COMMERCIAL MARITIME PORTS WITH INNOVATIVE MOORING TECHNOLOGY.

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5 authors, including:

Emma Díaz
Universidad de Cantabria

Andrés Ortega
Universidad de Cantabria

Lidia Sanchez-Ruiz
Universidad de Cantabria

Beatriz Blanco
Universidad de Cantabria

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Commercial maritime ports with innovative mooring technology

E. Díaz-Ruiz-Navamuel, A. Ortega Piris & C.A. Pérez-Labajos
Members of Ocean and Coastal Planning and Management R&D Group, School of Maritime Engineering, Department Sciences and Techniques of Navigation and Shipbuilding, University of Cantabria, Santander, Spain

L. Sanchez Ruiz & B. Blanco Rojo
Members of Bank and Finances of the Company I+D+i Group, University of Cantabria, Santander, Spain

ABSTRACT: This article is a fundamental part of a doctoral thesis that investigates the best system of automatic tie to install to tie automatically in the port of the Santander in Cantabria (Spain) (Diaz 2016). For the development, the doctoral thesis was necessary to do an exhaustive analysis of the systems that existed on the market to know who was the suitable one to be installed in the port of the study. This presentation is a synthesis of the study realized of the presence in the world of the selected AMS. In this article, a study has been made of the different ports in which the automatic mooring system using vacuum suction cups is installed (AMS). Currently there are 31 ports in which different models of this mooring system are operating. The reasons they have been installed are different but the results are equally good in all cases.

1 INTRODUCTION AND BACKGROUND

For thousands of years, the maritime world has used ropes, cables and lines to moor its vessels. These systems have been reliable and dependable, but now it seems that they are out of synch with the latest developments in the maritime industry, with its continuous improvements in productivity and efficiency.

In the case of container ship and bulk transport terminals, the most common problems are the need for docks with a greater draft, length and storage space, which means that these often have to be constructed in locations which are not sheltered from high tides and strong winds. In order to offset the movements caused by these adverse meteorological conditions, it is cheaper and easier to install these automatic mooring systems using vacuum cups than to construct seawalls

Innovation has taken place in the maritime sector in all areas, including that of mooring systems, though less intensely than in other areas since the conventional system is still used in most ports. At present, some innovative automatic mooring systems are being developed and installed in some terminals (Caro 2014, Díaz et al., 2016).

Until the Second World War, the exploitation and organization of maritime traffic did not change substantially. The loading and unloading operations were slow and laborious. Thus, in the post-war era, with the expansion of the market and the rapid rise in labor costs, the system was put under tremendous stress. Congestion in ports increased and the ingenuity had to be sharpened to seek through innovation in both technology and in processes a response to such problems. (Caro 2014).

The maritime industry responded to the new challenges with two "revolutions" in the two subsectors of maritime transport:

- In non-scheduled traffic through the development of integrated transport systems (bulk carriers)
- In regular lines by grouping together the general cargo by means of the phenomenon of containerization.

All of which led to profound changes being made in commercial seaports in order to respond to these challenges. (Camarero Orive et al. 2011).

As a consequence of these revolutions, new innovations have taken place in the technological as well as the organizational sphere, with the appearance of new means of traffic, new equipment and new methods.

In particular the increase in the production of cars and the incessant need to transport them from the factories to their different points of sale has led to different forms of regular traffic, such as combined train-boat-truck transport, and the need to transport and deliver goods in the shortest possible time and with the lowest costs in order to maximize profits. Subsequently, the possibility arose for using these types of vessels with aft or side ramps not only for the transport of cars but also for Ro-Ro goods and for goods on platform. Hence, it became necessary to construct larger vessels in order to be able to load greater volumes of merchandise and to make other routes.

This innovative process, though it is in advanced stages in the major industrial countries, cannot yet be said to have concluded. (Natarajan, Ganapathy 1997, Natarajan, Ganapathy 1995, Nakamura et al., 2007).

