

# Study on Ship Safety Pilotage in Shanghai Harbour by Way of FSA

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## ABSTRACT

Ship Pilotage is one of the most important parts in the construction and development of Shanghai International Shipping Center as it has the fundamental function for the promotion and speed-up of the ship navigation and cargo operation. Recently, Shanghai Maritime University and Shanghai Harbour Pilotage Administration Station had carried out a research project of “Study on Ship Safety Pilotage in the Shanghai Harbour by Way of FSA (Formal Safety Assessment)”. The aim of this project is to put out some proposes of the decision-making for the improvement of the safety pilotage in Shanghai harbour through the way of the FSA. Now these proposes of the decision-making have been adopted and conducted in practice and satisfactory results have been achieved. In the paper, some detailed information, methods and ideas about this research project have been introduced and explained for improving the safety pilotage in Shanghai Harbour.

## 1. Introduction

FSA is a systematic and standardized method using integrated safety assessment. It, as a well-structured methodology, aims at enhancing maritime safety, which embodies the protection of life, health, the marine environment and property. Through its five formal assessing steps, including the identification of hazards, estimation of the risks associated with those hazards, development and evaluation of alternative ways of managing the risks, cost benefit assessment of these alternative risk management options and recommendations for decision-making (Fig 1), FSA can be used as a tool to assist either in making new regulations/measures to prevent and reduce marine accidents, or in having a comparison between the existing and possibly improved regulations. Furthermore, FSA also makes it possible to achieve a balance between the various technical and operational issues, as well as between safety and costs. Therefore, it is expected that FSA studies will be of capability of framing a well-founded advice on the risk prevention and reduction <sup>[1]</sup>.

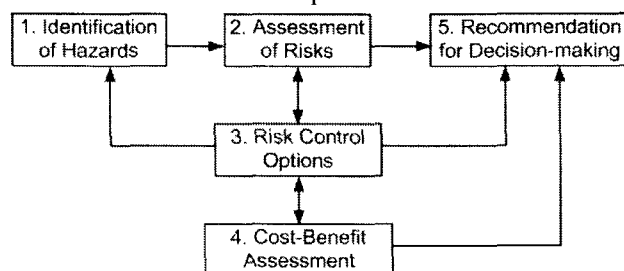


Figure1. The detailed steps and working flows of FSA

Since the end of last century, the IMO has encouraged the member countries to apply this modern safety assessment method to the research projects in the ship safety field <sup>[2]</sup>. In recent years, some of the advanced shipping countries have applied the FSA in ship design and construction, management, ship navigation control and operation. They have put out some recommendations of decision-making in combination with the practical necessities for reducing the risks and raising the safety levels at sea.

In comparison with other safety assessment methods, the assessment steps which used for the FSA have more standardized and reasonable characteristics. The analysis and assessment of the FSA have not only covered the marine accidents happened, but also the potential events which may occur as marine accidents. So it is an integrated method for the analysis and assessment of the past and expected marine accidents. Furthermore, the FSA has attached more emphasis to the practical quantity assessment in order to make the result more believable and reliable. Meanwhile, it is very important that the costs and benefits of each of the measures for the risk control should be carefully calculated during the processes of the FSA so that the best and most economized measure will be adopted <sup>[3]</sup>. For detailed information of the FSA, please refer to the papers which are listed in the reference of this paper.

## **2. Initial Work for the FSA of Ship Pilotage in Shanghai Harbour**

In order to raise the safety working level of the pilotage in Shanghai Harbour, the research group for “Study on the FSA of the Safety Pilotage in the Shanghai Harbour” had been established by Shanghai Maritime University and Shanghai Harbour Pilotage Administration Station (SHPAS) in early 2004. The research group used the way of FSA to investigate the safety working status of the pilotage in Shanghai Harbour from 1995 to 2003, and analyzed the results of the investigation, especially the identification of the hazards of the pilotage, and the causes & results of these hazards from 2001 to 2003. The research group put out the relevant recommendations for decision-making in order to improve the safety pilotage in Shanghai Harbour after finishing the first four steps of the FSA.

