REVISTA ELETRÔNICA DE ESTRATÉGIA & NEGÓCIOS
E-ISSN 1984-3372
unisul

ROADMAP FOR IMPLEMENTING SMART PRACTICES AT SEAPORTS AND TERMINALS

ROADMAP PARA IMPLEMENTAÇÃO DE PRÁTICAS INTELIGENTES EM PORTOS E TERMINAIS

ROADMAP PARA APLICAR PRÁCTICAS INTELIGENTES EN PUERTOS Y TERMINALES

Gabriela do Nascimento Dominguez
Universidade Federal de Santa Catarina – Joinville
E-mail: gabrielandominguez@gmail.com

Suzane Carolyne Gorges
Universidade Federal de Santa Catarina – Joinville
E-mail: suzanegorges@gmail.com

Vanina Macowski Durski Silva
Universidade Federal de Santa Catarina – Joinville
E-mail: vanina.durski@ufsc.br

Artigo recebido em 15/09/2021. Revisado por pares em 28/02/2022. Reformulado em 10/06/2022. Recomendado para publicação em 19/06/2022, por Ademar Dutra (Editor Científico). Publicado em 29/07/2022. Avaliado pelo Sistema double blind review.

ABSTRACT

Maritime transportation represents a significant part of international cargo transportation and ports need to be in constant evolution to remain competitive. Applying intelligence to the port's sectors turns possible to increase their connection and efficiency. Brazilian ports and terminals cannot be considered smart ports and to facilitate the process of intelligence application in ports and terminals, a roadmap was structured. Through a literature review 9 steps for the roadmap were defined: definition of the elements, survey of smart practices, establishment of the desired state of smartness, analysis of the current state, selection of the tools, characterization of the intelligence levels, delimitation of the deadlines, cost analysis, and selection of the actors involved. It is expected that the use of the roadmap will guide managers in implementing intelligence within the components of a smart port.

Key-words: Roadmap; smart ports; port modernization; smart practices, ports.

RESUMO

O transporte marítimo representa parcela significativa do transporte de cargas internacional. É necessário que os portos estejam em constante evolução para se manterem competitivos. A aplicação da inteligência nos setores do porto o torna mais conectado e eficiente. Os portos e terminais brasileiros não podem ser considerados smart ports e para facilitar o processo de aplicação da inteligência em portos e terminais estruturou-se um roadmap. Definiu-se através de uma revisão de literatura 9 passos para o roadmap: definição da componente, levantamento das práticas inteligentes, estabelecimento do estado desejado, análise do estado atual, seleção das ferramentas, caracterização dos níveis de inteligência, delimitação dos prazos, análise dos custos e seleção dos atores envolvidos. Espera-se que o uso do roteiro oriente os gerentes na implementação da inteligência dentro dos componentes de um porto inteligente.

Palavras-chave: Roadmap; smart ports; modernização portuária; práticas inteligentes, portos

RESUMEN

El transporte marítimo representa una parte importante del transporte internacional de mercancías. Es necesario que los puertos estén en constante evolución para seguir siendo competitivos. La aplicación de la inteligencia en los sectores portuarios la hace más conectada y eficiente. Los puertos y terminales brasileños no pueden ser considerados puertos inteligentes y para facilitar el proceso de aplicación de la inteligencia en los puertos y terminales se estructuró una hoja de ruta. Se definieron nueve pasos para la hoja de ruta a través de una revisión bibliográfica: definición del componente, estudio de las prácticas inteligentes, establecimiento del estado deseado, análisis del estado actual, selección de herramientas, caracterización de los niveles de inteligencia, delimitación de los plazos, análisis de costes y selección de los actores implicados. Se espera que el uso de la hoja de ruta guíe a los gestores en la aplicación de la inteligencia dentro de los componentes de un puerto inteligente.

Palabras clave: Roadmap; puertos inteligentes; modernización portuaria; prácticas inteligentes, puertos

1 INTRODUCTION

The large capacity of cargo transported at low costs by ships makes maritime transport responsible for a significant portion of the international trade flow. In Brazil, the importance of the sector can be noted by the fact that the country comprises 20.2% of the number of port terminals in Latin America and the Caribbean, according to data from the Economic Commission for Latin America and the Caribbean (ECLAC, 2020a), in addition to having handled 10,396,182 TEU's in 2019, which represents 1.25% of world handling (ECLAC, 2020b) and 10,786,170 TEU's in 2020, which represents 1.43% of world handling in the same year (FAL, 2021).

By the year 2019, shipping was boosted and predicted to expand at the average rate of 3.4% industry growth for the period 2019 to 2024 (UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT - UNCTAD, 2019). In view of this and coupled with the expected post-pandemic recovery economic growth of 3.3% in 2021 and 3.5% in 2022 of advanced economies (WORLD BANK GROUP, 2021), the industry raises the adherence of technologies in search of increased competitiveness of ports (DOUAIOUI et al., 2018).

In this context, Industry 4.0, a term that, according to ROJKO (2017), encompasses the main technological innovations in tools applied to the digitalization of manufacturing processes, is seen as a path to increase efficiency and competitiveness (CHEN et al., 2019). Through technological tools such as the Internet of Things (IoT), Big Data, Cloud Computing and Artificial Intelligence, it provides an agile and cost-effective process within the supply chain and, in this way, digitalization is able to make communication between sectors fluid (DOUAIOUI et al., 2018).

However, to implement such technologies and keep up with the advance of Industry 4.0, the transformation of the current port structure is necessary. According to Gorges and Silva (2020), besides the issue of general infrastructure, Brazilian ports face problems such as high waiting time for ships to dock, high customs fees, poor intermodal infrastructure, road congestion, and high bureaucracy that increases the time of each process. This scenario, intensified by the current pandemic moment, makes ports unattractive for investments and even to perform services since, according to Karas (2020), without smart solutions, ports may not survive competitiveness.

Thus, the adoption of tools that allow the implementation of smartness in the port sector, characterizing the smart ports, shows itself as an opportunity to improve the sector's information technology (WU et al., 2013), being this an international trend already applied in reference ports such as Rotterdam in the Netherlands and Hamburg in Germany (DOUAIOUI et al., 2018). Thus, it is essential that Brazilian ports and terminals begin to worry about becoming "smart" if they want to remain competitive in the global maritime trade (SAKTY, 2016).

