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Research Article

Digitalization Roadmap for Turkish Seaports*

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Öz

Dijitalleşmenin en etkili ve gerekli uygulama alanlarından biri limanlardır. Bir ülkenin ticari karmaşıklığı, ihracat ve ithalat kapıları olan deniz limanlarındaki işleme kapasitesi ile ölçülür. Deniz limanları dijitalleşme yoluyla çalışma hızlarını ve kapasitelerini artırarak hata oranlarını azaltmaya çalışıyor. Singapur limanı, Rotterdam limanı gibi limanlar, dijitalleşme süreçleri ile limanların daha etkili hale geldiği ve yükleme ve boşaltma işlemlerinin çok daha hızlı olduğu örnekleridir. Türkiye, Seaports alanında muazzam bir potansiyele sahiptir, ancak Seaports'ta yenilikçi teknolojilere yapılan yatırım çok düşüktür. Dijitalleşmenin küresel pazarda rekabet edebilmek ve rekabetçi olabilmenin önemi liman işletmecisine daha açık olacaktır. Bu nedenle bir yönerge gereklidir. Liman için bir yol haritası oluşturulmasına rağmen, Türkiye'nin imalat alanında dijital yol haritaları oluşturulmamış ve verilmemiştir. Bu çalışma, Türkiye'nin deniz limanındaki dijitalleşme sürecine bir yol haritası oluşturacaktır. Bu yol haritasını oluşturmak ve anlamak için dijitalleşme ve Endüstri 4.0 hakkında genel bir anlayış verilecektir. Ayrıca Avrupa Limanlarındaki dijitalleşme süreçleri Hannover limanı ve Rotterdam limanı örnekleri üzerinde analiz edilecektir. Son olarak Türk limanlarında dijitalleşme konusundaki mevcut durumu incelenecek ve en büyük beş limanın kullandığı teknolojiler gösterilecektir. Bölüm 2'deki Materyal ve Yöntem de bu üç önemli konuya değinildikten sonra, 3. kısımda dijitalleşme adımları sunulmaktadır.

Anahtar Kelimeler: Endustri 4.0, dijitalleşme, Port 4.0, Liman, Roadmap.

Digitalization Roadmap for Turkish Seaports

Abstract

One of the most effective and necessary application areas of digitalization is seaports. The commercial sophistication of a country is measured by its processing capacity at sea ports, which are the export and import gates. Sea ports are trying to reduce error rates by increasing their operation speeds and capacities through digitalization. Ports like port of Singapore, port of Rotterdam are examples that through digitalization processes the ports become more effective and the handling of loading and unloading is much faster. Turkey has an enormous potential in the area of Seaports but the investment in innovative technologies at Seaports in very low. The importance of digitalization to become and be competitive on the global market will be more and more clear to the port operator. Because of this a guideline is needed. Digital road maps in the manufacturing area of Turkey despite the creation of a road map for the seaport are not formed and given. This study is a roadmap to the digitalization process in Turkey sea port was created. To create and understand this roadmap a general understanding for digitalization and Industry 4.0 will be given. Also the digitalization processes in Seaports of Europe will be analyzed on the examples of Hannover port and port of Rotterdam. Finally the current situation in Turkish Seaports in regarding to digitalization will be investigated and the technologies of the biggest five ports will be shown. After this three points in section 2. Material and Method, in section 3 digitalization steps are presented.

Keywords: Industry 4.0, Digitalization, Port 4.0, Seaport, Roadmap.

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1. Introduction

The advancing globalization and increased availability of innovative technologies result in rapidly changing market requirements. The maritime supply chains are not left unaffected. One solution to these developments is the flexibility of the infrastructures and transport chains. Infrastructures and transport chains are made more flexible through digitalization.

Digitalization has great potential to make maritime transport chains more efficient, flexible and agile and this opens up the possibility for ports to master the challenges posed by globalization, demographic change and urbanization.