The "AMS" system closed a great technological gap between the vessels and the installations. Prior to it, vessel mooring systems lagged behind the great technological advances made in the marine terminals (Fang, Blanke & Leira 2015).

This AMS is a good solution for RoRo and ferry terminals with RoRo freight, because today the sea plays an increasingly important role in reducing road traffic jams. Good examples are the maritime lines specialized in car transport, which form an integral part of logistics within the global automobile manufacturing chain, and passenger ferries that are mostly employed on short-haul routes where the reliability of the schedules and rapid handling are of vital importance.

As with container ships, RoRo ships and RoRo freight shipping on regular routes have also led to the adaptation of different ports in order to handle this type of traffic. With the increase in the size of vessels, the most important challenge is often safety, both environmental and personal, when the dock space for the ropes is restricted. The AMS is very effective in shortening the stay of ships in port, and allows the terminals to operate in adverse environmental conditions that are sometimes incompatible with the traditional mooring system. (Fang, Blanke 2011).

Container terminals have become a crucial link in today's global economy. They are often the main logistical hub of a broad geographic region that ensures a fluid exchange of consumer goods, raw materials and industrial products. The gains in efficiency and productivity that can be achieved by using automatic mooring systems both on the ship and on land are potentially significant for streamlining the logistics chain. This can have a major impact on the commercial success of container terminal operators and shipping (Jin et al., 2014).

2 AIMS, HYPOTHESES AND METHODOLOGY

2.1 *General and specific aims*

As mentioned above, the conventional mooring system is traditionally used to perform the mooring maneuvers of merchant ships, but a new method of automatic mooring by means of vacuum suction cups (AMS) for merchant ships is currently being developed and installed in different ports.

In this context, the general aim of this paper is to analyze the degree of implantation of these systems and their location in the world.

2.2 *Hypotheses*

The proposed aims are to be reached under the following hypotheses:

- Hypothesis 1: The AMS is increasingly present in ports around the world.
- Hypothesis 2: The AMS has been installed in different types of terminals covering, in each case, quite different needs.

2.3 *Methodology*

To assess the implantation of the automatic mooring system, a complete compilation of general and local information is made to clearly define the objectives of the study (González 2006, Moyano Retamero, 2002). In order to reach the proposed objectives, the following working methodology was proposed in which two parts can be distinguished. (Camarero Orive et al., 2011).

In the first part, the characteristics of the different types of automatic mooring system by vacuum suction cups that can be found on the market are analyzed (Ortloff et al., 1986).

In the second, a study is made of the presence of these types of AMS in the world.

Over the years, several different patents have been developed for automatic mooring systems for merchant and recreational vessels, but the focus of our study is a system with vacuum suction cups whose first registered patent dates from the year 2001 (Hadcroft, J. and PJ Montgomery, 2001), although the system was first used in 1998.

The paper begins by describing the different models of this AMS that are on the market; it then goes on to identify the different types of terminals and docks in which it is installed; and it finsihes by analyzing the data obtained.

3 MODELS OF AMS

The AMS has several different models, depending on the use to be made of it, the power of retention required, the vessels, frequency of use, docks, etc.

These systems can be installed on the ship itself or on the dock.

The Table 1 shows the images of the different models of the Quay Sailor range and the monitoring system.

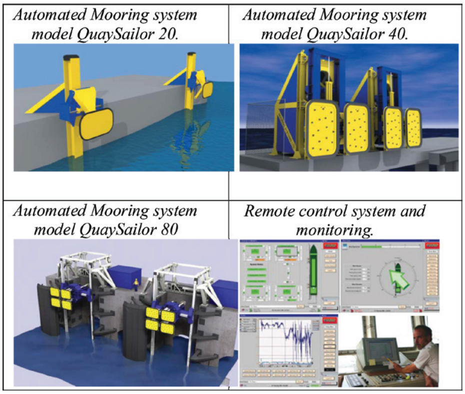


Table 1. Illustrations of the different models of AMS. *Source. http://www.cavotec.com.*

4 DOCKS WITH AMS AND VESSELS THAT USE IT

The system can be used in any type of dock and for any type of vessel. It is currently in use in container terminals, RoRo and passenger and bulk liquids and solids terminals.