However, the concept of smart port is still vague and without specific definition (KARAS, 2020), and the national literature on this subject is still scarce, which hinders the adoption of practices of a term that, not even, there is consensus about its definition, which may be a significant factor for the low adoption of smart practices in the country. The concept of smart port adopted in this work is taken from Gorges (2021), who, through the conceptualization of the term by a bibliographic survey, determines seven main components that characterize a smart port: Technologies, Environment and Sustainability, Energy, Security and Cybersecurity, Social, Management and Strategy, and Efficiency and Productivity.

The insertion of intelligence within the port is a desirable goal to achieve the mentioned development and to circumvent the problems presented, however, it is not a simple objective to be put into practice in the short term. It is also important to note that there is no standard set of elements to consider a port intelligent. According to Karas (2020) and Wu et al. (2013), each port has its own reality and distinct characteristics, which makes its process of becoming a smart port require tailored solutions. Thus, this work aims to develop a roadmap (containing steps to be followed) along with toolkits - that work as a guide to orient each port/terminal in the process of becoming smart.

2 LITERATURE REVIEW

2.1 SMART PORT

Durán et al. (2019) characterize a traditional port as an environment in which wasted time and high logistics costs limit the efficiency of the activities developed in the sector. In view of these problems, Shuo et al. (2016) reinforce the need for computerization to ensure and raise the quality and competitiveness of the port, tying it to logistics processes (considered the center of the logistics chain and link of nations involved in global maritime trade), where producers, consumers, and means of transport are integrated (DOUIAOUI et al., 2018).

Thus, acting in an integrated manner is a key point to add value to the process, since the benefits to the supply chain are directly related to the level of integration of sectors. However, according to Wang et al. (2021), the current technological scenario counts on a decentralized network, with most systems being incompatible and, thus, the integrating sectors act in an almost independent manner, a fact that does not contribute towards the development of the supply chain.

Therefore, the first step towards this integration is the automation of processes. Rojko (2017) points out that this association can be achieved through the Industry 4.0 approach, since it is based on the integration of processes and the components of the value chain in question through the adherence to new technologies, therefore, digitalization.

Among the technological solutions present in Industry 4.0, Douiaoui et al. (2018) and Chen et al. (2019) highlight the Internet of Things (IoT), Big Data, cloud computing, and artificial intelligence. As these technologies advance, smarter solutions emerge to make it easier to manage the services that use it (BOTTI et al., 2017). The construction of the smart port, therefore, meets this technological advance provided by Industry 4.0 (SHUO et al., 2016). Thereby, according to Gorges and Silva (2020), to be considered a smart port, it must first be considered a port 4.0, that is, a digitalized and automated port.

However, research about the conceptualization of the smart port term and the degree of adoption in ports are limited (WU et al., 2013). Although, they represent a current trend in maritime trade (CHEN et al., 2019), there is much divergence on the topic. Therefore, in order to characterize the concept of smart ports, Gorges (2021) identified the seven main components of a smart port, represented in Table 1. Thus, to a port be considered smart, it must develop and achieve success in each of the components mentioned, which, when interconnected, constitute a smart port.

Table 1 - Components of a smart port.

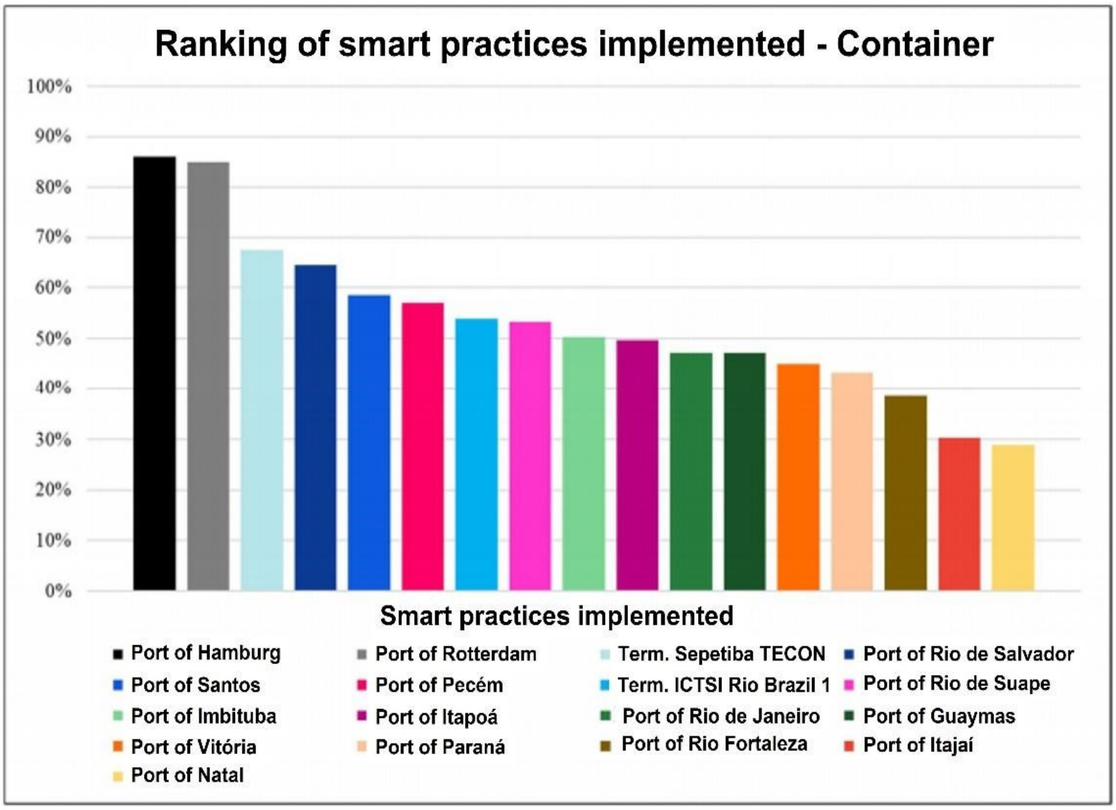
Component	Short Description
Technologies	Technological innovations that facilitate virtual or physical processes (HEILIG et al., 2017).
Technologies: Virtual Assets	Digital transformation technologies such as big data, cloud computing, Internet of Things, mobile computing, blockchain, machine learning, artificial intelligence, digital twin, and integration systems (HEILIG et al., 2017).
Technologies: Physical Assets	Technological solutions to control machines and processes and reduce human intervention (GARÍN, 2020).
Environment and sustainability	Measures that aim to harmonize port development with the region and the natural system (PIANC, 2014).
Energy	Technological innovations aimed at saving energy and reducing environmental impact (SARI and PAMADI, 2019).
Security and Cybersecurity	Security mechanisms to deal with attacks and vulnerabilities of technologies used in ports, in addition to physical asset security (GORGES, 2021).
Social	Measures for regional development and national economy through port impact (ZHANG et al., 2018).
Management and Strategy	Performing statistical data analysis for operations improvement (ATTIA, 2016) and strategic management of available resources (MONTIBELLER, 2020).
Efficiency and productivity	Meeting the needs of port users with the highest level of efficiency (OZTURK, 2018).

