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Port and City Integration: Transportation Aspect

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Abstract

ICTs enable city governments to interact directly with communities and urban infrastructure to keep track of what is happening in the city, how the city is developing, and what ways can improve the quality of life. A digital-enabled network and an IT strategy that combines land and sea traffic management help to maintain economic feasibility. City residents can move around easily and port operations become more efficient. In this article 3 big ports were observed: Shanghai, Rotterdam and Hamburg. There are many criteria by which to rate a big port. This is, in particular, the area it occupies, its cargo turnover. Transport planning allows to achieve coordinated development of all types of transport in conjunction with urban planning activities, as well as a reasonable choice of the most effective measures for the development of the transport system. The logistic control can increase the quality using IT technologies and in the paper major aspects are observed. The effective planning can be reached according to main strategic aspect of every particular port.

Keywords: Smart Port and City; Port/City Integration; Indusrtry 4.0; of Intermodal Transport Links; Survey.

1. Introduction

Globalization shows a orientation of leading countries in the world towards the service sector and the main area of progress will be in large cities. In most cases these are coastal cities which are laboratories for new developments.

Port cities should consider the importance for a competitive development. By analyzing negative factors of the connection between city and port, measured and well-grounded decisions can be made in the strategic planning of a city. The majority of positive benefits are of economic nature. Main negative consequences are the impact on the environment, traffic loads on infrastructure, and the needs of the port for new space (Notteboom and Rodrigue, 2008).

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Seaports are of strategic importance for the development of an economy by ensuring the export and import needs of a country. To comply with the trade and transport needs of the country, ports have to provide an internationally competitive infrastructure and high quality services in the short, medium and long term.

Problems in safeguarding a balanced development of port facilities are complex because of interdepartmental issues and are differentiated by sub-sectors of the economy, which requires the participation of various executive authorities to implement specific activities. A balanced development of port capacities implies the improvement of approach channels, the terminal and infrastructure such as road and railways. In order to solve these challenges, not only governmental regulation is needed but a high degree of coordinated actions of all federal and local authorities, businesses, the population and other economic agents (Carpenter and Lozano, 2020).

New realities of economic life, should make us look at the environment in a new perspective, where seaports operate are more rational and responsible in planning their activities. One of the exciting questions: will the transport infrastructure in general and seaports in particular be able to cope with the increasing volume of freight traffic and the growing demand for fast, efficient, reliable and environmentally friendly balanced transport solutions? Nowadays, it is necessary to learn to think in the long term and plan further development.

The purpose of this article is to analyze the interaction between ports and cities by the example of two of biggest ports in Europe (Hamburg and Rotterdam) and one Asian port (Shanghai) and then to define main instrument of logistic control and influence of ports on big cities.

2. Materials and Methods

The main idea of any business existence is to maintain economic feasibility. Under an increasing pressure ports are dealing with number of issues in order to stay competitive. The aspiration of development requires implementation of new approaches and methods to attain better forms of businesses (Fenton and Gustafsson, 2017).

Port activities are very sensitive to the local economy. In large and wealthy regions, like developed countries, cargo turnover is diverse. Shipped goods in agricultural and raw materials regions have specialized ports that create little additional value and low employment. This changes and the importance of ports have become substantial in recent decades, in accordance to the changes in transportation, informational technologies and expansion of customer markets. Currently large ports are involved in worldwide supply chains with around 80% of transported international cargo (Ng et al., 2014).

All successive development stages have always been connected with similar problems around the world. Among them are social, political, institutional, governmental and economic conditions (Hein, 2011). Connectivity is a result close collaboration between ports and surrounding cities. Ports are logistic hubs and thus provide cargo and people movement and therefore favor connectivity. Ports play thus a significant role for international trade and influence nearby cities by reducing transport costs for commodities and people (United Nations Conference on Trade and Development UNCTAD, 2017).

