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## Study on ro-ro passenger ship safety management in Qiongzhou Strait

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**WORLD MARITIME UNIVERSITY**

Dalian, China

**Study on Ro-Ro Passenger Ship Safety Management in  
Qiongzhou Strait**

By

**HUANG LEI**

**China**

A research paper submitted to the World Maritime University in partial  
Fulfillment of the requirements for the award of the degree of

**MASTER OF SCIENCE**

**(MARITIME SAFETY AND ENVIRONMENTAL MANAGEMENT)**

2015

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## DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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## **ABSTRACT**

Title of the research paper: **Study on Ro-Ro Passenger Ship Safety Management in Qiongzhou Strait**

Degree: **MSC**

This paper is a research on safety management of ro-ro passenger ship in Qiongzhou strait, the analysis of navigation environment in Qiongzhou strait, risks of ro-ro passenger ship. First, the article introduce the environment of the Qiongzhou strait, including the wave, wind, fog and temperature. Secondly, in order to demonstrate the importance of the safety management of ro-ro passenger ship, the author analysis the risk will affect the safety of ro-ro passenger ship. Then, the experiences of safety management in some countries and the requirements of them are introduced in the paper. Finally, the author propose suggestions to improve the safety management of ro-ro passenger ship in Qiongzhou strait.

**Key Words:** safety management,, ro-ro passenger ship, Qiongzhou strait, suggestion.

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## **LIST OF ABBREVIATIONS**

AIS	Automatic Identification System
CCTV	Closed Circuit Television
FSC	Flag State Control
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
IMO	International Maritime Organization
ISM	International Safety Management
SMS	Safety Management System
SOLAS	Convention on the Safety of Life at Sea
VDR	Voyage Data Recorder
VHF	Very High Frequency
VTs	Vessel Traffic Service



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## **Chapter 1 Introduction**

### **1.1 Research background**

Qiongzhou strait is one of the most important water traffic zone in China. Qiongzhou strait play a very important role in transportation between the Hainan province and the Guangdong province . It is one of the keys to bring up the economical level of Hainan province. There are more than 10 million passenger and plenty of materials transport through the Qiongzhou strait by the ro-ro passenger ships. With the operation of the Yuehai railway ferry in 2003, the ro-ro transportation of the Qiongzhou Strait had came higher level, it became the new engine for the development of economic in Hainan. Ro-ro transportation has become the indispensable part in the development of Hainan economic between Hainan and mainland China. After the accident of the ro-ro passenger ship DASHUN, China maritime safety administration(MSA) had raise level of the ro-ro passenger ship safety management work deployment, the ro-ro passenger ships of Qiongzhou strait for is one of the key work. The administration carried out the 24-hour on-site inspection, strengthen the management of the company safety system, the safety management of ro-ro passenger transportation on Qiongzhou strait had improved significantly. But this type of safety management, strengthen the duties and powers of the maritime administration, weaken the the responsibility of the shipping enterprise. The shipping enterprise is the base of the safety management. In this situation, the maritime administration had became the nanny of safety

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management.

In recent years, although there are no terrible accident happened in Qiongzhou strait, but the minor accident, such as collision and grounding never disappear. It proved that the existing model of ro-ro passenger ship safety management has not been fully adapted to the development of the ro-ro passenger ship transportation. The maritime administration needs to research new type of safety management for ro-ro passenger ship in Qiongzhou strait. At the same time, a scientific, complete and efficient maritime supervision mode should be explored. It need a mechanism with good structure and service efficiently.

## **1.2 The Significance of the research**

The research about the safety management of the ro-ro ship transportation in Qiongzhou strait is conducive to promoting the economic development of Hainan, improve the safety of navigation, promoting the level of travel convenient, showing a efficient service of the government and administration. The research on the safety management of the ro-ro passenger ship transportation in Qiongzhou strait is beneficial to strengthen the communication and coordination among the various government departments. And the research on the safety management of the ro-ro passenger ship transportation in Qiongzhou strait is better to the maritime administration do the service well and create new type of safety management.

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## **Chapter 2 The characteristics of the ro-ro transportation in Qiongzhou strait**

### **2.1 The characteristics of ships**

Ro-ro passenger ship is the product of passenger ship and ro-ro ship. It takes Car and passengers at the same time. SOLAS convention defined ro-ro passenger ship as passenger ships having ro-ro cargo spaces or special category spaces. The definition of ro-ro passenger ship in China is accordance with the international convention for the safety of life at sea (SOLAS) convention. ro-ro spaces are the space of ship which is abnormal separated and extending to either a substantial length or the entire length.

Ro-ro space can load motor vehicles with self-use inside fuel tank or goods in the horizontal direction. the goods is within the road or rail vehicles or on the packaging or bulk cargo and vehicle (including highway or railway tank cars), trailers, containers, pallets, detachable van ark, or in similar loading unit or other capacity goods).Special spaces refer enclosed spaces above or below the bulkhead deck which used for loading motor vehicles with self-use fuel in the tanks. These spaces have passenger channel and allows the vehicle driving out here.

Ro-ro transportation have convenient, efficient door-to-door transport features, compared with cargo types with aviation, railways and other transport mode ro-ro transportation plays irreplaceable characteristics in the transport, and play a larger

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role in local economic development services. However, ro-ro passenger ship bringing efficient and convenient services at the same time, it makes high demands of ship safety management because of ship design.

Ro-ro passenger ship can provide convenient service for passengers, vehicles. In order to load different specifications truck and buses, there are more than one layer vehicle cabin in ship hull, and also built passenger cabins on the deck in order to accommodate more passengers. But the superstructure of ro-ro passenger ship is particular huge and shipping wind area is large, the wind heeling moment increases, all of these bring greater influence to manipulate the ship.

The overall design of ro-ro passenger ship allows vehicles from one end and the other side out of the ship. But the upper deck cannot install a complete transverse bulkhead. Huge car deck throughout the entire hull, make the ship sinking resistance become worse, the hull will quickly tilt when the water inflow, and moving goods intensifying tilt, vicious circle formed, and then the ship will lost stability and buoyancy, and once the fire, the fire will spread rapidly, it is difficult to control.

