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WORLD MARITIME UNIVERSITY

Dalian, China

**Navigation Safety Analysis and Assessment of Entry
and Departure of Shanghai Port For
International Cruises**

By

XU SHIXUN

China

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

MATSER OF SCIENCE

(MARITIME SAFETY AND ENVIRONMENTAL MANAGEMENT)

2014

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THE 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.

(Signature):.....XU..SHIXUN...许师迅.....

(Date):2014/07/10.....

Signature:

Date: 10 July 2014

Supervised by: Zheng Yunfeng

Professor

Dalian Maritime University

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Title of Research paper: Navigational Safety Analysis and Assessment of Entry and Departure of Shanghai Port For International Cruises

Degree: MSc

ABSTRACT

The research paper is a study of navigation safety in Shanghai port for international cruise.

Shanghai lies in the middle of China's coastline and serves as the estuary of Yangtze River as well as it's located in the central of Yangtze Delta, so it is quite advantageous in developing cruise tourism. According to the prediction of World Tourism Council, the growth rate of world tourism economy from 2010 to 2020 is expected to be 4.4%, and the tourist quantity and international tourism revenue are expected to be increase by 4.3% and 6.7%, much higher than the incremental rate of 3% for the world wealth at the same time(Tang, 2012).

According to the statistics, nearly 200,000 tourists from mainland China went overseas by taking the international cruises in 2009, and the total tourist volume is approximately between 350,000 to 380,000. Owing to the effect of World Expo in 2010, 66 international cruises visited Shanghai with 240,000 tourists, which increased by 30%(Tang, 2012). Under the flourish of travel by international cruises, nautical safety of cruises is becoming extremely important. Though Shanghai Port has limited navigational fairway and water depth conditions, it is the central port of merchant shipping and the hub logistics wharf in Yangtze River, thus the navigational environment is fairly complicated. The paper focuses on the navigational safety of the international cruises within the scope of Shanghai Port. Fairway condition is analyzed at first, mainly concentrating on the fairway from

Yangtze Estuary to Wusongkou; besides, current navigational analysis of Shanghai Port is given especially on the most complicated navigational waters; in the end, by analyzing and assessing the navigational safety for international cruises to enter Shanghai Port , the potential risk and hazards are figured out and suggestions are provided based on the actual situation.

Keywords: Navigational safety, Analysis, Assessment, Fairway condition, Risk, Suggestion

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LIST OF ABBREVIATIONS

CCYIA	China Cruise & Yacht Industry Association
CSC	Changjiang Shipping Corporation
GT	Gross Tonnage
LOA	Length Over All
MSA	Maritime Safety Administration
n mile	Nautical Mile
TEU	Twenty-foot Equivalent Unit
VHF	Very High Frequency
VTS	Vessel Traffic Services

Chapter 1 Introduction

Cruise market is booming during recent years. According to the statistics from CCYIA, cruise reception volume was increasing rapidly in 2011, 262 cruises received, increased by 17.5% than the previous year. The total tourists were 5004582, among which 142 international cruises departed from coastal cities from China, a rise of 49.5%, and total tourists were as many as 252084; 120 international cruises called coastal cities of China, which had fallen by 6.2%, with 252,498 tourists altogether(Shanghai, 2012).

If we look at the world renowned cruise cities such as Miami, Barcelona, Singapore and Hong Kong, they have the subsequent characteristics in common: good water conditions, shore length and navigational conditions approximately to the market; large number of cruise calls and cruise visitor volume; large quantity of tourism resources with very high quality; convenient land and air transport in connection; sufficient shopping, dining and hospitality facilities which can accommodate large volume of tourists; immigration and border procedures in compliance of international regulations and customs; world class modernized wharf, berthing facilities and potential expansion conditions; and qualified ship maintenance base.

As the largest economic center in China, as well as an international shipping center, Shanghai boasts inherent favorable conditions in the cruise development. First and foremost, Shanghai has two large wharf that can berth cruises. Shanghai International Passenger Center is located in the North Bund opposite the most prosperous Bund across the Suzhou River. The water depth of 10 meters, a 100,000 GT class cruise, and the shore length is 850 meters to berth two cruises at the same time. Wusongkou International Cruise Terminal locates in the Paotai Bay near the beach of Shanghai Wusongkou of Yangtze River, with a length of about 1,500 meters, width between 30 to 40 meters and water depth between 9 to 13 meters, can berth a 20,000 GT class and a 100,000 GT class cruise simultaneously.(Tang, 2012) At present, the MV “Ocean Voyager ” of Royal Caribbean and MV “Victoria” of Costa have determined

Wusongkou International Cruise Terminal as the home port. Further, tourism resources near Shanghai are extremely abundant, such as one day or two day inland trip to Suzhou and Hangzhou, and one-day or two-day cruise trip to domestic port cities like Qingdao, Ningbo, Hong Kong and Taiwan. Plus, visits to overseas cities in Korea and Japan are always available as well. As a result, they are quite attractive to international tourists. Other advantages include the convenient inland transportation, since Shanghai Passenger Station and Pudong International Airport are both within 30 minutes' drive from the North Bund. In addition, Jiangnan Shipyard is the largest one in China(Tang, 2012).