To ensure the success of the investigation and other work of this research project, a FSA Working Group was formed by the experts from the university, and the head officers in charge of the safety pilotage and the representatives of pilots from Shanghai Pilotage Administration Station. The working group identified the range, contents of the research and made the schedule and detailed methods after discussion.

The investigation is the fundamental work and key step in the project, the researchers took the following various ways to carry out a thorough investigation about the practical situation and existing status of the safety pilotage of Shanghai harbour in recent years.

### **2.1 Investigation of Cases and Analysis of the Causes about the Pilotage Accidents in Shanghai Harbour**

For further improvement of the safety pilotage of the Shanghai Harbour, it is necessary to carry out a proper investigation and research on the history and existing status about the pilotage situation of Shanghai Harbour. According to the practical pilotage situation in this area, the researchers selected the cases of the pilotage accidents in Shanghai Harbour from 1995 to 2003, especially emphasizing on the hazards and risks of the pilotage from 200 to 2003. At the same time, the researcher carried out a careful analysis about the time, locations, ship, environment, pilots, and also the results, responsibilities and other relevant factors of these accidents.

In order to collect the correct information about the relationships of the external factors with human factors, and get the ideas and suggestions from the pilots and management staff, the researchers designed the specific registration tables in consideration of the various kinds of the pilotage accidents in Shanghai Harbour. The

contents of these specific registration tables were divided into three indexes and covered the various parts of the narrow channel, the condition and limitation of the external wind and currents, the individual element of the human factors which include relationship between live-ware to live-ware, live-ware to hardware, live-ware to software and live-ware to environment. The first index for the registration table included eight main causes involved in the pilotage accidents which are natural, channel/wharf, traffic, own ship, other vessel, crew, harbour tug and pilot. The other two indexes with more detailed causes belonged to the above eight main causes. After designing the registration tables, the researchers started the work for reading, checking, collecting and filling the information and data. For the convenience of data processing work, the specific database named “Management and Analysis System of Pilotage Accidents” had been set up with the database technology of the access software. Through the above work, all the relevant information and data of the pilotage accidents had been integrated into the database of the computer.

## **2.2 Collection of Pilots Information and Integrated Questionnaires**

In order to thoroughly collect the information about the personnel and working information of all pilots, know their recognition about the present safety pilotage working status, and get their ideas and suggestions about the hazards, risk of pilotage and the improvement the safety pilotage in Shanghai Harbour, the ways of integrated questionnaires had been used. Apart from the questions about the detailed personnel information of each pilot about their life and work, the contents of the integrated questionnaires cover the different questions and ideas about the identification of the hazards, risk assessment, risk control options and the suggestions for improving the safety status of the pilotage in Shanghai Harbour.

Through distribution and collection of these integrated questionnaires, the research group got the satisfactory results about all the personnel information of more than 200 pilots and their detailed ideas about the identification of the hazards, risk assessment, risk control options and the suggestions for improving the safety status of the pilotage in Shanghai Harbour. All abovementioned information, ideas and suggestions had provided the necessary basis for the further analysis on the status of the traffic control, pilotage management and administration, pilots' technology & skills and other factors involved in the improvement of the safety pilotage in Shanghai Harbour.

## **2.3 Other Investigation Work for the Safety Pilotage**

In order to ensure the success of the identification of the hazards, risk control and other work in the application of the FSA to the safety pilotage in Shanghai Harbour, apart from the work mentioned above, the researchers also carried out other various investigation through the visits to the seafarers training centers in Shanghai, the various shipping companies, on board the pilot vessels at the mouth of Yangtze River and the vessels proceeding in the harbour. They especially visited the experts of Shanghai (Groups) International Port Co. LTD and relevant units in Shanghai and other areas to get their ideas and suggestions for the safety pilotage in Shanghai Harbour.

# **3. Information Process and Some Relevant Results of the FSA to the Pilotage in Shanghai Harbour**

## **3.1 Process and Analysis of the Basic Information**

Due to the characteristics of the large workload to deal with the widely collected information & data, the researchers had to divide the information and data into the various documents according to the different types and purposes of the information. They also had to make the titles, formations and contents of these files with the various ways for processing the relevant information and data with the computer. These files include “Collection

and Analysis of the Information for the Pilotage Accidents”, “Collection of the Safety Information about the Pilots”, “The Causes and Results of the Pilotage Accidents” and so on. All documents had been formed as the useful supporting report and files for the research on this project.