The Ro-Ro passenger ship sets hatch door for quick dispatch vehicles. But hatch door are close to the water line, however, it is also the most easily inflow water when the ship damaged, especially when the hatch door used as watertight door gang board for the vehicles access, after few years later, their water tightness will lose due to the vehicle pass and the door switch up and down which make the hatch door very easy to damage and deformation.

Ro-ro passenger ships have thrust and anti-sway device to improve the operability of storm sail and Berthing. Because of larger superstructure, the wind impact

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operability obviously. Because the ro-ro passenger ship berth frequently, there is generally a transverse thrust to improve low speed maneuverability in order to achieve lateral translation and improve the flexibility of rotation in order to convenience berthing. ro-ro passenger ships have Fin to reduce roll. Especially when big waves, the Fin can reduced ship rolling amplitude, helping to restore the ship upright position, reducing the risk of the vehicle sliding, increasing comfortable.

Ro-ro passenger ships have good ventilation systems and fixed fire systems, Early ro-ro passenger ships were equipped with sprinklers fixed fire extinguishing systems, but as the increase of chemical products, there are more difficult for ship fire, currently more than half of the ro-ro passenger ship vehicle cabins are equipped with a carbon dioxide fire extinguishing system

Ro-ro passenger ship equipped with advanced navigation instruments and communication equipment. Ro-ro passenger ship are equipped with a global positioning system (GPS) , Automatic Identification System, automatic radar plotting system, echo sounder and voyage data recorder (VDR) and advanced global maritime distress and safety system (GMDSS).

## **2.2 Hydrometeorological characteristics of Qiongzhou strait**

### ***2.2.1 Atmospheric and temperature***

The annual average temperature is 23.8℃, the lowest temperature appears in January, the monthly average minimum temperature is 17.2 ℃ , the highest temperature appears in July, the highest monthly average temperature is 28.4 ℃. Annual extreme

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minimum temperature is 3.2 °C , appears in January, the annual extreme maximum temperature is 38.4 °C , appears in June and July.(Xu, 2011)

### ***2.2.2 Wind condition***

Annual average windy days with wind power level above 6 are 172 days, in which the windy days with wind level above 8 are 15.5 days. Each year, from April to September, there are more southeast wind and the wind level is generally level 3-4, October to April, with the cold transit, there are often blowing strong north and northeast wind with level 5-6. The wind with level 8-9 often occurs in August and September, the wind occurs ferocious, short and hard to forecast. From May to November is the typhoon season, in July to September, the influence of the tropical storms, strong tropical storms and typhoons is serious, during this period, attacks from the front Strait tropical storms, tropical storms and typhoons will occurs about 5-6 times on average and the maximum wind speed is 32 m per second.(Xu, 2011)

### ***2.2.3 Fog condition***

Winter and spring are the fog season, especially in January to April, foggy days will continue 35 days on average, the duration of foggy days will up to 13 days, sometimes fog come suddenly;

## **2.3 Traffic situation**

Currently Qiongzhou Strait has opened 3 routes, Haikou to Beihai, Haikou to Haian Route and Yuehai train ferry routes. The distance of Haikou to Beihai route is 119 sea miles; sailing time is about 12 hours. The distance of Haikou to Haian route is 18

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sea miles, sailing time is about 1.5 hours. The distance of Yuehai train ferry route is 11 sea miles, sailing time is about 1 hour. The number of ships in these 3 routes increase more and more.(Wu, 2014)

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## **Chapter 3 The risks of ro-ro transportation in Qiongzhou strait**

The ro-ro transportation in Qiongzhou strait is affected by environment, management, ship and human factors.

### **3.1 Environment for navigation**

Recently, with the increase in the number of passengers vehicle, the navigation times of the Haikou – Haian route also increase more and more. The ship which sailing in Qiongzhou strait was easily affected by winds, strong winds, typhoons, fog and other inclement weather. There are many operating risks and hazards caused by the nets which hinder the sailing on Qiongzhou strait.

### **3.2 Problems of management**

First, in the management of the port, the capacity of vehicle detection is insufficient; the car without detection is easily leading to dangerous behavior such as illegal loading with dangerous goods. Because of lacking effective measures to strengthen the control of vehicle into the port, it results in a large number of vehicles entering the port. Second, in corporate governance, through protracted and unremitting efforts, management ability of ro-ro shipping companies have been effectively improved, but there are still many problems of management, such as the safety management system. The shipping companies shall pay attention to re-effective



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and ignore the management. There are many problems in emergency disposal scheme of ro-ro passenger ship, there still have no professional fire boat, oil spill emergency plan. The emergency plan and oil spill equipment construction has not been established.

### **3.3 Problems of ship**

The characteristic of sinking resistance of the ro-ro passenger ship is worse than the other ship because of loading space. Once the cabin damaged, it is difficult to control and easily lead to accidents. In addition, as the great variety of vehicle, it leads the difficult to achieve effective binding, high center of gravity of vehicles and goods will cause rollover prone in large waves or high angle avoidance, then the ship will tilt even capsize.

In recent years, ro-ro passengers ship conditions and technical conditions of Qiongzhou strait had improved obviously, but the navigational equipment, fire rescue equipment of ro-ro passengers ship still go wrong frequently because of lacking maintenance and inspection and other reasons.

The safety precaution such as the implementation of people and vehicles, people and vehicles separate place without reserve and patrol fire safe passage and other security measures still implemented worse.

### **3.4 Human factors of crew**

Currently ,there are eight ro-ro passenger shipping companies. Most of the crew lack the higher education, they receive little education. Parts of crew work have many

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problems like poor operation ability, lacking the sense of responsibility. In recent years, many accidents occurred because of the crew excessive lacking responsibility and sailing with non-compliance of rules.

The problems existing in the ro-ro ship crew brings hidden trouble to safety operation of water traffic.

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## **Chapter4 The factors affect the safety of ro-ro passenger ship**

### **4.1 Big waves**

#### ***4.1.1 The influence of sailing safety***

Ro-ro passenger ship, will produce swaying and pitching, Vertical swing and roll, Heave and yaw pitching in the role of large waves. Roll and heave make great impact on the safety of the ship, and this influence also performed as the impact of large waves in passenger comfort and security .

