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Ships of the future. Autonomous and intelligent.

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ABSTRACT

In this article we want to give an insight into what is going to be the future of maritime navigation. We will start the article by describing the concepts we are going to work with, i.e. what is an autonomous vessel and what is an intelligent vessel. We will discuss their main differences, advantages and disadvantages. Subsequently, we will talk about the regulations surrounding these vessels, both national and international, and how they have been evolving according to what has been developed around these new types of vessels. We will see the classification given to these vessels according to the number of crew and how autonomous the vessel is. In addition, we will also mention how classification societies classify these types of ships and we will make a small comparison with what each of these societies establish. Finally, we will present some examples of autonomous and intelligent ships that have set sail and what experience we can draw from these first autonomous and intelligent ships.

1. Introduction.

Human beings have sailed since the beginning for different reasons, to trade, to fish, to defend territories... Navigation has evolved significantly since the beginning, from the first wooden boats propelled by oars or sails, to the era of modern steel ships propelled by engines.

The latest milestone in this evolution has been the move towards autonomous ships. Autonomous and intelligent ships have revolutionised the way in which navigation is conceived, allowing the operation of the ship with little crew on board in some cases or without the need for a crew on board and on the other hand ships controlled remotely by humans or autonomous ships (without any human presence or intervention).

To start talking about autonomous and intelligent ships, we must first define the concepts we are going to work with, establish what their beginnings were and, finally, we will see the main differences between the two, basing ourselves as far as possible on real examples of this type of ship. We will also make a brief outline of some of the classifications of this type of ship and the current information regarding their regulations or the moment in which they are being studied.

We will begin our journey with the evolution of autonomous vessels from their beginnings to the present day and to do so we will start by explaining what the abbreviations that define this type of vessel "MASS" mean: Marine Autonomous Surface Ship. [1]

The term "MASS ship" refers to an "autonomous mobile surface system" (Marine Autonomous Surface Ship, which is the name given to this type of ship). It is used to describe a type of autonomous vessel that moves on the surface of the water. The term began to be used in the context of research and development of autonomous ships in countries such as the United States and the United Kingdom, where projects and programmes for the development and implementation of MASS ships were initiated. The exact definition of what is considered a MASS vessel may vary depending on the context and the defining organisation. However, in general, a MASS vessel is considered to be an unmanned autonomous vessel capable of performing specific missions. Among the functions that such vessels could undertake are coastal surveillance, environmental monitoring or scientific research. There is no standard definition or specific regulation for MASS vessels at present. However, it is expected that regulations and standards for autonomous vessels will soon be defined by the various agencies

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and stakeholders with the capacity to determine and implement this new way of surface navigation. The acronym MASS as we have described it clearly leaves out submarines.

In this approach to the vision of autonomous and intelligent ships, we cannot ignore the regulations that must accompany any change that takes place and, in our case, in navigation systems. The International Maritime Organisation (hereinafter IMO) has an arduous task ahead of it. It has to review all the Regulations and Navigation Codes, all the regulations affecting maritime navigation, crews and ports. This involves analysing current and future conditions and a working team has been set up for this purpose. Also in Spain, a Commission for the Merchant Navy has been created within the Ministry of Transport, Mobility and Urban Agenda to carry out this analysis applied to our country.

All these studies should lead to the training of current seafarers and the necessary academic content in future curricula.

Figure 1: ¿Es lo mismo un buque autónomo que uno inteligente? Fundación Exponav en Ferrol [2].

Source: Caro, R. V. (2018, October 26).

2. Objectives.

The objectives we pursue with the development of this article is to show what will be the future of maritime navigation with the use of autonomous and intelligent ships. We will look at the concepts of autonomous and intelligent ships and the difference in concept between the two. We will cover aspects of the regulations and the proposals that exist regarding the classification of autonomous and intelligent ships. In the next section, we will discuss some particular cases of this type of vehicles due to their relevance in the future of autonomous navigation. We will end with some conclusions, shared by other researchers consulted.

3. Development.

We will begin by defining the concepts that we will need in order to be able to carry out a proper and accurate reading of the contents of this article.