4.1 *RoRo and passenger terminals*

Terminals of this type that are already operating with "AMS" allow the docking of larger vessels, without the need for expensive dock extensions, or berthing dolphins or similar. This system is installed in the following terminals:

Port of Picton, First System, New Zealand (1998)
The first AMS ever was used in this port in 1998. The first model that came onto the market was the AMS i-400, and it was installed in the hull of the passenger ferry "Aratere", a ship with a length of 150 meters and 12,000 tons of displacement. The system was used with a frequency of three times per day and made the regular route from Picton to Wellington.

The system consisted of the installation on the hull of four suction cups, with two cups at bow and two at stern, with a power of 20 tons of retention per unit.

The system operated from 1998 to 2009, but since 2003 it has been used simultaneously with a prototype that was installed on the dock, whose description can be fouind in the patent of Montgomery, P. J. and B. J. Rositer. (2002).

Port of Picton, prototype AMS 400, New Zealand (2003)
In 2003, a prototype of the AMS, was installed in the dock of Picton, New Zealand. In this case, a mooring robot of 400 KN was installed on the dock.

The system was also used by the ship, the "Aratere", with a frequency of three times a day. In this case, the operator was Kiwirail Ltd who installed the prototype in 2003 and used it until 2005 when the next model was installed.

Port of Melbourne & Davenport, Australia (2003)
The AMS was installed in these two docks (Melbourne and Davenport) on the edge of the dock. The retention capacity is produced by 4 robots × 400 KN = 160 tons and the frequency of use is of one berth per day.

The AMS technology was first installed in the port of Melbourne for RoRo vessels such as the 149-meter long Searoad Tamar, with 13,697 tons of displacement and the 118-meter Mersey Searoad, with 7,928 tons of displacement.

The units are placed in pairs, one at bow and the other at stern.

Port of Picton, New Zealand (2005)
In the year 2005, the prototype was replaced by the AMS TM 400 model, which is described in the patents of Montgomery, P. J. and B. J. Rositer. (2003), Montgomery, P.J. and B.J. Rositer. (2005). This model is the one that has been installed in the port of Melbourne, Australia, since 2003. In the dock at Picton, two robots with a power of 400 Kn were installed, making a total of 80 tons of power of retention.

Dover, UK (2005)
In June 2005, for the purpose of testing and trialling, installed the world's most powerful automatic mooring unit, the AMS with a holding capacity of 80 tons per unit, in a newly built dock in the port of Dover, in the United Kingdom.

It was installed in the busiest ferry port in northern Europe: Dover Quay 8 is used by Ro-Pax ferries of up to 185 meters in total length.

The high frequency of use of the docks and the conditions of strong winds of up to 60 knots and the height of the waves of up to one meter made it necessary to install an automatic mooring system that could withstand such extreme conditions.

During testing, this AMS successfully completed some 750 mooring operations, demonstrating the efficiency of the AMS automatic mooring system even with large variations in tidal height and extreme environmental conditions.

Ports of Hov and Sælving, Denmark (2009)
In the ports of Hov and Sving in Denmark, the AMS has been installed since 2009. It is also installed on the dock and operates below the edge. The retention capacity produced by the 2

robots × 400 KN. It is used on a dock where the 91-meter long Kanhave ship does the regular Hov-Sælving (Samsø) route.

These ports saw the need to reduce the times used in the maneuvers in order to maximize the regular passenger line between Hov on the mainland of Denmark and Saelvig on the island of Samsø.

The two AMS are installed on the two ports of this line, making maneuvering safer and reducing the number of crew members required for docking or departure, even in adverse weather conditions. In twenty-five seconds and through a remote control system located on the ship's bridge, the vessel is moored or released.