#### ***4.1.2 The influence of comfort***

Human beings have certain requirement to the comfort of the environment, when they are in suitable environment, they will be working effectively. When the ship is sailing in rough seas, people will be affected by roll and the acceleration of ship. Acceleration will cause people seasick; in general, seasick rate increases with increasing acceleration. Maximum acceleration occurs in the stern or bow, the human seasick will exacerbate when the acceleration, which caused by pitching and heave. Roll angle will affect the person exercise capacity.

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### ***4.1.3 Impact on navigational using***

#### ***4.1.3.1 Difficulty in operational***

When ro-ro passenger ship sailing in rough seas, it can easily shake because of the tall superstructure and the larger wind area, the ability of operational of become worse. It is difficult for ship maintain course and change course, Especially when the ship need to turn in a big storm, careless operation will bring unpredictable consequences.

#### ***4.1.3.2 Damage to the hull structure and equipment***

Violent shaking and rattling force storms will cause serious damage of the ship and equipment. When the wave is on top, the header structure will be damaged by intense slamming clap bottom. When sailing along the waves, the rudder and propeller may damage by the waves direct impact. Ro-ro passenger ship rudder door are easily deformed, the watertight of rudder door was damaged under the impact of large waves. Hull is chattering dramatic while waves come to deck , it can cause mechanical damage on a lot of deck propeller speed spindle is greatly torsional vibration and the parts of engine will be damaged.

### ***4.1.4 Impact on safety***

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Large waves can cause a host of key components, propeller, rudder and damaged the ship's navigation equipment, ships may lose control and cause serious consequences. The ship's stability and wind resistance may be reduced by greatly rolling. Greatly rolling may lead to serious car cargo movement and collision, it not only affect the stability of the ship, but also may lead to a fire, then make the ship at risk. On the deck of the waves can cause severe compartments water, the movement of goods, and even lead to the loss of the ship's stability and eventually capsized danger.

#### ***4.1.4.1 Impact on the stability of the ship***

Ship shaking caused by the wave is an important factor in changing the stability of the ship. Under the rules of wave action, stability curve cyclical changes. In the wavy surface cycle, the ship's stability sometimes is larger than the average draft, the other smaller than the average part-time draft

## **4.2 Analysis of factors affecting the safety of navigation of the ro-ro ship in the large wind and waves**

In the view of safety system engineering, the safety of the ship is determined by the interaction between the factors and conditions of the safety system composed of human, ship and the environment. Ship accidents are also caused by these factors: human factors, environmental factors and ship factors. From these three perspectives, the following analysis will be carried out.

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#### ***4.2.1 Human factors***

##### ***4.2.1.1 Operational skills***

Operational skills mainly refer to the qualifications of the master and senior crew and the level of familiarity with the ship handling performance as well as the skillful application and maintenance of the cabin crew on the ship's equipment. The management and leadership of the captain and chief engineer and the skillful nautical skills of senior officers are very important for ship navigation safety. Especially before the encounter waves, foreseeing what is likely to occur, and carry out a comprehensive inspection and preparations. In the event of large wind and waves, the use of appropriate navigation methods and effective measures can ensure the safety of the ship to the maximum extent. Sailing operational skills are not only for the rich navigation requirements, but also include multiplying sailing experience accumulated over a long period.

##### ***4.2.1.2 Sense of responsibility***

Sense of responsibility refers to the safety awareness, professional ethics and behaviors of the crew. All human activities, including the human language and body language communication are subject to the brain control and they must accept the brain's conscious thinking as well as decision-making command. In the voyage, many performances without sense of responsibility can cause marine accidents, such as, the crew not abiding by the Rules of the Fog, the International Regulations for Preventing Collisions and International Maritime Search and Rescue Convention, weak safety awareness, weak sense of responsibility, paralysis of thought, only

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bearing lucky hope or implementing ship operation with the attitude of taking everything for granted.

#### ***4.2.1.3 Mental state***

Mental state mainly refers to the mental state of the captain and officers, including the severity degree of seasickness, stress and fatigue. In the stormy voyage, the ship sways violently, the crew will appear seasick and depressed. Besides, the captain of the ship needs to command the ship personally at the navigation bridge. In highly stressful situations, long time duty will cause physical fatigue, in which case, processing capacity will be affected to some extent.

#### ***4.2.2 Ship factors***

The safety of the voyage is closely related to the ship's own characteristics and performance. The characteristics of Ro-Ro ships bring many advantages in transportation. But meanwhile, they also add a hidden trouble to the safety of navigation. In this paper, the risk factors of the safety of navigation of the ship are described from the following aspects.

##### ***4.2.2.1 Superstructure***

Ro-Ro passenger ships have a tall superstructure, greater freeboard, larger wind receiving area, and are seriously affected by the storm weather. Metacentric height is

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easy to change, and the range is large. Small initial metacentric height will make the ship less stable. And when the initial metacentric height is large, the rolling caused by this is more serious, so it is more difficult to control the ship. Seaworthiness of Ro-Ro passenger ships directly affects the safety of the ship and the cargo lashing, resulting in serious consequences.

#### ***4.2.2.2 Cargo stowing structure***

There is no or lack of transverse and longitudinal bulkhead in the vehicle. Once the vessel is damaged, it may soon be submerged and lost. If there is a fire, the fire will soon spread to the whole cabin, and it will be more difficult to control. There are vehicle traffic difficulties. For the purposes of security and the principle of benefit maximization, transportation usually has a higher warehouse utilization rate, and the distance between trucks will be naturally small. Moreover, the lashing equipment is complex and it's easy to form four inspection blind areas. Once the fire is difficult to be found at the first time, it is often more difficult to control. The fixed type sprinkler or spray fire extinguishing system is easy to cause a large amount of water in the deck or double deck, resulting in a similar situation with the cabin inlet water, resulting in serious damage to the ship.

