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Particularity of safety measures on board ships operating in the "Motorways of the Sea" service

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ABSTRACT

The concept of "Motorways of the Sea" represents a part of the door-to-door logistic chain in which the maritime segment of the journey is organized according to the principle of short sea shipping. The main principle of the concept is to encourage the use of the environmental friendly mode of transport such as the sea transport aimed at providing positive effect on the reduction of air pollutant emissions and enhancing connections within the EU member states. In this matter, maritime traffic is increasing in particular sea areas with the possibility of potential emergence and appearance of maritime accidents on board ships engaged in the "Motorways of the Sea" service. Generally, the "Motorways of the Sea" service uses RO-RO and RO-RO passenger ships, which have a design different from other types of ships, as well as some special features in terms of safety. This paper has analysed the particular safety features of RO-RO and RO-RO passenger ships, the maritime accidents involving these ships and the measures to increase safety of ships arising from maritime accidents.

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1. Introduction

In 1992, the European Commission[1] officially attempted, for the first time, to transfer short distance exchange of goods from road to sea transport. The main reason for such an effort is the environmental pollution caused by the discharge of air pollutant gases, particularly in summer months when increased road congestions are common. The European Commission is trying to solve this problem by developing the concept of the "Motorways of the Sea". The introduction of the "Motorways of the Sea" reduces road congestion, CO_2 emissions, as well as the consumption of road infrastructure and noise levels [1, 2, 3].

Through various projects the European Commission (Marco Polo and TEN – T) provides financial support for the introduction of the "Motorways of the Sea".

The network of the "Motorways of the Sea" is run by RO-RO (roll on – roll off), LO-LO (lift on – lift off) and FLO-FLO ships (float on – float off) [2]. In this paper, due to their specific design and structure as well as to their construction, organization and the fact that they are mainly used in the "Motorways of the Sea" service, only RO-RO and RO-RO passenger ships have been analysed.

Table 1 Air pollution in grams per ton kilometers (g/tkm) according to the means of transport [4]

	CO_2	SO_2	NO_x
Road transport	50 – 333	0.03 – 0.4	0.24 – 3.6
Railway transport	9 – 102	0.04 – 0.4	0.07 – 1.9
Maritime transport	7.7 – 31	0.05 – 0.51	0.11 – 0.72
Inland navigation	33 – 81	0.04	0.26 – 1.45

Flexibility, independence from port infrastructures, ability to transport various types of goods, speed and the possibility of integration with other modes of transport, make RO-RO and RO-RO passenger ships very popular on a number of different routes [5]. Furthermore, these ships are, due to their speed and flexibility, especially important for short sea shipping. But, in terms of safety and stability, there is a whole range of problems that can occur, primarily because of the possibility of rolling over as a consequence of deck flooding which is designed for the placement of vehicles.

This paper has presented an overview of maritime accidents of RO-RO and RO-RO passenger ships, the in-

[1] The European Commission examined for the first time the contribution of short sea shipping in the document "White Paper on the Future Development of the Common Transport Policy".

creased safety measures implemented after the accidents and an overview of what caused them.

In addition, the paper aims at contributing in the research activities of the IPA project entitled "Developing the Motorways of the Sea System in the Adriatic Region" – AdriaticMoS project.

2. "Motorways of the Sea" as a system of maritime connections in Europe

Since road transport contributes to traffic congestions and air pollutant emissions, the European Commission proposed, in its *White Paper* in 2001, the development of the "Motorways of the Sea". As a concept, the "Motorways of the Sea" are an integral part of the trans-European road network. The European Commission is developing a number of projects and thus provides funding needed for the development of the "Motorways of the Sea". Emphasis can be placed on two projects in particular – Marco Polo and TEN – T. The Marco Polo projects (PAC, Marco Polo I and Marco Polo II) which have been developing since 1992 and aimed at diverting freight from roads to other modes of transport. TEN – T projects have been developed aimed at ensuring infrastructure investment, and, since 2001, have been engaged in the promotion of short sea shipping and the "Motorways of the Sea".

The aim of these projects is to strengthen transport links in the transport of goods and passengers within the EU member states.

The "Motorways of the Sea" are part of the door-to-door logistic chain. They use sustainable, regular, frequent, high quality and reliable short sea shipping connections [2].

The European Commission in its *White Paper* points out that the "Motorways of the Sea" should:

1. be part of the door-to-door logistic chain,
2. offer efficient, regular, reliable and frequent services that can compete with land transport in relation to time and cost,
3. have ports with good traffic connections with the hinterland, rapid administration and high level of service [6].