Source: Authors (2021).

Currently, one can consider the ports of Rotterdam (Netherlands) and Hamburg (Germany) as a reference in the use of intelligent practices, which adhere to most of the technologies found in the components mentioned in Table 1. Thus, to remain competitive in today's market, ports and terminals should seek to implement as many of the technologies used as a reference as possible.

By the other hand, Brazilian ports and terminals cannot yet be considered smart ports, since their adherence to the smart practices used by the benchmark ports is still low, as can be seen in the comparative analysis performed by Gorges (2021) in Figure 1 among container handling ports.

Figure 1- Comparison of adherence to smart practices between Brazilian and benchmark ports and terminals.



Source: Gorges (2021).

As can be seen in Figure 1, the adherence of smart practices in Brazilian ports and terminals varies approximately between 28% and 68%, being considered low values when compared to the reference ports - considered smart ports. Thus, in view of the benefits of competitiveness and efficiency linked to the adoption of smart practices, the need for a structured roadmap to assist port managers in the modernization of ports and terminals towards the transformation into smart ports is emphasized, since this Brazilian scenario is repeated in the vast majority of ports and terminals around the world.

2.2. ROADMAP

Besides the difficulty in conceptualizing the term smart port, another challenge - this one encountered by ports and terminals - is the actual application of intelligent practices in the sector. Considering that to become a smart harbor it is necessary to pay attention to at least seven components inserted into the port environment, composed of various techniques that enable the insertion of intelligence, there is a need to create a way to organize the actors involved in the process, the devices to be used, the order of their application, the cost and time involved (FUNDACIÓN VALENCIAPORT, 2020).

Companies need appropriate approaches to take advantage of existing new technologies (SANTOS; MARTINHO, 2019). Therefore, through an organized roadmap, ports can have a holistic and practical view of the process of implementing smart practices, and then, analyze the possible tools to be applied considering the available budget and the desired degree of intelligence. By following a roadmap, the port/terminal can gradually become intelligent, initially consolidating a basic level of intelligence, then an intermediate level, and then advanced, respecting the limitations of the company and moving towards development.

In order to exemplify this procedure of implementation of improvement practices in a given process of insertion of Industry 4.0 in companies, Schumacher, Nemeth, and Sihn (2019) state that although decision makers are willing to invest in digital transformation, without prior knowledge about the degree of digitalization of the company, and a strategic way to implement it, there is no way the process can occur. The same can be said in relation to the application of intelligence in the port, since it is necessary that the port has knowledge of the intelligent tools already deployed in its company to then start the process of implementing them in a strategic manner.

Thereby, to occur this process in an organized manner, ports/terminals must have access to a roadmap that contains the toolkits needed to apply intelligence in the port sector. Roadmaps are descriptive tools used to facilitate the achievement of a goal through visual strategic steps that guide the process of implementing the tools and stakeholders necessary to achieve the purpose (ENDEAVOR, 2015). In this study, a roadmap is proposed to assist ports and terminals in the implementation of practices that lead them to achieve the smart ports concept.

The basic knowledge of the subject to be developed in the roadmap, that is, smart ports, is extremely important, since there is no way to raise objectives and perform analysis without characterizing the environment in which this research is inserted. Edelmann and Mergel (2021), in their research, analyze the universe of digital co-production through a literature review. Through the review, the authors develop the methodologies to be used in sequence to build their roadmap. The same should be considered for the process in question, a literature review to conceptualize the term smart port, and to develop the roadmap structure.

After the construction of the knowledge base of the issues in question, the first need that arises in the implementation process of a certain improvement is the characterization of the state of the agent that will adhere to the working practice. According to Santos and Martinho (2019), it is necessary to have a diagnosis of the current situation, since the development of the process will be different in each agent. In their work, the authors perform a maturity analysis to measure the stage of development of their area of interest in the study.

Without knowledge of the state the company wants to achieve in a given process, the construction of a segment strategy is difficult, since its needed a goal to select the devices to be used in the process. Thus, in addition to making sure of the current state of the agent in question, it is necessary to define the desired state. Sakty (2016), in his roadmap, develops a set of visions for a smart port in the year 2050, in order to presume the process and the tools to be used so that the elaborated vision is achieved.

To guide the process of achieving the desired state in a given process, it is necessary to select a set of techniques to be used strategically in each area of action, toolkits. In the case of the study by Schumacher, Nemeth, and Sihn (2019), this set of tools was called the "Industry 4.0 toolbox." Sakty (2016), in turn, cites a set of indicators from different topics involved in the conceptualization of a smart port, a useful methodology for defining the devices needed to achieve the defined indicators.

When defining the steps that will be considered in the roadmap, it is important to consider the project's priority fields of action (SCHUMACHER; NEMETH; SIHN, 2019). This requires defining a priority set of tools for implementing the process at basic, intermediate, and advanced levels, in a generalized way, to be customized according to the scenario and reality of each agent that will join the roadmap. Even before the roadmap is completed, it is necessary to have, at least the minimum follow-up of experts during the process, in order to ponder possible unforeseen issues along the development and align different visions.

3 METHODOLOGY

To elaborate the structure and components present in the roadmap proposed by this work, a systematic review method was used. A systematic review consists of using ordered methods to collect relevant research to be used to review a predetermined issue (MOHER et al., 2010). Thus, for the item 2.2, aiming to define the structure of a roadmap, a systematic literature review was performed by applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method proposed by Moher et al. (2010), since there are several existing structures in the literature for various themes.