Ports of Spodsbjerg and Tårs, Denmark (2012)
The model installed in these ports is also the AMS, installed on the edge of the dock, with a retention capacity of 400 KN = 40 tons, and is used with a frequency of 36 moorings per day. The vessels that use these berths are ferries of 99 meters of length, the "Lolland" and the "Langeland", which cover the regular line between Spodsbjerg and Tårs.

These AMS are installed in the two ports of call of the regular line, reducing costs of crew, time and maneuvering materials (ropes and lines), and equipment maintenance.

Port of Wellington, New Zealand (2012)
The AMS was installed in the Port of Wellington in the year 2012 in order to have the same system as in the Port of Picton, and thus have the same maneuverability conditions in the two ports of the regular line, which has a frequency of three times per day.

As in the Port of Picton, the vessel that uses it is the ferry of 180 meters in length, the "Aratere", later substituted by the vessel the "Kaitaki" de 181 meters in length.

Housælvig/Samsø Municipality, Denmark (2013)
In 2013, the port authority of Hou and Svlig in Denmark decided to install and put into operation two units of the AMS, similar to those operating on other docks of these two ports since 2009. The plan was to install a robot in each port of the regular ferry line between Hou in Jutland and Svlig on the west coast of the island of Samsø.

The problem that these two ports have is the strong wind of more than 40 knots, and the variations in the height of the tide. Hence, they needed to speed up the maneuvers and to increase security during the time the ship was docked.

The frequency of use is seven berths per day in each port and the vessel that makes the trips is a ferry of 99 meters.

Port of Helsinki, Finland (2014)
The Port of Helsinki granted a license to the company for the installation in the Länsisatama dock of six AMS 15 units. This equipment has been in operation since the end of the year 2015. The retention capacity of each of these devices is 40 tons per unit for the passenger ferries of 186 meters in length. The ferries cover the route between Helsinki and Tallin with a frequency of six times per day.

Den Helder/Teso, Holanda (2015)
The Teso company runs a high-speed ferry route between Den Helder and Texel Island with 2 passenger ferries. Following increasing pressure from municipalities to improve the environmental quality of air in port areas, Teso decided to change the ferry docking procedures for ferries of between 110 and 130 meters in length, which kept their engines running on idle all the time they were in the dock. This was made possible by the installation of two AMS units that ensured the secure mooring just by pressing the remote control button on the radio control on board the ferry.

The two units are able to exert a clamping force of 400 kN, and are attached to a floating steel structure (pontoon) in the terminal.

Teso is benefiting not only from the very fast and secure mooring of its ferries, but it also saves a lot of fuel. In addition, the saving in time has allowed the ferry line to better maintain the schedule of about 16 daily calls.

Lavik & Oppedal/Norled, Norway (2015)
In 2015, the AMS was installed for a renewable energy ferry line in Norled in Western Norway. This service is the first in the world to operate with fully battery operated ferries. The AMS has an electrical system that allows the recharge of the batteries of the ferry during its stay in the dock: the ship's batteries are connected to the mooring system by means of a connector that they have called AMP. (Murray et al., 2009).

The vessel that uses it has a length of 86 meters and a capacity of 120 cars and 360 passengers, and the frequency of use is 17 berths per day.

Port of Ballen & Kalundborg, Denmark (2015)
Færgen A / S purchased its first AMS system in 2008 when they won the Hou-Samsø route operation. In 2014, having lost the renewal of the concession, they decided to remove the two AMS units, restore them and install them in another nearby site, and did so on the route between Ballen and Kalundborg. The route is covered by a ferry of 91 m in length with a frequency of five times a day.