Short sea shipping is the movement of goods and passengers by sea between ports which are located within Europe in terms of geographic, and/or between those ports and the ports situated outside Europe that have a coastline which borders with Europe [7].

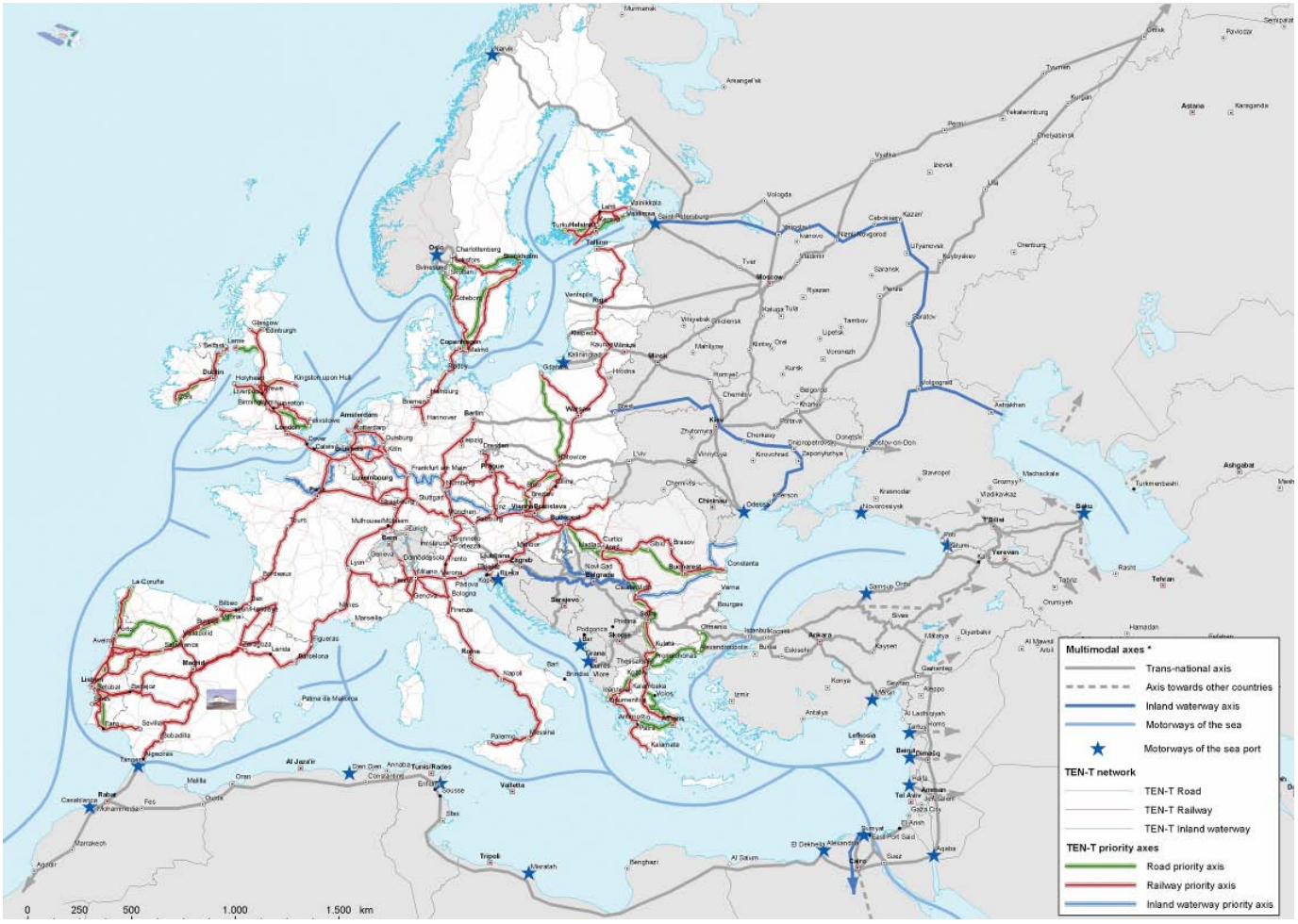

Fig. 1 "Motorways of the Sea" maritime routes and ports [8]

Thus, the concept of the "Motorways of the Sea" is a concept that is broader than the short sea shipping since it involves a land traffic segment, while the maritime part of the journey is organized according to the concept of short sea shipping [2].

The success and development of the "motorways of the sea" are largely dependent on the development and quality of the short sea shipping connections.