In view of the broad scope of the theme, we sought, a priori, to delimit the area of study addressed, aiming at areas related to ports or digitalization. The initial step, for the "Identification" phase, was to search the selected databases. For the present work, Scopus and Web of Science were chosen because they are internationally respected databases. Within the chosen databases, the following keywords were strategically used: ("roadmap") AND ("seaport" OR "seaports" OR "smart port" OR "smart ports" OR "logistic" OR "logistics" OR "digitalization" OR "industry 4.0").

In addition to the delimited search string, filters were also applied in relation to language, document type and source to further narrow the initial search, and thus, only articles in English from conference proceedings or journals were chosen. The search occurred on 07/19/2021. As a result of the first filtering, 202 articles were obtained from the Scopus database and 575 articles from the Web of Science database.

Through the use of a package designed to perform comprehensive scientific mapping analysis, bibliometrix (ARIA; CUCCURULLO, 2017), in R Studio software, the files of the two databases used were merged and then duplicate files were removed. After the aforementioned procedure, 665 articles remained for the "Screening" phase.

In the "Screening" and "Eligibility" stages, the process of inclusion and exclusion of articles followed criteria adapted from Liao et al. (2017) and da Silva et al. (2020), defined in Chart 2. Therefore, in the "Screening" step, it was checked in the databases used if the 665 articles grouped in the previous step have the full text available and in English, if not, the article was excluded. Then, 162 articles were discarded. For the "Eligibility" stage, the abstracts of the 503 articles selected were analyzed in order to discard those that met the criteria of "Not related" and "Freely related" in Chart 2.

Finally, when analyzing the abstracts in order to find those articles that actually met the research proposal, 481 articles were discarded for not meeting the "NR" and "RL" criteria, leaving a total of 22 articles to be used for the theoretical composition of this work.

Chart 2 - Criteria for inclusion and exclusion of documents.

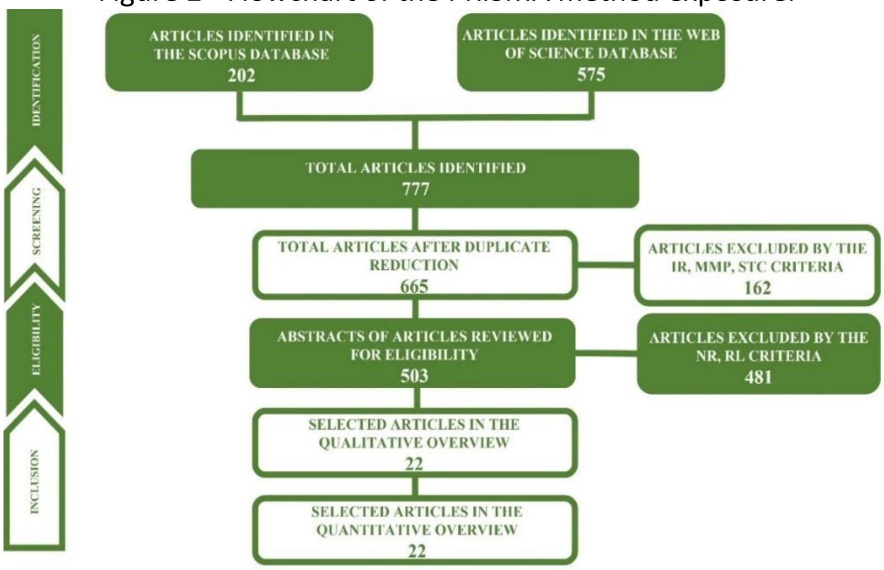
	Criterion	Explanation
Inclusion	Closely related (IR)	Research has roadmap structure dedicated to technology application; Period: before 07/19/2021; Document type: Article; Source type: Conference proceedings or periodicals; Language: English.
Exclusion	Search Engine Reason (MMP)	Article just has the title, summary and the keywords in English, but not the complete text.
	No full text (STC)	Article is not completed
	Unrelated (NR)	NR1: It is not an academic article; NR2: Doesn't have a *roadmap* structure.
	Free Related (RL)	The article does not focus on the discussion of roadmap where: LR1: Roadmap is used only as a factual example; LR2: Roadmap is used only as part of its future research direction; LR3: Roadmap is used only as a quoted expression;

		LR4: Roadmap is used only as a keyword or reference; LR5: Research that does not address the roadmap context.

Source: adapted from Liao et al. (2017) and Da Silva et al. (2020).

The process described above can be observed through the flowchart elaborated and exposed in Figure 2.

Figure 2 - Flowchart of the PRISMA method exposure.



Source: Adapted from Da Silva et al. (2020).

4 ANALYSES AND RESULTS

To develop a roadmap for the implementation of smart practices in ports and terminals, the priority factors raised in chapter 2.2 and the results of PRISMA literature review were taken into account. Thus, a structure similar to the one found in the reference articles was designed to be customized according to the needs of the ports and terminals that intend to use the roadmap.

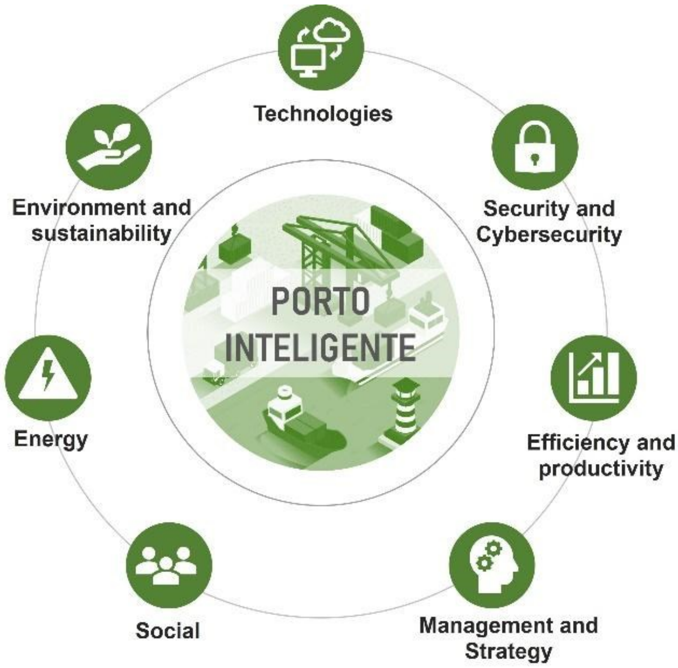
Thus, it was considered necessary to stipulate an organized structure of the elements to be considered in the roadmap proposal for the implementation of smart practices in ports/terminals, as illustrated in Figure 5, starting with the "Components" element. After that, the "Smart Practices" element is included, where those to be used in the process are listed. Next, the element "Survey of the Desired State" were considered, and consequently an analysis of the "Current State". It was also deemed necessary to consider the "toolkits" to be used in the process, and their respective "Level", "Deadline" and "Cost" of implementation, presented in order. Finally, the proposal of this organized structure should also include the selection of the "Actors Involved" in the process.

