navigation, since in this sector road transport offers the great advantage of network density and flexibility. Nevertheless, especially in conurbations, such as large cities, opportunities may arise for the use of inland waterway vessels for the transport of smaller consignments.

3.4. Driver 4: Cooperation in logistics sector

Increasing globalization and thus the growing division of labor in the economy has led many companies to focus on their core competencies. As a consequence, more and more make-or-buy decisions have to be made and thus it is necessary to cooperate with other companies on a global scale. Complex company and supplier networks have formed which in turn lead to increased international flows of goods and commodities, which in the end lead to an increase in freight traffic. Therefore, different challenges have arisen for freight transport, such as the increasing ecological demands on freight transport as well as the growing importance of cooperation between the various modes of transport in order to efficiently meet the increased demand for freight transport. A distinction can be made

[36] Cf. viadonau, 2019, 204ff.
[37] Cf. Wittenbrink , 2014, P 23f; Holderied, 2005, P 20; Statista, URL: https://de.statista.com/statistik/daten/studie/947968/umfrage/umsatz-im-stationaeren-handel-und-im-online-handel-in-oesterreich/ [19.05.2020]

between cooperation between actors at the same level of the logistics chain (horizontal cooperation) and cooperation between actors at subsequent levels of the logistics chain (vertical cooperation). From the perspective of logistics service providers, different reasons for horizontal or vertical cooperation can be identified.[38]

The increasing globalisation and thus the rising cost pressure (keyword low-wage countries), the high fixed costs in the transport sector and also the deregulation of the transport industry speak in favour of horizontal cooperation. Horizontal cooperation can open up new geographical markets, as international transport services can be offered. In addition, economies of scale can be exploited, allowing the existing infrastructure and means of transport to be efficiently utilised. Finally, cost savings can also be realized. In addition, horizontal cooperations can be used to offer different logistics services, thus addressing different customers and markets. The increasing concentration of companies on their core competencies as well as the increase in competition and thus the growing time pressure in the transport industry speak in favour of vertical cooperation. Through vertical cooperation, specific services can be offered to achieve a competitive advantage. Rationalization gains can also be realized through close integration into the value chain of upstream or downstream players. An advantage for the customer is, for example, the improvement in the reliability of transport demand forecasts through longer-term cooperation.[39]

For inland navigation, horizontal or vertical cooperation could also increase the competitiveness of the mode of transport. For example, economies of scale could lead to the efficient use of inland waterway vessels and thus also to cost advantages. Since transport by inland waterway is often international rather than national, international cooperation is also quite possible. Cooperation could also make it easier to open up new markets. Cooperation on a vertical level could also be simplified by increasing the number of companies settling near the port. This could promote a greater integration of inland navigation into the transport chain.[40]

In summary, new transport concepts that influence freight transport and other developments (e.g. generally increasing freight traffic, bottlenecks in transport infrastructure, etc.) are needed.

Existing infrastructure bottlenecks and the negative effects of transport volume lead to new trends in the logistics industry.

- The current development trends have arisen in the following areas:
- Sustainability
- Digitalisation/Networking
- Individualisation and increasing complexity

[38] Cf. Pfohl, 2004, P 141; Vahrenkamp & Kotzab, 2012, P 18, URL: http://www.springer.com/cda/content/document/cda_downloaddocument/9783642193323-c1.pdf?SGWID=0-0-45-1199838-p174123868 [14.05.2020].
[39] Cf. Claus, 2015, P 23ff
[40] Cf. Claus, 2015, P 23ff

4 Innovative transport concepts

Europe is faced with the challenge that in many cases only two modes of transport (road and rail) are available, as in many areas inland waterways and the associated waterways are not yet adequately developed or are not available in terms of infrastructure. As a result, European transport chains often do not have sufficient capacity, as the infrastructure, especially in the road sector, has already reached its maximum capacity utilisation level. Furthermore, the sustainability aspect is becoming increasingly important. This means that the optimal use of existing transport resources for freight transport is becoming increasingly important in order to ensure efficient and cost-effective transport for the future. In order to guarantee an optimal utilization of the different means of transport and thus to be able to counteract the emerging challenges, different transport concepts have been developed in the last years.