#### ***4.2.2.3 Cargo stowage***

Ro-ro passenger ships usually have a poor stability. Due to binding or stowage and other reasons, vehicle moves or a lot of water will cause hull to tilt. That will destruct original ship stability, endangering the safety of the ship. If the cabin of the vehicle, container and cargo move, it's extremely easy to cause a Domino effect. Other



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vehicles and goods are moved to one side in a short time, increasing the inclination of the ship. Or, collision with each other results in the loss of goods. Even worse, it will cause a fire, and even spread to the whole cabin. Types, weight and stowage of the loaded goods are not fixed. There is no uniform standard of banding techniques, so it is difficult to determine the binding effect. In addition, vehicle overload is more common for loading on the land, increasing difficulty and potential safety problems for loading and lashing security. Cargo goods are more special because the goods are not fixed. Usually, vehicle types, types of cargo goods are different. It's difficult for ship, port and maritime administrations to check and control the overloading of vehicles or loading and entrainment of dangerous goods which seriously affect the safety of the ship (especially in the container or trailer).

#### ***4.2.2.4 Ship age***

The aging of the ship directly affects the strength and equipment performance of the ship. Passenger airlines or sheer is provided with an entrance and exit of the cargo. Some are equipped with a side door. Although all have watertight structure, part of the hull structure is the weakest. After a few years of use, it is likely to damage and deform. Water tightness will be worse, especially watertight doors, also used as a springboard, are more likely to damage and deform. Some fore and stern doors of the Ro-Ro passenger ships also do as the vehicle handling boat ramp, which are easy to deform and damage under press, resulting in destruction of the ship water tightness, and increasing the possibility of vehicle loading inlet place. If equipment has been used for a long time, it will produce wear consumption and it is bound to affect the device performance. Especially in adverse weather conditions, equipment, especially power equipment is very easy to have fault, threatening the navigation safety. The influential factors of the ship are reflected by various forms of the ship itself, and its own factors play an important role in the safety of navigation.

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#### ***4.2.3 Environmental factors***

Environmental factor is a very important factor for the safety of the ship, and it is a carrier of the ship's operation. The environment is a combination of multiple factors. The three factors that affect the safety of the ship are the wind, wave and fog. The evaluation object of this paper is the safe navigation of ro-ro passenger ships in large waves, which has set the elements of natural environment. Because of the need of research, this paper only discusses the existence of two environmental factors, namely, wind and waves. The other is assumed to be not existent.

##### ***4.2.3.1 Wind***

For the surface sailing ships, because exposure of the hull above the water surface in the air is impacted by the wind pressure, the state of motion of ship in calm water is changed, affecting the ship maneuverability. Size of wind pressure acting on the ship wind area is related to the wind speed, wind area, wind angle and ship type. Ro-Ro passenger ships sailing in the wind under the wind pressure will be affected by the following aspects. First of all, the performance of ship's direction will be affected to a certain extent. Normal transverse wind has a greater impact than before the wind abeam; Secondly, ships will drift toward the downwind. Leeway angle changes with the change of the relative wind angle and speed. Drift velocity is related to the ship type, relative wind direction, relative velocity, condition and water depth and so on. Finally, the ship will swing. The swaying amplitude is relative to wind speed and relative wind direction.

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#### **4.2.3.2 Wave**

The ship will sway in waves. The intensity of swaying depends on wave factors, factors of seakeeping, ship scale and so on. Rolling, pitch and heave have a greater influence on the ship. In the rolling, a ship is prone to produce a large horizontal roll, causing the moving, collapse, and fire of goods. When the wave pitches, it is easy to produce the wave hitting the end of the deck, water on deck, galloping and so on. It may cause damage to the hull or power equipment failure, so that the ship is in danger.

### **4.3 The impact of fire on the safety of ro-ro passenger ships**

#### **4.3.1 Cause analysis of engine room fire accidents**

The main reasons for engine room fire accidents are: There are a certain number of second-hand ships in Bohai, which are aging, and the hidden part of the line is difficult to be found. It is difficult to check and repair relying on the ship's own ability. In the plant repair time, the time on the dock must be taken into account, so usually only the external line is maintained and replaced. The complex line is usually not repaired planned beforehand. At the same time, the ship's flight schedule is tight, the crew rest time is less, so there will be an inevitable discount in inspection and maintenance of the electrical appliances and line. In such unsafe factors, the electric overload, wire heating, rat bite bad lines and bad weather will lead to a short circuit fire, and it is easy to lead to electrical accidents. Ship wire layout is complex with more fuel, bunkers and lubricating oil. If the fire is not timely put out, it is likely to cause a fire disaster, and even an explosion.

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#### ***4.3.2 Cause analysis of vehicle cabin fire accidents***

In the analysis of the fire accidents caused by the vehicle cabin, it is found that there are 4 factors, namely, weather, passenger, vehicle and cargo goods.

##### ***4.3.2.1 The fire caused by meteorological factors***

Ro-ro passenger ships have a high superstructure. The wind area is large, and the draft is relatively small. Large waves will make navigation operation difficult, and it is easy to produce rolling, pitching and heaving. More seriously, it will clap bottom, deck wave, even dangers of pooping and melintang.

##### ***4.3.2.2 The fire caused by the passenger factors***

On one hand, passengers have such a weak security awareness that they carry flammable items and after smoking, the kindling is not extinguished are discarded everywhere, thus leading to a fire. On the other hand, criminals sabotage ships, such as placing explosives or ignite items or goods on the ship.

##### ***4.3.2.3 The fire caused by vehicle factors***

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Vehicle fuel oil are divided into gasoline and diesel fuel. If the tank is sealed, volatile gas or the oil spill with the ship swinging are the hidden dangers of fire.

Due to poor maintenance, the vehicle electrical equipment may lead to short ignition, even fire. In winter, drivers of long-distance vehicle usually use electric mattress in driving cab. If the ship has not cut off circuit, it is easy to cause accidents.

There is no suitable lashing point for the vehicle and its lashing state is not good. The problem of vehicle's lashing point has long been studied in international research. IMO also formulated relevant provisions. If there is no suitable lashing points, lashing state is poor and goods on the vehicle is not fixed, the goods will collapse with the swing of the ship. To a lesser extent, goods will be damaged. To a severe extent, automobile fuel tank will be stricken and cause a fire.

Vehicle entrainment of dangerous goods and chemicals are not only difficult to detect but it's easy to cause explosion or fire. Before the accident, the nature of dangerous goods and chemical properties are unknown, which brings great difficulties to the fire protection, easily leading to disasters.