The terms “port” and “city” exist one by one, but “port city” is described in the literature very blurry. Generally, “port city” can be defined as a city with a maritime hub, where the port acts as a junction point between land and sea transport networks. According to this concept, global trade starts from the hinterland, whereas ports are points of arrival and departure. Ports are strengthening the competitiveness of a city and increase the economic prosperity of a region (Jacobs et al., 2010). Another “port city” definition includes logistics, sustainable transition and circular economy (Ernst et al., 2016; Gravagnuolo et al., 2019). Hence all definitions lead to designation of “port city” as being smart.

Currently, the smart city concept is popular, with many leading city regions presenting strategies. It has a “governance dimension” as it provides direct cooperation between authorities and residents and empowers all residents (for example, allows them to invest in sustainable energy production). There is one another concept that is deeply related to the first one – “smart port”. According to the concept, ports can not only manage cargo traffic, but also have the ability control the import and export of goods from the port territory in automatic mode. Such systems implementation also reduces the overall cost of shipping, which will only increase the demand for port services from traders.

Over the last decades all technological developments have changed the industrial environment and caused the evolution of operations in ports. These phases are defined as Port 1.0 to port 4.0.

- Port 1.0 era: the port workers tied separate stages of the process in main operations, gate to yard (stack), yard to embankment tap and vice versa.
- Port 2.0 era: characterized as "process control" and showed introduction of the central terminal. Terminal process stage management system while operators make decisions in central control room and set up Terminal Operating system.
- Port 3.0 era: can be described as "Management by exception" rule and container terminal processes are managed steering algorithms Automatic stacker cranes (ASC) and automated vehicles (AGV), while people decide exceptions.
- Port 4.0 era: the time when movement to "managing to orchestration" occurs. That means that ports will increase their role by managing physical and information flows in internal or external terminals to increase efficiency of the port ecosystem as a whole transport chain. Each player - terminal operator, transport companies, shippers, logistics companies, authorities, communities and government - will be connected to refine not just the port structure, but also the entire system (Wollschaeger et al., 2017).

Any research in this area should pay particular attention to the use of the latest digital technologies, divided into the following eight areas that other industries today considered to be signs of advanced digitalization (table 1, adapted from (Sanchez-Gonzalez et al., 2019)):

Table 1. Main technologies used in Smart Ports in era of digitalization.

Technology	Description
Autonomous vehicles and Robotics	Aid for maritime transport services, shipyards and ports territory.
Artificial Intelligence	Technology implementation in combination with big data helps to use all information better.
Big data	Efficient usage of all inbound information from sensors (ship, road, rail etc.).
Virtual, augmented and mixed reality	Considered to be a a part of any vessel equipment; especially important in the industry while the need improve the scene with dynamic aspects is acutely important.
Internet of things	Nowadays all ships can be called megalopolises, totally equipped with sensors; embedded technologies to interaction with each other or with the external environment.
Cloud and edge computing	Make the implementation of the previous domains cost-effective; improved performance and monitoring in order to solve scheduling problems.
Digital security	Created as digitalization demands stronger security tools and processes.
Additive manufacturing (3D printing included)	They improve service processes; helps in transformation design and manufacturing principles, achieve optimal performance and reduce costs.

The authors argued that ports offer the greatest opportunity in robotics, artificial intelligence and big data areas due to their interaction with inland transport sectors that are already actively using digitalization (Sanchez-Gonzalez et al., 2019). The usage of such technologies allows to increase competitiveness and ability to reduce the human factor in many processes. The level of integration varies from field to field.

3. Results

The port logistics sector represents a complex system of different actors, actions, and relationships that support the movement of goods between remote locations. This network can be compared with a chain, where the strength of the whole is determined by power of its weakest part. Networks consist of nodes (ports, terminals, warehouses) and communicators (road, rail, water) with different throughput. Moreover, each node is totally connected with a communicator and they depend on each other (Hall, 2018).