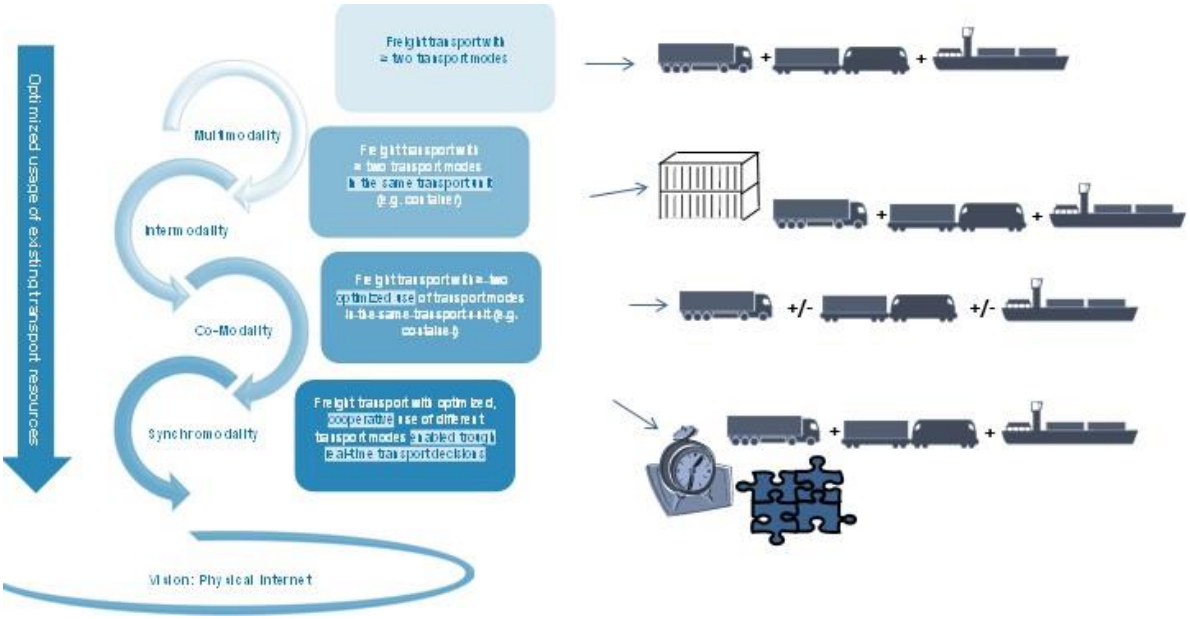

Figure 6: Innovative transport concepts – source: own

The use of different means of transport to exploit the strengths of each mode of transport is the idea of multimodality. Intermodality enables the use of different modes of transport by transporting products in the same transport unit, thus reducing handling costs. The idea of co-modality is to use the means of transport that are most suitable for the different transport routes (depending, for example, on the product). Synchromodality combines the best aspects of previous concepts - standardised transport units across all modes of transport, combining the strengths of the different modes of transport, avoiding unimodal transport - by adding real-time data to ensure the most efficient transport. The concept of synchronous modality can also be seen as a first step towards the Physical Internet, which was developed by the Canadian professor Benoit Montreuil.[41]

[41] Cf. Reis, Vasco, 2015, P 173–179.

4.1 Synchromodality

Synchromodality aims to create a flexible and cooperative transport network by making optimum use of the various transport resources available. The main prerequisite for the concept of Synchronous Modality is that the means of transport is not defined by the customer. When applying this concept, the customer can only define basic requirements such as transport costs and delivery time. The free choice of means of transport enables bundling effects that contribute to an efficient use of transport capacities. Thus additional transport routes can be avoided, which leads to a reduction of CO2 and other emissions. By exploiting bundling effects and eliminating decision-makers' prejudices against alternative modes of transport (rail, inland waterways), the concept can contribute to an increased use of rail and inland waterway transport. By adding real-time monitoring, it will enable advantageous transport mode and route selection. This leads to an effective use of the infrastructure and a reduction of waiting times. To ensure the success of this concept a close cooperation of all actors along the supply chain is required. Members of the synchromodal transport network must coordinate with each other to achieve optimal utilization of the means of transport and at the same time ensure that all delivery deadlines are met. A lively exchange of data and mutual trust between all actors is therefore absolutely essential.[42]