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## **Chapter5 The experience and inspiration of transportation safety management of ro-ro passenger ship in China**

There are four major ro-ro passenger transport waters of the mainland of China, namely, the Bohai Bay, the Zhoushan islands, the Qiongzhou strait and the upper reaches of the Yangtze River. The upper and middle reaches of the Yangtze River are inland waters, so they are of no significance. The Bohai Bay, Zhoushan waters and the Qiongzhou strait are in the coast, and they share the same national conditions and legal system. As a consequence, studying the safety management of the ro-ro passenger transportation and the management experience in the two waters has a reference significance and management suggestions for the safety management of the ro-ro passenger ship in the Qiongzhou strait. Foreign shipping developed countries have advanced, mature experience in passenger transportation safety management. Similarly, referring to the experience and absorbing it can also help to improve the safety management level of the Qiongzhou strait.

### **5.1 Safety management of ro-ro transportation in the waters of the Bohai Bay**

The Bohai Bay is a C - type coastal structure. Yantai and Dalian are located in the northern and southern endpoints. The unique geographical position and the economic needs of the city which is based on the core of Yantai and Dalian create unique conditions for the Gulf to develop ro-ro passenger ship transport. Especially, the linear distance at sea from Yantai to Dalian is only 89 nautical miles, which is 1800

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kilometers shorter than the highway bypass. Therefore, it is a major energy saving passage connecting the three northeastern provinces and the Shandong Peninsula as well as the East China region. With the opening of train ferry from Yantai to Dalian, the Yantai-Dalian route has become an important part of the national north-south traffic artery and has a significant influence on stimulating regional economic development. It is known as the golden waterway of the Bohai Bay.

#### ***5.1.1 The characteristics of ro-ro transportation in the Bohai Bay***

Ro-ro transportation bears a high security risk. Passengers and cars are loaded together. The area that suffers wind is large. In addition, car cabin is without horizontal separation. These characteristics cause a high security risk. At the same time, the Yantai-Dalian route lies first in key waters determined by the Department of transportation. Route traffic flow is complex. 70.7 percent of the traffic flow is the ro-ro passenger ship(Li,2013). It is a veritable roll-on route from north to South. Respectively, it crosses three east-west routes. Especially, it vertically crosses the east-west traffic flow from Chengshantou to Laotieshan waterway where ships frequently meet. The distribution of marine breeding near the ports of the Strait is widespread and there are many operation fishery ships. Affected by the Bohai Strait tube effect, the weather of the South Bank of Bohai sea is changeable, unpredictable and destructive. The complex navigation environment and harsh weather conditions increase the probability of accidents, raising a great challenge for the safety supervision of the ro-ro ships. With the continuous introduction of strict management measures and systems at all levels of government, ro-ro passenger ship capacity continues to update. Besides, the management of ship companies strengthens. The quality of the crew continues to improve. The adverse factors that affect the safety of the ro-ro passenger ships are effectively resolved and eliminated, and the safety

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coefficient is greatly increased. But the risk of collision (especially the occurrence of collision with other large ships) and the fire risk (especially in the case of the car cabin) are still the biggest risks to the safety of the ro-ro ships. Safety supervision of ro-ro passenger ships must firmly grasp these two keys.

### ***5.1.2 The safety supervision mode of ro-ro transportation in the Bohai Bay***

Faced with the natural defect of the ro-ro passenger ships and the risks inherent in the sea, the local maritime organization is also burdened with painful lessons of history and shoulder the people's new expectations and needs. Therefore, on the safety supervision of the ro-ro ships, the local maritime organization adheres to the scientific development and secure development. Additionally, it creates regulatory highlights and take the brand development strategy. The idea of "grasping law and scientific supervision" is established. The local maritime organization studies on the regularity of the ro-ro ships, standardizes law enforcement behaviors, establishes professional ro-ro passenger ships supervision team and integrates social supervision of various resources. Making full use of information technology and continuous innovation, the local maritime organization has established two levels of monitoring centers, namely, vessel traffic services(VTS) center and maritime department. Also, it carries out the clear identification and key monitoring for the ro-ro passenger ships, processing information at any time. It also establishes the "ro-ro passenger ship monitoring center" in the maritime affairs department to create the full range of ro-ro passenger ship monitoring network. Through the integration and processing of closed circuit television(CCTV), automatic identification system(AIS), VTS, very high frequency(VHF) and other information resources, the whole dynamic monitoring of the ro-ro passenger ship is realized, and the monitoring network of the ro-ro ship is



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preliminarily established. The supervision and service information system of the ro-ro passenger ship is developed, and the intelligent check is carried out for the suspected dangerous goods and overrun vehicles. The local maritime organization gets the passengers boarding and ticket information in advance. All business implementation are approved online, truly realizing the information management.

The ship companies should adhere to the source of the company management. The source management of the company is the key to the safety development of the ro-ro ship. The ship companies should form their own safety concept and safety culture, deeply implant them in the hearts of the crew and make them consciously apply to work on all aspects. That can really eliminate the safety hazards and play a multiplier effect. Over the years, the maritime sector has carried out strong implementation, establishment and effective operation of the security management system in order to strengthen the safety management of modern corporation, strengthen the main responsibility of the enterprise and improve the management level of the company to the ship and the crew. Ro-ro passenger ship companies should strengthen the implementation of the ship remote monitoring and establish the hidden trouble investigation system and the strict assessment system.

## **5.2 Safety management of ro-ro transportation in Zhoushan waters**

### ***5.2.1 Characteristics of ro-ro ship transportation in Zhoushan waters***

Numerous islands lie in Zhoushan waters. Navigable waters are complex with a dense traffic flow and developed fishery. There are a quantity of passenger ship types, passenger stations as well as numerous lanes. Trans-provincial and inter-city routes are arranged in a crisscross pattern.