With the help of digital solutions, the efficiency of the operation of a single port and its specific transport chains can already be increased, complex processes simplified or energy consumption reduced. In the international environment of the maritime economy, the digital networking of seaports offers additional opportunities to improve efficiency and security along the entire maritime transport chain. Through a targeted exchange of information and data, the ports can develop and use new business models.

The largest ports such as Hamburg and Rotterdam have been investing in digitalization for a long time to be able to call themselves a smart port. This is a must if you want to stay competitive for a long time. Because the future lies in Industry 4.0 and Digitalization is the basic building block of Industry 4.0.

Turkey has enormous potential in the area of the maritime economy because of its geographic location and its infrastructure. In order for this potential to be exploited, timely investment in digitalization must be made. (Birgun et al., 2005, Kia et al., 2000).

The following briefly gives an insight into digitalization and Industry 4.0 and their role and application in the maritime economy in the area of ports. Then the current state of the Turkish ports is shown and what is necessary to achieve digitalization.

In section 2, digitalization and the connection with Industry 4.0 and its impact on the three sectors logistics, maritime and port will be discussed in the following. Then 2.2 shows applications and investments in the context of digitalization in the port, using Hamburg and the port of Rotterdam as examples. Subsequently, section 2.3 first briefly discusses the current situation of Turkish ports. Then the roadmap will be presented. Finally it will be finished with the conclusion.

2. Material and Methods

To create the digitalization roadmap for Turkish ports is the first step a general understanding of Digitalisation and Industry 4.0 and their relationship. For this a shortly overwieve is given first. After that it is important to see which investments and searching are made in regarding to digitalization of ports in Europe. For this in section 2.2 are examples of Hannover port and port of Rotterdam shown. To createthe roadmap is also important to state the actual state of Turkish port. This will be presented in 2.3.

2.1. Digitalization and Industry 4.0

Digitalization and Industry 4.0 are terms that concern business and science, because when implemented correctly they offer enormous opportunities in terms of flexibility and innovative technologies. These in turn increase international competitiveness. Digitalization is seen as a basic prerequisite for the successful implementation of Industry 4.0 (Urban et al., 2016).

The innovative technologies such as Internet of things, cloud computing, machine learning, cyber physical systems etc. are technologies which Industry 4.0 includes. Those technologies enable new ways of communication and intelligent approaches, as well as new business models in the context of increasing market complexity (Saxe et al., 2017).

Here, the use of cyber-physical systems (CPS) is an important point, since objects, devices, production facilities must be made communicable with the use of the Internet of Things and Internet of Services. The connection of people with CPS creates dynamic and independent value creation networks. (Urban et al., 2016, Bertenrath et al., 2016).

The Internet of Things enables communication and cooperation in real time between workers, sensors and applications as future logistics systems (Saxe et al., 2017).

In regarding to the points above it can be said that the focus of "Industry 4.0" is the real-time, intelligent, horizontal and vertical networking of people, machines, objects and information and communication technology systems for the dynamic management of complex systems (BMWi, 2015).

Industry 4.0 is becoming mandatory for all areas of the company, particularly in the areas of logistics, ports and the maritime economy. This results in the concepts of Logistics 4.0, Port 4.0 and Maritime 4.0, which are interconnected. Logistics 4.0 describes the connection of processes, objects, supply chain partners and customers using information and communication technologies. Maritime 4.0 refers to shipping and can be used to redesign the supply chains of the maritime industry through Digitalization and networking. Port 4.0 is the digital port of the future, exploiting the specific role of ports as hubs for the physical and information flow within global supply chains and connecting all actors involved (Bichou et al., 2004). Through a value network, digitalization issues such as improved connectivity, autonomous systems, and big data analysis will lead to greater reliability and efficiency (Saxe et al., 2017).