An autonomous vessel is a ship capable of operating and performing tasks without the need for a human operator on board. This type of vessel can be fully autonomous or partially autonomous, which means that they can be controlled remotely.

Autonomous vessels use advanced technology such as artificial intelligence, satellite navigation, automation, data analysis and connectivity to optimise performance, improve efficiency and reduce costs. They are vessels that are equipped with sensors and assisted by robotics to perform any type of task inherent to the vessel, from navigation to loading and unloading.

Autonomous vessels offer advantages in terms of efficiency, safety and cost compared to manned ships, as they do not require accommodation and food for the crew, nor do they require space for safety equipment. However, they also present new challenges and concerns, such as the need to maintain information security and the ability to respond to emergencies in real time. But we will also have to take into account, as Professor Raúl Villa points out in his article ”The study of autonomous, intelligent and sustainable surface ships: the extinction of crews on ships”, in which he suggests that we will have to be attentive to the ”laytime” (time needed to be berthed) in which daily maintenance tasks must be carried out, and if possible with greater rigour than in unmanned ships, so that unforeseen events do not arise. [3]

These vessels may be autonomous, or manned, but in either case, they are designed to take full advantage of available technologies to perform tasks more safely and efficiently.

Some of the features of smart ships are:

- Advanced navigation systems that use real-time data to optimise routing and reduce costs.
- They are equipped with sensors and remote monitoring that allow operators to monitor and control the vessel's performance from anywhere in the world.
- They are predictive maintenance systems that use data analytics to detect problems before they occur and schedule repairs more efficiently.
- Another feature is that they are collaborative platforms that allow crew and shore operators to share information and make decisions more effectively.

Some added benefits of smart ships are to improve safety, reduce costs as mentioned above and increase sustainability by reducing greenhouse gas emissions through the application and implementation of new, less polluting propulsion systems.

Differences between autonomous and intelligent ships

The main differences between autonomous and intelligent vessels lie in their decision-making capabilities and their degree of autonomy.

Autonomous ships are able to operate and perform tasks without the need for humans on board. They use advanced technologies such as artificial intelligence, satellite navigation, sensors and robotics. In this sense, they help, if in cooperation with the human operator, in navigation tasks, loading and unloading, inspection of certain elements arranged with sensors, and can even repair underwater infrastructures. They may also be suitable for scientific missions to monitor marine species, water pollution and a long etc. yet to be explored. Today's autonomous vessels can be designed to operate with or without human intervention, either directly or indirectly and from within or remotely from land.

Smart ships use artificial intelligence, automation from data analysis and connectivity to optimise their performance. It can improve efficiency and reduce operational costs. In the case of smart vessels, they can make decisions based on real-time data analysis and pre-programmed algorithms to determine the best course of action in the event of incidents or unforeseen events. If these are pre-determined situations, it will allow the system to take action and make decisions more quickly and accurately. We insist that this will be as long as it is previously programmed and in an appropriate manner.

In summary, the main difference between an autonomous and an intelligent vessel lies in its decision-making capacity and its degree of autonomy.

Figure 2: Autonomous vessels.

Source: imo.org [4].

3.1. *Brief history and origin of autonomous ships.*

To talk about the origin of ships, submarines or unmanned vehicles, we could go back to the early years of the last century. Around 1910, US Navy engineers began experimenting with the first elements designed to operate autonomously at sea: torpedoes. Originally, torpedoes used gyroscopes to maintain a constant course. Torpedoes were powered by internal combustion engines and guided by cables. From the 1930s onwards, we can begin to see autonomous torpedoes that could follow a predetermined course without the need for the guide wires they had previously required. There is no doubt that the study and improvement of tactical weaponry by the United States and later by other countries led to technological improvements in autonomous weaponry, such as torpedoes, which would later be applied to other scientific and civilian uses. An example is the use of autonomous torpedoes (equipped with sensors and other technologies) for the oil industry from the 1950s onwards.

Unmanned underwater vehicles (UUVs) were developed in the 1960s as a response to US military needs during the Cold War. These early UUVs were primarily used for reconnaissance missions and the exploitation of underwater areas that were dangerous for divers.