4.1 COMPONENTS

According to Kumar (2021), the practices to be implemented must be grouped in the dimensions to which they belong, therefore, the whole structure of the proposed roadmap will be divided into dimensions referring to the different areas that make up a smart port.

In this study, it was chosen to follow the organization of smart port components proposed by Gorges (2021) since this is the one that best details the stages involved in the smart port conceptualization. Thus, the components to be considered in the roadmap proposition are: Technologies (virtual assets), Technologies (physical assets), Environment and Sustainability, Energy, Security and Cybersecurity, Social, Management and Strategy, and Efficiency and Productivity, as shown in Figure 3.

Figure 3- Components of a smart port.



Source: Adapted from Gorges (2021).

4.2 SMART PRACTICES

In order for a port to be considered smart, at a minimum, each of the seven components within the port/terminal must modernize and seek appropriate technologies and resources to improve efficiency in each area. Such technologies and resources will be referred as smart practices, and will be used as a manner of measuring the degree of smartness of each port or terminal. As such, smart practices will be considered as a set of performance indicators, which are defined as measures for comparing something that has been accomplished against a goal or strategy (FRANCISCHINI et al., 2017).

To select the indicators for each component, a broad assessment of the smart practices adopted by ports/terminals currently considered as smart ports must be conducted in each of the seven areas. As an example, a similar approach for the Environment and Sustainability component is the set of indicators developed by the National Agency for Waterway Transport (ANTAQ) for the Environmental Performance Index (IDA), which can be seen in Chart 3.

Table 3 - Environmental Performance Index Indicators (IDA) - ANTAQ

Category	Global indicator	Specific Indicator
Economic and Operational	Environmental Governance	Environmental licensing of the port
		Quantity and qualification of professionals in the environmental core
		Environmental training and capacity building
		Environmental auditing
	Security	Oceanographic/hydrological and meteorological/climatological database
		Risk Prevention and Emergency Response
		Occurrence of environmental accidents
	Port operations management	Vessel waste removal actions
		Container operations with dangerous goods
	Power Management	Reduced energy consumption
		Generation of clean and renewable energy by the port
		Ship power supply
	Costs and benefits of environmental actions	Internalization of environmental costs in the budget
	Environmental Agenda	Disclosure of environmental information from the port
		Local Environmental Agenda
		Institutional environmental agenda
		Voluntary certifications
	Condominium management of the organized port	Control of environmental performance of leases and operators by the Port Authority
		Environmental licensing of companies
		Individual terminal emergency plan
		Environmental audits of the terminals
		Solid waste management plans for the terminals
		Voluntary certification of companies
		Environmental education programs at the terminals
Sociocultural	Environmental Education	Promotion of environmental education actions
	Public Health	Health promotion actions
		Port Health Contingency Plans
Physicochemical	Water Monitoring	Environmental quality of the water body
		Storm Drainage
		Actions for water reduction and reuse
	Soil and dredged material monitoring	Dredged area and disposal of dredged material
		Environmental liabilities
	Air and noise monitoring	Atmospheric pollutants (gases and particulates)
		Noise pollution
	Solid Waste Management	Solid Waste Management
Biological-ecological	Biodiversity	Fauna and Flora Monitoring
		Synanthropic animals
		Aquatic alien/invasive species

Source: Adapted from Gorges (2021) and ANTAQ (2016).

4.3 DESIRED STATE

To determine the desired state of "intelligence" that the port/terminal wants to join the roadmap, one must initially take into account ports considered smart as a reference. As mentioned before, this work has as reference the ports of Rotterdam, Netherlands, and Hamburg, Germany, which currently have the most modern technologies and integration of sectors in the maritime scenario. The use of more than one reference port is recommended, since different technologies may be exclusive to some ports, and thus the use of more than one provides more options.

To analyze the selected ports, the alternative is to search the port websites, which provide in their news or infrastructure tabs, the technologies adopted or even those under development. Another option suggested is the use of articles that address the technologies used in the ports of reference, or yet, a more reliable alternative is the direct contact with the port, which can be by answering a questionnaire on smart practices adopted or through a direct visit to the chosen location.

However, regardless of the research mode adopted, it is necessary, as highlighted in the roadmaps used as a basis, that the agents responsible for the development of this process have a knowledge base about the theme addressed, in this case, smart ports. This knowledge is necessary at this point of the research, and can be acquired through rapid training of the agents, inserting them in workshops and webinars on the subject, besides reading related articles, to acquire the minimum knowledge on the subject.

A survey must be made of the intelligent practices adopted for each of the components cited in the ports chosen as reference, and thus have them as a parameter for the subsequent section, which addresses the current state of the port to be worked on.

4.4 CURRENT STATE

As analyzed in the bibliographic survey about smart ports, it is of utmost importance to know the state of intelligence adoption in which the port finds itself, so this can be the starting point for the achievement of the desired state. Thus, in the current stage, the port must investigate its level of adoption of the intelligent practices selected in the previous stage, in order to understand which components are initially more lacking in "intelligence", and thus begin the work of implementing these.

Among the most recurrent methods cited in the bibliographic survey on roadmaps for this purpose, the maturity level analysis was the most present methodology in the analyzed articles. Thus, its use is recommended for determining the current degree of intelligence of the port or terminal, since the definition of maturity model can be understood as a conceptual structure that, through its parts, defines the stage of development of a given study area (SANTOS and MARTINHO, 2019).

4.5 TOOLKIT

To provide the implementation of smart practices desired by the port or terminal, the toolkit needed for this action must be determined. Within the toolkit will be inserted the necessary structure, initially in a generalized way, for the application of the practice in question.

As an example, for the insertion of the smart practice related to the use of solar energy within the Energy component, one of the toolkits required is the use of solar panels. The same will be true for all the smart practices inserted into the seven smart components. In order to have the toolkit as faithful as possible to reality, the determination of these tools should occur through consultation with experts in each area related to the practice worked on.