Big data analysis plays an important role in the areas described above. This means the collection and calculation of extensive data sets over time. The enormous data sets offer the possibility to make predictions, such as about delays in arrivals and departures of ships (Saxe et al., 2017). Maintenance can also be planned better by analyzing these data records. These data sets are generated from

multiple sources such as machine controls, sensors, manufacturing systems, people and many other things (Bortolini et al., 2017). Industry 4.0 includes the technologies Internet of Things (IoT), Big Data, Mobile and Augmented Reality, Additive Manufacturing, Cloud and cloud computing, Cyber security (Santos et al., 2017). And like mentioned above digitalization is the main key for Industry 4.0.

2.2. Port 4.0

The importance as an economic success factor has been recognized worldwide and it is invested diligently. The ports of Rotterdam and Hamburg, which are the largest ports in Europe, continuously research and invest in digitalization. Digitalization is being tackled in various areas on the way to the Smart Port. HPA (Hamburg Port Authority) relies on intelligent control systems. Efficiency is increased through the smooth interaction of information, analysis and forecasting techniques, as well as sensor technology. Some of the intelligent solutions presented by the HPA include Navigation in Real Time, Intelligent Railway Point, Smart maintenance and Virtual Depot. Real Time Navigation allows making the traffic in the port more efficient by combining different services and functions, thus offering a personalized navigation system to customers and partners in the port. In short, it enables access to up-to-date information on traffic, parking and infrastructure, as well as bridge closure times. With Intelligent Railway Point, maintenance measures or repairs can be identified at an early stage, thus avoiding downtimes. This is done by collecting information through port railway switches equipped with sensors. (Hamburg-Port, 2019).

In order to make maintenance processes more efficient and effective, measurements are automatically sent to downstream IT systems using mobile devices such as tablets or Smartphone's. This is where the data is processed, saved and processed. The so-called Smart maintenance takes place.Virtual Depot is used so that cloud-based systems can identify which containers should be delivered back to the depot. This means that empty runs are canceled, which in turn also prevents unnecessary pollution of the environment.HPA networks shipping, rail and road traffic with one another through an intermodal PortTrafficCenter. Optimal data acquisition and a fast exchange of information enable logisticians, forwarding agents and agents to choose the most efficient mode of transport for the transport. (Hamburg-Port, 2019, Bertenrath et al., 2016).

The port of Rotterdam is the largest port in Europe and one of the ten largest in Europe (Portofrotterdam, 2019). In 2019, 469.4 million tons of goods were handled (Smartport Rotterdam, 2018). To make sure that the port can remain competitive in the future, they have to invest constantly in digitalization. Like noted above, the future lies in digitalization. On the way to the Smart Port, the port of Rotterdam tackled digitalization in various areas. One of the biggest projects is the automation of ship handling in collaboration with IBM. All relevant processes are planned to become digitized by 2025. For this purpose, the port is equipped with sensors. These are intended to continuously collect information on, among other things, ship movements, free berths, water and wind data. A digital twin is to be created with the support of IBMa IoT technologies. The virtual image should increase the efficiency of the processes (Bertenrath et al., 2016). This digital twin allows detect such things like delays, need of maintenance and other things, which can cause problems, before they appear.

Furthermore, the Rotterdam port has developed an intelligent container, the Container42. This was equipped with sensors and communication technology, which allows data on temperature, vibrations, position humidity, etc. to be determined during the trip. This Conrainer42 is also equipped with solar modules to record how much energy a container can generate during transport. This container, which records everything, offers the possibility of an insight into the challenges of transport and logistics. (Horstmann, 2019).

Furthermore, the Port of Rotterdam is working on portals that offer interfaces to other ports in the world. Among other things, these portals should optimize planning and departure and arrival times. The connection between ports is important to optimize the supply chain process. Those interfaces will improve the optimization of these processes.

The ports of Europe have recognized that the future lies in digitalization and are investing in development and research in this area. These both ports, Hannover port and port of Rotterdam are leader in field of Digitalization of ports in Europe.