Originally, these vehicles were relatively simple, with limited range and limited autonomous operational capability. However, the ability to operate in hostile and dangerous locations and to remain in the water for long periods of time is noteworthy. This last aspect is one of the determinants for their use as a valuable tool for underwater exploration and research.

There was an awakening towards exploration in the use of this technology applied to autonomous underwater vehicles with a wider range and projection. It was also in the 1960s that the first autonomous submarines, equipped with cameras and sensors, began to be used to map the seabed, as well as to measure other factors to be studied. In this case, the vehicles were connected either to a ship by a cable or to another submarine.

It was in the 1970s that the first autonomous battery-powered underwater vehicles began to be manufactured. From this moment on, other more civilian and research uses began to be given to this type of vehicle, such as for the search and recovery of objects and vessels from the seabed or the study of marine fauna and flora. Another example is the first expedition organised with autonomous battery-powered submarines to recover the first remains of the Titanic.

The next step in the evolution of autonomous marine systems were drones prepared to carry out their activity in the sea. The evolution of this vehicle system received a major boost in 1990 with the development by the US Navy of autonomous maritime drones (USV), which were used for reconnaissance and surveillance of its maritime space. Designed for the purpose of reconnaissance and surveillance of coastal areas, they were equipped with sensors and cameras that could detect and collect information about the marine environment, relaying this content to servers on land that would subsequently analyse the data captured. Gradually, USVs became more sophisticated and a wide variety of applications were implemented that provided other functionalities and uses, in addition to those described for the search for ships or submerged objects, for the rescue of boats and people. As drones evolved, their dimensions and functionalities increased with the incorporation of equipment for measuring all kinds of factors, as well as improving the necessary load capacity to support all these elements and tools that would allow the extraction of elements from the seabed. These larger drones are known by their acronym ASV.

It is not surprising that from these first approximations of human-unmanned vehicles (drones), technology continued to evolve towards the search for solutions for surface navigation using autonomous vessels. Later on, we will talk about the first autonomous submarine "Papa Mau" manufactured in 2010 by the American company Liquid Robotics, which made the crossing of the Pacific without a crew, container barges or the case of the Mayflower.

3.2. *Classification of autonomous vessels.*

There are several classification societies in charge of certifying the safety and efficiency of ships, including autonomous ships. Specific rules and guidelines need to be defined in relation to autonomous vessels, their construction, navigation, safety and other aspects that are analysed in an equivalent way for traditional vessels.

Among the most important classification societies that have carried out a classification and definition of autonomous vessels are: Det Norske Veritas (DNV), Germanischer Lloyd (GL) which has developed a classification framework of its own and based on existing industry standards, the Lloyd's Register which has carried out the classification known as the "Autonomous Design Code", the American Bureau of Shipping (ABS) or Bureau Veritas.

In 2018, the first international conference on sustainable ships was held, at which the research that had been carried out up to that point was made known.

Since we are facing a new technology and a new model of navigation, different organisations and societies are working on the definition of an appropriate classification of autonomous and intelligent ships. Each one of them, starting from more or less the same general principles, calls each of the levels in a different way.

Each vessel to be defined as autonomous must be assessed individually. In order to determine the level at which it should be classified, not only its level of mechanical and navigational autonomy should be taken into account. Emphasis should be placed on the assessment of other objective factors such as safety, resilience and the ability to adapt to unforeseen situations, among others.

In 2017, the Unmanned Marine Systems Code was released, establishing guidelines for the design, construction and maintenance of autonomous vessels. Among other elements, factors such as structure, stability, control and electrical systems, as well as manoeuvring and navigation systems or propulsion and auxiliary systems are considered.

The first classifications were rather elementary, without wishing to detract from the beginnings of these definitions. Some referred to conventional, intelligent or autonomous vessels. Others classified ships as having automated processes, remotely controlled ships with crew on board, remotely controlled ships without crew on board and fully autonomous ships. Inevitably, the development of research and technological improvements has made it necessary to broaden and better specify the definitions in the classification of these vessels as well.