4.2 *Container terminals*

Container ships are becoming larger and larger and in many ports the docking of these large ships with ropes and lines can easily take longer than 40 minutes. AMS can guarantee the docking of these large ships in a matter of seconds, allowing port staff to have faster access to the vessel to begin loading operations. In the ports that have this system, an increase in the effectiveness of the cranes has been observed, as AMS provides a stable docking, with few movements of the ship, providing greater security in the handling of the containers. This increases loading and unloading rates, thus shortening the stay of the vessels in port (Sakakibara, Kubo, 2007). The container terminals where the system is installed are:

Dock Nº 6, Salalah, Omán (2006)
In this dock, the model installed since 2016 is the AMS. This system is also installed on the dock and operates under the edge of the quay. The retention capacity is 600 KN times 4 units, the frequency of use of the dock is three or four times per week and the vessels that use it are of 350 meters in length and 130,000 GTs.

Dock Nº 1, Salalah, Oman (2009)
In dock Nº 1 of the Port of Salalah, Oman, 12 robots of 200 KN are installed on the dock, though they work below it. The dock is used three or four times per week by different container ships of around 362 meters in length.

Beirut, Lebanon (2014)
Since 2014, the AMS has been operating in the Port of Beirut in the container ship terminal for vessels of up to 350 meters in length, made up of 42 robots of 20 tons of retention each.

Economically, it was not feasible to extend the existing breakwater to protect a new dock extension of 500 meters, and the Port of Beirut sought a solution to protect ships from the wave-induced movements on that dock (Lee, Hong & Lee, 2007).

The docking frequency on this quay is 5 to 8 berths per week and it is operated by the owner of the facility, which is the Port of Beirut itself.

Port of Salalah, Oman (2015)
In 2014, 8 units of 400 Kn each were installed in the Port of Salalah in another of its six container ship docks. At the same time, the retention capacity of the 2009 facility of Dock No. 1 was increased by 2,400 tons and that of Dock 6 was raised to 3,200 tons. The increase was requested by the Port to ensure that more ships could benefit from the system where the ship's structure prevented all units from being used.

The frequency of use of this dock is 3 to 4 times per week and it is used by vessels up to 350 meters in length.

Port de Ngqura, South Africa (2015)
In 2013, the Transnet Port Authority installed the automatic mooring system in the Ngqura Port in the container terminal. They installed 26 units of the AMS for the four container docks of this port on the east coast of South Africa. Each unit has a retention power of 200 Kn.

The units were installed to moor container ships from 1,500 TEU up to 13,000 TEU and up to 366 meters in length.

The main reason for the introduction of the system was to cushion on board the effects of long waves and strong winds, especially during the winter, which cause excessive movement in the vessels along the dock wall and interfere with the crane operations.

4.3 *Bulk load terminals (solids and liquids)*

The transportation of bulk cargo, both solids and liquids, accounts for the largest volume of trade and transportation worldwide, shipping by sea being the best option for this kind of goods.

The vessels are not usually used on fixed routes, but rather are usually chartered for a single trip. The terminals in which they operate normally have to compensate the ship-owner if there is a loss of time for unjustified delays in the loading or unloading terminals.

The AMS makes the ship's stay more predictable and stable, reducing downtime due to adverse conditions in the port.

These systems are installed in the following ports:

Bulk liquid and fuel jetty, Parker Point, Dampier, Australia (2011)
The model installed in this jetty is the AMS, positioned on the jetty and made up of 8 units of 200 KN each. The jetty is used with a frequency of one time per week and is used by tankers of up to 60,000 displacement tons (dwt). These units can resist winds of up to 45 knots and tides of up to one meter of wave height.

Port de Utah Point, Port Hedland, Australia (2012)
The model used in this port is the AMS, which is installed on the face of the dock, as if it were a defense. The Hedland dock is in the west of Australia.

Its retention capacity is produced by 14 robots of 200 Kn each. The frequency of use of the system is once every two days and it is used by vessels that do not cover a regular line. This berth can house bulkcarrier vessels of up to 295 meters in length.