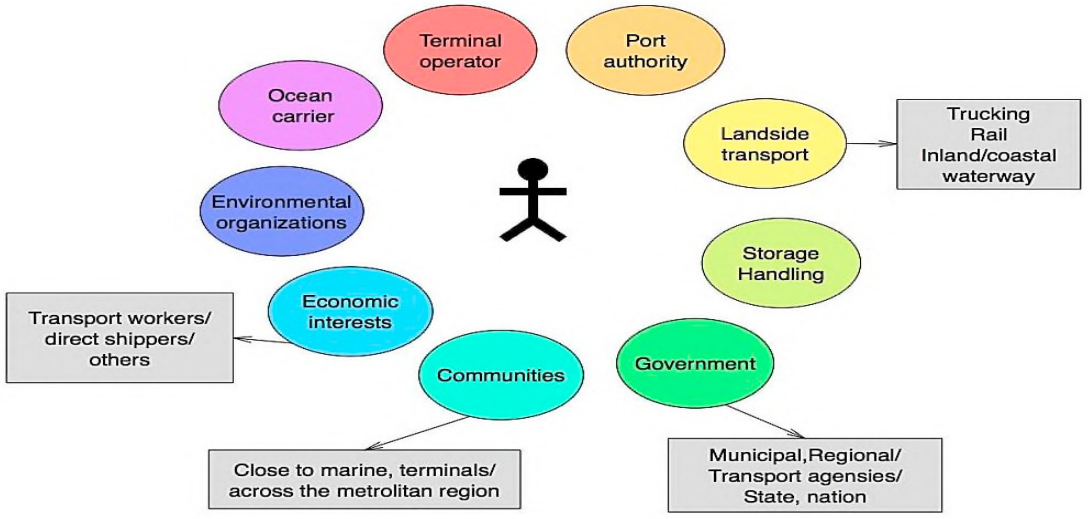

Fig. 1 Actors involved in "port-city" collaboration. Adapted from (Hall, 2018).

Actors involved in the supply chain are always trying to find possibilities of independency and strive to remain flexible because the requirements for the movement of goods depend on the season. Likewise, every actor is looking for a stable and long-term partneship, based on mutual understanding and trust. Examples are described in Johnson and Styhre (Johnson and Styhre, 2015). When long-term partnerships and confidence-building are preferred, the shipping company does not just terminate the contract and use another company; the shipping line will discuss this issue and even offer the stevedore assistance in improving their performance.

This random iterreaction will lead to many alinements inside the network built by many supply chains in which all participants connect to one or more than one participants inside and outside. While one actor can be involved in numerous cooperations they can help other participants widen their network on the assumption of referral (Bening et al., 2020).

Many of the smart ports are located in port cities, which in turn there is a smart city project that did not include the port, paying special attention to urban transport, but both projects must converge and collaborate where necessary. Commonly ports structure is the same as others. Figure represents a main object on the example of Hamburg Port which located in the heart of the city (Hamburg Port Authority (HPA): smartPORT – The intelligent port, 2020).

A combination of transport modes can provide opportunities for addressing supply chain inefficiencies. This is because different transportation options appear to be connected to international highways or railway facilities, air or ocean terminals, and to provide different modes of transportation to make the business better for delivering goods. This allows to select the alternative variant. From this point of view, the logistics management component of supply chain integration is a critical factor for assessment (Silva, 2007). World trade has strengthened the demand for effective services, and the reliability of transport depends on the smooth distribution and maximization of transport modes. The efficiency of the movement of goods is then ensured through the supply chain network (Rana, 2019).

The following cases shall illustrate the port city interaction and the influence of industry 4.0.

3.1. Case of Shanghai

The port of Shanghai is located in the middle of the east coast of the Peoples Republic of China. The highway and railway network are crisscrossed, the collection and distribution are smooth, the geographical position and the natural conditions are superior, and the hinterland is economically developed (Sanchez-Gonzalez et al., 2019). It has some main competitive aspects:

- Excellent geographical location. The port is located at the T-shaped intersection of the coastline of China and the Yangtze River Golden Waterway. With the river as the main economic hinterland route, the geographic location is unique and the collection and distribution network extends in all directions.
- Good environment development. Increase the innovation of the port supervision system, focus on improving the level of international trade facilitation, and expand new space for the port's development. Following the Chinese "One Belt One Road" initiative, the "Yangtze River Economic Belt" and the Yangtze River Delta with vigorous implementation of strategies such as regional higher-quality integrated development, advantageous industries in the economic hinterland will continue to develop steadily, and port and shipping logistics resources will also increase.
- Efficient operation and control management. The port continues to deepen the "Yangtze River.

