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Study - Port Cities of the Future

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1. Introduction

Nowadays, the maritime transport plays a key role in the distribution of today's products. Nearly 90% of the world's wares are moved by sea[1] [2] [3]. Ports play a central role connecting different actors inside the maritime transport's supply chain. They are the link between land and seas, rivers or lakes.

Ports can significantly contribute to a city's growth and prosperity. They not only bring benefits in terms of direct and indirect job creation due to the establishment of companies to work along the ports, but they also contribute to the economic and social growth of a city[4] [5]. For example, according to a study conducted by Planco in 2010 in, the Port of Hamburg contributed with almost more than 70.000 direct and indirect jobs to the City of Hamburg, which represented around 8,7% of the whole employment of the city[6]. Moreover, the port and port-related activities in that same year provided an output value of 8.3 billion EUR in 2010, from which 7.6 billion EUR remained in the City of Hamburg[7]. A similar case can be found in Finland, where approximately 75% of imports and 89% of exports in 2008 were delivery by ships. Just the Port of Helsinki, which in 2010 processed circa 10.9 million tonnes of goods (11% of total throughput in all Finnish ports) represents 5,3% of the city of Helsinki´s GDP and 1% of Finland´s national GDP[8].

Nonetheless, not all the ports have the economy growth or impact that they expect. Although the ports of Le Havre, Rouen and Caen, also known as Seine Axis seaports, provide a high amount of employment, 136.000 jobs in 2010, they have experienced in the last years a loss of the market share against other northwest Europe ports, going from 9.9% in 2001 to 8.6% in 2010. The lack of hinterland connections, efficiency, reliability, among other reasons, have influenced their reputation, which leaves the opportunity to many improvement options[9]. According to [10], the principal factors for port competitiveness are maritime connectivity, efficiency of port operations and hinterland connectivity. Whereas the enhancement of the maritime connection and efficiency of port operations don't require a long investment of time, infrastructure of hinterland connectivity can only be ameliorated in the long-term.

Furthermore, some other challenges may appear derived from port's activities which conflict with the cities' performance. Congestion, air and water pollution, waste, noise, parking spots, available

[1] Castonguay
[2] Alamoush (2016)
[3] Siemens (2017)
[4] Merck and Dang (2013)
[5] Siemens (2017)
[6] O. Merk and Hesse (2012)
[7] O. Merk and Hesse (2012)
[8] O. Merk et al. (2012)
[9] Olaf Merk et al. (2011)
[10] Biermann and Wedemeier (2016)

areal space, etc. are some examples of issues that arise from a port-city interaction[11] [12] [13]. For instance, the city of Rotterdam has been facing a serious problem of local air pollution originated from the port-related transport, emissions from factories in the port area, and because of a scarcity of green space[14].

As a countermeasure, a new perception of both ports and cities have been developed with the support and usage of new technologies such as Internet of Things (IoT), artificial intelligence (AI) and big data. Their roles reside in the compilation, storage, processing and understanding of large volume of information captured along the whole ware's supply chain, namely, port and cities[15]. As a result, the concepts of smart-port and smart-city have been conceived, aiming not only to increase the performance of both as individual actors but also to outmost their port-city relation.

On the one hand, the term smart-port can be understood as the implementation of embedded sensors, RFID sensors and cameras on different points along the port area, in order to capture information of the different players inside a port; for instance, ships, vessels, cranes, trucks, containers, etc. Moreover, it embraces the usage of internet, digital platforms, cloud-based services, apps for smartphones or tablets, blockchain technology and big data in order to storage, process and communicate captured data[16]. The smart-port's goal is to maximize the usage of current infrastructure and space and therefore the port's efficiency with help of technology. On the other hand, a smart-port focuses on the self-generation of most of its resources, such as energy, and in the preservation of its environment, e.g. water maintenance and its relation to cities.

On the other hand, the concept of smart-city involves also the employment of technologies but with a different emphasis. It focuses on the improvement of the life quality, security, prosperity and economy development of its habitants and all stakeholders established within it, through intelligent and innovative infrastructure, efficient mobility, conservation and optimization of its resources and having less negative impact to the environment[17] [18] [19].

[11] Chen et al. (2019)
[12] Merck and Dang (2013)
[13] Molavi et al. (2019)
[14] O. Merk and Notteboom (2013)
[15] Buck et al.
[16] Riedl et al. (2018)
[17] hamburg.de (2014)
[18] Beltrán (2015)
[19] Molavi et al. (2019)

2. Port-City relation

A port-city relation starts with the port's hinterland area where incoming goods are afterwards inland distributed and where exports to be shipped are also gathered[20]. Many authors agree that the improvement of hinterland's connections and its performance are critical matter to stand out from other ports, in order to generate more economic benefits to both ports and cities, as well as to reduce the negative environmental impact generated from transportation[21] [22] [23] [24] [25].

The hinterland distribution of goods can be segmented in three types of transport: road, railway and inland waterway. From those three modes, road distribution is the most used way of transport. In average, more than half of all cargo received and distributed in/from European ports is carried through this mean[26]. On the one hand, the fact that not all the cities have access to inland waterways propel the use of both road and railway transport. On the other hand, the road infrastructure is the most developed in terms of road-kms in comparison to railways-kms and kms of water inland used for shipping[27]. Furthermore, railway and inland waterway require a consolidation of cargo in order to offer some logistics and economic advantage for unloading, while cargo on trucks can be directly loaded and shipped[28]. Nonetheless, there are some punctual examples, like the port of Hamburg, where both railway and inland waterway combined represent a bigger slice than 50% of the transport usage[29] [30]. Moreover, truck transportation is the kind of mode with more interaction with cities. Considering that in most of the cases trucks have to transit through urban areas to reach the ports, the road infrastructure employed to haul the goods is the same as the one used by the residents for their daily activities. As a result, most of the smart technologies have been developed to the road transportation segment with focus on the improvement of the port-city relation.

Nevertheless, a good port-city relation not only requires support and benefits on the technological and economical area but also on the social level. As a result, ports have focused their efforts also on supporting social and environmental projects.

[20] Woodburn (2010)
[21] Logistics Pilot (2018)
[22] O. Merk and Notteboom (2015)
[23] Woodburn (2010)
[24] OECD and International Transport Forum (2008)
[25] Munim and Schramm (2018)
[26] O. Merk and Notteboom (2015)
[27] Alamoush (2016)
[28] OECD and International Transport Forum (2008)
[29] O. Merk and Notteboom (2015)
[30] Port of Hamburg

2.1 Social projects of ports

It is worthy to mention some examples of those type of projects that some European Ports have been supporting.

2.1.1 Port of Bremen

The port of Bremen has been supporting since 2018 the environmental campaign called “Artic Commitment” which focuses on the prohibition by the International Maritime Organization (IMO) of vessels whose fuel power is heavy fuel oil (HFO) in the Artic zone[31]. The campaign, which started in January 2017, was lunched at the Arctic Frontiers Conference and it is managed by a group of nonprofit organizations called Clean Arctic Alliance[32]. Heave Oil fuel has a negative impact to the environment because it produces around 30%-80% more black carbon emissions than low-sulphur distillate fuels; therefore, the warming impact is higher[33].

2.1.2 Port of Antwerp

- Galgeschoor plastic challenge

Annually, the Port of Antwerp arranges a decontamination campaign for the nature reserve Galgeschoor, which is adjacent to the port and the Scheldt river. It consists primarily in the recollection of small particles of plastic gathered in the marshes area of this reserve. In 2019, almost 8 tons of waste was recollected by more than 400 volunteers. Moreover, the campaign promotes the collection of ideas to accomplish the recollection of waste in an automated manner. The Port of Antwerp not only extends a monetary prize to the best idea but it also helps in its implementation[34].

- Support for social associations

Furthermore, diverse social associations, sports and cultural events are being sponsored by the Port of Antwerp. For example, the employment association “De Steenschuit” which gives the opportunity to long-term unemployed and disadvantage people to apprentice new skills receives financial sponsorship. The “White Raven Project” that provides help to disadvantaged school

[31] bremenports GmbH & Co. KG (2018)
[32] Logistics Pilot (2018)
[33] HFO-Free Artic
[34] Port of Antwerp

children and the “Cantabile” association which supports young talented pianist are example of other social responsibility programs from the Port of Antwerp[35].