Synchromodality also offers some potential for inland waterway transport: the establishment of transhipment points enables bundling effects and thus higher volumes can be transported. Since inland waterway vessels are particularly attractive for bulk goods transport, this bundling has a positive effect on inland waterway transport. Furthermore, current prejudices can be overcome and the image of inland navigation as a reliable transport option can be strengthened. Furthermore, the modal shift is also in line with political objectives. Since personal preferences are essential, among other factors, in the decision making process for transport modes, the centralisation of the decision-making process neglects personal preferences. Another potential for inland navigation is that there are many unused waterways in Europe, e.g. only 15% of the capacity of the Danube is used.[43]

Practical example - Syncromodality: European Gateway Services

EGS offers a network of rail and inland waterway connections between Rotterdam and other hinterland terminals in Europe. The website provides an overview of the transport network, including journey times, as well as the services offered by the individual terminals. For shipping companies, logistics service providers, transport companies and shippers EGS also offers other services such as transport planning. Wherever possible, transports are carried out syncromodally. All customers have to do is specify the time at which the container should arrive at its destination. The transport is carried out by the most favourable mode of transport at the time and over the most favourable route. In addition to economic aspects, sustainability also plays an important role.

[42] Cf. Reis, Vasco, 2015, P 173–179.
[43] Cf. Fraunhofer, http://www.scpfraunhofer.de/content/dam/scs/de/dokumente/studien/Wirtschaftliche_Rahmenbedingungen_des_Gueterverkehrppdf p.14 [14.05.2020]; Youtube, https://www.youtube.com/watch?v=5ofhMxRRyec [14.05.2020].

The most optimal solution is selected from rail, inland waterway, truck or a combination of these modes of transport.[44]

4.2 Physical Internet

Another innovative transport concept is the Physical Internet. The Canadian professor Benoit Montreuil is considered a pioneer in this field. The basic idea of the Physical Internet is to send freight and information flows over the Internet (Fig. 3). For example, when sending an e-mail, in most cases it is not known which provider is used by the recipient or via which "route" the e-mail reaches the recipient. One relies on the Internet to send the e-mail to the correct recipient. In the Physical Internet, this message consists of a physical object such as a packet. A network of hubs that send and receive the products is the basis for the Physical Internet (this network is modelled on the various servers on the Internet). The nearest hub to the customer / recipient carries out the last delivery. In the Physical Internet, all carriers and service providers are networked with each other to ensure efficient dispatch and use of the network. To ensure barrier-free and seamless transport, standardized PI containers, parcels, warehouses and transhipment points must be installed. These are connected to the Internet of Things and communicate with each other independently. Furthermore, processes must be standardised to minimise the risk of discrepancies. These standardised transport units and processes lead to a reliable and resilient smart network in which the units communicate almost independently. This smart network should be accessible to all actors in the supply chain (including at global level). This enables the transport units to choose the best transport route themselves and to interact with other transport units and stations. This makes human interaction almost superfluous (e.g. planning a transhipment process is no longer necessary). The connection between the actors, the infrastructure and the different modes of transport is essential for the Physical Internet and leads to comprehensive interconnectivity. The exchange of all relevant information and ensuring that data is up-to-date in real time are also crucial elements for the concept of the Physical Internet.[45]

5 Innovative business models

According to experts, new business models will develop in four areas in particular:

1. booking and optimization platforms
2. carriers and terminal operators
3. supply chain specialists
4. service providers[46]

[44] Cf. European Gateway Services Website, URL: http://www.europeangatewayservicepcom/de [18.05.2020].
[45] Cf. Montreuil, Benoit, 2011, P 71–87; Modulushca project (2014): Physical Internet. Online verfügbar unter https://www.youtube.com/watch?v=lltcWVNrjl0 [19.05.2020].
[46] Cf. Kalaidos Fachhochschule Schweiz, URL: https://www.kalaidos-fh.ch/Blogs/Posts/2017/01/uf-1065-Logistik-vier-Geschaeftsmodelle [04.05.2020].