With regard to the initial classification of MASS, there are four levels, in the definition given by the IMO, based on and respecting the content given therein, we would like to highlight the participation or not of the human factor:

- Ships with crew on board to operate and control the system and functions on board, where there may be automated processes, but there is human support in decision making and control.

- Ships with few crew on board and operated remotely, but with seafarers on board willing to take control.

- Ships with no crew on board and managed and operated from shore.

- Vessel with no crew on board, no human interaction, fully autonomous and the on-board system making decisions on its own.

This IMO Committee undertook an extensive and rigorous study, not only of aspects of the SOLAS Convention, the COLREG, etc., but also of the regulations affecting cargoes of all types of goods. Among the clarifications to be carried out was the clarification and definition of the meaning of the figure or term of Master, crew or responsible person. [5]

With the new rules, some of the shipping related societies have proposed autonomous ship classification systems.

Lloyd's Register (LR) is one of these societies and in 2017 carried out a study of this type of vessel, as did Bureau Veritas, and proposed a definition of classification of vessel autonomy levels. This classification defines six levels of ship autonomy, from 0, which implies no automation, to 5, which is fully autonomous, as we will see below. The name of this classification is the "Unmanned Marine Systems Code", published in 2017, which aims to describe what should be applied to the design, construction and maintenance of autonomous ships [6].

This classification can serve us as a reference to know and understand the scope of what we are talking about in each of the levels of autonomy in navigation, both with respect to the human part and the technological part, It includes elements such as the capacity for autonomous navigation and the ability to avoid collisions, as well as decision-making, which are very important factors for maritime safety.

But we will not stay only with these, but we also want to provide the one provided by Professor Raul Villa Caro of the University of A Coruña, who in an interview on Cope + Galicia on 30 October 2018, exposed the classification that he would make of the MASS and it is as follows: Intelligent ships with reduced crew, Remotely controlled ships (drone type) and Fully autonomous ships (for a future). [2]

3.3. Lloyd's Register definition of levels together with the compendium of other given classifications of similar content.

- Level 0: No automation, which implies that the vessel is completely controlled and operated by the human crew, under the direction of the master. Lloyd's Register defines this level as AL 0: Manual (other classifications refer to it as manual steering) which is where the operator is on board and navigation is manually controlled.

- Level 1: Partial assistance of the vessel, which may include automated systems that can assist the crew in specific tasks, such as propulsion control or navigation. The Lloyd's Register AL 1 On board decision support (defined by others as on board decision support) defines this level as a ship with an operator on board who, aided by sensors on board, and based on different parameters and programme references, enters speed and route values in the form of waypoints, and can modify speed and course if necessary manually.

- Level 2: Remote control. The vessel has automated systems that can control some functions remotely, but has crew on board to intervene if necessary. In the case of AL Level 2 On &Off-board Decision Support, it is for

Lloyd's Register classification as an external, remote system that is able to enter a new route. In this case it is also envisaged that the operator can act if necessary to modify course and speed.

- Level 3: Vessels that have limited automation. That is, the vessel is capable of operating autonomously under certain predefined conditions. This level still maintains crew on board and can take control of the vessel at any time. For Lloyd's Register classification, it defines AL level 3 Activ' Human in the loop, (as execution with human operator approving). The operator approves the system's proposals, which are based on the information transmitted by the ship's sensors.

- Level 4: In the definition of high automation, the vessel is able to operate autonomously in most situations and the operator performs supervision and decision making for contingencies, etc. At this level, we have to indicate that Lloyd's Register defines the next level as AL 4 Human on the loop, Operator/Supervisory (defined by others as execution with human operator who could intervene) and for Lloyd's Register the level where operational and navigational actions are calculated automatically by the system, but are executed only when approved by the operator. This operator does not need to be present on the ship, but can carry out the actions from shore and intervene if necessary remotely.