Because of the importance of digitalization the British Ports Association and the Port of Rotterdam have already drawn up a four-step milestone plan, which broadly represents a signpost for the digitalization and networking of a port (Santos et al., 2017) (Horstmann, 2019). These four stages are as follows.

1. Digitalization of the process participants in the port: Recommendation: Start on a small scale to digitize the processes of the individual participants.
2. Creation of integrated systems in a port community
3. Via a central platform, acquired data enables reliable, efficient and paperless information flows.
4. Integrating the logistics chain with the hinterland

2.3. Identification of Actual State

The actual state of Turkish ports will be identified in this part, before the solution for digitalization of Turkish Sea Ports will be presented.

There are 27 large container ports in Turkey, two are under state management and twenty five are managed by private companies (Balık et al., 2019). The five largest ports are MIP (Mersin International Port), Asya Port, Safi Port Derince, Marport and Kumport. These five container ports of Turkey should be examined in more detail with regard to digitalization.

In their work Balik and his colleagues examined these five ports for digitalization and summarized the digital technologies, which are in use at these ports in the table 1(12). These relevant technologies were taken from their table and shown below. These results were checked again by searching the individual websites of the ports.

Table 1. Used technologies at Turkish Sea ports

Ports	Digital technologies
MIP	customs declaration software, Container and Port tracking system,
Asya Port	automatic identification system, Vessel tracking system, robotics, traffic control system
Safi Port Derince	-
Marport	-
Kumport	-

Like seen in table one only MIP and Asya Port has some technologies like tracking and identification systems, but these are basics. To become and be competitive they have to apply and implement more innovative technologies like sensors for connecting data and information exchange.

The table shows that Turkey's five largest ports still have a long way to go in terms of technology. The possibilities offered by the technologies of Industry 4.0 must be exploited. The ports mentioned here have enormous potential, also due to their geographical location. However, they still have to start investing and doing research to get connected to digitalization.

During searching through the individual websites of these ports there wars no information about steps or projects towards digitalization.

Based on the information above the Roadmap will be create and presented. Like seen aboveturkish Seaports does nothimg in the area of digitalization and because there is a need to use digitized technologies we came to the following result.

3. Roadmap for Turkish seaports

Turkey has to invest in digitalization in the area of its ports, as seen above, hardly anything has happened in this area to date. Since digitalization cannot take place all at once, a plan must be drawn up how this can be achieved step by step.Building on the four-step milestone plan of British Ports Association and the Port of Rotterdam which is shown in section 2.2, a detailed roadmap for the Turkish ports is presented.

In the first step, before the digitalization process can begin, the current status of the ports must first be determined. That means to identify which technologies are in use, can customer requirements be met and what are the requierements of all users of logistics agents, customs etc.. In the second step, it must be determined which areas or processes will be "digitized" first or where to start. For this the most important processes must be selected and prioritized. In the third step, building on the second step, it must be determined which technologies and investments are necessary to achieve the desired, and to find out who can provide these technologies and how much the investment will be.In this step the use of the Internet of Things is a must. Applications that can be used via Smartphone's, tablets, etc. must be created here. In parallel to the second and third steps, the advantages of these decisions are to be determined. The fourth step is implementation and application. Here is an important point to train and educate the stuff in regarding to the new technologies. It can and will be necessary to built a new department are adjust extern experts for application and using of those technolgogies.

It is also important to consider the connection of the partners from the second to the fourth step. The connection means that, for example, customers, partners can use the technologies used or the data determined by them to optimize processes in order to optimize processes.Interfaces must be built for connection. These steps can be seen in Figure 1.

Let's take a closer look at the roadmap using an example. There are many processes in the port, but the information flow and processing time for loading should be considered here. The arrival time of the ship is important so that the ships can be loaded. This depends on many parameters. In order to be able to make correct forecasts, the collection and evaluation of data is necessary and this is where big data comes into play. These can be collected by sensors and information via tracking systems. The organization of the loading is also important with regard to the trucks, their arrival, waiting time and sequence must be determined and optimized. Relevant technologies are determined here, in addition to Big Data smart applications with which the truck driver can use his Smartphone to track when he needs to be where. Weather conditions also play an important role here, which can be detected by sensors and transmitted.