### 3.2 Collections and Process of the FSA Data for the Pilotage in Shanghai Harbour

In consideration of the detailed requirement of the relevant steps of the FSA, the researchers carried out each of the steps using the various analysis ways of the quality and quantity which included Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA) and Hazard and Operability studies (HAZOP). Through the logical assumption to mathematical calculation and vice versa, they had got the thorough and correct assessment about the risks in the individual areas of the channel for the pilotage and other operation in Shanghai Harbour [4].

### 3.3 Some Results of the FSA

#### 3.3.1 Various degrees of risk in the individual pilotage areas in Shanghai Harbour

Through the processed data and information from the risk distribution and the analysis of the status of the movement and operation of the pilotage, it provided the three various risk levels with the relevant various degrees of dangers in different individual pilotage navigation areas. Among these risks, the risk for the pilotage navigation in the area from No.101 to 107 light buoy occupied 37.7% of the total risk. The percentages of the navigation in the areas of No.107 to 114 light buoy and Yuanyuansha to Wusongkou were nearly the same, it is about 20% percentage of the total risk. The percentages next to the above are berthing and unberthing operation between No.101 to 107 light buoy, the navigation from No.114 Light buoy to Longhua, Longhua to Harbour Limit and Wusongkou to Baoshan basin and fairway, and the turning within the area of No.107 to 114 light buoy. All above have occupied 91.2% of the total pilotage risk in Shanghai Harbour (please refer to Table 1).

Table 1: Comparison of the situation of accidents in various time durations

Location of Shanghai harbor	1995-1997		1998-2000		2001-2003	
	percentage of accidents	percentage of risks	percentage of accidents	percentage of risks	percentage of accidents	percentage of risks
Roadstead	0.690%	0.029%	1.111%	0.000%	0.565%	0.019%
Yangzi river entrance deep channel	0.690%	0.000%	4.444%	0.756%	4.520%	0.698%
North Branch to Yuanyuansha	3.448%	0.265%	5.556%	1.345%	1.695%	0.078%
Yuanyuansha to Wusongkou	4.828%	1.445%	8.889%	3.025%	15.254%	13.111%
South Branch Channel	3.448%	0.737%	4.444%	0.756%	2.260%	0.310%
Wusongkou to Liuhekou	2.759%	0.472%	2.222%	0.336%	2.825%	0.485%
Wusongkou to Baosan Basin	9.655%	5.780%	8.889%	5.378%	3.390%	0.175%
Chongming Waterarea	1.379%	0.118%			1.130%	0.078%
Buoy 101-Buoy107	29.655%	40.372%	33.333%	70.672%	32.203%	60.822%
Buoy 107-buoy 114	26.207%	40.372%	12.222%	6.807%	17.514%	17.455%
Buoy 114-Longhua	12.414%	9.555%	7.778%	4.118%	8.475%	3.801%
Longhua to harbour limit	3.448%	0.737%	11.111%	6.807%	7.345%	2.793%
Lvhuasan anchorage	1.379%	0.118%			2.260%	0.175%
Jinsan harbour Area					0.565%	0.019%
Total	100%	100%	100%	100%	100%	100%

#### 3.3.2 The main effected factors of the pilotage accidents in Shanghai harbour

According the analysis of the data and information about the causes of the pilotage accidents in Shanghai

harbour, it can get the following conclusion about the main causes of these accidents.

A. Among all effected factors of the pilotage accidents, the Pilot Factor, Other Vessel Factor and Nature Factor are the top three most important main factors. It is obvious to know from Fig. 2, the first main important effective factors of all pilotage accidents is the Pilot Factor ( 92.23%), the second one is the Other Vessel factor (41.75%) and third one is the Nature Factors (37.14%). In fact, most of the pilotage accidents have been caused by the above three effected factors.