- Level 5: Fully autonomous vessel, which is a vessel capable of operating autonomously in all possible situations and without crew on board. At this level of autonomy, Lloyd's Register distinguishes two sub-levels:

- For AL level 5, Fully autonomous (but which is defined by other classifications as partial autonomy). The system performs all operational and navigation calculations. It is able to resolve the risks of situations and is supported by sensor information that is interpreted by the system and performs calculations on the actions to be taken. If doubts arise in a specific situation regarding the interpretation of information and data, it is the operator (who can be on board or on the ground) who acts and defines how the situation should be resolved.

- AL 6, fully autonomous, (defined by others as total autonomy), is for Lloyd's Register where the system is the one that makes the decisions about navigation and the operations to be carried out, being able to assess risks and analyse the consequences in order to resolve incidents. In this case, we assume that the operator is on the ground and will only intervene if the solution proposed by the system is not safe, but there is no human involvement in navigation. [1]

In summary, classification societies for autonomous vessels play a crucial role in the safety and efficiency of these vessels at sea. Their rules and guidelines are fundamental to ensure that autonomous vessels meet the safety and efficiency standards necessary for their operation.

This technology can be applied to all types of vessels, from goods transport vessels, fishing boats, pleasure boats, etc., each with its own characteristics and particularities in terms of their use, dimensions and routes, which must be perfectly regulated.

On the other hand, in this globalised world in which we live, standards are necessary and they must be commonly accepted and applied by all. The rules of the game must be the same in order to avoid problems, while at the same time allowing a greater transaction of human and material assets between all countries.

4. Regulations.

As we have indicated above, reality is ahead of the norm. Research has led us to the development of a type of autonomous surface vessel (MASS) that currently lacks complete regulation, but which is already being worked on by all international organisations and also in Spain.

4.1. International regulation.

In 2018, work began on the analysis of existing regulations by a commission created by the IMO, with the aim of developing a regulatory framework for the safe and efficient operation of these ships for the future. Work is underway to identify the problems and risks associated with these types of ships and their navigation, as well as to develop solutions. First standards and recommendations for autonomous and intelligent ships have already been established. The study covers issues related to cybersecurity, data maintenance and management, and the integration of smart technology into safety systems and the environment.

In 2018, the IMO got down to work and set up a first group to study everything related to MASS. It had to start with an initial assessment of all types of regulations and standards, such as SOLAS regulation III/17-1 (which deals with the rescue of persons at sea), as well as regulation V/19.2 of the same convention (which contains the carriage requirements for on-board navigation equipment and systems). The study and adaptation of Regulation 10 of the Load Lines Convention, on information to be provided to the master, should also be carried out. Many other aspects and contents of the SOLAS Convention will have to be reviewed, as well as other regulations currently in force to adapt them to the new technologies, such as the COLREG rules, the sea watch conventions (STCW), UNCLOS Convention, MARPOL, without forgetting everything related to new maintenance required by this type of ships, their registers and their regulation in ports (berths, location, etc.).

The first amendments by the IMO were proposed in 2019, adopting amendments to existing international instruments to enable the safe, efficient and environmentally sustainable operation of unmanned autonomous vessels. This included changes to the 1966 International Convention on Load Lines. It is in this year, in June, that Interim Guidelines on the tests that could be carried out on MASS were adopted, the document of which can be found at the following link: INTERIM GUIDELINES ON THE TESTING OF MASSES (https://wwwcdn.imo.org/localresources/es/MediaCentre/HotTopics/Documents/MSC.1-Circ.16-04 - Directrices Provisionales Relativas A Los Ensayos De Los Mass (Secretar%C3%ADa).pdf) [7].

In November 2020, the IMO adopted amendments to the 1974 International Convention for the Safety of Life at Sea (SOLAS). These include guidelines on the testing and approval of autonomous and automated systems on ships. They set out the requirements for the testing and evaluation of autonomous systems, including interaction with the crew and the safety of remote control operation, as well as the operational requirements for these ships.

In 2021, the work of the "IMO Maritime Safety Committee on the Review of the Ship Safety Treaties" was completed. With this work, it was assessed what the next steps would be to define the next steps for autonomous surface ships (MASS)

The Maritime Safety Committee would actually be in charge of the assessment of the safety treaties, while the Legal Committee would deal with all matters related to the treaties.