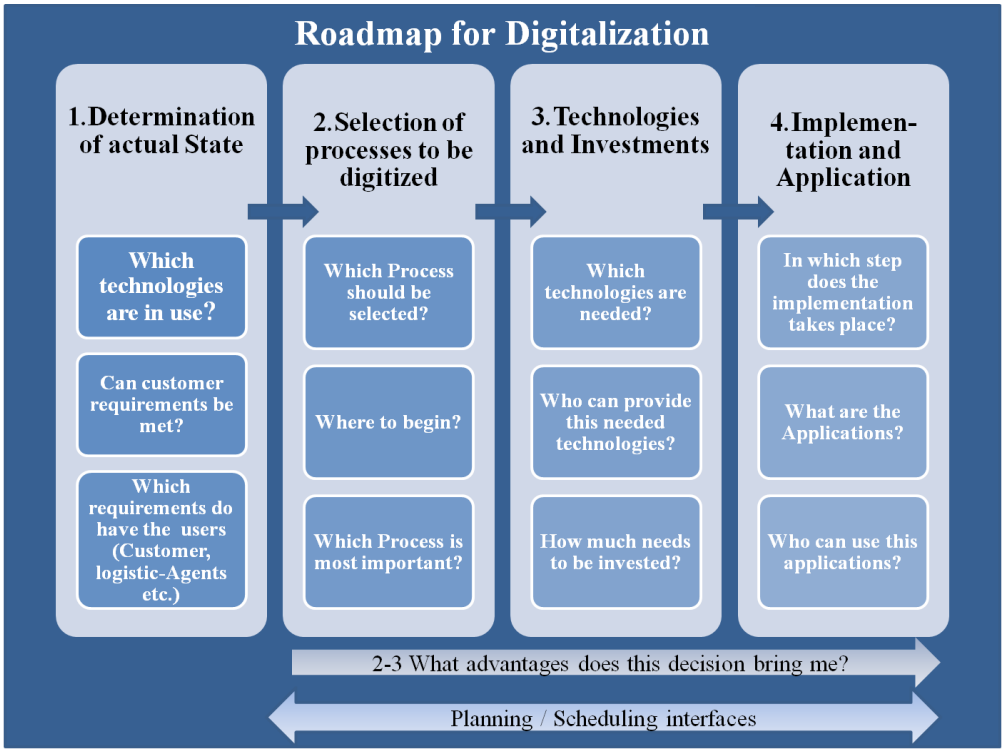

Figure 1. Roadmap for Digitalisation

The process of loading shows that sensors, applications for tracking, navigation are necessary. These applications work with the Internet of Things. So you should also deal with the Internet of Things.

After determining which technologies and applications are necessary, the investment in development begins. Finally, the implementation and application takes place.

Finally, it should be noted that there is a close need for cooperation with external technology partners and one of the most important things is to create interfaces, so extern partner and ports can connect with your port to exchange data to improve and optimiye the whole supply chain.

4. Conclusion

The ports in Turkey still have a long way to go in terms of digitalization. However, it is not too late to get the connection. When the ports begin to analyse their current state and divide their processes and procedures with regard to digitalization. You can identify your weak points and thus start investing step by step towards digitalization.

For the first application of this Roadmap is recommended to choose a port which is new built, because such a new port gives the opportunity to apply new technolgies and changes in infrastructure easier. Because most things are not established so it is easier to create the infrastructure for new technologies and educate the port stuff in regarding to operating and handling the new technologies.

Turkey is still in its infancy in the area of the maritime economy, but you can use the road map presented here to start the digitalization process in the area of ports. In this field is a lot which needs to be analysed. But with thos Roadmad the first step to Digitalisation in the area of Sea ports will be given, which can be used from everyone.

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