Dock Nº 7, Gerald ton, Australia (2012)
In this dock, the model used is the AMS, installed on the edge of the dock. It consists of 12 units of 200 Kn each. The dock is used with a frequency of three or four times a week, in which ships of different sizes dock, generally Panamax bulkcarriers (294 m. in length).

In the past, this port used to suffer from many delays in the cargo operations due to the continuous swells, and on some occasions the ships had to leave the dock and wait at anchor for the sea to calm (Banfield, Flory, 2010).

Jan de Nul, Brisbane, Australia (2013)
In 2013, the company Jan de Nul was hired to run the dredging operations required to obtain the necessary landfill to build a second runway at Brisbane Airport. This process consisted of the dredging of seafloor sand and its unloading in a fixed location. This dredging and unloading cycle had to be undertaken in 12 hours but during the last stages of the planning of the project, a complication arose concerning the mooring of the dredger/hopper, "Charles Darwin" for the unloading of the filler material, as required by the Brisbane Port Authority. This made it impossible to meet the 12 hour cycle time requirement using conventional methods. Hence, Jan de Nul could not meet the landfill delivery obligations for Brisbane Airport on time.

The use of the AMS with 20-ton retention per unit from a previous customer, thus shortening the delivery, installation and start-up times. was pro-

Table 2. Mooring system installed on pier.

Year	Country	Nº Robot	Cap Tons/unit	USE	Vessel	Length (m)	USE year
1998	N Zealand	1	20	3 per day	Ferry	150	1080
2003	N Zealand	2	20	3 per day	Ferry	150	1080
2003	Australia	4	40	1 per day	Ro-Ro	150	360
2005	N Zealand	2	40	3 per day	Ferry	150	1080
2005	UK	1	80	2 per day	Ro-ro	185	720
2006	Oman	4	60	4 per week	Bulk	350	208
2007	Canada	4	20	15 per day	All	225	5400
2009	Oman	12	20	7 per week	Cont.	362	364
2009	Denmark	2	40	7 per week	Ferry	91	364
2009	Denmark	2	40	7 per week	Ferry	91	364
2011	Australia	8	40	1 per week	Tanker	300	52
2012	Australia	14	20	3 per week	Bulk	295	156
2012	Denmark	1	40	36 per day	Ferry	99	12960
2012	Denmark	1	40	36 per day	Ferry	99	12960
2012	N Zealand	1	40	3 per day	Ferry	180	144
2012	Australia	12	20	4 per week	Bulk	294	208
2013	Denmark	1	40	7 per day	Ferry	99	364
2013	Denmark	1	40	7 per day	Ferry	99	364
2013	Australia	2	20	2 per day	Dredge	183	720
2014	Lebanon	42	20	7 per week	Cont.	300	364
2014	Finland	6	40	6 per day	Ferry	186	2160
2015	Norway	18	20	3 per week	Bulk	305	156
2015	Holland	2	40	16 per day	Ferry	130	5760
2015	Holland	2	40	16 per day	Ferry	130	5760
2015	Norway	1	20	17 per day	Ferry	86	6120
2015	Norway	1	20	17 per day	Ferry	86	6120
2015	Oman	8	40	4 per week	Cont.	350	208
2015	Denmark	2	40	5 per day	Ferry	91	1800
2015	Denmark	2	40	5 per day	Ferry	91	1800
2015	S Africa	26	20	2 per day	Cont.	366	720
31		191					69916

Source: Author.

posed o solve the problem and to reduce mooring times from two hours to approxiately 30 seconds.

This AMS with eight AMS has a frequency of use of several berths per day with a dredge of 183 m. LKAB Narvik, Norway (2015).

Since 2015, a mooring system made up of 18 units of the AMS of 200 Kn each have been installed in the dock of Narvik, Norway, located on the new iron mineral dock of LKAB.

In this dock, bulk carriers of up to 185,000 dead-weight and 305 meters in length can berth. This is the first AMS installation on a solid-bulk dock in Europe, and the first on the Arctic Circle. The frequency of use of this dock is 2 to 4 times per week.