In April 2022, the Maritime Safety Committee began drafting a document setting out the objectives governing the operation of MASS. The idea is to develop a code on MASS, planned for 2024, with the aim of being operational by 2028. This entire project is part of the organisation's Strategic Plan (2018-2023), which includes the integration of new technologies into the regulatory framework among the issues to be addressed. [4]

4.2. Spanish regulation.

Spain does not yet have specific regulations governing autonomous vessels, although studies are being carried out by universities and specialists in the field. Something similar to what is being carried out by the IMO, but applied to the Spanish case and within the objectives contained in the framework of the Safe, Sustainable and Connected Mobility Strategy 2030.

In 2018, the Interministerial Coordination Committee for the Development of Autonomous Vessel Technology was created. Its aim is to coordinate the necessary actions for the development of this technology in our country and to promote the collaboration of the different bodies and associations involved.

On the other hand, in 2019 the National Working Group on Autonomous Vessels was created and organised by the Directorate General of the Merchant Navy, which published a guide of good practices for the use of autonomous systems on board ships, which establishes the necessary recommendations to guarantee the safety of these systems and their correct integration into the ship.

The requirements and obligations for the operation of ships in Spanish waters, including requirements for crew, safety, environmental protection and pollution prevention, are regulated in Spain by Legislative Royal Decree 2/2011 of 5 September, which approves the Consolidated Text of the Law on State Ports and the Merchant Navy, as well as Law 14/2014, which regulates Maritime Navigation.

Well, these regulations have been modified and approved in part by the Council of Ministers on 1 March 2022, where the changes regarding ports, MASS vessels and other elements must be included in the new Spanish regulations. Autonomous vessels will be included in the new articles of the amendment of the first book of the revised text of the Law on State Ports and the Merchant Navy and the Law on Maritime Navigation. For one thing, the Directorate General of the Merchant Navy is a pioneer in having drafted a Service Instruction for autonomous vessels. In this regulation, reference is made to registration, ship registration, licensing, crewing of autonomous vessels or certification, as well as the incorporation of bunkering as a service in ports. It also includes the approval of ship documentation to bring it into line with the requirements of the international framework and creates the new certificate of registry, replacing the current certificates of registry and navigation licence.

On the website of the Ministry of Transport, Mobility and Urban Agenda, we can read the information regarding the 1st Technical Conference on Autonomous Vessels, held in October 2022, which summarises in headlines as follows:

- "The Directorate General of the Merchant Navy leads the National Working Group on Autonomous Vessels, created in 2020 within the framework of the Safe, Sustainable and Connected Mobility Strategy 2030.

- This same entity has issued a Service Instruction for autonomous vessels, a pioneer in its field, which refers to aspects such as registration, licensing, crewing of autonomous vessels or certification.

- Autonomous vessels will have a specific article in the future Law on the reform of the Consolidated Text of the Law on State Ports and the Merchant Navy and the Law on Maritime Navigation". [8]

We cannot fail to mention the work being carried out by a State Ports commission, which has held meetings with different Public Administrations, several Ministries and consultations with social agents. Alvaro Rodríguez Dapena, President of Puertos del Estado, informs through the website of Puertos del Estado of the progress that has been made from 2018 onwards and which will not culminate until the approval of the general budgets for 2022, in which important aspects are incorporated for the possible implementation of the Strategic Framework. Three dimensions are proposed, 7 action criteria framed in 16 strategic lines for the fulfilment of a total of 56 general management objectives. It is planned to review the fulfilment of the objectives of this Strategic Framework by 2025 and to define what kind of jobs we want in Spain by 2030. It will be necessary to take into consideration the agents involved, the shipping companies, the users and everything involved in the implementation of the transformations. It will be necessary to study the current infrastructures and the changes needed in the future, as well as the requirements of the companies dedicated to and working in this sector. Of course, the challenge of matching people's talents and skills is also a matter of concern. [9]

Figure 3: Autonomous vessels will be subject to the general rules of navigation in Spain.

Source: Palau, J. C. (2022, March 1). elmercantil.com [10].