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### ***5.2.2 The safety supervision mode of ro-ro transportation in Zhoushan waters***

Zhoushan maritime administrative agencies actively explore the establishment of the water passenger traffic supervision mechanism, keep the passenger transport in the jurisdiction secure and focus on building comprehensive governance responsibility mechanism. Besides, Zhoushan maritime administrative agencies implement the chain network engineering, and actively promote the new situation of controlling and administrating cooperatively the safety of waterway passenger transport. The jurisdiction maritime affairs department is established. Adjacent maritime agencies establish the joint inspection mechanism to carry out joint inspection and off-site sampling of the jurisdiction waters, companies and ships regularly. At the same time, Zhoushan maritime administrative agencies initiatively strengthen communication and cooperation with safety supervision, transportation, shipping, ship inspection, marine and Fisheries Department so as to ensure the safety of water passenger transport. In addition, they promote the implementation of responsibility of the main corporate security, and supervise jurisdiction water passenger transport enterprises to establish and improve the safety of passenger transport and treat much information as the elements of water hazard assessment, namely, the passengers' basic situation, company management, crew, passenger terminal, path channel, risk areas and so on. Static and dynamic factors are taken into comprehensive consideration. They sort out and identify the safety management information of water hazard source by season, formulate the corresponding control measures, and effectively improve the risk prevention and emergency response capabilities. Also, they establish and implement a comprehensive mechanism including rolling investigation, evaluation, report, rectification, tracking and listed supervision of passenger safety hazard. Moreover, they strengthen the rectification of significant security hazards, and improve the ability of water security prevention and risk control.

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Focus on building scientific and regulatory long-term mechanism. The ship's seaworthiness is essential. On basis of it, Zhoushan maritime administrative agencies strengthen on-site supervision of passenger ships. First, they should make sure the passenger ship is seaworthy. They establish and implement passenger ship safety inspection, the evaluation system after the security check and the inspection quality evaluation system of passenger ships. Medical archives of passenger ships are formed. Inspections of operating ability of passenger crew are continued to carry out. Second, they should pay attention to a good ship sailing. Master and verify conditions of crew, sailing route conditions, berth conditions, weather conditions, passenger and cargo loading and other factors as well as timely report the relevant information. Third, they should guarantee the good on-site check. Strengthen on-site supervision, crack down on non passenger ships carrying passengers, overloading, anti wind sailing and other illegal acts.

The safety management of the passenger transportation enterprise is standardized by the company management. First, strengthen the audit work of passenger company system and track the rectification of problems found in audit. Supervise and urge the passenger transportation enterprises without a safety management system to establish one, and promote the construction of safety management standardization system. Second, promote the level of enterprise security management, help companies find the shortages of security management, and implement the rectification. Third, the navigation safety of passenger ships is guaranteed by the navigation management. Additionally, strengthen the construction of water passenger emergency rescue system, and actively organize various emergencies of passenger ships. Fifth, establish and implement the sailing dynamic monitoring system of passenger ships. Implement sailing dynamic supervision of passenger ships and safety information alert by means of VTS, AIS, CCTV, VHF and other technical means. Especially in fog, strong winds and bad weather, supervise ships to strictly comply with the

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alignment, speed limit and so on, Remind ships to avoid sailing risks consciously, and explore the development of speed limit management regulations on special passenger routes. Sixth, establish and implement dynamic reports of passenger ships' entering and leaving the port. Receive full dynamic reports of passenger ships' entering and leaving the port through telephone, fax and VHF and other effective ways. Combine dynamic monitoring of the passenger ship, and master the dynamic and time of passenger ships' entering and leaving the port as well as capacity and other related information. Prevent illegal behaviors such as super classification of wind resistance of passenger ships, navigation in fog and overload. Dynamic report system has covered passenger ships owned by the jurisdiction and ships in key remote areas. Seventh, supervise and urge the assessment of passenger routes. Instruct and urge all passenger transportation enterprises to carry out the assessment of the routes of the jurisdiction in time. And timely supervise the dock owners to measure the port frontier water depth and report the result.

Based on the management of the crew, the improvement of the capacity of the passenger crew is promoted. First, strengthen the duty and performance inspection. Through effective means such as cross unannounced visits, Zhoushan maritime administrative agencies strengthen the normalization of inspection on driving double duty, crew handover, airlines before repeating, drunk driving and fatigue driving and so on. Supervise the crew to strictly perform their duties in order to ensure the safety of passenger ship navigation. Second, strengthen the inspections of crew's practical ability and skills. The equipment operating ability and the emergency survival ability of passenger ship crew should be especially checked.

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## **Chapter 6 Safety management of passenger ship transportation foreign ro-ro in world**

The ro-ro passenger ships in world can be divided into carrying only freight cars, carrying containers or truck, carrying private cars and so on. But the main type is still carrying commercial vehicles or cars, carrying a large number of passengers. The design idea of ro-ro ship is different from that of ordinary merchant ships, which brings more security problems. For example, the lack of internal watertight bulkhead ship influences stability and structural strength of the ship, fore and aft cargo doors easily deform by extrusion goods and goods move or larger wind pressure can produce heeling moment and decrease the ship's intact stability, the low dry boat deck is easy to make the water into the cabin, dangerous goods leak or errors of gravity estimation of cargo easily damage the hull structure, highly equipped life-saving equipment impacts cost, the complex ship's condition easily induces crew to make mistakes and so on. Due to the existence of safety defects in ro-ro passenger ships, there have been a number of major sea accidents.

### **6.1 General requirements of the International Maritime Organization (IMO)**

Since International Maritime Organization was established, it has been carrying out the safety management of ro-ro passenger ships, and has achieved a number of results. For example, in the cabin and damaged stability, vehicles must be parked above the waterline, below the deck area and must be divided by a longitudinal

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watertight bulkhead; On fire prevention, it is considered that the large open area will affect the fire performance of the ship, and the ships shall install additional fire detection and alarm devices, improve fire fighting equipment, ventilate and prevent flammable gas, and so on. On the security of goods, it is pointed out that the ro-ro passenger ships have a lower center of gravity. Therefore, the goods owners are asked to provide relating data before loading. Additionally, the specific requirements of cargo stowage and lashing are come up with. Regularly, the results of the study are included in SOLAS (The chapter 2-1 of 1995 amendments increased the content of ro-ro passenger ships) and the international convention on load lines(LL) to form the mandatory provisions. State parties are required to comply with them and implement them in order to enhance the safety management level of ro-ro passenger ships.