2.1.3 Duisport

The Authority in charge of the Port of Duisburg, named Duisport, not only supports sports and cultural events but it also organises several social initiatives for people at different ages.[36]

- “Dialog with Youth” (Dialog mit der Jugend) is an annually event organized by the Initiativkreis Ruhr where the Chief Executive Officer of Duisport visits students at different senior classes in the Ruhr region and dialog with them, answering personally to their inquiries.
- While the “Get Ready” initiative encourages secondary school students to develop and utilize their talents, the “Joblinge” program supports young adults with a second education opportunity in the Ruhr region.
- “LogistiKids” is a social initiative focused on children where the world of logistics is explained throughout games and other fun methods. As a result, kids can get a better idea of how the logistics industry nowadays works.

2.1.4 Port of Rotterdam

- Startbaan

“Startbaan” is one of the social projects supported by the Port of Rotterdam. It provides young people without employment expertise the opportunity to develop their competences and to obtain a diploma, which afterwards should help them to find a good job[37].

- Zuid-Holland heat alliance

The Port of Rotterdam along with other institutions are working together to create the infrastructure for a new low-carbon heat supply. The companies in the Port of Rotterdam’s area generate an immense amount of industrial residual heat which currently goes to the environment in form of waste. According to the port, the amount of residual heat annually generated could cover the heat’s need of approximately 500 domestic places. However, not only should

[35] Port of Antwerp (2019)
[36] duisport
[37] Port of Rotterdam Authority (2018b)

households benefit from this new heat supply but also horticultural companies for heating greenhouses and other businesses established in the province of Zuid-Holland[38].

- Bird Valley redeveloped and enlarged

One example of ecological engagement from the Port of Rotterdam Authority is the redevelopment of the Maasvlakte's bird valley, a nature reserve area where approximately 20 to 25 bird species can be found. This conservation area was enlarged in 2015 to 21 hectares, creating new banks where birds can rest and brood[39].

- Bee paradise in the port area

As part of its sustainable program, the Port of Rotterdam has created a "Honey Highway" along the route A15 towards the port. Around 5.000 square meters of green area have been dedicated to the seed of flowers rich in pollen such as the Evening Primrose and Viper's Bugloss. Approximately, 10.000 of bees are expected to be collecting pollen and nectar. 50 types of bees can be found in those areas. This supports the reintroduction of the native Dutch honeybee into the region[40].

Despite the importance of social and environmental projects and initiatives not only for the welfare of the citizens but also to protect the environment and the natural resources, the aim of this research relies on pointing out the advances of smart-port and smart-city technologies in order to ameliorate the pain points originated from the combined interaction of both actors, ports and cities.

3. Actual Pain Points of Port-Cities' relation

The quotidian activities performed in ports have a negative impact not only on the environment, but they also deteriorate their respective port-city relation. Some challenges (issues) which not allow a properly development of both, as individuals and as a group, are next listed and explained in more detail:

3.1 Congestion is one of the major problems that clearly affects the ports and cities' performance[41] [42]. This issue influences negatively primarily the ETA (estimated time of

[38] Port of Rotterdam Authority (2017)
[39] Port of Rotterdam Authority (2016)
[40] Port of Rotterdam Authority (2018a)
[41] OECD and International Transport Forum (2008)
[42] Siemens (2017)

arrival / ATA (actual time of arrival) and ETD (estimated time of delivery) / ATD (actual time of delivery) of all road transports that want to either charge or discharge goods in the port, causing bottlenecks in the ports processes and at the gates to enter them[43]. As a result, ports' productivity and competitive position are being negatively impacted due to the lack of planning. Since hinterland road's connectivity are most of the time shared with cities' road infrastructure, congestion unquestionably impacts both ports and cities. On the side of the ports, hinterland's efficiency and competitivity advantage as well as port's growth are being affected. On the side of the cities, traffic jam not only causes bottlenecks creating inconformity in the society, but it also impacts the productivity of other businesses[44] [45].

Port's repercussions can be tangible in the Seine Axis ports where the port's growth have been decreasing since 2001[46]. The negative impact of congestion can be perceived, as well, in the Angeles/Long Beach ports where ports' growth and market shares have declined due to high congestion levels[47].

This problem might cause monetary penalties not only to the port itself but also to the other supply chain stakeholders. For example, in the port of Rotterdam, hinterland's congestion originated costs of around 425 Million Euros in 2010, 80% more than in 2000[48]. Generally, over the past 14 years, the world's container port traffic has more than tripled; therefore, the necessity to transport goods out of the port without creating congestion is a huge hurdle that is expected to get worst[49].

3.2 Environmental pollution is another delicate challenge that affects a port-city relation. It encompasses air and water pollution, noise and odors[50] [51].

Air pollution is originated from emissions either from factories adjacent to the port area, the port activities or due to the port-related transport, either maritime or road[52]. As a result, a high-density transport plays a negative role in this matter due to the elevated emission of CO2 gases[53].

Despite the maritime transport only contributes 2,2% of global carbon emissions, it accounts for 15% of the world's nitrogen oxides (NOx) emissions and 6% of global sulfur

[43] Siemens (2017)
[44] Siemens (2017)
[45] Biermann and Wedemeier (2016)
[46] Olaf Merk et al. (2011)
[47] OECD and International Transport Forum (2008)
[48] O. Merk and Notteboom (2013)
[49] Siemens (2017)
[50] Merck and Dang (2013)
[51] Molavi et al. (2019)
[52] O. Merk and Notteboom (2013)
[53] Merck and Dang (2013)

oxides (SOx) emissions[54]. These two types of gases are serious pollutants that create acidifying substances such as sulphuric and nitric acid which causes severe damages on forests and in the maritime ecosystem due to the acidification of soil and water[55]. According to Chen et al.[56], around 70% of the world's maritime emissions are produced in the ports' costal area which have a significant repercussion to the cities. For example, the city of Rotterdam suffers considerably from this externality. Combined, the Ports of Rotterdam and Amsterdam gather approximately 10% of the maritime emissions from all European ports[57], which clearly indicates the important role that ports play in this problem.

Water pollution is mainly originated from the maritime transport itself and from port-related activities. An example of this type of impact can be found at the adjacent green areas of the port of Antwerpen called Galgeschoor, where many tons of small particles of plastic can be found[58]. Moreover, fuel can be spilled or leaked to the ocean during fuel loading and unloading to/from the vessels to lorries[59].

Noise is another environmental externality that not only affects fauna, like birds and marine life, but also humans. It is mainly originated from diesel machinery employed in the ports when the vessels are docked. Nevertheless, high sounds can also be provoked during vessels' construction or repairment. Sounds registered in ports can reach 80-120 dB, which can be considered harmful for human beings[60] [61] [62].

Last but not least, freight transport is another major contributor of CO2 emissions. While trucks and buses represent approximately 5% of all road mean of transports, they comprise more than 25% of the total road CO2 emissions in Europe. Moreover, this amount will continue increasing as the demand for road freight keeps growing[63].

3.3 Parking spots for trucks is a sensitive constraint that affects the cities and their population. Multiple variables make truck drivers to park on spots that were originally meant to be for citizens' means of transport. On the one side, they are obligated by law to make a pause after 9 hours of driving. Since some trips take more than one day or even weeks, trucks have to be parked on the streets for long periods of time. It is necessary to point out that lorries are not allowed to be driven in some countries on

[54] Siemens (2017)
[55] OECD (2013)
[56] Chen et al. (2019)
[57] O. Merk and Notteboom (2013)
[58] Port of Antwerp
[59] Peris-Mora et al. (2005)
[60] Siemens (2017)
[61] Peris-Mora et al. (2005)
[62] Healthwise Staff (2018)
[63] Transport & Environment (2019)

Sundays. On the other side, congestion affects the arrival the to the ports either to load or unload goods. Consequently, truck drivers must plan some buffer of time on their journey in order to arrive on time to the ports (given a time date) which results in some cases in parking on the streets. Additionally, the available parking areas are either fully booked during high peak hours or avoided due to a limited financial margin which outcomes in the search for a spot on the roadways.