4.4 *Installations in locks y prototypes*

St. Lawrence Seaway Dock, Great Lakes, Canada (2007)

The model installed on this dock is the AMS consisting of 4 units of 200 Kn each. The first installations were carried out in Welland Canal Lock No. 7 with 2 different versions of the AMS.

The dock is used with a frequency of several times per day, between 5 and 15 times, by different vessels of up to 225 meters in length.

Since 2007, AMS has worked on the development of the best possible AMS system for use in the locks and the result was a new system. It was installed in 2013 in Lock # 4 of Beauharnois, with a change of level of 13.5 million liters of water.

The AMS is currently being installed in the remaining 13 locks.

5 DISCUSSION

This automatic mooring system was present in 31 Ports in the year 2016, according to the information compiled, (Cavotec, 2015), and they are currently scheduled to install it in a further three ports.

Today, AMS is a widely accepted technology that has made more than 40,000 mooring operations, with a security ratio of one hundred percent, and is installed on all types of docks and used by different types of ships such as ferries, bulk carriers, and RoRo and container carriers.

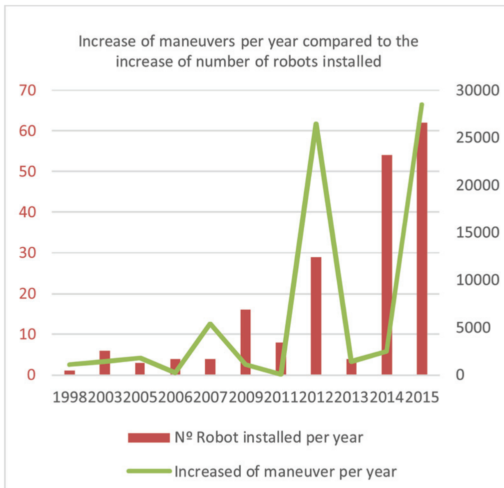
The total number of maneuvers currently carried out with this type of automatic mooring system is 69,916. The year 2015saw the highest number of installations undertaken, nine in total, and also the largest increase in the number of maneuvers, reaching 28,444.

In 2012, the increase in the number of maneuvers (26,428) was almost the same with just 5 installations, the explanation for this being that the installations made in 2015, although they were

Table 3. Maneuver with AMS installed on dock each year.

Year	Nº of installation per year	Nº Robot installed per year	Increased of maneuver per year	Sum of maneuvers
1998	1	1	1080	1080
2003	2	6	1440	2520
2005	2	3	1800	4320
2006	1	4	208	4528
2007	1	4	5400	9928
2009	3	16	1092	11020
2011	1	8	52	11072
2012	5	29	26428	37500
2013	3	4	1448	38948
2014	3	54	2524	41472
2015	9	62	28444	69916
Total	31	191	69916	

Source: Author.

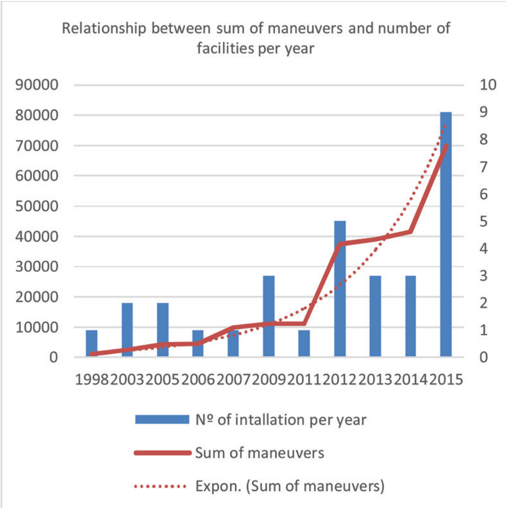


Graph 1. Increase of maneuvers per year compared to the increase of number of robots installed. Source: Author.

mostly in ferry terminals, were in terminals with fewer daily stops.