## **6.2 Specific requirements of some party states in IMO**

In order to reduce the safety risk of the transportation of passenger ships, the safety management of ro-ro passenger ships is studied. In 1983, after studying the reasons of 341 heavy accidents of ro-ro passenger ships which occurred in the years between 1965 and 1982, Det Norske Veritas(DNV) thought the main causes of accidents were: collision (24%), mechanical failure (17%), stranding (17%), the shifting of the cargo (16%), and fire and explosion (14%). Europe, the United States, Japan, Korea and other countries are the State Party of IMO. The ship safety management of the country's ro-ro passenger ships basically depends on the relevant conventions and circulars of IMO. At the same time, because of different national conditions, there are some differences in the specific management mode. For example, Greece is developed in ro-ro passenger ship transport. It is made up of the main routes distributed in the nine basic islands, second class coastal routes and a total of 1,5000

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ferry routes which respectively connect more than 40 ports and 100 multiple islands. All of the ro-ro passenger ship owners in Greece are private. The government authorities provide ports, terminals and other public goods, and supervise them. The Greek law provides that the ferry over 30 years or above shall be out of operation. Denmark is a big country in the shipping industry, with 65 domestic ferry routes and about 20 international routes. The Danish government has ferry and parking facilities, providing them to the operating companies, which must be determined through government tenders; Through public service obligations, Denmark ensures that the ship owners provide ferry service between the appropriate intervals of the ports.

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## **Chapter 7 Countermeasures for improve the safety management of ro-ro passenger ship in Qiongzhou strait**

In 1995, IMO set up the expert committee which is responsible for evaluating the safety of various aspects of the ro-ro ships. According to the accident statistics and experience in recent years, there are more than 60 questions submitted to the expert committee for discussion. The main problems include the complete stability and damage stability. The potential danger of the car deck and the preventive measures. Human factors and potential human negligence, including watertight doors closed and vehicle solid, passenger and ship safety system, effectiveness of rescue equipment as well as effectiveness of search and rescue, an emergency deployment. Including estimation of situation required information and effective emergency control, special training and special requirements that the crew of ro-ro passenger ships need, communications, including the communications inside the ship and external communications and so on. This shows that the potential danger of the ro-ro ship involves a wide range, but not all the factors will cause serious consequences. Therefore, in the course of the analysis, attention should be focused on the risk factors that occur frequently in a certain period of time and the consequences are serious. According to the experience of design personnel, staff and the administrative staff, as well as the previous data, the main potential risks of operating ro-ro passenger ships include: the risk of fire, including car deck, cabin, and passenger room. Collisions, including collision with other ships or boats; running aground, including stranding. Sailing accidents in bad weather, human factors,



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equipment failure and so on. In this paper, safety management suggestions for the problems that occur frequently in the operation of ro-ro ships will be put forward.

### **7.1 Combine actual situations, implement international conventions**

According to the problem of insufficient implementation of the International Convention, China should combine the actual situation of our country, amend, supplement and improve the laws, regulations, standards, norms and guidelines which are not suited for the situation of our country. Besides, our country should actively make effort to make international conventions fit for Chinese situations. Similarly, in Qiongzhou Strait and its adjacent waters, relevant management sectors and local governments should also associate actual situations and make international conventions fit for local situations.

### **7.2 Increase the dynamics of safety supervision of maritime sectors**

Strictly guarantee the audit quality of security management system of shipping enterprises, and promote the effective operation of the safety management system. Increase the implementation dynamics of safety management questioning system of shipping companies and strengthen interviews, visits and communication. Strengthening the safety inspection of ro-ro passenger ships, further improve the site visa management, urge the ship's reasonable cargo stowage, and severely punish illegal ship loading behaviors. Supervise and urge the shipping companies to strengthen the maintenance and the renewal of the equipment and the fire protection system. Supervise and urge the port and shipping enterprises to effectively carry out the safety management requirements of transporting dangerous goods, and provide

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advice and guidance on the knowledge of dangerous goods for port, ship and crew. Strengthen the check of the actual operation ability after the crew get certificate to ensure the crew are qualified for the navigation. Organize and develop safety knowledge training on navigation in fog, anti-typhoon and the special inspection of practical operation, urge the ship to regularly carry out emergency drills on fire, rescue and passengers stranding, improve the crew's ability to deal with bad weather and emergencies. Strengthen on-site supervision and inspection dynamics, and severely punish the ship with insufficient crew, supervise and urge the shipping companies to protect the crew's rest time to prevent the crew fatigue driving. Speed up the construction process of anti-typhoon anchorage. Strengthen the supervision and inspection of the maritime books and information. Strengthen the cruise control in the Qiongzhou strait.

### **7.3 Improve the technology research on the safety of ro-ro passenger ships**

From the point of view of the safety of the ro-ro passenger ships, some of the following improvements can be envisaged: Install protection measures on bozrdside, namely, strengthen the hull structure, or take gas expansion protection, which can inflate and increase buoyancy, improve stability and not sinking in case of emergency. But it must be under the prerequisite that the power device can work normally. Freeboard and the ratio of breadth has a larger influence on the broken GZ curve. Therefore, appropriately increase the inlet angle and reserve buoyancy of freeboard and deck, so as to improve the stability of the vessel and guarantee the safety state of the ship. Double bottom horizontal subdivision can reduce the impact of free surface on the stability. Widen the gunwale tank, reasonably subdivide, and properly maintain watertight on superstructure. Even after water gets into the vehicle compartment, the ship can also float for a period of time, thereby increasing buoyancy.

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#### **7.4 Systematically take essential security prevention measures**

Marine traffic engineering believes that traffic system consists of three elements, namely, human, boat (machine) as well as environment. Interaction problems of one or any two or three factors may lead to traffic accidents. The safety of ro-ro passenger ships fundamentally can not be separated from the safety science, Take essential security measures for these three major elements, that is, take the measures fundamentally away from the accident risks for these three factors as much as possible. Control the technical state and operation, eliminate and limit the risk of accidents, which can reduce the navigation risks and accidents of ro-ro passenger ships to a large extent. In order to prevent the safety accidents, it is necessary to control the professional quality and operation of the ship's personnel, strictly control and maintain the technical state of the electrical equipment on the ship hull to ensure the normal operation. Correctly estimate natural forces in navigation environment and the inherent ability to resist. Timely and accurately predict conditions of weather and sea, avoid disaster weather as well as avoid the attack of force majeure. Strengthen the safety management of the company's on land and ship, improve the organizations, regulations and operation. The International Maritime Organization requires companies to establish a safety management system (SMS) in accordance with the international safety management (ISM) codes and effectively operate and obtain a certificate. Only in that case is a ship capable of engaging in international navigation; Monitor the technical status and safety operation of the ship through the flag state control (FSC). In addition to the progress of science and technology, the human factors should be controlled in nature to prevent accidents from the root.