Given that the parking places in the cities were designed for 2-axis vehicles or motorcycles, trucks occupy not only more than one spot, but they also are wider than the designated breath space. Therefore, trucks must be parked in an insecure way either on the sidewalks or obstructing some space of the roads. Furthermore, as roadways weren't intended for trucks, they don't contain the required facilities that truck drivers necessitate for their physiological needs or for disposal of garbage[64].

A clear example can be found in the Niederrhein area of Germany where the port of Duisburg, world's biggest inland port, resides[65] [66]. In Duisburg it is possible to find streets where almost 40% of the vehicles are lorries where the drivers spend the night, which is the case of the street "am Blumenkampshof" located in an industrial area[67]. According to Strassen NRW [68], approximately 4.000 parking spots extra are going to be needed for 2025.

3.4 Available areal space where ports can physically expand their facilities is unfortunately limited. On the one hand, unoccupied space starts to scarce once a city starts to grow. They require more area for households, commercial or industrial buildings and broader road and public transport. On the other side, it becomes more complex and difficult to restructure and to increase the roadways, waterways and rail-tracks[69]. The world's port-city relation is being deeply affected by this issue, provided that ports are in need of more space area, which deeply conflicts with growing metropolitan zones[70]. Amsterdam and Hamburg are two metropolitan cities which faces this areal constraint and where there is little gap of expansion in case of an increase of cargo freight. Paradoxically, both cities and ports are interested in a port' throughput increase because

[64] Szymiczek et al. (2017)
[65] Barnard (2015)
[66] Szymiczek et al. (2017)
[67] Szymiczek et al. (2017)
[68] Straßen.NRW (2019)
[69] hamburg.de (2014)
[70] O. Merk and Notteboom (2013)

every additional million tonne of cargo throughput results in circa 300 additional jobs and more economical benefits to both[71] [72].

Moreover, the continue growing of vessel's size to locate more and more containers, in order to reduce maritime shipment costs, has a meaningful impact on the throughput capacity of the ports and on the hinterland connectivity[73]. Consequently, given the areal space constraint and the desire to grow without neglecting the other externalities previously mentioned, an increase of cargo throughput can only be reached through an increase in efficiency of the infrastructure by implementing smart technologies on both ports and cities[74].

4. Current Port-Cities smart technologies

Smart-port and smart-cities technologies encompass different approaches to improve a port-city relation and their individual needs. Maximization of current infrastructure and space is vital and only achieved through the implementation of smart technologies. Furthermore, they put emphasis on the self-generation of resources and the reduction of pollutants for an environmental enhancement.

The current smart technologies either available or under development for the improvement of the port-city relation can be segmented under the challenges to be solved.

[71] Klaffke et al. (2017)
[72] O. Merk and Notteboom (2013)
[73] Siemens (2017)
[74] Klaffke et al. (2017)

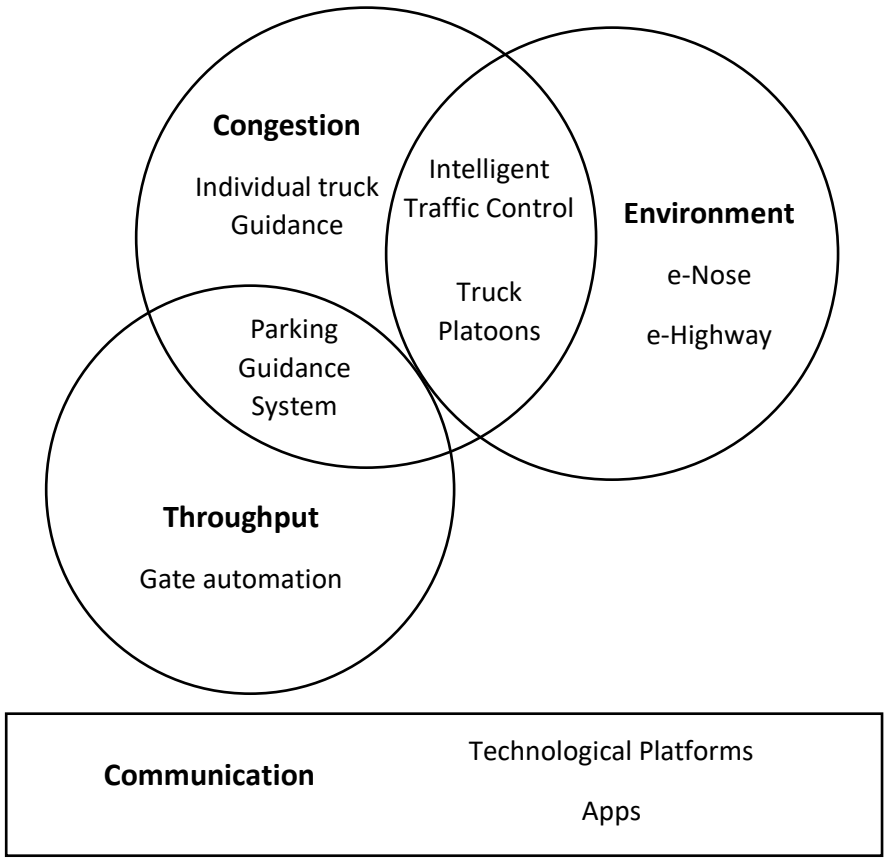

Figure 1: Segmentation of smart-ports and smart-cities technologies (Source: own presentation)

Next sections will fully describe these smart port-cities technologies.

4.1 Intelligent Traffic Control

Provided congestion is one of the main factors which deteriorates the port-city relation and their individual operative capacity due to the ever-growing number of means of transports[75], the need of an intelligent traffic control has been raised. In general, the aim's technology is to ameliorate the truck congestion, to help truck companies and ports operations with a better transport planning and to provide truck drivers accurate information regarding the traffic status[76] [77].

Several solutions have been presented. For instance, the Port of Hamburg has opted for a traffic management system called "EVE" that monitors the traffic flow in the port area. It encompasses the use of bluetooth, video cameras and inductive loops in the roads to supervise the flow of

[75] Khanna et al. (2019)
[76] Riedl et al. (2018)
[77] Siemens (2017)

vehicles[78]. Approximately 300 record points have already been installed in the port area[79]. Moreover, this system employs a software called “DRIVERS” which gathers the information obtained from the above-mentioned hardware and analyses it. This system is able to forecast the traffic status up to 60 minutes[80]. The outcome results in a real-time representation of the traffic situation that is later presented in led signs called “DIVA”, which displays a map of the port with the up-to-date traffic status. This enable truck drivers to avoid congested or blocked roads, rerouting on time and avoiding idle time on queues[81]. Further to this, the DIVA boards depict the remaining time an articulated bridge is still blocked[82]. According to Siemens [83], this system positively contributes with the reduction of CO2 emissions cutting it off by up to 20%.

Other smart advances in this rubric have been focused on creating a smart system for traffic lights. For instance, an intelligent traffic control system has been in operation since 2012 in Pittsburgh, USA. This system called “Surtrac”, developed by the Carnegie Mellon University, employs AI technology to distinguish patterns on the traffic flow. Through video recording this technology recognises the number of road users and pedestrians and the type of transport at every intersection. Afterwards, the employed software analyses the information and comes up with the best solution to manage the flow of transit, controlling the traffic lights to keep the traffic moving. Furthermore, the traffic lights already installed in 50 intersections are capable to communicate with each other, so that they can know in advance how much flow of vehicles, trucks and bicycles should be expected[84]. Results of its applications are promising. Idle time at those intersections have decreased 40%, diminishing travel times through the city by 25%. Moreover, there has been a positive impact in reduction of 20% of CO2 emissions[85]. Additional 150 intersection will be equipped with this Surtrac AI technology by late 2020[86].

Similarly, a pilot project of an AI traffic control system by Siemens has been launched in Hagen, Germany. The first phase, already concluded, consisted in equipping one intersection with AI technology. The system was able to learn how to balance the traffic flow and to select the corresponding best traffic lights’ solution. Waiting time at that cross was decreased by 47%.

[78] Hamburg Port Authority
[79] Beermann and Höltkemeier (2014)
[80] GEVAS software GmbH
[81] Port of Hamburg (2016)
[82] Hamburg Port Authority (2011)
[83] Siemens (2017)
[84] Baker (2018)
[85] Technologies Rapid Flow
[86] Opdyke (2019)

Future steps are to provide this technology to 4 more intersections, analysing how they interact between them; afterwards, a whole network is expected to be created[87] [88].