At the very beginning of their development, the "Motorways of the Sea" were mentioned as one of the measures for the revitalization of short sea shipping. It was believed that the benefits of maritime transport were not sufficiently utilized. However, the aim of the European Union today is the integration of maritime and land transport, which is ensured by the "Motorways of the Sea".

Nowadays, the "Motorways of the Sea" are a part of the trans-European network and they combine multiple types of transportation, together with the mandatory use of short sea shipping [2].

The "motorways of the sea" are defined by four main corridors [9]:

1. "Motorways of the Baltic Sea",
2. "Motorways of the Sea of Western Europe",
3. "Motorways of the Sea of South East Europe",
4. "Motorways of the Sea of South West Europe".

The only way for the "Motorways of the Sea" system to be competitive with the road transportation is to have the following properties [2]:

1. the concentration of the cargo flow through a particular line,
2. regularity,
3. frequent schedule,
4. reliability,
5. excellent quality and door-to-door logistic services.

Several European sea regions have initiated the promotion of the concept[2]. In the Adriatic Sea region the development of the "Motorways of the Sea" was initiated several years ago through the implementation of the EU initiative and supported projects such as the "East Mediterranean Motorways of the Sea Master Plan" and the "AdriaticMOS Project" aimed at developing the concept of the "Motorways of the Sea" in the Adriatic Sea region. The "Motorways of the Sea" on the Adriatic Sea should make an integral part of the "Motorways of the Sea of south-east Europe" which connects the Adriatic Sea with the Ionian Sea and the eastern Mediterranean, including Cyprus [10].

The "Motorways of the Sea" concept, in its entirety, should bring a positive impact on reducing road congestion, reducing environmental pollution and should contribute to the improvement of the connection between European ports as well as of the EU ports with the neighbouring states and continents.

[2] Some of the projects that deal with the "Motorways of the Sea" are "Motorway of the Sea Rostock-Gedser", „Motorways of the Sea Projects in the Baltic Sea Area Klaipéda-Karlshamn Link", "Motorways of the Sea Esbjerg – Zeebrugge", "Building the Motorways of the Sea – the Mediterranean".

3. RO-RO ships – a part of the "Motorways of the Sea" concept

RO-RO ships generally represent all ships which can carry various types of cargo on wheels. RO-RO ships have very specific structural features, i.e. large garages and undivided spaces. The superstructure is generally located at the stern of the ship. The number of decks depends on the size of the ship. The main deck has access to the shore via a ramp while the loading of the cargo on other decks is done by using the internal ramps or lifts.

The main characteristics of these types of ships depend on the navigational routes, expected oceanographic and meteorological characteristics of the area, while the berth dimensions and port basin limits the size of the ship.

As a rule, they are used on permanent lines, which are according to their transport function a continuation of a road transport network [11].

3.1. Analysis of the RO-RO ships fleet

RO-RO ships can be categorised according to several characteristics. The generally accepted division of the RO-RO ships fleet follows the categorisation according to the types of cargoes/vehicles and/or passengers they carry. Thus, the RO-RO ships fleet could be divided as follows [12]:

1. Ships for the transportation of cargo on wheels,
2. Ships for the transportation of passengers and vehicles,
3. Ships for the transportation of passengers, vehicles and cargo on wheels,
4. Ships for the transportation of containers and trucks,
5. Ships for the transportation of cars and/or trucks,
6. CON-RO ships, and
7. RO-RO/LO-LO ships.

In addition to these the following simplified division is also common [13]:

1. Ships for the transportation of cargo on wheels,
2. Ships for the transportation of passengers and vehicles,
3. Ships for the transportation of passengers, vehicles and cargo on wheels.

The implementation of the "Motorways of the Sea" concept generally requires the transport of trucks and vehicles. However, in addition and commonly on some lines, there are demands for passenger transport as well. Following this condition the following two basic types of RO-RO ships have been considered in this paper:

1. RO-RO ships for the transport of cargo on wheels in which the maximum number of passengers is 12 – the standard type of RO-RO ship,
2. RO-RO passenger ships or ships in which the number of passengers is more than 12.

RO-RO Ship **RO-RO Passenger Ship**

Fig. 2 Typical RO-RO ships used in the "Motorways of the Sea" [14]

The RO-RO ships fleet that corresponds to the "Motorways of the Sea" concept generally consists of ships with large parking area for trucks and with cabins for passengers or drivers. It does not include double-ended ferries or ships of smaller size which sail in national voyages and between the coast and the islands.