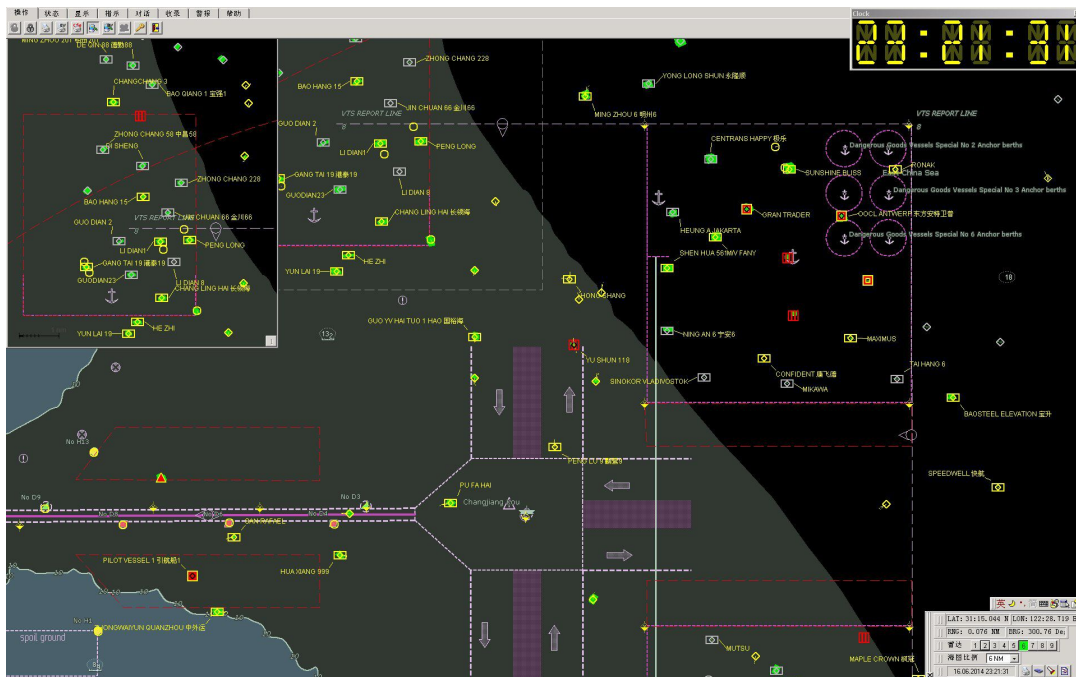
Chapter 2 Current Navigational Situation in Yangtze River Fairway of Shanghai Port

2.1 Distribution of fairways in Yangtze Estuary

2.1.1 Deep Water fairway in Yangtze Estuary

Deep Water fairway in Yangtze Estuary(Second Phase) means the fairway between Light Buoy #D6 and #D47, with a length of 39.66 n miles. The bottom width is 350 meters and the width is 500 meters of the fairway from Light Buoy #D12 to #D47, while the bottom width is 400 meters and the width is 550 meters of the fairway from Light Buoy #D6 to #D12. The maintenance depth of deep water bottom width is 10 meters below the lowest astronomical tide.

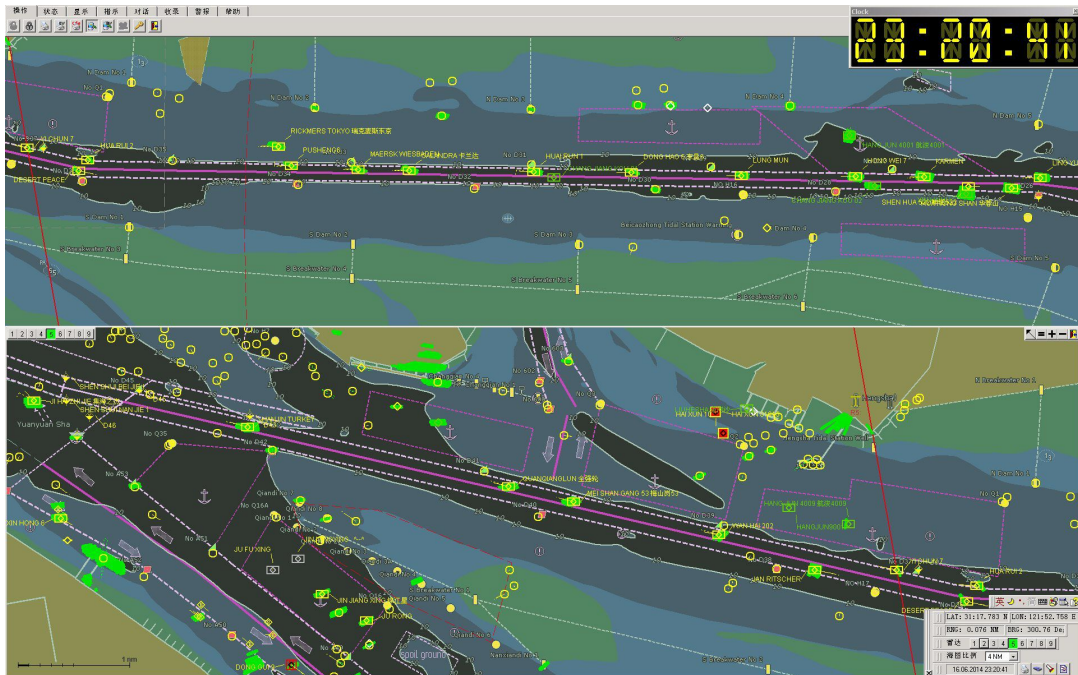
Figure.1 The Deep Water Fairway of Yangtze Estuary