4.6 IMPLEMENTATION LEVEL

Smart practices must be classified between basic, intermediate and advanced levels of intelligence, and this subdivision may also occur within the same practice, since it can be implemented in stages. In other words, a port/terminal may implement solar energy initially only for use in its internal facilities, which characterizes a basic level of adherence, and in the future, when adhering to use in its external facilities, it may configure an intermediate or advanced level of implementation, according to the percentage of adherence.

The subdivisions should be related to the level of intelligence that the adoption of the practice in question will confer to the port, i.e., the set of basic level practices of intelligence will confer the minimum structure necessary for recognition as a port that is beginning the process of becoming smart. Such practices will be selected taking into consideration those that every smart port has and classifies as indispensable, besides being present also in harbors that are already implementing intelligence but are not yet considered smart.

The set of intermediate-level practices will confer consistency in the process of intelligence adoption to the port and external recognition. In other words, by implementing the intermediate level practices, the port becomes an initial reference for ports seeking to start the process of intelligence adoption and is on its way to becoming a smart port. These practices will be selected taking into consideration those that reference smart ports classify as not urgent in a first moment, but necessary.

The set of advanced level practices, on the other hand, will confer recognition as a de facto smart port. Thus, by implementing the advanced level practices, the port/terminal becomes a reference in that component implemented for ports of all levels of intelligence adoption. These practices will be selected taking into consideration those that intelligent reference ports/terminals have adopted last or that are still in the process of adoption, as well as practices that have not yet been adopted by any of them but are being studied and will contribute to their modernization.

Finally, the analysis of the intelligence level of the components can occur in an indirect way, analyzing through the ports' websites and articles the components already implemented, or in a direct way, through questionnaires, interviews or visits to the reference ports.

4.7 IMPLEMENTATION DEADLINE

The implementation deadlines for each practice must be classified as short, medium, and long. This subdivision may also occur within the same practice, as in item 4.6, so that it is implemented in stages, which may occur in different periods or simultaneously.

Such deadlines should be determined from the analysis of the time it took each reference port to fully implement each practice to be consolidated. It is recommended to analyze the implementation time of the smart practices of at least 3 reference ports, to consider external differences that may cause changes in times, such as previous structure of the port and its location, for example. After the survey of implementation times, one can have as a basis the period needed to be classified as short, medium and long, and thus determine to which subdivision each practice belongs.

4.8 IMPLEMENTATION COST

The implementation cost of each smart practice should be classified between low ($), medium ($$) and high ($$$) levels, and this subdivision may occur within the same practice, so that it can be implemented in stages for different costs.

The implementation costs should be determined from market research with suppliers, manufacturers and labor involved in each smart practice. In addition, one can also consider the contribution of ports in providing information about the costs spent by them in the implementation of their smart practices. Therefore, after surveying the costs, one can have as a basis the amount needed to be classified as low, medium, or high, and thus classify the practices among the 3 subdivisions.

4.9 STAKEHOLDERS

From the beginning to the end of the implementation of the selected practice, a several people are involved. Initially there is the involvement of experts for the planning and monitoring of the process, of partners from universities to strengthen quality scientific research, of employees for the execution, of companies to materialize the structure of some practices, and of investors to provide that the process occurs.

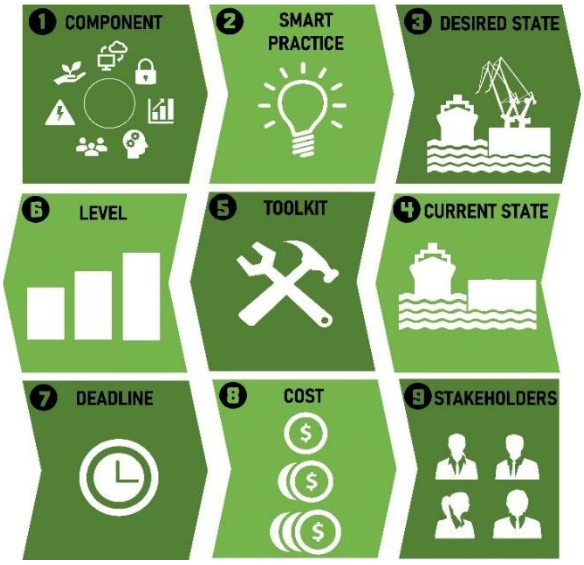
Thus, for each intelligent practice, the stakeholders involved must be selected, in order to facilitate planning and to ensure that the entire structure of people necessary for the application of intelligence is present.

4.10 ROADMAP STRUCTURE

Thus, in order to illustrate the steps involved in the application of intelligence, the steps of the roadmap are illustrated in Figure 4, and it is essential that the port or terminal applies it in the presented order.

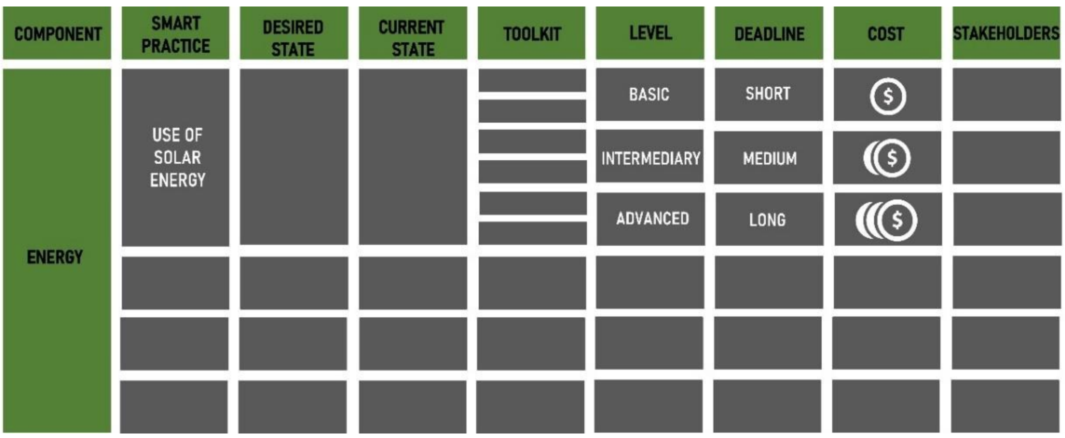
Thus, through the guidelines provided in items 4.1 to 4.9, the port or terminal will fill in the roadmap provided in Figure 5 in order to complete the gaps still missing for each of the seven components of a smart port, according to its reality and needs.