The fleet of RO-RO ships is increasing slightly over the years, while the RO-RO passenger fleet is decreasing in the number of ships. Comparing the number of ships and their capacity, it can be noticed that they are becoming greater with an increase in lane meters and passenger capacity[4].

According to [16], almost 70% of the world's RO-RO ships fleet is used on European and Mediterranean markets. However, a 2% decrease has been recorded, together with an increase in lane meters of 18%, and a growth in medium-size ships by 20% in capacity.

Table 2 RO-RO ships and RO-RO passenger ship fleet (ships of 300 GT and over)

Year	RO-RO Ships				RO-RO Passenger Ships			
	Number of ships	% share of world total	1,000 dwt	Order book (No./1,000 dwt)*	Number of ships	% share of world total	1,000 dwt	Order book (No./1,000 dwt)*
2010	1,373	2.9	6,770	-	2,624	5.6	4,409	-
2011	1,353	2.8	6,339	-	2,556	5.3	4,361	-
2012	1,462	3.0	7,866	-	2,413	5.0	4,114	-
2013	1,457	3.0	7,794	51 / 1,288	2,405	4.9	4,188	40 / 68
2014	1,447	2.9	7,366	31 / 934	2,432	4.9	4,205	53 / 144

Source: Authors according to [15][3]

Table 3 RO-RO ships and RO-RO passenger ships by age (ships of 300 GT and over)

Age of ships	RO-RO Ships		RO-RO Passenger Ships	
	Number of ships	%	Number of ships	%
0 – 4 years	261	18.0	243	10.0
5 – 9 years	258	17.8	250	10.3
10 – 14 years	197	13.6	298	12.2
15 – 19 years	158	10.9	268	11.0
20 – 24 years	114	7,9	286	11.8
25 + years	459	31.7	1,087	44.7
Total	**1447**	**100**	**2,432**	**100**

Source: Authors according to [15]

[3] Data are related to 1st January

[4] The number of RO-RO ships in 2005 was 1,384 [17] which show that the number of ships was increasing faster during the period of huge market expansion.

Regarding new buildings, data show that the size of RO-RO ships is increasing with an average size of ships reaching 30,000 dwt. The same trend could be seen for RO-RO passenger ships where the average size of ships on order in 2014 was 60% larger than in 2013.

The distribution by age of RO-RO ships has shown a very much equalized distribution among pure RO-RO ships and RO-RO passenger ships. As the number of ships on order is relatively small in relation to the number of the existing ships (less than 2%), the average age of ships is relatively high. The majority of ships are over 15 years old, while almost 50% of the fleet is over 25 years old. Older ships are more dominant among RO-RO passenger ships which are generally generated by ships of a smaller size operating in the enclosed seas within national waters.

Although data covering the 2010 to 2014 period show that the number of ships over 25 years old is decreasing, still the largest number of ships includes those over 25 years old [18].

Generally, RO-RO ships are under a continuous maintenance and upgrading which results in prolonged services exceeding 25 years. Despite this, the RO-RO ships and RO-RO passenger ships fleet must continuously strive to reduce the average age of the ships as an important factor in improving the safety record.

The number of ships depends on the routes that need to be served, but also on the situation on the transport market. Since 2005, there has been a slight increase in the number and capacity of RO-RO ships and RO-RO passenger ships. The configuration of the maritime navigable waters in the EU and the Mediterranean is suitable for the development of short sea shipping or/and the "Motorways of the Sea". Enclosed seas, waterways and straits between densely populated areas, impose maritime transport of goods and passengers as a logical choice. The introduction of the concept of the "Motorways of the Sea" can affect the increase in the number of ships and the investment in new ships, mainly by introducing larger ships with improved cargo/vehicle area and better quality service for passengers.

3.2. Safety factors on board RO-RO ships

RO-RO ships are, from an economic standpoint and due to their capability of carrying various types of cargo and their independence from the port infrastructure, the most competitive type of ships. However, in terms of safety and stability, there is a fairly number of problems that can occur [19]. As part of this analysis, an overview is provided of the main hazards that can occur during navigation together with the risk associated to this type of ships. In addition, the description of the characteristics of the safety systems and an overview of maritime accidents of RO-RO ships and RO-RO passenger ships has been analysed.

RO-RO ships have a different design when compared to other ships belonging to the merchant fleet. It is precisely this design that makes them unique within the context of safety issues related to possible hazardous occurrence. The following research presented in [20] recognized safety issues on RO-RO ships could be summarized as follows:

1. Lack of internal bulkheads,
2. Cargo access doors are located at a small height above the waterline,
3. High superstructure,
4. Possibility of the movement of cargo on the vehicle deck,
5. Firefighting ability due to the large open spaces and carriage of vehicles,
6. Life-saving appliances,
7. Organization and training of the crew.