Source: Wusong VTS screen-shot, Wusong MSA

Deep Water fairway of Yangtze Estuary(Third Phase) means the fairway between Light Buoy #D4 and #D47, with a total length of 41.86 n miles and the same width and bottom width as the Second Phase. The maintenance depth of deep water bottom width is 12.5 meters below the lowest astronomical tide. Deep Water fairway in Yangtze Estuary can satisfy the tidal two-way navigation requirement of the third and fourth-generation container vessels and 50,000 GT vessels(with a load draft $\leq 11.5\text{m}$). In addition, the fifth and sixth Generation container vessels , fully loaded 100,000 GT class vessels and de-load 200,000 GT class vessels can pass the fairway by tide(Shanghai Institute of Navigation, 2010).

Figure.2 The Deep Water Fairway of Beicao



Source: Wusong VTS screen-shot, Wusong MSA

2.1.2 Nancao Fairway

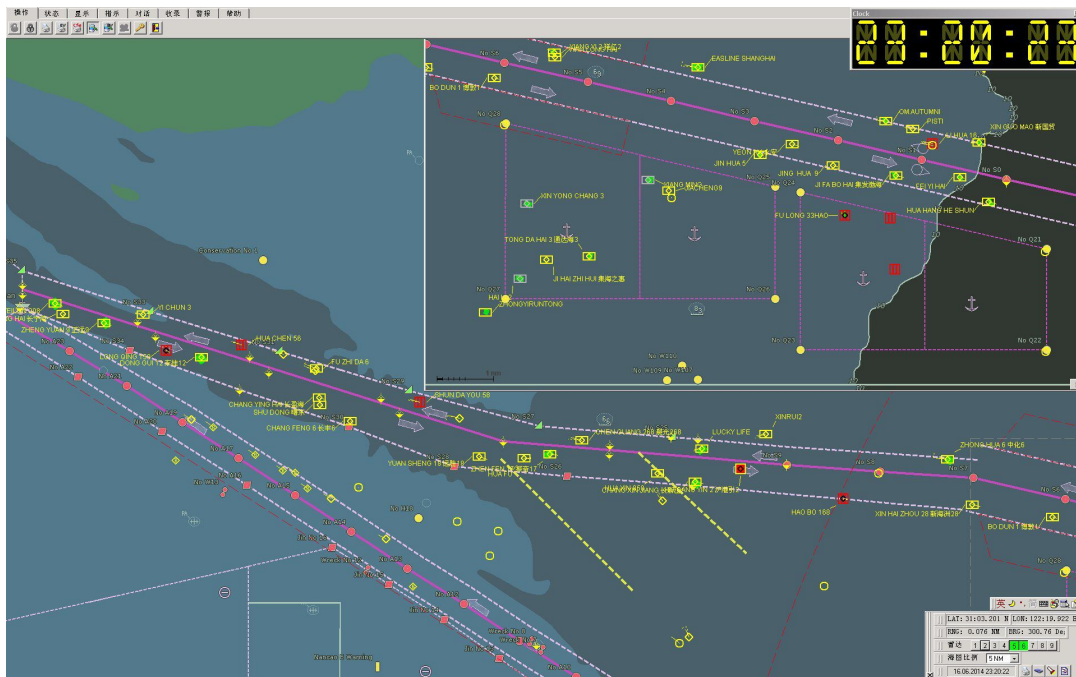
The downstream Nancao fairway, with a length of 31.2 n miles, starts from the Nancao Light Boat in Yangtze Estuary to Jiudian Light ship. 3.4 n miles upstream of the Nancao Light Boat lies an #S0 Buoy Light. Light Buoys starting from #S0 to #S18 are all central buoys, separating the fairways to import and export fairways. Among them, the width from #S0 to #S7 is 900 m, while the width from S7 to Jiudian Light ship is 500 m. The shallowest depth of the fairway is 5.2 m near Buoy #S18.