In Milton Keynes, UK, more than 411 traffic lights in 104 crossing points with AI cameras that control the change of traffic lights according to the current traffic situation in principal avenues of the city. Emergency vehicles such as ambulances, cyclists and buses are prioritized in the crossings. Moreover, the system is able to forecast the traffic up to 15 min ahead with an accuracy of 89%[89]. According to [90], up to 2.500 AI cameras will be installed to cover the whole area around the city.

Notwithstanding that intelligent traffic lights have just been implemented within cities, they could be rolled-on and applied as well to ports' areas and to other hinterland locations.

4.2 Individual Truck Guidance

Real-time location of the truck represents a big advantage for the coordination and planning of road transport with port's operations, hinterland connections, vessels departures, gate appointments and parking places[91].

Not only does this smart technology guide truck drivers throughout non or less congested roads by mean of a communication device such a smartphone or tablet, depicting in real-time the best route for that freight transport, but it also creates a communication channel with the port. It takes into account the current traffic situation, contemplating such as disruptions, construction sites, incidents, bridge status, gates situation, parking lots status, etc.[92] [93]. Another characteristic of this technology is the capacity of provide guidance through LED signs at the roads, indicating the required time to reach the port throughout different predefined routes. In case trucks are expected to arrive too early, either operations at ports can be ahead arranged or they can be directed to parking areas near ports[94]. Consequently, operations' planning is enhanced. On the other hand, in case the estimated time of arrival (ETA) of the heavy vehicle passes the allowed time window to come in, the system indicates automatically the port of such criticality and a new slot is assigned[95]. If necessary, trucks would be rerouted to parking lots in case of a long waiting time,

[87] Stone (2018)
[88] Baker (2018)
[89] Baker (2018)
[90] ("'Thinking' Traffic Lights to Be Launched in Milton Keynes," 2017)
[91] Siemens (2017)
[92] duisport (2015)
[93] Carlan et al. (2019)
[94] Mayhew (2017)
[95] Gill (2015)

avoiding unnecessary CO2 emissions. In order to achieve this, a tracking and tracing system through GPS (floating car data) and (automatic number-plate recognition) cameras, positioned at strategic points, are employed[96].

In Duisburg, Germany, this technology is already in used, where truck drivers are informed and guided, thanks to an app, about the suitable route to follow. Moreover, other stakeholders are kept informed of the trucks position for their processes' scheduling[97]. Several benefits can be counted from its utilization. For example, travel time of trucks in peak hours are reduced 38.500 hours per year; there are 1.600 trucks' delays less per year; in sum, there is a reduction of approximately 43.000 hours of waiting time at terminals[98].

This technology works properly together with an intelligent traffic control system, parking system, automatize ports' gate smart system and truck platoon's technology.

4.3 Parking Guidance System

Truck parking is another major concern not only for government and port authorities but also for the communities located in the surroundings of ports. A Parking Guidance System aims to decrease the nuisance of truck parking. It comprises a smart strategy to assign trucks an available parking spot according to their arrival and departure time, to the actual traffic flow on roads and the status at port's gate[99].

A reservation of a parking spot has to be done beforehand indicating the time window for cargo loading or unloading. According to this information, truck drivers get assigned to a parking space. This method permits a proper designation in accordance with other trucks of the same time window. Additionally, truck drivers get information of an optimal departure time from the parking area in order to arrive on time to the port's gate. For this, real-time information regarding the traffic status is provided to the Parking Guidance System. In case of unforeseen events either at ports' gate or traffic situation, the departure time the from parking area is recalculated. Such information is communicated through mobile devices such as smartphones or tablets. Moreover, the parking area has to be provided of digital visual aids that signalized the corresponding proper place for each truck. An internet network, induction loops and video surveillance are needed to

[96] Mayhew (2017)
[97] Siemens AG and Duisburger Hafen AG (2017)
[98] Mayhew (2017)
[99] Siemens (2017)

guarantee the available number of parking spots[100]. A bumper to bumper layout could maximize the parking space[101].

A reduction of waiting time and overloading in parking spots are to be expected thanks to its implementation. Parking space is more efficiently employed. Moreover, truck drivers would be able to send on-site the port authorities the required documents for the entrance to the ports, speeding up the time at ports' gates[102] [103]. As a result, this technology is easily applicable in companion with other smart approaches such as intelligent traffic control and gate automation.

An example of this smart technology can be found in the Port of Hamburg where the parking ground "Autohof Moorfleet" has been equipped with this system. It operates as a pre-gate parking area for the port. It intends to minimize the traffic on roads towards the port[104].

Nonetheless, a "light" version of this Parking Guidance System has been developed as well, in which truck drivers are just able to book a parking spot through an appointment. Moreover, truck drivers are able to visualize the number of available spots in real-time of the surrounding parking areas[105] [106] [107]. This system has been implemented in the parking grounds of "Dessauer Straße", "Autohof Altenwerder" and "Dradenauer Hauptdeich" in Hamburg[108].

4.4 Truck platoons

In the search of reducing the CO2 footprint originated from road transport and to decrease its economic costs, a new trucks way of travel, which consists in grouping trucks in one or more platoons, each of three to five trucks that would travel one behind each other, is in development. The peloton of trucks simulates the structure of a train[109]. The truck at the front is categorized as the leader of the convoy. The lorries at the rear follow and change their speed and direction according to the leader's movement[110].

Advantages of this approach can be divided threefold. Firstly, driving one truck behind each other with a small gap between them results in fuel savings and therefore CO2 emission given that the dirty wind emitted at the truck's front is reduced. Air drag is responsible for up to 25% of trucks'

[100] Beermann and Höltkemeier (2014)
[101] Meier (2014)
[102] Siemens (2017)
[103] hamburg.de (2014)
[104] Beermann and Höltkemeier (2014)
[105] Nagy and Sandor (2012)
[106] Beermann and Höltkemeier (2014)
[107] Robert Bosch GmbH (2018)
[108] Beermann and Höltkemeier (2014)
[109] Port of Rotterdam Authority (2018c)
[110] European Automobile Manufacturers Association (ACEA) (2017)

combustible consumption[111]. As a result, a diminution of 10% of fuel is foreseen[112] while a decrease of 8% of CO2 emissions for the first truck and 16% for the subsequently trucks is expected[113]. Secondly, congestion is being benefited as they can drive smoother through traffic jams because roadways are used more efficiently[114] [115]. Last but not least, safety will tend to increase as truck-driving and truck-braking are automatically performed by autonomous trucks. These transport means would have the ability to communicate using vehicle-to-vehicle (V2V) communication technology, radars sensors, and actuators[116]. Under this condition, trail trucks would react 5 times faster than humans to changes done by the leader truck[117]. Additionally, trucks can be arranged inside the platoons according the sequence containers have to be processed in the port.

Whereas this approach has been in use since 2016 in a one-company mode, a multi-company mode across different EU countries is under review towards an expected implementation in 2023. Further steps consider the implementation of self-driving technology either partially or full automated[118].

The Port of Rotterdam and the Port of Singapore are one of the pioneers in implementing this technology. While the Port of Rotterdam focuses on launching an app which will be in charge of connecting trucks and giving indications to drivers[119], Port of Singapore leans on driverless trucks for the trail trucks[120]. By 2020, the Port of Rotterdam expects to have at least 100 of truck platoons driving on the Highway A15 from the port. Maasvlakte Plaza, parking area next to the port and the Highway A15, should be used as the meeting place for many trucks[121]. Meanwhile, the Port of Singapore along with two automotive companies, Scania and Toyota Tsusho, would be finalizing trials of a driverless automated truck system to be implemented in the following trucks to transport containers from one port to another in Singapore. This should help to improve the usage of Singapore's roadways and to combat the lack of truck drivers in the region[122].

Furthermore, other technologies such as intelligent traffic control, GPS truck guidance, parking guidance and gate automation can also come into play.