#### **7.5 Improve the professional quality of the crew and the administrators of the shipping company**

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The professional quality of the personnel determines the quality of the professional behaviors, including the professional moral quality, technical quality, physical and mental quality and ability. Company's safety management regulations need to be developed and improved by high- quality personnel, but also need the initiative follow of those who have the appropriate quality in order to achieve the unity of safety and economic benefits. At present, the maritime safety supervision departments only require physical health and knowledge skills of the crew, which is not sufficient. The company's management regulations or SMS, should contain complete personnel professional quality management system, which makes a complete set of plan of the crew on board and at shore, including staff hiring, selection, training, assessment, and continuous education. They need to be effectively implemented. The personnel with serious quality defects which are difficult to correct, should be eliminated. Carry out education and training and exercise which is often persistent, in various forms, rich in content and focuses on safety according to plan. That can effectively improve the professional quality of employees. Companies and captains should guide and supervise this kind of training as well as provide the necessary resources.

## **7.6 Master weather dynamics to avoid disaster weather**

Voyage in compliance with sailing standards and cargo securing regulations can fight against common navigation risks. The captain must not only correctly analyze and estimate the weather dynamics and its impact on the ship but also take prevention measures at an early time . Accounting the wind resistant grade in the safe sailing and making comprehensive evaluations on the safety of navigation provide essential theoretical basis to ensure safe navigation. Take avoiding attitude towards the disaster weather, namely, avoid the encounter and confrontation as far as possible,

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but should be prepared for emergency. The captain who does not pay attention to the weather and can not analyze the weather information is not competent and should be resolutely eliminated. Some companies often do not consider the weather, forcing captain sailing companies always don't take weather conditions into consideration and compel the captain to make adventurous voyage. In this case, the captain should decisively use ISM code, using the decision-making power granted to the captain to ensure the safety of the vessels and lives.

### **7.7 Perfect emergency exercise system**

Emergency response plan can make the personnel responsibilities and relationships as well as the program clear. Emergency exercises can make the crew comprehensively use relevant knowledge and skills and be familiar with the group. The plan preventing the ship average should include the vehicle moving and ship transverse inclination, mechanical and electrical failure, ship damage and water getting into the ship, running aground, processing water while putting out the fire and other individual processing. In order to ensure the exercise effect, give lectures and demonstrations a few days before. Exercises should be as real as actual combats. Comment and summarize after the exercise. If necessary, carry out supplementary training. Abandoning ship drills should be at least once a month, so that the crew can hold confidence on effectively resisting overturning and quickly abandoning the ship when it is necessary.

### **7.8 Improve the safety management of the company**

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The company has the responsibility to make strict implementation of supervision and correction of the maintenance of the ship, the quality of personnel duties and operation management regulations. Companies should give the captain decision-making power and perform necessary guidance. Besides, provide the captain with enough maintenance operation and lashing resources. Additionally, according to the provisions, inspect and supervise anti-overturning reaction plan and other emergency plan exercises. The companies should carry out corresponding training to scheduling personnel to avoid blind command. In particular, never force the captain to take risks and fight against disastrous weather, which embodies the people-centered scientific concept of development.

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## **Chapter 8 Conclusion**

Qiongzhou strait is key waters of China's marine transportation. RO- ro passenger ship is the ship type to which China pays special attention. Transportation safety of ro-ro passenger ship in Qiongzhou strait has always been highly concerned about by the state and local governments, which has top priority in the work of maritime safety supervision departments. After years of exploration and summary, the safety supervision work of ro-ro transportation in the Qiongzhou strait has gradually formed a good situation. Various sectors carry out collaboration management. Safety assurance ability has significantly improved. The safety awareness and skills of the crew have gradually improved. Enterprise security principal responsibility has been gradually implemented. Accidents and danger get effective control. However, there are still many problems in the safety supervision of the transportation of the ro-ro passenger transport in the Qiongzhou strait. Meanwhile, the government function changes put forward new requirements for the safety supervision work of the Qiongzhou strait.

Aiming at the maritime supervision of ro-ro passenger ships in Qiongzhou Strait, in this paper, the author introduces the development process of the ro-ro passenger ships in the Strait of Hainan, and the changes of the maritime supervision mode at each stage in detail. In addition, the author points out the drawbacks of current maritime supervision mode. Combining the new public service theory, the advanced

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experience of foreign countries, objective requirements of the development of the maritime work and the status of ro-ro passenger ships in the Qiongzhou strait, the author believes that the construction of the service type maritime supervision mode of ro-ro passenger ships in the Qiongzhou strait should be divided into two steps. The first step is to strengthen the concept of maritime service. The second part is to improve the maritime service mechanism. Construct digital maritime to enhance the level of information. Strengthen the renovation of navigation environment and resource integration to provide navigation safety service products. Improve the level of emergency search and rescue to meet the needs of social emergency. Provide a variety of support services, as well as promote the upgrading of the ship and the level of business management.

From the point of view of the service type and innovative type of maritime construction, under the guidance of the new public service theory, the maritime sectors should establish the concept of safety and regulatory services, continuously promote the improvement of the ro-ro passenger ship transportation safety management system of Qiongzhou strait, promote implementation of transportation safety comprehensive synthetic governance mechanism, and strengthen itself and urge the port, shipping companies to strengthen the talent team construction, make joint effort to promote transport security level of ro-ro passenger ships in the Qiongzhou strait. Because of the limit of my ability and the length of the paper, I haven't made the feasibility analysis of the above measures and suggestions. In short, the study of ro-ro passenger transportation safety supervision of the Qiongzhou strait under new public service theory is a long-term, systematic and complex work. In the future, I will continue to strengthen study and research in this aspect, and make unremitting efforts to promote the construction of service-type maritime as well as innovative maritime. I will make my due contribution to continuously improving the safety supervision level of ro-ro transportation in the Qiongzhou strait.



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