The water near Jiudian Light ship is the junction for the end Nancao fairway and South Branch fairway. The fairway between Jiudian Light ship and Yuan-yuan sha Light Boat, with a total length of 17 n miles is in the upstream of Nancao fairway(Shanghai MSA Website).

2.1.3 Nancao Branch Fairway

South Branch fairway, with a length of 15.2 n miles and a width of 0.32 to 0.5 n miles, starts from south branch light boat to Jiudian Light ship. The fairway is designed for small vessels entering the Yangtze River. Vessels like this mainly sail between Shanghai, Yangtze River, Jiangsu, and Zhejiang.

Figure.3 Nancao Fairway and Nancao Branch Fairway



Source: Wusong VTS screen-shot, Wusong MSA

Fairway Depth: The depth of water downstream of Light Buoy #A10 is over 5 meters, while depth of water between Light Buoy #A10 and #A29 is less than 5 meters, with the shallowest depth of 4.7 m. The current direction between South Branch Light Boat and Light Buoy #A14 is the 360°revolution current, and its variance is similar to the water near Light Buoy #S11 near the end of Nancao fairway. Current direction near the upstream of Light Buoy #A13 is the recurrence current along the fairway.

2.1.4 HengSha Fairway

The HengSha fairway is a north-south direction water fairway, and its total length is 4.2 n miles from the South Light Buoy to the Hengbei Light Buoy. The fairway has a width of approximately 1000m on both banks. The south part is as narrow as 200m

with water width of 10 m, while the width near North End is as wide as 550m, and the widths of Red Star Port in the middle and HengSha Passenger Station are 400m and 500m respectively.

At present, 0.5 n miles is not through with the depth of 10 m, but its depth is above 9m.

The upstream of the fairway to its south is the west HengSha anchorage, while its downstream is the HengSha Tanker dangerous cargo anchorage.

The 1820m Changxing Underwater Dam lies to the north of the South End Gate of HengSha fairway(Shanghai MSA Website).

2.1.5 Navigational Situation near HengSha Fairway

(1)Cables

The cable from Changxing Island to HengSha Island lies overhead the downstream of HengSha Passenger Wharf.

The cable height is 29.9m above Wusong Original Point. At present, naval communication cables still lie in the downstream of HengSha Passenger Wharf.

(2)Anchorage Point of Fishing Boats

Fishing boats usually anchorage at the East Bank of Changxing Island (which is close to the 5m Equal Depth Shore, the west 10m Equal Depth of Changxing Island as well). Quite a few fishing boats, small motor vessels moored in HengSha fairway during the heavy wind, which influences the normal navigation to a large extent.

(3)Anchorage outside the Fairway

Three anchorages is located in the south end of HengSha fairway, namely HengSha East Anchorage, HengSha West Anchorage and HengSha Dangerous Cargo Anchorage.

(4)The vessel traffic volume of HengSha Fairway

The vessel traffic volume is 7000 vessels per day in 2007, excluding ferries. At present, 16 ferries pass on the Wusong-HengSha voyage (8 high speed vessels and 2 car ferries every day)(Ji, 2010).

2.2 The fairway from Overseas to Wusongkou International Cruise Terminal

Two fairways are available for the overseas large cruises, i.e. by passing through Yangtze Deep Water fairway or Nancao fairway. The both fairways meet in Yuan-yuan sha Light Boat (Yuan-yuan sha Guard Zone) whichever fairway is chosen. Then 12 n miles navigation in Waigaoqiao fairway is needed to pass through Wusongkou Guard Zone to arrive at the junction of Baoshan fairway End and Baoshan Branch fairway End, Wusongkou International Cruise Terminal lies here.

2.2.1 Waigaoqiao Fairway

The fairway starts from Yuan-yuan sha Light Boat to Wusongkou, with a length of 8.8 n miles, a width of 0.4-0.5 n miles, and a depth of over 10m. Wusongkou Anchorage lies to its north, and is divided into 11 anchorage sections altogether.

The North Boundary: The line which links Light Boat #51, #53,#55, #57 and the geographical point of 31°23'27"N, 121°34'54"E.

The South Boundary: The line which links and the geographical point of 31°19'57"N, 121°40'40"E and Light Boat #52, #54,#56, #58 and #60.

The central line of the fairway is the separation for entry and departure. The current is the reversing current, with a rising tide with the direction of about 300° and the ebb tide of about 120°

Figure.4 Waigaoqiao Fairway



Source: Wusong VTS screen-shot, Wusong MSA

2.2.2 Baoshan Fairway

The North Boundary: The line which links Light Boat #65, #67,#69 and the geographical point of 31°27'36"N, 121°27'33"E.

The South Boundary: The line which links Light Boat #66, #68, #70 and #72.

The fairway is about 4 n miles, with a width between 800 to 1000m and the depth is above 10m.