In case of flooding, large undivided garage spaces allow for a sudden inrush of water and the generation of free surfaces that can threaten the stability of the ship, and can cause the rapid listing and possible capsizing of the ship. The main problem and the uniqueness of RO-RO ships and RO-RO passenger ships is the potential loss of the positive stability due to water ingress into the vehicle garage, caused by an accident such as collision or a contact.

The ramps at the bow and stern of the ship pose a potential risk of water leakage because they are large openings in the hull, close to the water line. The first danger is the possibility of an accidental or deliberate leaving the ramp unsecured. The second potential danger is the result of a frequent loading and unloading of vehicles that eventually causes ramps to become damaged due to the distortion and fatigue of the material. The cargo access doors are located at a small height above the waterline, which, in the case of an unplanned trim or heel of the ship due to the displacement of the load, both during navigation and while being located in a port during loading and unloading of cargo (the ramps are open), can lead to sudden leakage of large amounts of water into the cargo accommodating area.

The high superstructure of RO-RO ships makes them more affected by the wind and heavy seas in bad weather conditions. The elevated superstructure, characteristic for this type of ships, represents a construction challenge and a challenge for the use of safety equipment, namely boats and rafts. A higher superstructure requires longer lowering wires. Abandoning ship is more risky when launching lifeboats from a higher platform. Maintenance is more complicated and costly, etc.

The movement of the cargo on the vehicles deck due to poor security of the vehicles in heavy sea conditions can affect the intact stability of the ship causing it to list. In this respect it is of outmost importance to rigidly follow the recommendations and instructions given in the Cargo Securing manual.

A large undivided garage space allows also for the rapid spread of flames in case of a fire. The same reason reduces the efficiency of the firefighting teams in case of possible firefighting attempts within the garage.

A special type of lifesaving appliances is to be applied on board RO-RO passenger ships. According to SOLAS,

ships must be equipped with Fast Rescue Boat and Marine Evacuation System which are not compulsory for any other type of ships. These appliances are intended to provide fast and effective evacuation in case of rapid sinking.

In addition to the above-mentioned, special attention should be paid to the organization and training of the crew on board RO-RO passenger ships, highlighting possible problems on board RO-RO passenger ships in cases when the need for the evacuation of passengers occurs. The problem arises because of the large number of passengers in relation to only one crew member. The usual ratio is 1:10-12.[5] It is a problem in situations when there is a need for the evacuation of passengers.

In most cases, the period of time from the moment between the occurrence of a potential threat and the moment when the accident actually occurs [21], is sufficient to follow the correct procedures in order to prevent the occurrence of an accident. And when an accident occurs it is important to have a well organised crew. The crew should be trained to behave properly in a situation when maritime accidents occur. A rapid action taken by the crew on board RO-RO ships or RO-RO passenger ship can prevent consequences that may arise from maritime accident in its early stages.

The requirements for a training programme, which, according to the STCW Convention, must be carried out by the master, officers and crew members, exist only for the RO-RO passenger ships, while regular RO-RO ships are having no special training requirements. The IMO has recognized the importance of this and emphasized requirements for the training programme of the crew in the STCW Convention as an important part of the improvement process.

The safety issues related to RO-RO ships and RO-RO passenger ships are resulting from the unique design of those ships. Therefore, the following safety issues connected to RO-RO ships could be emphasized: large undivided vehicle garage, high superstructure, cargo loading ramps close to the waterline, possible movement of the vehicles in the garages and ability to fight fire. Beside this, a great difference in the ratio between the number of the crew and the passengers on board RO-RO passenger ships highlights problems that appear in connection with the evacuation of passengers, crowd management and abandoning the ship.

4. Analysis of maritime accidents involving RO-RO ships and RO-RO passenger ships

When establishing the "Motorways of the Sea" concept, attention should be paid to the potential increase in the number of maritime accidents and, consequently, implement adequate safety measures. The outcome of maritime accidents involving RO-RO ships and RO-RO passenger ships generate the possibility of a potential loss of human lives.

The Marine Accident Investigation Branch (MAIB) investigates all types of maritime accidents. In the following graph, an overview of maritime accidents involving RO-RO ships and RO-RO passenger ships is presented by the classification of maritime accidents.