As can be observed in the graph 1, which compares the number of maneuvers performed with the increase in the number of robots installed each year, a greater number of maneuvers does not correlate to a greater number of robots installed. In the years 2006, 2007 and 2013, 4 robots were installed and 2008, 5,400 and 1,448 maneuvers were performed, respectively.

There is no direct relation that indicates that the more robots installed per year, the more maneu-



Graph 2. Difference between Nº of installation per year with sum of maneuvers and Nº of robots. Source: Author.

Table 4. Terminals where the AMS is installed and its use.

Terminal Type	Number of terminals	Number of Robot	Maneuvers per year	Maneuvers per day
Pax-RoRo	19	35	61360	170
Container	4	88	1656	5
Bulk Load	5	56	780	2
Others	3	12	6120	17

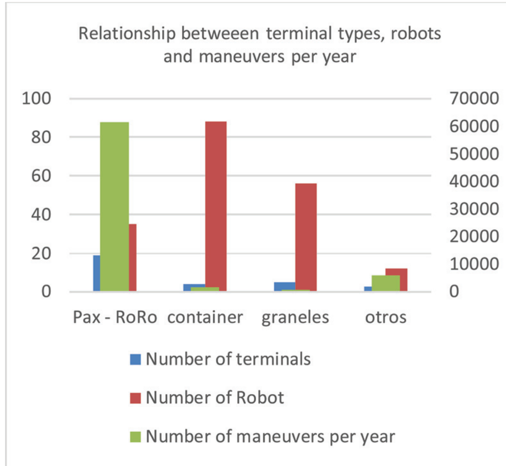
Source: Author.

vers performed. This is because each port requires an independent study to verify the need for the installation, the feasibility of its use and the determination of the most suitable model for the environmental conditions, type of dock and type of vessels using the berth (Baan, J.1983).

As can be seen in Graph 2, the number of maneuvers performed is always on the rise, but not at a continuous rate.

The same occurs in the relation between the number of ports in which the system is installed each year and the number of robots installed in these ports. It can be observed that the exponential tendency line of the number of ports in which the system is installed is upward.

The table 4 shows the relation between the different types of terminals in which this type of automatic mooring system is installed with the number of docks, number of robots and number of maneuvers per year and per day.



Graph 3. Difference between terminal types, Nº of robots and Nº of maneuvers per year.
Source: Author.

Table 5. Pictures of some models of the ports on which it is operating.
Source: Author.

The graph 3 shows the relation between the different types of terminals, the number of installations in these ports and the number of robots and maneuvers performed per year in each type of terminal

6 CONCLUSIONS

It can be observed that this type of installation is more commonly found in Roro and passenger terminals, but the highest number of robots are installed in container terminals, the system being installed in four docks with 88 between them.

In view of the results obtained from the research described above, the following conclusions have been reached:

1. The use of the automatic mooring system allows the safety margins to be increased during the stay of the docked vessel. The ship can remain safely docked with more virulent winds than with the conventional system, without the need to resort to tugs.
2. This type of installation is more commonly found in Roro and passenger terminals.
3. The highest number of robots are installed in the container terminals.
4. The number of robots installed in each dock depends on the size of the vessels, the type of dock and the meteorology of the place, not on to the number of stops.
5. With the automatic mooring system, the cost of the mooring service is reduced.
6. The number of maneuvers performed with this system is always on the rise, but not at a continuous pace.
7. Nowadays engineers continue to develop AMS automatic mooring systems and are perfecting new forms of technology which may be used to improve safety, operational efficiency and infrastructure savings.
8. The utilization of any system of automatic tie is beneficial for the whole personnel involved in the maritime business.
9. In Ferry and RORO terminals, the main objective is the optimization of the time scale: with the installation of these systems, the time required to perform the maneuvers is reduced and safety during the maneuvers and the stay in port increases

We can assure that both raised hypotheses are fulfilled.

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