The fairway only allows large vessels to pass through.

2.2.3 Baoshan Branch Fairway

Baoshan Branch fairway has a length of about 4.5 n miles, a width about 250 and 600m. The depth is between 7.8 to 14.5m except the 7.5 to 6.5 m near the Downstream Exit near A72 Light Buoy.

The North Boundary: The line which links Light Boat #66, #A73, #A75, #70 and #72.

The South Boundary: The line which links the River Pool Light Tower, 45m outside Floating Jetty of Ship Base in Paotai Bay, #A72, #A76, #A78 and the geographical point of 31°27'10"N, 121°27'00"E.

2.3 Guard Zone

Large cruises must cross two Guard Zone, namely Yuan-yuan sha Guard Zone and Wusongkou Guard Zone, to arrive at Wusongkou International Cruise Terminal.

2.3.1 Yuan-yuan sha Guard Zone

To regulate the vessel traffic order, reduce accident risk degrees and improve vessel safety, Shanghai Maritime S A publicized the scope of Yuan-yuan sha Guard Zone formed by the following seven point on 1 June, 2007:

- 1) 31°20'30"N/121°40'57"E;
- 2) 31°19'57"N/121°42'17"E;
- 3) 31°19'20"N/121°43'38"E;
- 4) Yuan-yuan sha Light Boat;
- 5) Light Buoy #A54;
- 6) 31°19'43"N/121°40'19"E;
- 7) Light Buoy #52(Shanghai Institute of Navigation, 2010).

2.3.2 Wusongkou Guard Zone

The Guard Zone is formed by the area encompassed by the following 10 points:

- 1) 31°25'28"N, 121°30'57"E;

- 2) 31°24'49"N, 121°32'11"E;
- 3) 31°23'50"N, 121°34'07"E;
- 4) 31°23'28"N, 121°34'53"E;
- 5) 31°22'41"N, 121°34'23"E;
- 6) 31°23'09"N, 121°32'54"E;
- 7) 31°23'23"N, 121°31'12"E;
- 8) 31°24'26"N, 121°30'48"E;
- 9) Light Boat #66(Shanghai Institute of Navigation, 2010).

Vessels entering and departing Huangpu River, Baoshan Port and Yangtze River all have to pass Wusongkou Guard Zone, therefore the vessel density in the water is quite large and their directions may contradict with each other. Especially when small motor vessels sail from Huangpu River to Yangtze River and the their counterparts from the opposite direction at the end of falling tide and at the beginning of rising tide, the large traffic volume concentrates in the Wusong Guard Zone.

The Article 13 of ‘Navigational Safety Management Regulation of Shanghai Huangpu River’ requires that when vessels enter, depart and navigate in the Guard Zone, crew must operate the vessel with extreme caution. It is forbidden to surpass other vessels in the Guard Zone.

The Article 25 of ‘Navigational Safety Management Regulation of Shanghai Huangpu River’ requires that vessels sailing in the Wusong Guard Zone should comply with the following collision avoidance rules:

- 1) Avoid large vessels coming into and leaving Huangpu River
- 2) Vessels sailing against the water should prevent collisions from vessels sailing along the water
- 3) Small vessels should avoid collision from large vessels

(China Ministry of Transport, 2005)

2.4 Current Navigation Circumstance in Yangtze Estuary

2.4.1 Main Dimensions, Navigational Regulations and Traffic of Deep Water Fairway in Yangtze Estuary

Deep Water fairway in Yangtze Estuary is the major deep water fairway for large vessels and mega vessels entering and departing the ports along Yangtze River. The deep water fairway from Light River in Yangtze Estuary to Yuan-yuan sha Light Boat (Light Buoy #D47) is 45n mile, and the length between Light Buoy #D4 and #D47 is 42.16 n mile, which is dredged manually. Within this fairway, the fairway between Light Buoy #D4 to #D12 has a bottom width of 400m and the width for surface signs is 550m; while the fairway between Light Buoy #D12 and #D47 has a bottom width of 350m and the width for surface signs is 500m.

According to “Regulation for Navigation Safety Management of Deep Water fairway of Yangtze River (12.5m depth)”, “owing to vessel draft” the time for passing through by utilizing high tide was stipulated as “5 hours before Changxing high tide to 1 hour before Changxing high tide is the traffic control period. 4 hours before Changxing high tide to 3 hours before Changxing high tide is the entry traffic control period owing to vessel draft; 2.5 hours before Changxing high tide to 1.5 hours before Changxing high tide is the departure traffic control period owing to vessel draft” (China Regulation for Navigation Safety Management of Deep Water fairway of Yangtze River, 2010).

2.4.2 The Current Navigation Circumstance in Nancao Fairway

The Downstream Nancao fairway starts from Nancao Light Boat and ends at Nine Light Boat, with a total length of 31.2 n miles. Signs of #S0 to #S18 were set and separate the entry and departure fairways. The fairways between #S0 and #S7 are as wide as 900m, and the remaining is 500 m wide. The water depth near Light Boat #S18 is the shallowest, about 5.0m. Nine Light Boat joints the Yuan-yuan sha Light Boat with a length of 17 n miles. The fairway deepens and widens from Nine Light Boat to the upstream.