Similar data were presented in the research done by DNV in 1982 on behalf of the IMO[6]. During the research, a comparison was made with other types of ships for which the frequency of collisions was 9 %, while the frequency for RO-RO ships and RO-RO passenger ships was 24 % [20]. The following research covered the period from 1994 to 2004 and included collision, contact and fires as the most common accidents taking place on board RO-RO passenger ships [5].

For the analysis of maritime accidents in the "Motorways of the Sea" concept, better statistical data are presented by the EMSA[7]. The EMSA regularly collects, analyses and publishes data on maritime accidents in the EU waters. The following tables show the number of maritime accidents of RO-RO ships and RO-RO passenger ship operating in the EU waters, in the period between 2007 and 2010.

It is obvious that collision and contact are predominant types of accidents while fire and groundings follow. They account for almost 50% of all accidents for both types of RO-RO ships. The total loss of ships is very rare. It can also be noticed that the number of accidents of RO-RO passenger ships is increasing, bearing in mind that its fleet is decreasing in the number of ships at the same time.

Although the data for RO-RO ships are not separately specified, it can be assumed that the total number of accidents of pure RO-RO ships is much lower than the number of accidents of RO-RO passenger ships. The possible explanation could be the increased number of accidents which happened on board RO-RO passenger ships (ferries) operating in coastal navigation and national voyages.

Some of the most significant maritime accidents that took place in the period between 2007 and 2010 were connected to the most dominant types of accidents. The following severe accidents recently took place in the European waters on board ships which operated mainly in the "Motorways of the Sea" service:

– Fire on board the RO-RO ship UND Adriyatik[10], in 2008, which was in danger of sinking on the coast of northern Croatia;

[5] For example: Ro-Pax ship (project No. 987D Brodosplit) – 400 passengers and 38 crew members; Car passenger ferry (Amorella, Isabella) – 2170 passengers and 193 crew members.

[6] The research covers the period from 1965 to 1982.

[7] European Maritime Safety Agency.

[8] This category comprises generally RO-RO and refrigerated cargo ships, bulk carriers and vehicle carriers, which collectively represent the great majority of commercial shipping.

[9] In the year 2010, the following categories were included: RO-RO passenger ships and cruise ships (126 RO-RO passenger ships and 21 cruise ships).

[10] The ship carried around 200 heavy goods vehicles, 9 tons of hazardous material (including 2 tons of matches and 6 tons of truck grease), 1,000 tons of fuel, 9 passengers and 22 crew members on the route from Istanbul to Trieste [23].

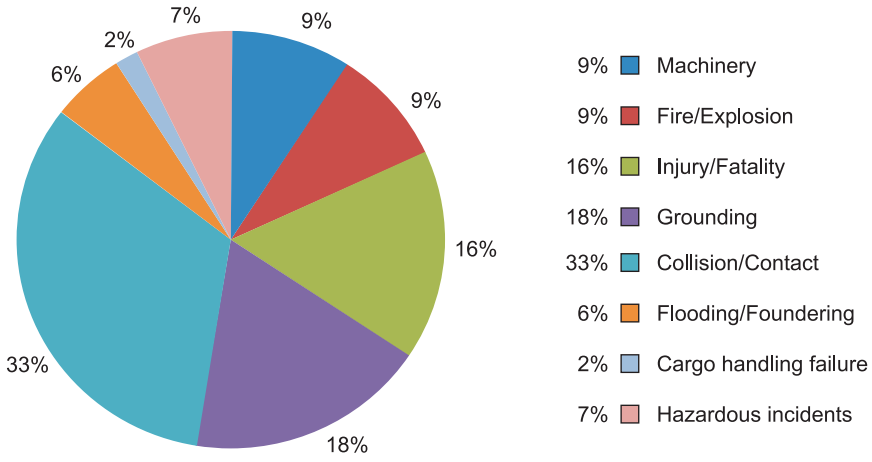

Fig. 3 Maritime accidents involving RO-RO ships and RO-RO passenger ships from 1990 to 2014

Source: Authors according to [22]

Table 4 Maritime accidents of RO-RO ships[7] operating in the EU waters

	2007	2008	2009	2010
Collision/Contact	132	120	93	97
Sinking	11	10	6	6
Grounding	108	115	76	72
Fire/Explosion	29	26	30	17
Other	50	36	20	42
Total	**330**	**307**	**225**	**234**

Source: Authors according to [23]