[111] Daalderop et al. (2018)
[112] Port of Rotterdam Authority (2018c)
[113] ACEA (2017)
[114] ACEA (2017)
[115] Port of Rotterdam Authority (2018c)
[116] Daalderop et al. (2018)
[117] ACEA (2017)
[118] ACEA (2017)
[119] Port of Rotterdam Authority (2018c)
[120] Ministry of Transport (2017)
[121] Port of Rotterdam Authority (2018c)
[122] Ministry of Transport (2017)

4.5 Gate automation

Since delays might appear on both sides of the supply chain route, either from the maritime side or from the road transport side, entrance and departure to/from ports' gates might be more agile and benefit from an automatized gate[123].

This system assigns terminal appointments for truck's arrival, requested beforehand, reducing time that they must spent either at gates due to probable long queues or at adjacent roads near to the port. The technology has the ability to adjust those scheduled times according to real-time traffic flow and truck position in the road network. As a result, trucks utilization can be better planned, and air pollution is being deal with[124] [125].

Thanks to recognition of trucks by intelligent video detection of ISO numbers and container codes, RFID tags, biometry scanners, laser sensors or a license plate recognition system, an automated arrival and departure at the gates can be achieved. It helps improving operational times, keeping estimated times of arrival and departure (ETA and ETD) and avoiding monetary penalties[126] [127] [128]. A software analyses the images and information recorded, matching it with the data previously given when the appointment was applied for. Further to this, evidence of cargo condition can be filmed and documented in case of damaged containers[129]. Moreover, it is able to proof whether customs revisions have already been performed or are missing in case of departure of trucks[130].

This technology has been widely applied in different ports. For instance, the ports of Bremerhaven and Wilhelmshaven in Germany have implemented an automated gate system[131]. Similarly, the Port of Algeciras in Spain has installed an automated gate system, experiencing a reduction of truck idle times and an increasing of efficiency of 30% at gate operations[132].

4.6 e-Nose

[123] Siemens (2017)
[124] Siemens (2017)
[125] Port Equipment Manufacturers Association (PEMA) (2013)
[126] Riedl et al. (2018)
[127] Siemens (2017)
[128] PD Ports
[129] PEMA (2013)
[130] Eurogate (2016)
[131] Eurogate (2016)
[132] CERTUS Port Automation

As an environmental countermeasure against the hazardous gases and odour nuisances produced inside a port, a sensor able to identify the composition of gases in the air called “e-Nose” has been put into operation. It is capable to detect irritating gases that are not easily perceivable for human beings and helps to identify their source[133]. Through software analysis, the detected gases are compared to a pallet of patterns of known gases in order to recognize them[134]. Acting as an early warning system, this technology enables environmental protection agencies, governmental and port authorities and companies inside and next to the ports to work together to diminish as soon as possible those dangerous and malodorous gases. Through this mean, it is avoided that those air particles reach adjacent cities, workers at the port can have a healthier working environment, and nature is not being endangered[135] [136].

These e-Noses have been implemented in various ports such as the Port of Rotterdam, Port of Amsterdam and Port of Tallinn, Estonia. In case of the Port of Rotterdam, by 2016 were already 250 e-Noses active inside the port[137].This formed part of the approach implemented by port authority to diminish the 5.000 to 6.000 yearly odour grievances received from part of the residents of Rotterdam’s region by 2012. In this zone, adjoining to the port and inside of it, several chemical and petrochemical companies are located which account for most of the malodorous gases encountered in the area[138]. In a similar way, the Port of Tallinn has invested in 20 e-Noses to detect anomalies in the air and to downsize the imperil of odour nuisance in the Muuga Harbour, where several oil companies have been established[139]. Likewise, the Port of Amsterdam placed a network of 41 e-Noses to detect odour gases in the port and near to the North Sea Canal to track emissions from vessels[140].

4.7 e-Highway

Road transport is the main mean of transport employed in the European Union. Approximately, three quarters of the total inland cargo is moved by road, which equalize 1.750 billion tonne-kilometres of cargo[141]. This has an enormous impact in CO2 emissions. Just one diesel heavy duty vehicle generates 104 g/tkm of CO2 gases. Therefore, to achieve the CO2 reduction’s target set by the European Union, a new conception of motorways called “e-Highway” has been

[133] Port of Rotterdam Authority (2015)
[134] Mahmoudi (2009)
[135] Port of Rotterdam Authority (2015)
[136] Port of Tallinn (2016)
[137] Port of Rotterdam Authority (2015)
[138] Milana et al. (2012)
[139] Port of Tallinn (2016)
[140] Port of Amsterdam (2018)
[141] Daalderop et al. (2018)

conceived. It consists in electrifying one or multiple lines of roads where electric and hybrid trucks can obtain on-road the required energy source to charge their batteries or to complete their routes without producing contaminants[142] [143]. For this, two new smart technologies are being developed: catenary electric technology and inductive charging technology.

4.7.1 Catenary electric technology

This approach constitutes a catenary overhead infrastructure, similar to the one employed for trains, and an intelligent pantograph which identifies the overload infrastructure, connecting and disconnecting automatically itself to the power cables at high velocities of up to 90 km/h[144] [145]. This enable trucks to overtake and to change to battery mode easily. This technology is not only an electricity provider, but it can also capture energy generated from the braking of the trucks, either storing it or supplying other trucks due to its long contact lines' sections and its double contact system[146] [147] [148].

Pilot projects have been tested in the port of Los Angeles and Long Beach, California, USA and in Sweden. The first one encompasses a 1-mile catenary system in both directions of the Alameda Street in Carson, which connects both ports and the hinterland highway[149] [150]. Given that approximately daily 35.000 trucks come in and out from this port, it represents a major opportunity to reduce air pollution and noise[151]. The second one consists of a segment of 2 km electrified of the E16 freeway near the city of Gavle, which connects an industrial zone with the port of Gavle[152] [153].

Furthermore, three projects to electrify motorways in Germany are in development. The first one already finished and in operation consists of a 5 km track length in both directions of the Highway A5 between the city of Frankfurt and Darmstadt[154]. The energy will be generated from renewable resources. The economy and ecological aspect of this project in trial will be tested until 2022 by the Technical University of Darmstadt[155]. The second project located at the north part of Germany

[142] Siemens (2017)
[143] Zhao et al. (2018)
[144] Zhao et al. (2018)
[145] Chandra Mouli et al. (2019)
[146] Siemens (2017)
[147] Chandra Mouli et al. (2019)
[148] den Boer et al. (2013)
[149] Zhao et al. (2018)
[150] den Boer et al. (2013)
[151] Siemens (2017)
[152] Zhao et al. (2018)
[153] Stumpe (2018)
[154] ("Gedrosseltes Tempo Für Deutschlands Elektro-Highway," 2019)
[155] Johnson (2019)

in the state of Schleswig-Holstein constitutes a 5 km track length, already operable, in both directions of the highway A1 between the cities of Reinfeld and Lübeck[156] [157]. This highway connects the Port of Lübeck with the hinterland road[158]. Similarly, the technical, economic and ecological insights of this project will be tested until 2022 and will serve as an inflection point for the expansion and creation of more e-Highways[159]. The third project still under construction involves a 6 km track length in both directions situated in the state of Baden-Württemberg between Rastatt and Rottweil[160]. According to [161], further implementation of this type of e-Highways will help Germany to reach its climate-goals of reducing 80 to 95% its CO2 emissions compared to 1990.

4.7.2 Inductive charging technology

This technology opposites the previous one setting the electrification underneath roads or pavements. The system is comprised of a primary coil beneath the road surface, connected to the electric grid working as energy conductor, and a secondary coil attached under the trucks which acts as energy receiver. The primary coil induces a magnetic field which generates electricity in the second coil. The energy that is transferred to the receiving coil is then transformed to charge the battery of the trucks or to supply the motor with electricity. In general, a maximum of 20 cm of interspace between receiver and charging zone has to be considered for an efficient charging[162] [163]. Through this technology, energy can be transmitted in two different ways, either stationary or dynamic.

By the stationary inductive charging method, it is required that the vehicle is stopped or parked. Consequently, it is mostly implemented in parking areas, garages, bus stops or taxi stands where electric or hybrid vehicles can stay over charging zone for some period of time. However, in this case the primary coil can either be found below the surface or above it[164].