2.4.3 Navigation Circumstance and Boat Sailing Near the Water of Yuan-yuan sha Light Boat

Three waters meet near Yuan-yuan sha Light Boat: one comes from the downstream of Nancao and South Branch, meeting the upstream fairway, and enter the upstream Nancao fairway to sail to the Yuan-yuan sha Light Boat Direction. One comes from Shanghai and vessels sailing from Yangtze River to Yuan-yuan sha Light Boat, splitting into two streams of boats, one departs from Nancao, the other one departs from Yangtze Deep Water fairway. The third stream comes along Waigaoqiao fairway and departs from Nancao.

The navigation circumstance near Yuan-yuan sha follow the three points:

- (1) Vessels entering from Nancao are split into two streams of boats: having passed Yuan-yuan sha Light Boat, medium and large ships sail along the main fairway upwards to the right. The other stream of small vessels passes through the Yuan-yuan sha Guard Zone and enters North Waigaoqiao Lane.
- (2) Vessels entering deep water fairway of Yangtze Estuary pass Yuan-yuan sha Light Boat and sail along the main fairway.
- (3) Large vessels from Yangtze River and Huangpu River and ships with a draft over 7.0 m still sail along the main fairway to enter the deep water fairway. In another stream, medium and small ships or vessels with draft less than 7.0 m sail to Light Buoy #52 and turn right to navigate along the

Nancao fairway. Such departure vessels cross with the vessels from Nancao and through Waigaoqiao fairway.

- (4) Another type is the small motor vessels from Waigaoqiao fairway and intersect with the medium and large vessels from Nancao fairway and form the small angel crossing.

(Chen and Zhang, 2009)

As a result, the water above is the accident-prone area in Shanghai Port.

2.4.4 Berths and Anchorage along Waigaoqiao Fairway

The south bank of Waigaoqiao fairway (Pudong Side) is full of container terminals, dangerous cargo terminals and large shipyards. Owing to the rapid development of container transportation, the container handling berths are evidently not sufficient, especially for feeder vessels which do not have specialized berths yet.

Thus the 3rd Ocean Geology Investigation Team of Ocean Oil Bureau of Shanghai cooperated with Shanghai Container Limited Share Corporation and renovated the previous third ocean berth into the feeder container ship berth. The wharf one to wharf five Waigaoqiao berths are to its downstream, with 17 large container ship berths altogether.

The 35,000 GT class coal berth is also there. At present, wharf for the Shanghai rescue and salvage Bureau, wharf for ship dredging base of fairway Bureau, sewage handling wharf of China Shipping Corporation (large tanker, chemical dangerous cargo ship carries out tank cleaning and handling operations) as well as Waigaoqiao shipbuilding base are under construction. In the downstream of Waigaoqiao shipbuilding base, 5 large scale container berths of Waigaoqiao Wharf 4 have been established, as well as 4 large scale container berths of Waigaoqiao Wharf 5. The Waigaoqiao Wharf 6 berths are still under construction. 9 anchorages are in the north of the Waigaoqiao fairway.

Vessels passing through Waigaoqiao wharf are mainly container vessels. The cargo throughput of Shanghai Port was 580 million tons in 2008, and the container throughput is 28.01 million TEU. 30 vessels berth in the wharf on average every day, among them over 10 international ships enter and leave the berth(Shanghai Institute of Navigation, 2010). Since the large container vessels are of huge capacity, deep draft and fast speed, they usually arrive at Waigaoqiao Berth around the Medium High Tide. With the assistance of tugs, they turn left first and berth then.

The general rules of the departing vessels are, ships departing from the original berth by the rising tide and current does not need to turn around. Vessels departing by falling tide and current need to turn right and around, which will exert some influence to the ships sailing in the fairway, especially the departing ships(SUN, 2012).

Since the present berths are relatively scarce, there is no chance for the vacant berths to wait for the importing ships. Generally one vessel just departs the berth and the importing one will come to receive service. However, owing to the reasons of cargo handling, when the importing ships have arrive near the berth, but the vessel in the berth has not left, thus the approaching one has to linger along the fairway or turn around and wait(Sun,2012). Such circumstances certainly enhance the ship intensity in the water. Especially before and after the Wusong High Tide, the importing vessels are quite concentrated and form a long queue. Vessels which would like to enter Huangpu River, Baoshan Bay, Main and auxiliary berth of BaoSteel generally comes when the tide has just fallen, so the speed decreases in the Waigaoqiao Water. On the contrary, vessels near the upstream of Huangpu River and approaching Yangtze River, still pass the fairway at a fast speed, forming the surpass.