Table 5 Maritime accidents of RO-RO passenger ships operating in the EU waters

	2007	2008	2009	2010[8]
Collision/Contact	61	69	75	70
Sinking	3	0	0	2
Grounding	21	21	28	22
Fire/Explosion	14	14	9	30
Other	17	10	9	23
Total	**116**	**114**	**121**	**147**

Source: Authors according to [23]

- Sinking of the RO-RO cargo ship Captain Michalis, in 2009, in the Aegean Sea, which sank as a result of a collision with the bulk carrier Santana[11];
- Explosion on board the RO-RO passenger ship Lisco Gloria, in 2010, in the southern Baltic Sea near the island of Fehmarn, Germany[12];
- These examples have show the possible severity of the consequences related to accidents of RO-RO ships, especially when related to fires and explosions. Potential causes of fires on board RO-RO ships are mainly linked to cargo which can be combustible, like gasoline and goods of various kinds (parked cars and trucks) as well as to the passengers' activities on board.

In recent years, there has been an increase in the number of accidents of RO-RO passenger ships in the European waters. Maritime accidents due to collisions/contacts are the most common maritime accidents of RO-RO ships and RO-RO passenger ships. Since 2007, there has been an increase in the number of collisions/contacts in

[11] 8 of 9 crew members were rescued, but one was lost, although the bulk carrier was not reported to have sustained any serious damage [23].

[12] The blaze is reported to have begun in a truck on the upper open car deck and then to have spread and gutted the decks below. 248 passengers and crew members were rescued [23].

Lisco Gloria [23] **Jolly Nero**[13] [24]

Fig. 4 RO-RO ships encountered accidents in the EU waters in recent years

the European waters as well as in the number of all other accidents. They are directly connected to the high frequency of operations when entering and leaving ports, the confined navigational area where RO-RO cargo and RO-RO passenger transport is carried on, high density of traffic and limitations in navigation, etc. With that in mind, the crew's fatigue can be highly emphasized as a strong contributing factor.

The analysis has shown that, although the number of ships is relatively steady or is decreasing, the number of accidents is increasing. Furthermore, it is obvious that additional measures for increasing safety on board any type of RO-RO ships should be promoted.

5. Measures for increasing safety on board RO-RO ships

When discussing the measures for increasing safety of RO-RO ships, the constant reoccurring problem is the fact that such measures are implemented only after a maritime accident occurs. Almost all regulations related to RO-RO ships and RO-RO passenger ships were created after maritime accidents. A number of accidents can be listed such as the *Herald of Free Enterprise* in 1987, which resulted in the loss of 193 human lives, the *Scandinavian Star* in 1990, which resulted in the loss of 158 lives, and *Estonia* in 1994, resulting with the loss of 852 human lives [25]. After these accidents, the IMO has adopted a series of amendments that have defined the requirements for technical solutions on board RO-RO ships, some of which are:

- Indicators on the bridge for ramps and doors in an open position may cause water leakage,
- Indicators on the bridge for the detection of water within the cargo space,
- Indicators on the bridge for the unauthorized entry of passengers in the cargo area,
- Emergency lighting for RO-RO passenger ships,
- *"SOLAS 90"* standards for passenger ship stability in damaged condition,
- Amendment relating to intact stability with the requirement that masters have the information necessary for the maintenance of an intact stability, including information related to various trims, and taking into account the operational limits,
- Cargo loading doors must be secured before the sailing of the ship, and must remain insured until the ship is at her next berth,
- The ISM has become an integral part of the SOLAS Convention,
- Safety measures on passenger ships and around them,
- Strengthening and securing the system for the locking of the doors/ramps on the outer part of the hull of RO-RO passenger ships,
- Checks and inspections on board the RO-RO passenger ships,
- Navigational guidance schemes and operational information for RO-RO passenger ships,
- Recommendations for masters on board passenger ships regarding support systems in decision-making,
- Proper training for the crew on board RO-RO passenger ships was suggested.

Beside measures already implemented in the past following above mentioned accidents, an adequate education and training of the crew is important in the reduction of the number of maritime accidents. After known maritime accidents, the IMO has adopted a series of technical improvements in regard to the ships construction and construction of the equipment on board, and recommendation for specialized training of the crew on board RO-RO ships and RO-RO passenger ships. Proper training and education effectively reduce consequences that could arise from maritime accidents as well. According to the STCW Convention, the master, the officers and the crew of a ship must go through the following training programme [26]:

[13] The RO-RO ship "Jolly Nero" hit the Port of Genoa Tower. The tower collapsed while 7 persons died.