On the other hand, dynamic inductive charging solves the requirement of staying in one point for a long time in order to charge a battery and the need of frequently charge a vehicle, which is not economical suitable[165]. In this case, vehicles can be in motion while charging or providing direct

[156] ("Gedrosseltes Tempo Für Deutschlands Elektro-Highway," 2019)
[157] eHighway.SH
[158] Stumpe (2018)
[159] eHighway.SH
[160] ("Gedrosseltes Tempo Für Deutschlands Elektro-Highway," 2019)
[161] Gerbert et al. (2018)
[162] Zhao et al. (2018)
[163] den Boer et al. (2013)
[164] den Boer et al. (2013)
[165] Panchal et al. (2018)

energy to the motor[166]. Mean of transports may travel at constant or changing speed above dedicated lanes where the charging configuration would be installed. The primary coils are divided into segments, so only the segments where vehicles are driven are provided with energy. By communicating the mean of transports with the inverters that supply the electricity (at the roads), only the required segment is powered. Series of segments can be sequentially activated in accordance to the movement of vehicles. In this way power scraps are reduced [167]. Pilot projects of the inductive charging technology have been taken place. For instance, in 2012 in Korea, two electric buses provided with this type of charging method, running 10 times per day, were tested operating one bus route. Similarly, Bombardier, Canadian company, has tested this technology on electric buses and trams in Germany in 2012, using both approaches stationary and dynamic inductive charging[168] [169].

Provided less fuel energy is required for the competition of transport routes, a reduction of contaminating gases such as CO2 can be reached. Longer useful life of trucks and less investment in reparations is expected, while providing a high transport performance[170] . Moreover, these technologies empower the entrance and usage of full-electric trucks, reducing the size of their batteries, considering that they can be charged while driving[171] [172].

Notwithstanding the cost of the trucks with either catenary or inductive technology are similar to conventional diesel trucks, the cost of infrastructure of both approaches for roadways are their main hindrance. Nevertheless, operating and maintenance expenditures and cost per mile of trucks are lower with the implementation of these techniques[173].

4.8 Technological platforms

[166] den Boer et al. (2013)
[167] Zhao et al. (2018)
[168] Zhao et al. (2018)
[169] den Boer et al. (2013)
[170] Siemens (2017)
[171] Stumpe (2018)
[172] Zhao et al. (2018)
[173] Zhao et al. (2018)

Digital platforms are not only the base of communication and data transfer between different stakeholders in ports' supply chain, but they also provide the interface for algorithms and other analytic methods such as artificial intelligence (IA).

Platform's significance resides in their ability to integrate multiple companies of a supply chain through a unique communication platform. This represent a big challenge because some firms show reluctancy regarding the share of information. Nonetheless, collaboration through an integrated platform bring benefits in terms of better analyses and allocation of data and a better planning of operations and equipment[174]. Some examples of platforms are next presented.

"Pronto", platform utilised in the Pronto of Rotterdam, serves as a data base and as a communication point between vessels, terminals, shipping companies, port authorities, and other port service providers. Utilising analytic algorithms, an estimation of ETAs and ETDs of vessels can be provided through the platform, which serves to coordinate better all logistics chain players. Moreover, congestion in ports and hinterland can be diminished, since the exact status of the cargo is known. It has helped to decrease approximately by 20% the vessels' idle time[175] [176].

The Port of Hamburg employs the platform "SmartPort" created by InternationalTM which gathers, processes and analyse collected data regarding every process and status in the port area[177]. For instance, information such as traffic inside the harbour, closure of bridges, congestion at terminals, available parking space is gathered, analysed and presented through this platform[178]. In addition, it determines a priori traffic casualties, benefiting the economical, operative and ecological aspect of the port. Furthermore, it enables a better visualisation and utilization of data which is transferred in efficiency advantages[179] [180]. On the other hand, the implementation of a recognition systems of RFID tags allows the identification of vessels' position in the port offers a better tracking and tracing service of the goods[181]. In essence, the creation of a communicative ecosystem throughout this platform enables all stakeholders to make better decisions about how and when to charge, discharge and direct cargo through the harbour[182].

The digital platform "MindSphere" has been designed to create a communication network between different partners in the maritime supply chain, where information of concerned ports activity can be shared to different stakeholders, improving the shipping of goods. From this

[174] Lacey et al. (2020)
[175] Buck et al.
[176] Berns et al.
[177] Molavi et al. (2019)
[178] Lacey et al. (2020)
[179] Biermann and Wedemeier (2016)
[180] hamburg.de (2014)
[181] Molavi et al. (2019)
[182] Lacey et al. (2020)

platform, other channels such as apps can be developed, as well. It offers the possibility to englobe and analyse the current status of entity, no matter when. Advantages such as a foreseeable vessel maintenance and operational improvement of crane and container handling systems are economic benefits reached through its application[183].

5. Analysis of Interviews with 6 Port-Cities in Europe and Latin America

In order to achieve the next generation of port-cities community systems, a new port-city concept should be developed. This concept should serve as an indicator of new available logistics solutions permitting optimization of freight flows in ports and extending the digitalization of their process to increase operations efficiency, security, compliance, modal integration and environmental friendliness in order to improve the relationship ports-cities and their access to international markets. For purpose, a study was conducted with 6 ports worldwide: Port Buenos Aires in Argentina, Port of Gdynia in Poland, Port of Valencia in Spain, Port of Panama, Port of Guayaquil in Ecuador, and Port of Duisburg (Duisport) in Germany. From this study, it was possible to identify that this new port-city concept should consider the following functionalities.

On the one hand, a digital freight matching open market for the enhancement of vehicle, infrastructure and operation in port cities should be taken into consideration. This tool encompasses machine learning algorithms to foresee transport and operation events, the use of IoT technologies for real time monitoring and interaction with transport means and equipment, or the use of blockchain for the development and/or integration with collaborative distributed environments or platforms to share transport offer/demand and manage transport documents, events and payments. It provides efficiency and optimizes port-hinterland's transport capacities and operations. Moreover, an idle time's reduction is expected as a result of an enhanced planning and coordination of transport. For example, in the Port of Valencia, on average a 50% reduction of trucks throughput time in ports is being reckoned. Furthermore, an increase of transports utilization of around 20 to 40% is fostered (Port of Valencia, email interview, 2019).

On the other hand, the implementation of an intelligent port transport management system is within the scope of the developed concept model. This approach attempts to enrich the communication of a port's network within the domain of the logistics and IT processes in order to share best practices and technology and to boost collaboration within the stakeholders. Additionally, it deals with the search and use of several transport modalities towards ports and

[183] Siemens (2017)

hinterland locations, decreasing the carbon footprint derived from transportation. Moreover, it loops in the scheduling optimization of freight routes and port's time windows considering traffic flow and port's operation status (Port of Buenos Aires, email interview, 2019).

Another approach proposed by the port-city model is the implementation of an IoT based port security and surveillance system together with a tracking and controlling systems of freight movement for security means. It contemplates set-up of GSM and wi-fi antennas and CCTV cameras along the routes connected to a web-based network for the identification and follow-up of cargo and vehicles, as well as floor sensors for the discernment of empty and employed space inside a port (Port of Panama, email interview, 2019).

As a mean where all the collected data can be consolidated, an integrated building information modelling is suggested for the conception of a smart port. This system depicts graphically all the relevant information and actuators' links inside a port lifecycle. Moreover, this approach will serve a decision framework whenever new technologies or designs are to be implemented. This framework includes details regarding investment and operational costs, terminal performance and capacity, energy utilization, and environmental impacts on vicinity areas of a port. It stipulates a base for a smart port that should integrate intelligent, green and multimodal transport, eco-friendly operations and automated technologies (Port of Gdynia, email interview, 2019).

Last but not least, the development of a port-city's symbiosis diagnostic tool is considered to understand and manage the traffic relation resulted from both entities. Data such as urban morphology, distances between harbors and hinterland connections (industrial and commercial zones and multimodal connections), road flow and infrastructure, zoning, etc. has to be studied. The port of Guayaquil, Ecuador proposes a data envelopment analysis to examine the gathered information. Locating critical points along a port supply chain contributes to provide a better assessment for infrastructure's improvement and to have a clear picture of the port-city's architecture. Furthermore, this tool should serve a decision mean for further structure implementations that affects a port-city relation (Port of Guayaquil, email interview, 2019).