Figure 4 - Roadmap stages



Source: Authors (2021).

Figure 5 - Roadmap structure



Source: Authors (2021).

5 CONCLUDING REMARKS

Given the great importance of maritime transportation in world trade, it is necessary that ports/terminals constantly evolve and modernize in order to remain competitive in the global arena. Thus, the present work intended to propose an organized roadmap so that this evolution can be facilitated and guided. We hoped to define the steps that make up the roadmap and present them in an organized way so that, in a future study, they can be detailed and deepened.

It is important to emphasize that the current work is the product of a bachelor thesis, and it configures a roadmap model proposal and thus, it is recommended to be applied in at least one port/terminal as a pilot project to evaluate its execution. Likewise, it is suggested as an expansion of this study, to advance in the detailing of intelligent practices and toolkits, since the constant advancement of technologies brings up recurrent novelties that can be implemented by harbors and terminals in the process of becoming intelligent.

It is also suggested that a project tracking tool be developed so that the progress of the roadmap can be monitored.

REFERENCE

Agência Nacional de Transportes Aquaviários (ANTAQ). **O Índice IDA**: índice de desempenho ambiental para instalações portuárias. Índice de Desempenho Ambiental para Instalações Portuárias. 2016. Disponível em: http://portal.antaq.gov.br/wpcontent/uploads/2016/12/O_Indice_IDA_Indice_Desempenho_Ambiental_Instalacoes_Portua rias.pdf. Acesso em: 13 mai. 2021.

ATTIA, Tarek Mohammed. Importance of communication and information technology and its applications in the development and integration of performance in seaports. **Renewable Energy and Sustainable Development**, [S.L.], v. 2, n. 2, p. 137-146, 30 jun. 2016. Arab Academy for Science, Technology, and Maritime Transport (AASTMT). http://dx.doi.org/10.21622/resd.2016.02.2.137.

BOTTI, Antonio; MONDA, Antonella; PELLICANO, Marco; TORRE, Carlo. The re-conceptualization of the port supply chain as a smart port service system: the case of the port of Salerno. **Systems**, v. 5, n. 2, p. 35-35, 23 abr. 2017.

CHEN, Jihong; XUE, Kai; YE, Jun; HUANG, Tiacun; TIAN, Yan; HUA, Chengying; Zhu, Yuhua. Simplified neutrosophic exponential similarity measures for evaluation of smart port development. **Symmetry**, v. 11, n. 4, p. 485, 3 abr. 2019.

COMISSÃO ECONÔMICA DA AMÉRICA LATINA E CARIBE. **América Latina y el Caribe:** la industria de terminales portuarias y los indicadores de actividad del año 2019. 2020. Boletim 380. Disponível em: https://www.cepal.org/sites/default/files/publication/files/46008/S2000560_es.pdf. Acesso em: 24 abr. 2021.

COMISSÃO ECONÔMICA DA AMÉRICA LATINA E CARIBE. **La calma antes de la tormenta:** comportamiento del movimiento de contenedores en los puertos de América Latina y el Caribe en 2019 y de los principales puertos durante los primeros meses de 2020. 2021. Disponível em: https://www.cepal.org/sites/default/files/publication/files/46417/2020_informe_portuario_2019_v.pdf. Acesso em: 24 abr. 2021.

CONFERÊNCIA DAS NAÇÕES UNIDAS SOBRE COMÉRCIO E DESENVOLVIMENTO. **Informe sobre el transporte marítimo 2019**. 2019. Disponível em: https://unctad.org/system/files/official-document/rmt2019_es.pdf. Acesso em: 24 abr. 2021.

DA SILVA, Maurício R. F.; DE SOUZA, Nicollas L. S.; RODRIGUEZ, Carlos M. T.; FRAZZON, Enzo M. Logística Portuária: Revisão Sistemática de Literatura utilizando o método PRISMA. In: SIMPÓSIO DE ENGENHARIA DE PRODUÇÃO, 27., 2020, Bauru. **[Anais ....]** Bauru: UNESP, 2020. Disponível em: https://simpep.feb.unesp.br/anais_simpep.php?e =15.

DOUAIOUI, Kaoutar; FRI, Mouhsene; MABROUKI, Charif; SEMMA, El Alami. Smart port: design and perspectives. *In*: **Proceedings of 2018 4Th International Conference On Logistics Operations Management (Gol). 4,** p. 1-6, Le Havre: IEEE, 2018.

DURÁN, Claudia; CÓRDOVA, Felisa M.; PALOMINOS, Fredi E. A conceptual model for a cyber-social-technological-cognitive smart medium-size port. **Procedia Computer Science**, v. 162, p. 94-101, 2019.

EDELMANN, Noella; MERGEL, Ines. Co-Production of Digital Public Services in Austrian Public Administrations. **Administrative Sciences**, [S.L.], v. 11, n. 1, p. 1-21, 27 fev. 2021. Disponível em: http://dx.doi.org/10.3390/admsci11010022. Acesso em: 17 Ago. 2021.

ENDEAVOR. **A bússola para desenvolver seu produto ou projeto.** [S.L]. 2015. Disponível em: https://endeavor.org.br/estrategia-e-gestao/roadmap/. Acesso em: 19 abr. 2021

FACILITACIÓN, COMERCIO Y LOGÍSTICA EM AMÉRICA LATINA Y EL CARIBE. **Informe Portuario 2020:** el impacto de la pandemia del COVID-19 em el comercio marítimo, transbordo y *throughput* de los puertos de contenedores de América Latina y el Caribe. 2021. Disponível em: https://repositorio.cepal.org/bitstream/handle/11362/46979/1/S2100302_es.pdf. Acesso em: 14 abr. 2021.

FUNDACIÓN VALENCIAPORT. **Smart ports manual:** strategy and roadmap. 2020. Disponível em: https://publications.iadb.org/en/smart-ports-manual-strategy-and-roadmap. Acesso em 29 mai. 2021.

FRANCISCHINI, Andresa S. N et al. **Indicadores de desempenho**: dos objetivos à ação - métodos para elaborar KPIs e obter resultados. Rio de Janeiro: Alta Books, 2017. 435 p.