Exporting vessels arriving at the falling tide or initial rising tide usually come to the berths below Lujiazui, Huangpu River, which causes a complicated navigational environment. Except for vessels passing through Waigaoqiao container berths, tankers approaching and departing ship sewage handling terminal of China Shipping,

chemicals and dangerous cargo ships of Oriental Storage Tanker Company, Coastal Tanker Terminal of China Shipping and Refinery of Waigaoqiao are also not to be neglected.

9 anchorages lie in the north side of Waigaoqiao fairway, and most of such vessels have to surpass the fairway. Vessels sailing from Huangpu River and vessels from Yangtze River to enter the anchorage must cross the Waigaoqiao fairway from left. Ships waiting for the tide turn left when the tide has fallen completely, passes the Waigaoqiao fairway exit. If they would like to exit from the deep water, after passing the import fairway and have to enter the exit fairway. If they want to exit from Nancao, they have to pass the whole Waigaoqiao fairway and Yuan-yuan sha Guard Zone. Ships from Nancao to enter the anchorage, have to pass Yuan-yuan sha Guard Zone and Waigaoqiao fairway to reach the anchorage.

2.4.5 Navigation Circumstance of Waters outside Wusongkou

Waters outside Wusongkou is the junction of five nautical lanes. Thus Wusongkou Guard Zone is set up outside Wusongkou, and ships must sail with great caution in the Guard Zone without surpass.

2.4.5.1 Navigation Law for Small Motor Vessels Outside Wusongkou Water

Some small motor vessels enter Wusongkou from Yangtze River around the low tide. Most of them are yellow sand vessels. These vessels generally sail between Baoshan Branch fairway and Baoshan fairway, and some of them navigate through Baoshan Branch fairway downward. The small vessel cluster does not decrease until 2 hours after Wusong Low Tide. While small motor vessels sailing upward from Wusongkou generally leave Wusongkou at low tide of Wusong and pass through Wusongkou Guard Zone and Baoshan fairway, in the end they enter upward navigational fairway 100m north of Baoshan fairway for small vessels. During the initial Wusong High Tide, they have departed Wusong Kou and lies around Light Buoy #67 near Baoshan fairway. The stream of vessels laterally crosses with the large vessels passing

Baoshan fairway. Another stream of small motor vessels sails upward after Wusongkou through Baoshan fairway.

2.4.5.2 Navigation Law for Large Motor Vessels outside Wusongkou

Generally large Yangtze River vessels enter Waters outside Wusongkou and pass through Baoshan fairway before the high tide of Wusong. Large ships berthing at BaoSteel and Luojing generally pass through outside Wusongkou 1 hour earlier than the Wusong High Tide. In Baoshan fairway, after passing Light Buoy #71, they enter Baoshan South fairway via Baoshan fairway.

2.4.6 Baoshan fairway

2.4.6.1 Introduction of Baoshan fairway

Baoshan fairway starts from Light Buoy #66 to #72, with a length of 4 n miles and width between 800m to 950m, and the depth is more than 10m.

2.4.6.2 Sailing Direction(Entry), Width and Depth of Baoshan Fairway

Baoshan Guard Zone is set up between Light Buoy #72 and #74.

Table.1 – Lighted Buoy Particulars

Name of Light Buoy	Distance (n mile)	Sailing Direction(°)	Width of the fairway(m)	Water Depth(m)	Notes
61#~63#	1.95	300	1700~2000	10~20	
63#~65#	1.2	302	850~1500	15~19	
65#~67#	1.0	304	800~850	13~18	
67#~69#	1.34	304	800	12~15	
69#~69A#	0.95	314	800	12~14	
69A#~71#	1.1	314	900~1200	12~16	
71#~73#	2.0	331	1000~250m	10~15	Two segments navigation of 331°/1.2 and 345°/0.5
73#~75#	0.85	340	550~800m	10~13	
75#~75A#	0.97	322	900~1000m	10~16	
75A#~77#	1.2	293	960m	13~20	North of the scope is the north Baoshan Anchorage

Source: Shanghai Institute of Navigation. (2010). *Research of Water Safety Management for Wusong International Cruise Terminal Operating*. Shanghai: Author.

2.4.6.3 Navigation Law of Vessels in Baoshan fairway

(1) Medium and Large Vessels

Baoshan fairway is the inevitable path for ships coming from the outer seas or Shanghai to arrive at Bao Steel Terminal, Huaneng Electricity Factory, Second Phase of Luojing Terminal that lie along the south Baoshan fairway, as well as for vessels entering Yangtze River. Generally before Wusong high tide, ships entering from out sea to the river arrive at Baoshan fairway and it lasts for 2 hours. Waters near Light Buoy #69 is the junction for Shanghai and Yangtze River Pilot. Pilots transfer by the vessel sailing downwards from Yangtze River between 1500pm to 1700pm, and the ship quantity is greater than in the morning. Vessels approaching terminals on the south bank of Baoshan South fairway arrive at 1 hour later than the Wusong High Tide. The largest ship in the River is as long as 364.04m and sails upwards through the Baoshan North fairway. In the later six months of 2007, over 130 ships pass through Baoshan North fairway every day. Vessels sailing downward the fairway is less concentrated than the import ones.