Booking and optimization platforms can make the traditional business of transport companies more efficient and cost-effective. The direct networking of customers and logistics service providers enables optimised processing and efficient transport capacity utilisation, which in turn reduces freight costs. It is advantageous for logistics companies to enter into cooperation agreements with other logistics companies in order to be able to act jointly as a neutral platform provider. With the help of cooperations, it is possible to achieve a greater reach.[47]

Carriers and terminal operators are an essential part of the value chain. In the future, they will have to use economies of scale & latest technologies to optimize utilization and costs. Special freight packages should be designed to not only depend on the orders of booking platforms, thus small companies with simple logistics chains could save the booking fees of the platforms. The development of an own online platform in cooperation with other freight carriers or terminal operators would be conceivable for this purpose.[48]

Supply chain specialists require industry-specific know-how to handle complex supply processes. In order to make complex supply chains more efficient and transparent, the automation of processes must also make greater progress. One of the biggest challenges for supply chain specialists is to be innovative and not to miss technological leaps at the same time, and to remain competitive in terms of price. Cooperation with service providers would make sense.[49]

Service providers provide software products and solutions for the collection and systematic analysis of large amounts of data and other digital services. The range of services extends from online payment systems to automated customs clearance. Service providers are thus the core of digital logistics. It is through service providers that the processing of transactions becomes possible in the first place. Access to valid data, in real time and seamless networking with partners is a prerequisite for the success of digital solutions and software products.[50]

These business models also influence inland navigation. Especially the trend towards digitalisation and the resulting business models are very relevant for inland navigation. A major challenge for the implementation of innovative and data-driven business models is to find suitable data. Although the volume of data is constantly increasing, the data can only be used directly to a limited extent, many of them are even still recorded in analogue form.[51]

[47] Cf. Kanal Egal, URL: https://www.kanal-egal.de/wie-digitale-geschaeftsmodelle-die-logistikbranche-veraendern/ [19.05.2020]; iBusiness, URL: https://www.ibusinespde/aktuell/db/568814veg.html [19.05.2020] Erste Bank und Sparkasse, URL: https://newsroom.sparkasse.at/2016/11/03/logistik-4-0-vier-geschaeftsmodelle-digitalen-zukunft/34626 [18.05.2020].
[48] Cf. ebenda.
[49] Cf. iBusiness, URL: https://www.ibusinespde/aktuell/db/568814veg.html [19.05.2020].
[50] Cf. Kanal Egal, URL: https://www.kanal-egal.de/wie-digitale-geschaeftsmodelle-die-logistikbranche-veraendern/ [19.05.2020]; iBusiness, URL: https://www.ibusinespde/aktuell/db/568814veg.html [19.05.2020]
[51] Cf. Deutsches Zentrum für innovative Binnenschifffahrt, Studie- Digitalisierung in der Binnenschifffahrt, URL: https://d-zib.eu/wp-content/uploads/sites/2/2019/02/190212-Handout-EIBIP.pdf [18.05.2020].

6 Summary

In general, the transport sector is facing the challenge that the volume of goods will increase strongly in the future, which also triggers the emergence of new innovative developments. New transport concepts that influence freight traffic and other developments (e.g. generally increasing freight traffic, bottlenecks in the transport infrastructure, etc.) are required.

The current development trends have arisen in the following areas:

- Sustainability
- Digitalisation/Networking
- Individualisation and increasing complexity
- Cooperation
- Innovative transport concepts

New development trends may favour an increased integration of inland navigation in multimodal transport systems. As will be shown, the inland navigation sector is not an innovation-resistant sector of the transport industry, as different innovative solutions have already been developed. Therefore, a positive development of inland navigation can be expected in the future. Nevertheless, different conditions must be taken into account to ensure success This requires cooperation between the various players, political measures and awareness-raising (mind-shift) for inland navigation as a sustainable means of transport.

5. Sources

Abimagazin, URL: http://doku.iab.de/abi/2011/abi0311_22.pdf [14.05.2020].

ACEA, URL: https://www.acea.be/uploads/publications/SAG_17.pdf P10 [14.05.2020]

Aymelek, URL: https://www.researchgate.net/profile/Murat_Aymelek/publication/274379729_Challenges_and_opportunities_for_LNG_as_a_ship_fuel_source_and_an_application_to_bunkering_network_optimisation/links/55e5bf9f08aecb1a7ccd4ab6.pdf P768 [14.05.2020].

Bearingpoint, URL: https://www.bearingpoint.com/de-de/ueber-uns/pressemitteilungen-und-medienberichte/pressemitteilungen/digitale-plattformkonzepte-pr/ [14.05.2020].

Best Practice Factory for Freight Transport, URL: http://www.bestfact.net/mokum-mariteam/ [18.05.2020].

Bundesvereinigung Logistik (BVL) e. V., Digitalisierung in der Logistik P 20, URL: https://www.bvl.de/positionspapier-digitalisierung [14.05.2020].