Strategy, Northeast Asia Strategy and International strategy", committed to building an efficient and convenient logistics system that serves the economic development of the Yangtze River Basin, and strengthen the port in the international transit segment, gradually participate in cross-regional port operations. The Shanghai port actively benchmarks global terminal operators and continuously improves service its efficiency. The quality and operating performance, continue to strengthen the technological innovation and corporate culture, actively and gradually corporate social responsibility, and always maintain industry leadership. The Shanghai deep-water port is located not in the city area. It is a mega-structure on several islands, connected to the mainland by a 30-kilometer bridge (Shiphub – The port of Shanghai, 2020).

The "China's Major Cities Traffic Analysis Report in 2019" jointly released by a number of institutions announced the congestion rankings of 50 cities across the country in the second quarter of 2019. Shanghai ranked 15th, falling out of the list of "Top Ten Congested Cities". In the same period last year, Shanghai ranked eighth in this list, and in the same period of 2014, Shanghai's congestion status ranked first (China's Major Cities Traffic Analysis Report, 2019).

In order to reduce traffic in such a metropolis, all actors involved in supply chain have to cooperate and act together. In May 2017, Accenture won a Shanghai Port management information tender and implemented the Oracle software in Huawei's FusionCloud. This corporate private cloud will help Shanghai Port to become a smarter port (Huang, 2018). This system supports hyper-converged computing, storage, networking, virtualization, physical machines, management, and the cloud. By delivering high performance through linear capacity expansion, the FusionCube helps to realize the data centers in blocks for a superior performance, increased reliability, ease of management, and a tight integration.

While the majority of processes in port are automated, the problem with delivery and traffic control stays acute. The majority of ports have two main transportation points: road and rail.

In order to control the road traffic the Chinese government implemented a "digital police" that works 24 hours a day. In recent years, Shanghai Public Security has continued to improve its "digital police" in accordance to the digitalization and informational transformation. This system can not only collect evidence for illegal behaviors such as speeding, red light running, and illegal parking, but also locate and capture motor vehicle sirens, not wearing seat belts, changing lanes and congestion, and making turns. At the same time, the original "electronic police" has been continuously upgraded, and a set of equipment can simultaneously capture multiple common traffic violations. Up to now, the city has nearly 300 such composite electronic police stations (China Police network: Digital Police, 2020).

Before the first China International Import Expo last year, a brand-new "intelligent signal light system" was unveiled for trial in Shanghai. This set of signal lights is not a simple signal to stop or pass, but to perceive and collect traffic data through multiple channels, and give the best plan for signal control and traffic organization. According to Wang Liang, deputy head of the traffic police corps of the Shanghai Public Security Bureau, the data collected by this intelligent traffic system can provide a basis for a traffic police on-site management: "For example, if you know which road and which direction the traffic load is too large, the traffic police can guide vehicles to divert, dynamically allocate rights of way, and improve traffic efficiency" (Wu, 2019).

Regarding the railway, high-speed rail lines were added. In 2019 transport has been expanded by increasing the capacity of existing lines. Now that through institutional reforms and technological upgrades, customers can not only deliver goods without leaving their homes, but also wait at home to pick up tickets; the integrated automation

system for railway marshalling stations (CIPS) can be used accurately. Grasp the time of train departure to avoid peak conflicts between passenger and freight; and the electrification of bill information greatly reduces the labor intensity of freight crews, and enables full freight data sharing inside and outside the station. Thus, can reduce the pressure on roads in rail favor (Wu, 2019).

Xue Meigen, deputy dean of the Shanghai Urban-Rural Construction and Transportation Development Research Institute, pointed out that in 2018, the penetration and integration of new transportation modes based on the concept of sharing into traditional transportation formats will continue (Shanghai observer: Industry Observation – Shanghai traffic congection, 2018). Moreover, the high-speed railways to other countries are a good link for transit operations.