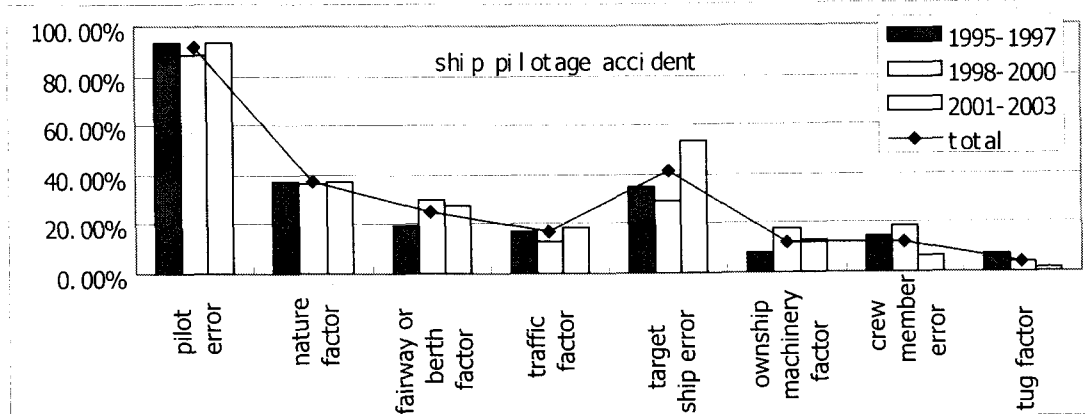


Fig 2: The various effected factors of all pilotage accidents

B. Among all Collision Accidents, the most effective factor is the Pilot Factor, which has occupied 98.81% of all. The other Vessel Factor is the second one, with a percentage of 80.36%. These mean that the human factors are the most important effective factor in the pilotage accidents (Fig. 3).

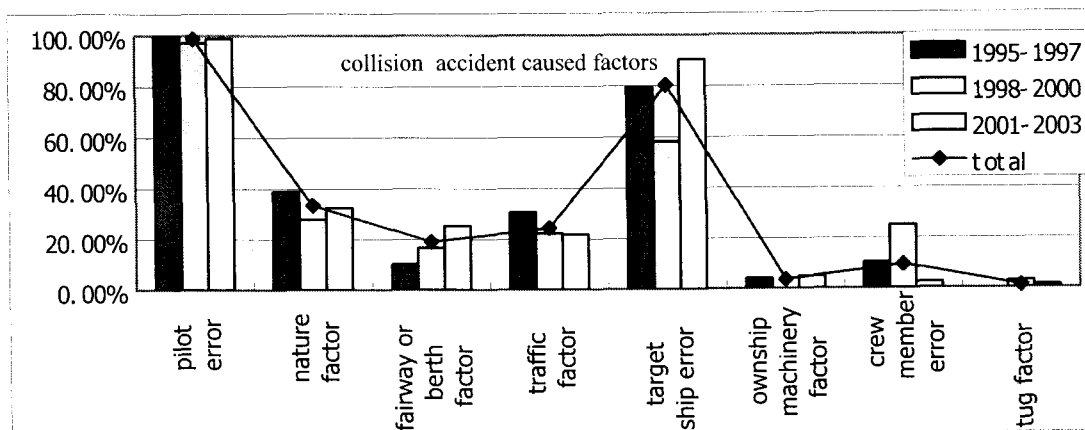


Fig 3: The various effected factors of the collision accidents

C. Among all Touching (Contacting) Accidents, the most effective factor is still the Pilot Factor, which has occupied 97.09% of all. But the second one is the Nature Factor, whose percentage is 47.67% and the third one is the Fairway/Wharf Factor. These mean that the human factors are the most important factor in the pilotage accidents. For detailed information about these and other effective factors, please refer to Fig. 4

E. Among all Grounding Accidents, the most effective factor is the Fairway/Wharf Factor, which has occupied 72.73% of all. The second one is the Pilot Factor (69.23%) and the third one is the Nature Factor (23.08%). For detailed information about these and other effective factors, please refer to Fig. 5.