BVL, 2019, URL: https://www.bvl.de/files/1951/1988/2128/Begleitende_Publikation_zur_Session_Maennerdomaene.pdf [14.05.2020].

Cargo Center Graz Website, URL: http://www.cargo-center-graz.at/dienstleistungen/logistik-plattform/ [18.05.2020].

Claus, P. (2015): Werteffekte durch Ankündigung von Kooperationen mit Logistikdienstleistern, Masterarbeit.

Deutsches Zentrum für innovative Binnenschifffahrt, Studie- Digitalisierung in der Binnenschifffahrt, URL: https://d-zib.eu/wp-content/uploads/sites/2/2019/02/190212-Handout-EIBIP.pdf [18.05.2020]

Die Macher, URL: http://n.diemacher.at/1083/logistik-4 [14.05.2020] .

Der Wirtschaftsingenieur, URL: https://www.der-wirtschaftsingenieur.de/index.php/die-7-dimensionen-der-logistik/ [14.05.2020].

Die Welt, URL: URL: https://www.welt.de/motor/news/article155884171/Nutzfahrzeug-Studie.html [05.05.2020].

Erste Bank und Sparkasse, URL: https://newsroom.sparkasse.at/2016/11/03/logistik-4-0-vier-geschaeftsmodelle-digitalen-zukunft/34626 [18.05.2020].

Europäische Kommission: Der europäische Grüne Deal, 2019.

Europäische Kommission, “Weißbuch - Fahrplan zu einem einheitlichen europäischen Verkehrsraum – Hin zu einem wettbewerbsorientierten und ressourcenschonenden Verkehrssystem” (2011).

European Gateway Services Website, URL: http://www.europeangatewayservicepcom/de [18.05.2020]

Eurostat, “Freight transport statistics – modal split”, (2020), URL: http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics_-_modal_split [28.04.2020].

Fraunhofer, http://www.scpfraunhofer.de/content/dam/scs/de/dokumente/studien/Wirtschaftliche_Rahmenbedingungen_des_Gueterverkehrppdf p.14 [14.05.2020].

Fraunhofer, URL: https://www.iml.fraunhofer.de/de/abteilungen/b3/verkehrslogistik/dienstleistungen/synchromodalitaet.html [18.05.2020].

Hafen Hamburg, URL: https://www.hamburg-port-authority.de/de/hpa-360/smartport/ [14.05.2020].

Holderied, C. (2005). Güterverkehr, Spedition und Logistik. Managementkonzepte für Güterverkehrsbetriebe, Speditionsunternehmen und logistische Dienstleister. München: Oldenbourg Wissenschaftsverlag GmbH.

iBusiness, URL: https://www.ibusinespde/aktuell/db/568814veg.html [19.05.2020].

Industriemagazin, URL: https://industriemagazin.at/a/fachkraeftemangel-bei-logistikern-wir-sind-kurz-vor-dem-versorgungskollaps [14.05.2020].

Kalaidos Fachhochschule Schweiz, URL: https://www.kalaidos-fh.ch/Blogs/Posts/2017/01/uf-1065-Logistik-vier-Geschaeftsmodelle [04.05.2020]

Kanal Egal, URL: https://www.kanal-egal.de/wie-digitale-geschaeftsmodelle-die-logistikbranche-veraendern/ [19.05.2020]

Karriere.de, URL: https://www.karriere.de/arbeitsmarkt-logistik-karriere-in-der-container-welt/23040246.html [14.05.2020].

Kauder, V., Hasselfeldt, G., & Oppermann, T. (2016). Intelligente Mobilität fördern - Die Chancen der Digitalisierung für den Verkehrssektor nutzen. http://dip21.bundestag.de/dip21/btd/18/073/1807362.pdf [19.05.2020].

Lehmacher W., „Wirtschaft, Gesellschaft und Logistik 2050 in Logistik – eine Industrie, die (sich) bewegt. Strategien und Lösungen entlang der Supply Chain 4.0“ (2015)

LNG Masterplan, URL: http://www.lngmasterplan.eu/images/D_111_Status_Quo___Trend_Analysis_-_Danube_and_Italy_v2.1_FINAL_2015-3-12.pdf

Manner-Romberg, H., Symanczyk, W., & Miller, J. (2016): Die Individualisierung der Lieferung - Wie neue Konzepte den E-Commerce verändern: https://www.bevh.org/uploads/media/Die_Individualisierung_der_Lieferung_Studie.pdf, Abfrage: 20.02.2018

Montreuil, Benoit (2011): Toward a Physical Internet: meeting the global logistics sustainability grand challenge. In: Logistics Research 3 (2), P 71–87. DOI: 10.1007/s12159-011-0045-x.