3.2. Rotterdam Case

Rotterdam demonstrates transformation in port cities through extreme divisions that have taken place. It annually receives about 30,000 sea vessels and 120,000 inland navigation vessels. The port covers an area of 105 km². According to statistics, about 40% of goods imported into Europe (not only by sea, but also by rail, road or river) are unloaded in Rotterdam (Eurostat, 2020).

The total length of the port of Rotterdam is 42 kilometers. The port infrastructure consists of the elements digital, road traffic and nautical. In the most recent port infrastructure of the port of Rotterdam you can read which facilities can be found within these 42 kilometers. The measurement of port quality and pros are measured by four points (Rotterdam port infrastructure).

- The Port of Rotterdam is constantly improving existing operations and innovating activities. This creates an exceptional foundation for the international competitiveness of the Netherlands, providing the access to global markets for companies and consumers.
- A great number of large multinational companies in the Port of Rotterdam are the basis for innovation in infrastructure and knowledge development in the Netherlands.
- Leading Firms encourage clusters of related and supporting industries in the Port of Rotterdam to offer innovative solutions, which in turn benefits other companies in the Netherlands.
- The Port of Rotterdam stimulates business development, innovation, productivity, strategic collaboration, and competitiveness among other ports.

The main idea is to provide a better service to the customer through technological implementations and digital transformation of main processes. The port of Rotterdam is 37% of Rotterdam area. That can cause a variety of problems on the roads like congestion.

The port of Rotterdam has an extensive network of intermodal transport links: rail, inland water ways and road. A lot of European destinations in the interior can be reached within 24 hours (TomTom Traffic Index, 2020).

Rail transport. The port of Rotterdam is the start and end point of more than 400 international rail connections. In addition to containers, block trains run daily with dry and liquid bulk and trains for general cargo. Transit times are short: cargo is past the German border within 3 hours and at many European destinations within 24 hours. The OnTrack app provides parties with insight into the real-time progress of goods transported via the rail network. All parties involved share their data about incoming and outgoing trains at one central point.

Large inland vessels deliver the cargo from Rotterdam directly to the main economic centers of the Netherlands, Germany, Belgium, France and Switzerland via the Meuse and the Rhine. Inland water transport is very suited for transporting large quantities. For example, 6-barge pushers can only run between Rotterdam and planning of intermodal logistics. Truck transport is also very flexible and is often kept close to hand in case something goes wrong during transport by rail or ground.

The TomTom Traffic Index, published annually, shows that Rotterdam scores relatively low in terms of congestion compared to the other major seaports in Northwestern Europe. On average, a journey during rush hour in the Rotterdam region takes 25% (fig. 3) longer due to traffic. That is considerably less than in Hamburg (34%). A striking conclusion from the worldwide research by TomTom is that the congestion around Rotterdam mainly results from non-motorways: 33% (Rotterdam road transport, 2020). Portbase system can also be applied to road

transport. Via the Road Planning service, terminals and empty depots can easily be informed by the transporter of trucks that are on the way.

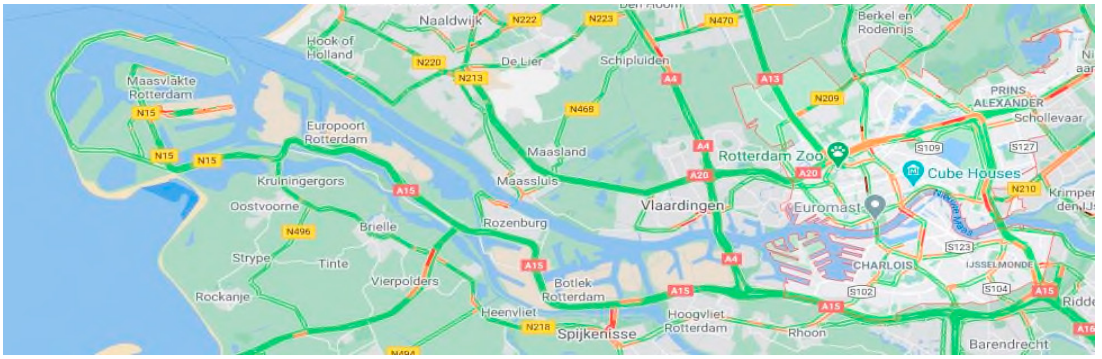

Fig. 2. Rotterdam traffic situation at a rush hour (17:00).