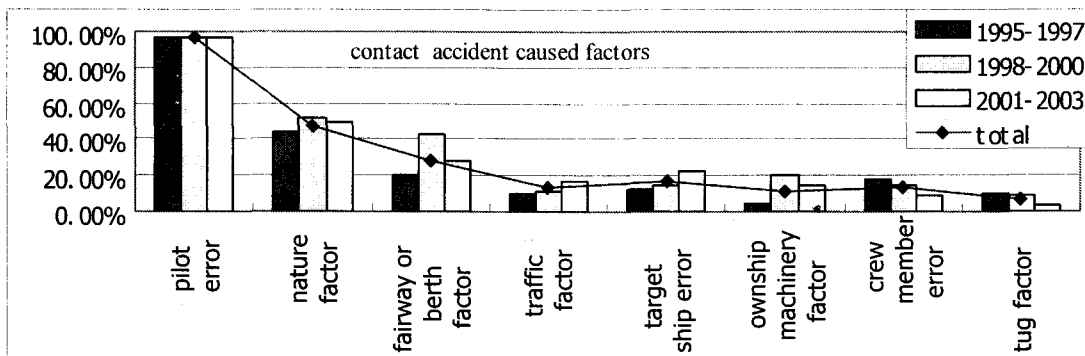


Fig 4: The various effected of contact accidents

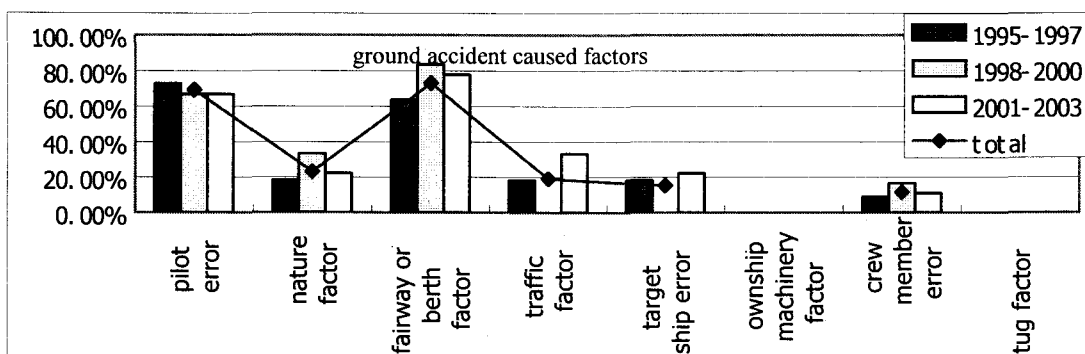


Fig 5: The various effected factors of grounding accidents

From the above data and information, it has been identified that the most important main factor of the pilotage accidents in Shanghai Harbour is the human factor. It also indicated that the traffic condition, fairway, wharf were getting more and more complicated and the operations of vessels were getting increasingly more and more difficult in recent years simultaneously. In fact, the heavy vessel traffic density, the limitation of the fairway, wharf, anchorage and other relevant factors in Shanghai Harbour were closely linked with the pilotage accidents as well.

#### 4. Recommendations for Decision-making of the FSA for Safety Pilotage in Shanghai Harbour

On the base of the research work of the identification of the hazards, risk assessment and risk control options through the careful and effective investigation and analysis of the practical situation and future development of the safety pilotage in Shanghai Harbour, the research group finally put out the following main recommendations for decision-making to the SHPAS [5].

##### 4.1 Taking Special Safety Measures for the Specific Dangerous Navigation Areas

The results of the risk assessment indicate that there are some specific dangerous navigation areas in Shanghai Harbour due to the specific environmental factors. For example, there are hundreds of small vessels which are often in violation of navigation rules and regulations from the Yangtze river in the area between No. 101 and 107 light buoy when the tide starts flooding. The problem is that there are there are also many moderate and large vessels will proceeding, berthing or unberthing in this area during this period of time. All these have contributed to so many risks for the safety pilotage. For controlling the risks in this area, the research group suggested to adjust the time for the berthing and unberthing of the piloted vessels in order to avoid the congested navigation

situation, and to enhance the control and of the navigation and operation of the piloted vessel through the way of the on-site commanding from the administrators. In consideration of the serious risks of navigation from the Yuanyuansa to Wusongkou, the research group put forward the suggestion to strictly control the speed and positions of the ships and to overtake other vessels for avoidance and reduction of the natural and traffic risks in this area.