6. Study Cases of technology and service providers in maritime sector

In the previous chapters, the importance of a port-city relation was stated, the status-quo of smart technologies that have been/are being developed for the enhancement of the relation port-city were presented, and a port-city concept model from the perspective of different ports was developed. Now, in this chapter, study cases of various interviewed companies inside the

maritime sector are presented in order to gain their point of view on topics such as port-city relation and its challenges, as well as smart technologies and their contribution to this relation.

6.1 CyberLogitec

Connecting maritime supply chain actors employing state-of-the-art technology is one of many services that CyberLogitec offers to the marine industry. It is an international leading technological and consultant enterprise with focus in maritime, port and logistics industries, providing services to customers located in Asia, America, Europe and Middle East, in countries such as Korea, Malaysia, UAE, USA, Indonesia, Turkey, Saudi Arabia, Spain, Brazil, Turkey, Taiwan, Thailand, among others.

CyberLogitec specializes in providing customized solutions to port's terminal operational area with regards to system automation as well as real-time tracking assistance within ports; optimization of stowage planning to maximize loading and unloading capacity and operating times; and management solution creation for container liners. Furthermore, it concentrates on the improvement and standardization of port's communication with their stakeholders by developing collaborated communication tools that automatize data exchange, promoting a more efficient collaboration between them. Its services include training and implementation of technology, customization and consulting.

In order to coordinate the different individuals of a maritime logistics' network, CyberLogitec introduced the collaborative platform "CARA" that functions as an integrated communication channel. In essence, it standardizes and automates the communication process between shipping carriers; furthermore, it connects carries with ports and other parties such as warehouses, customs, and linking hauliers, creating an ecosystem between them. Information such as cargo IMDG data, special cargo applications, vessel's schedules, slot allocations, etc. is analyzed and exchanged through CARA, gaining access and visibility to the data with updates in real time. Moreover, it allows to get a better picture of vessels' operational activities. Thus, business processes can be enhanced by having a better understanding of the supply chain complexity and necessity throughout the collected data; ships traffic congestion can be diminished thanks to a better operative coordination; real time visibility and redundancy in the communication process is eliminated by having a unified platform; and data validation is guaranteed.

As for the port's terminal operating area, CyberLogitec's gamut of technology encompasses:

- OPUS Terminal for container / OPUS Terminal M for multipurpose are intelligent terminal operating system platforms that employ up-to-date technology to cover the necessity of

handling increase in ports through automation. OPUS Terminal systems encompass functions of planning, operations, electronic data exchange, and KPI analysis. They assist ports simplify operational complexities by meliorating equipment usage, yard management and vessel planning. They handle data flow and integration between liners and terminals in order to enhance operations.

OPUS Terminal systems enable a dynamic assignment of yard space by analyzing data through optimized algorithms regarding the most frequent operational conditions such as travel distance, crane workload, and yard congestion. Moreover, they upmost the productivity of terminal devices by reducing their travel and idle time. Last but not least, the berth and vessel productivity are enhanced by minimizing operation times and cost inefficiencies. The turnaround time of external trucks ends positively impacted, as well.

- Eagle Eye is a terminal automation solution for equipment and devices utilized in a port. On the on hand, it uses tracking and monitoring technology to know the real-time usage and location of each object in consideration. On the other hand, it employs artificial intelligence, big data and machine learning to analyze and to predict congestion as well as utilization time and availability of each object and to control them. In essence, Eagle Eye ameliorates the real-time status of every activity inside a port, and it permits a better utilization of resources and time by reducing waiting, queuing and storing time originated from the lack available machinery. It highlights the status of each object through real-time alerts empowering prompt decision making. Furthermore, all information can be visualized through dashboards which provide a better insight on ongoing operations around the terminals. Another key characteristic of this technology is the increment of safety on both terminal equipment and personnel in ports.

According to CyberLogitec, the current challenges that ports are operationally facing can be threefold categorized:

- Ever growing volume of cargo transported by ships in hub ports: The persistent increment of vessels' size challenges continuously the handling capacity of ports' terminals. As a result, ports are entailed to increase their productivity and efficiency by adopting automated systems in order to avoid congestion in the system.
- Advance requirements for systems: The ability of handling multiple types of cargo such as bulk, containers, roll-on/roll-off, while connecting the port to all types of transport modes, ships, barges, trains and trucks, is nowadays vital for the successful of a port. Additionally, ports have to be able to deal with hybrid operations, both conventional and automated operations in one same terminal, and (they have) to be accessible through new communication devices such as mobiles.

- Foreseeable and predictive analyses: The capacity to anticipate required maintenance to equipment to elude downtime from break down machinery is essential to keep operations and avoid unnecessary costs. Besides, ports' activities planning, scheduling and deployment must be dynamically anticipated to meet market needs.

Nonetheless, CyberLogitec affirms that other factors such as port-city relation is of matter of interest for the ports. Given that most of the ports still uses equipment with internal combustion engine as a power source, it represents a hurdle that concerns the sustainable environment. Yet, this is changing as more and more hybrid and electric machineries are being available in the market. Further to this, this company is of the opinion that traffic jams generated by truck trips from/to ports should be avoided. In order to achieve this, harbors should work together with their communities in order to come up with collaborated solutions to address this problem.

As for the smart port term accounts, CyberLogitec stated that it alludes to an ecosystem in which multiple processes are combined and optimized for the purpose of creating an effective collaboration whilst bearing in mind the impact on the environment. Moreover, it empowers communication that stems a promptly and accurate decision making. As more and more AI technologies are being applied, more decisions will be made on the basis of real-time facts and prevailing conditions.

Making an analogy of the services provided by CyberLogitec and its point of view regarding the topics of smart technology and port-city relation with the aforementioned chapters, similar approaches, needs and thinking can be found. For instance, the necessity of a unified communication channel is highlighted. The importance of real-time tracking and tracing technology, as well a real-time visibility of processes status and availability of equipment status is reinforced. Common challenges for ports such as the increment of demand due to constant capacity grow of vessels, prediction of events for a better process and equipment planning, and the inclusion of automated systems are reasserted. Moreover, the implementation of AI technology, analysis of data, and machine learning smart approaches to improve operations are considered, as well. Finally, the improvement of environmental and social factors and the tackle of congestion are key elements restated by CyberLogitec to empower a port-city relation.

(J. Foo, email interview, March 3, 2020)

6.2 CPL

An example of a service provider that assists in the conceptualization of a smart-port and smart-city's mindset is CPL Competence in Ports and Logistics, a management consultancy company with focus on all logistics and transportation activities related to ports and hinterlands. Located in

the north-east part of Germany, it works along with multiple relevant key players in the maritime transport and value chain in the north and Baltic Sea coast of Germany, as well as in the Baltic sea region and worldwide.

In essence, CPL advise customers on strategic and process-oriented challenges with regard to the maritime sector. For instance, CPL occupies itself with activities such as port and terminal planning; market analyses (e.g. in the areas of transport, industry and competition in general); technological and traffic optimization methodologies in relation to handling facilities and logistics chains; business management and technical problematics like investment calculation and due diligence; organizational recommendations related to organizational structure and processes; regional economic analyses; and superior consultancy on project management and corporate alliances or acquisitions.

Since April 2020 the CPL consulting team is part of the Ramboll Group. This step of collaboration leads to joined forces and a customer-oriented alliance of market, economical and engineering expertise.

Being an expert in the maritime sector, CPL opined that even though the challenges in the maritime area differ from port to port. It stated threefold complexities (challenge/problem) that ports are currently facing:

- Energy and emissions: The increase pressure regarding a negative footprint on climate derived from CO2 emissions has affected not only the social responsibility of many ports but also their economic feasibility. For example, in Germany, the CO2 tax to come into force as of 2021 will economically negative impact those ports whose terminals have a large number of equipment with intern combustion engines using fossil fuels. As a result, it would be just matter of time for the diesel fuel to be substituted for green fuels, which in turn require an economical investment.
- Hinterland connectivity: The necessary increment usage of rail transportation as a hinterland modality and its resulting infrastructure requirements have become a latent challenge to the ports. For instance, a consolidation of electrification current and the constraints related to the creation and processing of information has to be addressed
- The continuously trend of creating bigger vessels and its derived effects at ports and its logistics and transport chain.