Modulushca project (2014): Physical Internet. Online verfügbar unter https://www.youtube.com/watch?v=lltcWVNrjl0 [19.05.2020]

OPEN Insights, https://www.openinsightpde/so-funktioniert-das-blockchain/ [14.05.2020].

Pfohl, H. C. (2004). "Freight Integrator" - eine neue Rolel in der Logistikkette? In H. C. Pfohl, Erfolgsfaktor Kooperation in der Logistik (P 139 - 166). Darmstadt: Erich Schmidt Verlag GsmbH & Co.

Physical Internet Manifest, URL: https://de.slideshare.net/physical_internet/physical-internet-manifest-19-2011-0426-mled-ger [14.05.2020].

Projekt Munin, http://www.unmanned-ship.org/munin/about/the-autonomus-ship/ [14.05.2020].

Projekt NOVIMAR, URL: https://www.researchgate.net/publication/330359084_Platooning_auf_Wasserstrassen_-_Erste_Ergebnisse_aus_dem_Projekt_NOVIMAR [14.05.2020].

Psaraftis, H. N. (2016). Green Transportation Logistics: The Quest for Win-Win Solutionp Dänemark: Springer Verlag.

Reis, Vasco (2015): Should we keep on renaming a +35-year-old baby? In: Journal of Transport Geography 46, P 173–179. DOI: 10.1016/j.jtrangeo.2015.06.019

T3, URL: https://t3n.de/magazin/innovative-logistik-trends-onlinehandel-zukunftspaket-238987/ [14.05.2020].

The Guardian, URL: https://www.theguardian.com/cities/2016/mar/01/paris-french-retailer-franpix-delivers-goods-by-boat-river-seine-transport-water-future-urban-logistics [18.05.2020].

Transportlogistic, URL: https://www.transportlogistic.de/de/messe/industry-insights/logistikkonzepte-der-zukunft/ [14.05.2020].

Vahrenkamp & Kotzab, 2012, P 18, URL: http://www.springer.com/cda/content/document/cda_downloaddocument/9783642193323-c1.pdf?SGWID=0-0-45-1199838-p174123868 [14.05.2020].

VDA, URL: https://www.vda.de/de/themen/innovation-und-technik/automatisiertes-fahren/platooning.html [14.05.2020].

viadonau (2019): Handbuch der Donauschifffahrt, Wien.

Wittenbrink , P. (2014). Transportmanagement - Kostenoptimierung, Green Logistics und Herausforderungen an der Schnittstelle Rampe. Lörrach: Springer Verlag.

WKO, URL: https://www.wko.at/branchen/handel/Studie_Internet-Einzelhandel_2014.html [05.05.2020]

WKO, URL: https://www.wko.at/service/aussenwirtschaft/logistik-branche-struktur-zukunft-trendphtml [14.05.2020].

WKO, URL: https://www.wko.at/branchen/ooe/transport-verkehr/spedition-logistik/1---4.0-Branchenleitfaden-WKOOe-Fachgruppe.pdf [14.05.2020].

Youtube, URL: https://www.youtube.com/watch?v=WyZTuzUzR68 [14.05.2020].

Youtube, URL: https://www.youtube.com/watch?v=Z5cTxSjjEXI [14.05.2020].

Youtube, https://www.youtube.com/watch?v=5ofhMxRRyec [14.05.2020].

Youtube, https://www.youtube.com/watch?v=lltcWVNrjl0 [14.05.2020].

Zentralkommission für die Rheinschifffahrt, Marktbeorbachtung 2019, URL: https://www.ccr-zkr.org/files/documents/om/om19_II_de.pdf [14.05.2020].

Zentralverband für Spedition und Logistik, URL: https://www.otpat/presseaussendung/OTS_20191129_OTS0158/logistik-branche-als-innovationstreiber-digitalisierung-mehr-chance-als-bedrohung-bild [14.05.2020].

Zukunft Mobilität, URL: http://www.zukunft-mobilitaet.net/117213/binnenschifffahrt-seeschifffahrt/innenstadtlogistik-binnenschiff-lastenrad-amsterdam-utrecht-paris/ [18.05.2020].