GARÍN, Miguel. **0:00 / 1:49:32 Webinar Puertos Inteligentes y Nuevas tecnologías.** 2020. Disponível em: https://www.youtube.com/watch?v=DHmeGRAXZks. Acesso em: 30 Mai. 2021.

GORGES, Suzane C. **Smart Ports: Caracterização e investigação da implementação de práticas inteligentes em portos e terminais brasileiros**. 2021. 167 f. TCC (Graduação) - Curso de Engenharia Naval, Centro Tecnológico de Joinville, Universidade Federal de Santa Catarina, Joinville, 2021.

GORGES, Suzane C.; SILVA, Vanina M.D. MODERNIZAÇÃO PORTUÁRIA: O ESTADO DA ARTE SOBRE PORTOS INTELIGENTES. In: Congresso Internacional de Desempenho Portuário, 7., 2020, [S.L.], **Anais [...].** p. 696-713.

HEILIG, Leonard; LALLA-RUIZ, Eduardo; VOß, Stefan. Digital transformation in maritime ports: analysis and a game theoretic framework. **Netnomics:** Economic Research and Electronic Networking, [S.L.], v. 18, n. 2-3, p. 227-254, dez. 2017. Springer Science and Business Media LLC. http://dx.doi.org/10.1007/s11066-017- 9122-x.

KARAS, Adrianna. Smart port as a key to the future development of modern ports. Transnav**, The International Journal On Marine Navigation And Safety Of Sea Transportation**, v. 14, n. 1, p. 27-31, mar. 2020

KUMAR, Aalok. Transition management theory-based policy framework for analyzing environmentally responsible freight transport practices. **Journal of Cleaner Production**, [S.L.], v. 294, p. 126209-126209, abr. 2021. Elsevier BV. Disponível em: http://dx.doi.org/10.1016/j.jclepro.2021.126209. Acesso em 10 Ago. 2021.

MONTIBELLER, Gilberto. **0:00 / 1:33:16 Inovações na análise de cenários e gestão de risco**. 2020. Disponível em: https://www.youtube.com/watch?v=K72MJPOI9HI. Acesso em: 03 Jan. 2021.

OZTURK, Metin; JABER, Mona; IMRAN, Muhammad A. Energy-Aware Smart Connectivity for IoT Networks: enabling smart ports. **Wireless Communications and Mobile Computing**, [S.L.], v. 2018, p. 1-11, 28 jun. 2018. Hindawi Limited. http://dx.doi.org/10.1155/2018/5379326.

PIANC. '**Sustainable Ports' A Guide for Port Authorities**. 2014. Disponível em: https://sustainableworldports.org/wp-content/uploads/EnviCom-WG-150-FINALVERSION.pdf. Acesso em: 24 jul. 2020.

ROJKO, Andreja. Industry 4.0 Concept: background and overview. **International Journal Of Interactive Mobile Technologies (Ijim)**, v. 11, n. 5, p. 77-90, 24 jul. 2017.

SAKTY, Khaled Gaber El. Smart Seaports Logistics Roadmap. **Renewable Energy And Sustainable Development**, [S.L.], v. 2, n. 2, p. 91-95, 30 dez. 2016. Disponível em: http://dx.doi.org/10.21622/resd.2016.02.2.091. Acesso em: 4 Abr. 2021.

SANTOS, Reginaldo Carreiro; MARTINHO, José Luís. An Industry 4.0 maturity model proposal. **Journal Of Manufacturing Technology Management**, [S.L.], v. 31, n. 5, p. 1023-1043, 9 dez. 2019. Http://dx.doi.org/10.1108/jmtm-09-2018-0284.

SARI, A. Y.; PAMADI, M. The Smart Port Concept of Batu Ampar Port in Batam. In: IOP CONF. SERIES: EARTH AND ENVIRONMENTAL SCIENCE, 343., 2019, Bristol. **IOP Science**. Bristol: Iop Publishing Ltd, 2019. p. 10-10. Disponível em: https://doi.org/10.1088/1755-1315/343/1/012095. Acesso em: 01 jun. 2020.

SCHUMACHER, Andreas; NEMETH, Tanja; SIHN, Wilfried. Roadmapping towards industrial digitalization based on an Industry 4.0 maturity model for manufacturing enterprises. In: CIRP CONFERENCE ON INTELLIGENT COMPUTATION IN MANUFACTURING ENGINEERING, 12., 2018, Gulf Of Naples. **Proceedings [...]**. [S.L.]: Elsevier, 2019. 6 p.

SHUO, Chen, JIAN, Wang; RUOXI, Zhao. The analysis of the necessity of constructing the Huizhou. *In:* INTERNATIONAL CONFERENCE ON INTELLIGENT TRANSPORTATION, BIG DATA & SMART CITY (ICITBS), 19., 2016, Rio de Janeiro. **Proceedings [...]**. Piscataway: IEEE, 2016. p. 159-162.

WANG, Lei; LIU, Zhengchao; LIU, Ang; TAO, Fei. Artificial intelligence in product lifecycle management. **The International Journal of Advanced Manufacturing Technology**, [S.L.], v. 114, n. 3-4, p. 771-796, 22 mar. 2021. Springer Science and Business Media LLC. Disponível em: http://dx.doi.org/10.1007/s00170-021-06882-1. Acesso em 9 Ago. 2021.

WORLD BANK GROUP. **Global economic prospects january 2021**: heightened tensions, subdued investment. Washington: World Bank Group, 2021.

WU, Yunjian*;* XIONG, Xiaoting; GANG, Xiong; Nyberg, Timo R. Study on inteligent port under the construction of smart city. *In:* **Proceedings** of 2013 IEEE INTERNATIONAL CONFERENCE ON SERVICE OPERATIONS AND LOGISTICS, AND INFORMATICS. p. 1-5. Dongguan: IEEE, 2013. Disponível em: https://ieeexplore.ieee.org/document/6611405. Acesso em: 28 abr. 2021.

ZHANG, Lu; ZHAO, Junjie; SHOU, Youping; WANG, Ning; QIAO, Jianzhe; TIAN, Mingjing. The construction strategy and measures for ecological analysis of China's ports. **Iop Conference Series**: Earth and Environmental Science, [S.L.], v. 133, p. 012027, abr. 2018. IOP Publishing. http://dx.doi.org/10.1088/1755- 1315/133/1/012027.