#### **4.2 Improving the Monitoring and Controlling System of the Ship Safety Pilotage**

For strictly monitoring and controlling the ships' safety pilotage, it is necessary to raise the administration level by using and improving the monitoring and controlling system for the ship safety pilotage. The research group also advised the SHPAS to improve and establish an effective monitoring and controlling system for the ship safety pilotage by way of the ECDIS and AIS system in order to raise the ability of the automatic tracking of the piloted ships and ensure the safety pilotage in the specific important and dangerous areas of the harbour.

#### **4.3 Taking Effective Measure to Reduce the Workload of the Pilots**

Due to the rapidly increasing number of piloted vessels in Shanghai Harbour during recent years, there are some problems to have enough pilots to meet with this new situation. In fact, the pilots in Shanghai harbour have already been very busy with their pilotage work. So firstly it is very important to ensure enough time for their rest through the scientific arrangement of the plan and time for the pilotage task of each pilot. Secondly it is urgent necessary to increase the number of qualified pilots through effective ways such as the proper introduction of some captains who can become pilots after training for a relatively short period, and taking proper measures to train more new pilots from the potential personnel for a certain period of time.

#### **4.4 Paying Attention to the Physiological Effects of the Traffic Environment to the Pilots**

It is clear that most of the pilots feel heavy risks and have more stress due to the complicated traffic environment in Shanghai Harbour nowadays and these heavy risks and stress cause more risky factors for the pilotage accidents. To ensure the safety work of the pilots, it is necessary to organize the pilots to involve in the specific study about the basic knowledge of physiology and to provide some lectures for them to reduce their physiological stress.

#### **4.5 Emphasizing Further education and Training for the Pilots**

In consideration of the development of the scientific technology and the necessity of safety pilotage in the future, it is necessary for Shanghai Harbour Pilotage Administration Station to continually emphasize further education and training of the pilots. The SHPAS shall utilize the academic resource of the society and have close cooperation with the maritime institutions to offer the various knowledge updating training courses for further education and training of the safety pilotage in accordance with the practical situation and needs. At the same time, it is especially necessary to provide the "Bridge Resource Management of the Pilotage" training course for the pilots and help them to get more knowledge about the situation awareness, teamwork and other new concepts dealing with the safety pilotage.

#### **4.6 Putting out Some Positive Suggestions to the SMSA for Improving Traffic Environment**

To ensure the safety pilotage in Shanghai harbour, the pilots should strictly follow the rules and regulations of navigation and operation made by Shanghai Maritime Safety Administration (SMSA). Meanwhile the SHPAS shall keep proper communication and relationship with the SMSA for the improvement and administration of the

navigation environment for the ship pilotage. For the improvement of traffic environment, it is very important for the SHPAS to provide latest information about any change of the traffic environment and put out some reasonable and positive ideas or suggestions to the SMSA on basis of the investigation and analysis of the FSA. As a matter of fact, the SHPAS had already done this dealing with the establishment of additional emergency plan and areas for the piloted vessels, emphasis of the on-site control and administration of the deepwater fairway, strictly control of the drafts of the traffic vessels and strict report system for particular vessels navigation in the channel.

## **5. Conclusion**

The abovementioned recommendations for decision-making for improving the safety pilotage in Shanghai Harbour have been accepted and used in the practice by the SHPAS after finishing this FSA research work. The work for the improvement of the safety pilotage operation regulations and procedures, the education and training of the bridge pilotage resource management, the establishment of the Pilotage Monitoring and Control System of AIS raised the situation awareness of the pilots and promoted the safety administration work of the pilotage. With common efforts of the pilots and management staff, the SHPAS has kept the best safety pilotage record of recent years since the late half year of 2004. It has already been proved that FSA is not only a very useful tool for assessing safety pilotage of ships, but it can also be used in the assessment of the safety navigation and operation of the shipping companies. Because Shanghai Maritime University has just successfully finished another research work on the “Application of the FSA to the Ship Navigation” together with the Container Line LTD of China Ocean Shipping Company. With the broad application of the FSA, it can play more and more important role in the safety aspect of the shipping industry around the world.

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