1. Master, together with officers and other designated on muster list to assist passengers must undergo the training for managing groups of people in case of emergency.
2. The personnel offering direct services to passengers in passenger spaces must undergo the training for the providing of services to passengers in passenger spaces.
3. The master, chief engineers, first officers, other engineer officers, as well as all other personnel in charge, according to the muster list, must undergo the training for crisis management and human behaviour.
4. The master, chief engineers, first officers, other engineer officers, as well as all other personnel responsible for the embarking and disembarking of the passengers, the loading, discharging or securing of the cargo, as well as for the closing of the cargo access doors on the hull of the Ro–Ro passenger ship must undergo the training related to the safety of passengers, cargo safety and hull integrity.

Furthermore, the crew of the fast rescue boat must receive adequate training in "Proficiency in Fast Rescue Boat Operations". In general, the training of crew members aims at improving crew behaviour in case of an accident and their better control and management of the large number of passengers.

Furthermore, measures to increase safety in general are connected to the work of the classification societies which are focused on determining the compliance of ships with the requirements of international maritime conventions and the recommendations of the International Maritime Organization. It is necessary to actively supervise the implementation of the regulations in order to minimize the possibility of maritime accidents. The responsibility of flag states is to certify that the ships under their jurisdiction satisfy safety requirements. Apart from the classification societies and flag states, another important factor in this process is the Port State Control (PSC). Port State Control is the inspection of foreign ships in national ports to verify that the condition of the ship and her equipment comply with the requirements of the international regulations and that the ship is manned and operated in compliance with these rules [27]. Almost all European ports are part of the Paris MOU regime so inspections of RO-RO ships operating in the EU should follow strict and uniform standards and procedures of the Paris MOU which can lead to reducing the number of accidents.

In addition to the above-mentioned measures, special attention should be paid to the manoeuvring of the ship. Because of the frequency of operations of entering and leaving ports, possible problems can occur even during routine manoeuvres. The problem occurs when a person operating a ship perfected a single routine manoeuvring "scheme" or in other words does not have sufficient training to perform manoeuvres in several different ways [28]. Bearing in mind that collisions and contacts are the most frequent accidents related to RO-RO ships and RO-RO passenger ships, it is necessary to point out the importance of the VTMIS (Vessel Traffic Monitoring and Information System). The VTMIS provides the oversight and management of maritime traffic, thus enhancing the safety and efficiency of it, and improving the response of authorities to incidents, accidents or potentially dangerous situations at sea.

Safety measures, required and implemented on board RO-RO ships, are one of the strictest and the most comprehensive measures in the shipping industry. It is the outcome of the particular design of the ships as well as the result of continuous efforts done by the shipping community, particularly by the IMO, in order to avoid accidents and to increase safety. Nowadays, the imperative is to predict the existing safety imperfections on board RO-RO ships and to take actions to prevent the possible accidents.

6. Conclusion

Due to the environmental pollution caused by the discharge of air pollutant, the European Commission is trying to redirect a portion of the freight trade from the road to sea. The financial support needed for the strengthening of the transportation network within the EU member states is obtained through a variety of projects dedicated to the promotion, analysis, development and proposal for establishing the concept of the "Motorways of the Sea". In this process, special attention should be given to the ships actively serving in the "Motorways of the Sea" concept, predominantly to RO-RO ships and RO-RO passenger ships.

Although these ships are economically the most competitive due to their specific design and structure, in terms of safety, there are a number of problems that can occur. Maritime accidents of RO-RO ships cause the loss of human lives.

The presented analysis emphasizes maritime accidents such as collision and contact, as the most common within RO-RO ships and RO-RO passenger ships. The reasons for that are numerous and the most dominant are the frequencies of operations of entering and leaving ports, confined areas where ships sail, traffic density, etc.

In recent years, the International Maritime Organization has presented a number of regulations aimed at improving the safety of RO-RO ships. Some of the regulations that can be highlighted are the ISM Code and the STCW regulations in relation to the training of the officers and the crew serving on board RO-RO passenger ships. These requirements apply only for the RO-RO passenger ships, while for the RO-RO ships there are no special training requirements. Proper education and training of masters, officers and the crew can result in the reduction of maritime accidents, but it can also reduce the consequences arising from maritime accidents.

Despite the implementation of safety measures, accidents on board RO-RO ships and RO-RO passenger ships are generally not decreasing in numbers. It means that the already implemented measures for increasing safety are

not satisfactory. Consequently, new measures should be looked for. New measures should be preventative in order to reduce the possibility that accidents occur and, therefore, to reduce the number of accidents and to increase the level of safety of RO-RO ships.

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