With reference to the port-city relationship, CPL affirmed that those ports which are not located on “greenfield”, far away from cities, are more perceptible from arisen challenges that affect the sustainable development of a city. Whenever the industries and societies’ interests found themselves in a tight space, friction can be encountered. The current port-city issues can be threefold enclosed:

- Emissions derived from port's businesses and from the industries located either next to them or inside a port's area.
- Increase of territorial demand for urban projects and infrastructure as a result of the continuously growing immigration to the cities which lead to an increment need of households, and because of the augment in average of living space pro citizen that has been perceived in the last decades. The need of public infrastructures increases likewise herewith, as well.
- Decrease of willingness of commitment in the society towards the ports' areal space and terminal operations in the past few years.

In order to improve the port-city relation, CPL encourages in every port's project the early consideration of those groups that might get involved or affected in its execution, in order to detect potential conflicts in the future and to be able to balance different interests. Further to this, communication platforms such as "Hafendialoge", allow stakeholders of diverse groups of interest in the maritime sector to exchange their point of views, enrich the further development of a port. CPL participate in these dialogue platforms either as representator of a port, neutral moderator or conflict mediator.

As for the implementation of smart technologies concern, CPL was of the opinion that these innovations should be applied to a certain extent in specific activities, yet they shouldn't be developed for their own purpose. Even though logistics is a field with many opportunities for digitalization, according to CPL, at the moment, artificial intelligence technologies are being restrained in the decision making because of a limited availability and transfer of processable data along the whole supply chain. Nonetheless, some smart technologies are already in function for ships' traffic and berth planning, optimizing the utilization of ports' infrastructure. CPL, itself, assists ports within the framework of project support by assessing them, for example, in the viability and implementation of hardware and applications that enable an early detection of the status of heavily used components in handling facilities. In this way, machineries' down time or technical malfunctions could be avoided beforehand. In the same way, along with CPL cooperation, it is being tested the feasibility of weighting bulks optically. In essence, under smart approaches, prediction of processing times and the provision of information to ports' customers are encompassed.

Examining the services offered by CPL and its perception of the actual port-city relation and smart technologies with the previous chapters, many similitudes can be highlighted. On the one hand, it pops out all the attention and action that the topic environment gets from ports and cities. On the other hand, improvement of communication is another key factor being address by CPL by bringing together different stakeholders in the maritime sector stablishing a symbiosis between

them. Furthermore, topics such as hinterland connectivity and public infrastructure contrast as relevant points for the improvement of ports' operation and port-city relation, respectively. Last but not least, digitalization and intelligent automated systems are reaffirmed as exemplary solutions to handle the continuously increase of ships' sizes and demand; to improve communication between multiple players in the maritime supply chain; and to enhance productivity and efficiency in ports and handling facilities.

(T. Rust, email interview, March 4, 2020)

6.3 IT developer company

It is an international IT company specialized in the development of software for maritime logistics actors. It is based in Germany but with presence in Middle East, as well, with customers in countries such as Jordan and Lebanon. This IT developer enterprise is one of few that offers a complete automatization and digitalization of processes for harbors and terminals in a consolidated system. Their application results in an accurate planning of ships' arrival and departure, improvement of truck transportation, minimizing traffic jams and enriching parking space management. Furthermore, digitalization makes possible the enhancement of employee's utilization, a faster ships processing, optimization of capacity's utilization, and time saving in operative and administrative tasks. Under its pallet of services, it offers port management software, terminal operating software and port community software which enable savings of time and costs and a high reliable accomplishment and processing of deadlines, machining operations and digital services.

This IT company stated that the necessity of a sustainable digitalization of processes is more latent than ever. However, for most of its customers exist a lack of employees' qualification such as process and project management and IT competences that has to be fulfilled to outmost the benefits that digitalization offers.

As for the mindset of smart-port and smart-city stands, the IT developer enterprise was of the idea that most of the time both terms are employed for solutions with single applications for determined group of users. They depict instead a strategy that is being pursuit.

Even though the software solutions, above mentioned, are intended for ports and terminal operations, they indirectly provide a benefit for a port-city relation. For example, by encouraging other transport modes to connect to the hinterlands, such as inland waterway, the traffic caused by trucks from/to a port can be reduced, having a positive impact to the road infrastructure of a city.

Comparing the services and ideas of this IT developer company with the information presented in the previous chapters, it stands out the current demand of implementing automated and digital systems to boost productivity and efficiency on ports' processes. Moreover, the hindrance caused by traffic congestion to both ports and cities is being reaffirmed as latent problem that is being seriously addressed by ports and extern technology provides like this interviewed IT company, in order to improve hinterland connectivity.

(IT developer company, email interview, March 6, 2020)

As it can be seen, many challenges that might affect a port-city relation are reaffirmed by the companies interviewed. Creation of a sustainable communication channel between the different players in the ports' logistics and a maritime supply chain is vital for a proper functioning of each entity.

7. Conclusion

In modern times, ports are important players for cities' growth. They not only contribute economically in terms of job opportunities and with the establishment of companies, but they also represent a connection with other countries and cities. Nowadays, almost all consumed products are transported via maritime channels; therefore, ports' significance in the maritime supply chain has increased. In order to work along both properly, a good port-city relation is needed, in which the interest and points of view of both of them are taken into account, creating an ecosystem and a sustainable collaboration. However, issues such as congestion, environmental pollution parking spots and available areal space hurdle a port-city relation.

Congestion not only impact negatively a port-city relation, questioning the infrastructure of a city and creating inconformity in the society, but it also affects the hinterland connectivity of a port in terms of reliability and in an economic way. In the present, hinterland connection is a decisive quality for ports in terms of good logistics performance and grow. Even though there are multiple transport modes to reach hinterland points and the fact that ports try to have a balanced use them, the most frequent transportation type is road transport. This last mean of transport requires the city road infrastructure to connect ports with its hinterland locations. Hence, a proper functioning of hinterland connectivity involves both ports and cities, relying on a good port-city relation to overcome challenges and to propel improvements.

Environmental care has been gaining importance the last years. Governmental countermeasures for environmental pollution such as extra taxes for CO2 emissions is impacting ports financially. Moreover, harbors next to cities have experienced an increase of pressure to reduce their

contaminations. They are a hotspot for CO2 emissions in the maritime supply chain. Moreover, trucks, being the most used mean of transport, play a significant role in this matter.

Furthermore, the ever-growing increase of vessels' dimensions challenges continuously operatively ports, increasing the need of more synchronized process. In the same way, cities' infrastructure is being overloaded by handling more and more transports. Further to this, cities have experienced in the las years the need to expand itself territorially in order to create more household, being areal space a limitation for both ports and cities.

As a result, approaches such as smart-port and smart-city are gaining force. They implicate the use of smart technologies, such as digitalization, automated processes, data analysis and machine learning. These permit an operative improvement while maximizing current infrastructure and preserving the environment by taking care of its natural resources. Smart technologies such as automated software for ports, new strategies to electrified trucks, intelligent infrastructures on the streets such as traffic lights, collaborative communication platforms, navigation systems for trucks, intelligent automated parking areas, and new ways of traveling were presented in this research. All these technologies together provide ports and cities the basis to gain a smart mindset and functioning. They tackle several problems that today's society, economy and environment are facing.

Even though some ports have already started to implement smart technologies for the improvement of its own processes and for their relationship with their respective cities, there is still a gap to fulfill. However, taking into account the information from ports and companies interviewed, it can be said that ports have the willingness and are trying to implement more and more of smart-technologies. The financial burden of these approaches is dictating how fast they are applied. Moreover, as the technology advances, much more technologies are going to be appear in the market with a greater scope and for a more accessible price.

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Appendix 1: Questionnaire for maritime logistics companies

Questionnaire of the subject "Port Cities of the Future"

1. Where are your customers located (countries)?
2. What type of technology/services does your company develop/offer to ports?
3. Which benefits do these technologies/services bring to the ports?
4. How do your technology/services differentiate from your competition?
5. How do these services/technologies help your clients to stand out from their competition?
6. Which do you think are the new challenges in the port sector?
7. Are your port customers worried about matters of sustainable development of both city and port?
8. What does Smart-Port and Smart-City mean for you (for the company)?
9. Do you offer technologies/services to improve the port-city relationship?
10. Could you mention some characteristics of these technologies/services?
11. What are the benefits achieved with this systems/services?

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