In order to control all traffic operations, the PortXchange application was launched. It is an app for shipping companies, agents, terminals and other service providers, with which they can optimally plan, execute and control all actions during port calls based on a standardized data exchange. It was extensively tested during the development last year and is now available to the port community for a fee. PortXchange offers shipping companies, agents, terminals and other service providers a common platform for the exchange of port call information. They can use the dashboard or use the data directly on their systems via API links (PortXchange: Port Call Optimization. Rotterdam port, 2020).

3.3. Hamburg Case

Hamburg is located by the Elbe River and has been an port-city from the beginning. It is the largest seaport in Germany and is of global importance. The port of Hamburg has about 10,000 ship calls per year, along 43 km of quay walls for sea vessels, more than 1,200 freight trains per week, four modern container terminals and about 50 facilities specializing in the handling of project cargo and bulk cargo, as well as about 7,300 logistic companies within the city (Hamburg Port Authority (HPA): smartPORT – The intelligent port, 2020).

In order to stay competitive the port of concentrated on the following main goals (Hamburg Port Authority (HPA): Philosophy and goals, 2020):

- To contribute to the creation of industries and the creation of added value port area logistics – for consistent, long-term value creation in the port of Hamburg.
- To be a gateway for other ports. This applies not only to increased trade with growth regions. Port authorities are also closely linked by a regional network. Long-term and trusting cooperation with European ports of the North Sea and inland ports of the Lower Elbe makes the port strong for the future.
- High demands and expectations. This includes specially designed and reliable infrastructure on water and land, as well as future-oriented road traffic development. The networking of IT systems makes the exchange of information even faster and more efficient. Intermodal solutions accelerate freight turnover.
- High standards. Transparency is one of the most important principles of the corporate activity. Operating in accordance with the Hamburg Corporate Governance Code (HCGK) and, among other things, have established an internal anti-corruption committee that helps to identify and prevent bribery and the provision of benefits at an early stage.

The port is located in the relatively close to the center of Hamburg and occupies 10% of the city. That can cause a variety of traffic problems, especially in rush hours (fig.3). The majority of traffic jams occupy on the bridges in

peak hours which operation and maintenance are under control of the Hamburg Port Authority (HPA) (Hamburg Port Authority (HPA): road and rail, 2020).

Rail. The infrastructure of the port railway consists of eight station sections and four groups of tracks. The tracks are divided into four categories, according to which the fees to be paid are based. In addition, the Hamburg port railway has locomotive parking spaces, loading tracks, brake test systems as well as fuel pick-up facilities and a wagon workshop. Some of the tracks are electrified. Loading tracks can also be used to service a freight car upon request, provided that loading is not planned the same time.

Road. The port area of Hamburg stretches along the Elbe. It is impossible to walk here without bridges: only 133 bridges connect the Elbe Islands. The Hamburg Port Authority is responsible for the operation, maintenance, reconstruction or construction of all of these bridges. Free passage is a long-term goal: bridges are an important part of the port infrastructure. Removable bridges will be opened upon request during work declared by the competent authority, if traffic and operating conditions permit. Outside business hours, the opening occurs only if the vehicle is registered at least half an hour before closing.