As mentioned at the beginning of this article, we will name some examples in the evolution of submarines and autonomous vessels.

4.3. Papa Mau submarine.

The first "robotic boat" for which we have data is the so-called "Papa Mau". As a curiosity, the name of this vehicle is in honour of Mau Piailug (Polynesian navigator who participated and helped to revitalise the traditions of navigation in the Pacific islands and the balance between technology and marine exploitation). This autonomous underwater vehicle (AUV) was designed and built by Liquid Robotics (a US company specialising in marine technology). It was launched in 2011 and navigated from San Francisco to Australia without a human crew. It was used to collect environmental and oceanographic data from the Pacific for 365 days. Equipped with a large number of sensors that could measure variables such as temperature, salinity, depth and water speed, it had a satellite communication system that enabled it to identify its location by GPS and transmit data to researchers in real time. The possible uses for this type of vehicle, in addition to all those related to research, include offshore oil and gas exploitation and monitoring.

4.4. Container vessels in Norway.

By 2024, an autonomous (but crewed), all-electric vessel is planned to set sail in Norway, which would mean zero emissions. This first ship is intended to operate between the port of Ekornes, Ikomnes and the port of Alesund, known to serve many of Europe's sea freight ports.

DB Schenker in collaboration with Ekornes and the ship design company Dynamics are working together with the development company Kongsberg (which will be the supplier of the technological part) and Massterly (operator and technical director of the vessel) for the implementation of this project. As for its numerical data, it will be 50 metres long and have a payload of 300 tonnes. Its average speed will be 7.7 knots and it will be able to cover a 43 km route in 3 hours. The next project of this group will be the 100% autonomous container ship, which will have no crew on board and will be controlled from land. We do not yet know the name that will be given to this new ship.

Figure 4: In 2024, an autonomous container ship will start operating in Norway.

Source: worldenergytrade.com [11].

4.5. An example o fan autonomous vessel: The MyFlower.

The origin of the name of this autonomous ship is given in memory of the ship of the same name that transported the first Anglo-Saxon settlers from the United Kingdom to North America. [12]

Its planned functions are aimed at studying marine pollution, monitoring human activity and its impact on the sea, and tracking marine species, in particular aquatic mammals.

Built by a non-profit company ProMare and the collaboration of IBM, the University of Plymouth and the electronics company NVIDIA. To describe it, it is a trimaran weighing 9 tonnes, 15 metres long and fitted with solar panels to ensure it has zero pollutant emissions. It was presented at the Nor-Shipping 2019 conference in Oslo, Norway. [13]

It was scheduled to set sail, after several date changes, on 15 May 2021 for a two-week sailing, but did not. She intended to make the crossing from the United Kingdom (Plyouth) to the port of the same name in the United States, State of Massachusetts.

Figure 5: The captain is a computer: a fully autonomous ship prepares to embark on its first Atlantic crossing.

Source: estamosaqui.mx [12].

Conclusions.

As Raúl Villa Caro, professor at the University of A Coruña, points out, "*Given the imminent arrival of autonomous ships, the question we should ask ourselves is the following: is the maritime world ready for the new vessels to sail our seas?* "He goes on to explain some of the questions we have raised in this article, such as the necessary definition and regulation of MASS by the IMO, which will also have to be regulated in Spain, as well as how to integrate and balance the new technologies and the growing concern for maritime safety, environmental protection and how it will affect personnel on board and on land. [1]

When teaching at university level, we cannot fail to consider what we have outlined in the introduction and throughout the development of this article, and that is the necessary analysis of the training conditions of current seafarers and their necessary adaptation to new technologies, as well as the training of future generations. This analysis should go hand in hand with this and we should consider what kind of training future seafarers should have and what academic content should be incorporated into future curricula in order to adapt them to the reality that awaits our students in the working environment.

On the other hand, we should also reflect on the future as far as human aspects are concerned: can this system of work lead to more stress in human beings, can we be more and more isolated and less connected due to the application and use of these new technologies, what harmful effects can this new way of navigating have, and what are the consequences of this new way of navigating? These are undoubtedly questions that need to be taken into consideration because of their importance.

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