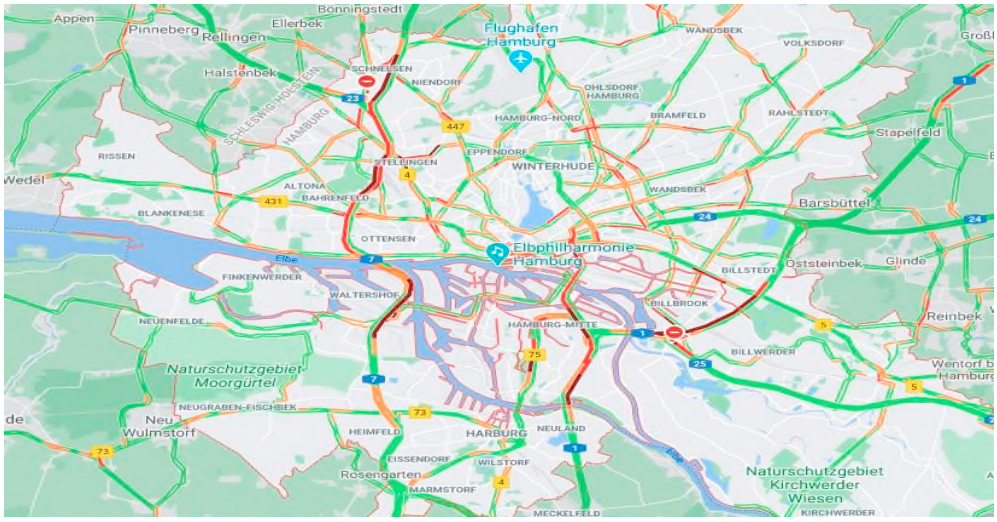

Fig. 3. Hamburg traffic situation at a rush hour (17:00).

A high degree of networking facilitates electronic data exchange. The port of Hamburg has developed into a paperless port with DAKOSY solutions (Hamburg Port Authority (HPA): road and rail, 2020). The central system of the ports community includes the Export Message Platform (EMP) and the Import Message Platform (IMP). Both, in turn, integrate other solutions specifically tailored to the requirements of individual areas or industries, such as export customs clearance (ZAPP-AES), monitoring of dangerous goods in the port (GEGIS waterway police system) and Port River Elbe Information System (PRISE).

All these ports are connected with each other through a global network called chainPort. It's a cross-national partnership between leading ports and helps to improve current supply chains. The main aim is to bring port authorities and stakeholders together to share benchmarks and jointly develop strategies on how ports can and should work together in the future to achieve common goals such as globally needed performance. This idea gives a chance to share not only important information as quick as possible, but to give a constructive feedback and new solutions in order to provide a faster and better service (Hamburg Port Authority (HPA): smartPORT – chainPORT, 2020).

4. Discussion

Reducing congestion in ports is a very diverse research field. In future it is important to strengthen the interfaces between these approaches and to use the results from existing research. The biggest problem now is that not all ports

have PCS, that causes great difficulties in communication and cargo coordination with other ports worldwide. More and more industries see the commercialization of 5G as a driving force for development, especially the port industry, which is taking serious steps to create 5G-enabled smart ports. Technology implementation not only improves the efficiency of operations, but also reduces the burden on employees.

Moreover, ports need to reach an agreement in scheduling, managing and organizing processes on the whole supply chain. Workflows also should to be updated in order to improve port connectivity, efficiency and to save money by growing in scale and delivering better user experiences.

5. Conclusion

One thing that is characteristic for successful logistics is efficiency. It is important to quickly and smoothly deliver goods from point A to point B. Fast clearance is required, as well as an invisible registration process and smooth processing processes, for example with customs. In fact, thanks to modern digital platforms, there is an electronic "parallel world" that supports the actual transport of goods, making it faster and more transparent.

In this article three ports were observed. Despite the fact that they are so different they have one thing in common: traffic congestions and logistic operations improvement. The best way to achieve harmony is to stay in close collaboration between each port-city with the use of digitalization. Effectiveness may be reach by usage of artificial intelligence (Shanghai case) or by automation main processes and business as a whole (Hamburg and Rotterdam).

The best collaboration may be achieved by creation an interconnected integrated system of good transport infrastructure for all types of transport and cargo owners and also a unified information environment of technological interaction of various modes of transport and participants transport process for a modern distribution network, ensuring the volume and quality of transport services in the country.

Additionally, special attention should be paid to integrated development of large transport hubs and the creation of a transport and logistics infrastructure, as well as the formation of a single information environment of technological interaction of various modes of transport and participants current process. Innovative technologies for construction, reconstruction, infrastructure maintenance and full integration of seaports into common transport space should be taken into account during the development of ports.

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