(2) Medium and Small Ships

Small motor ships sail within 100m along the Baoshan fairway outside of right side sign line (to its north). However, several yellow sand ships no less than 1000 tons all sail in the Baoshan main fairway. Plus, 3000 to 5000 empty yellow sand ships and medium to large tug fleet depart Wusongkou in half to 1 hour before initial Wusong Tide and pass Wusongkou Guard Zone to enter Baoshan fairway and sail in Yangtze River. During the initial phase of rising tide, the ships have arrived near Light Buoy #67 of South Entrance of Baoshan South fairway, and ships of this kind all navigate before the end of tide fall and sail along the Baoshan fairway. But, quite a few small motor ships sail toward Baoshan Branch fairway, which is not in compliance with the regulations.

Chapter 3 Wharf Facilities and Ship Navigation Circumstance near Wusongkou International Cruise Terminal

3.1 Wharf Facilities near Wusongkou International Cruise Terminal

3.1.1 Ship Base of CSC

Not only vessels of CSC(Changjiang Shipping Corporation) berth in the base, but some other vessels from Baoshan Branch fairway pass through the East West Gate of the base and cruises between Shanghai and other Yangtze Ports, forming a navigational path.

For instance, there are berths for high speed passenger ships across Chongming Islands and military transport ships and vehicle transport vessels in the base.

3.1.2 Baoshan Harbor

9 berths owned by Shanghai International Port Company and 5 berths owned by BaoSteel Products lie in the Baoshan Harbor. Container ships, timber ship, general cargo ship loaded with steel and barges of CSC sail across the harbor.

3.1.3 Main and Auxiliary Material Wharf of BaoSteel

Main and Auxiliary Material Wharf of BaoSteel lies in the junction of Baoshan Branch fairway and Baoshan South fairway. Besides, the following terminals are also in the Baoshan South fairway:

- Shidongkou Electricity Factory(Factory One and Factory Two) Terminal
- Shidongkou Coal Gas Factory Terminal
- Luoqing Tanker Storage Terminal
- Luoqing Ore Storage Terminal
- Luoqing Second Phase Terminal(one 70,000 GT class coal unloading terminal, two 200,000 GT ore unloading terminal, six 30,000 to 50,000 GT steel general berth and 25 water transshipment berths)

3.2 Current Navigation Circumstance near Wusongkou International Cruise Terminal

3.2.1 Vessel Volume and Navigation Law

3.2.1.1 Baoshan Branch fairway

Baoshan Branch fairway is a navigational lane for small vessels between Shanghai and Yangtze River Ports. At present, since Baoshan Harbor, BaoSteel Comprehensive Wharf, BaoSteel Chemical Products all lie in Baoshan Branch fairway, so medium and large ships also pass through the branch fairway. Medium and small size river ships from Yangtze River Ports to Shanghai approximately account for 50% of the total ships passing through Wusongkou(Zhang & Li, 2007). These ships sail between Yangtze River, and the ships sailing downward all lie in Baoshan Branch fairway. In addition, small ships coming into the river always sail in the Baoshan Branch fairway.

3.2.1.2 Jetty of Paotai Bay

Medium and small size river ships from Yangtze River to Shanghai account for 50% of the total ships passing through Wusongkou. These ships sail along Yangtze River and mostly sail in the Baoshan Branch fairway.

An observation of front water vessel volume was carried out by Shanghai Institute of Navigation in Yatong Terminal 2, Baoyang Road from 10:30 am on 23 Aug, 2008 to 11:00 am on 24 Aug, 2008(lunar 23rd July, to 24th July).The detailed data are in the following table

Table.2 – Data of Tide

23, Aug	24, Aug
0351 (364)	0037 (156)
1151 (127)	0441 (326)
1626 (377)	1205 (143)

Source: Shanghai MSA, (2007). *Tide Table of Shanghai Port and Hangzhou Gulf 2008*. Beijing: China Communication Press.

Table.4 – Ship Volume of Front Water in Paotai Bay

Time	<500GT	500-3000GT	>3000GT	Sum	Passenger Ship	Proportion of Passenger Ships
Sum of Anti-tide	187	121	130	438	19	4.34%
Sum of Along-tide	380	136	127	643	31	4.82%
Sum of Total	567	257	257	1081	50	4.63%

Source:Shanghai Institute of Navigation. (2010). *Research of Water Safety Management for Wusong International Cruise Terminal Operating*. Shanghai: Author.

1081 ships were spotted to pass the water. Among them, 187 ones under 500GT, 121 ones between 500 to 3,000GT, 130 ones over 3,000GT and this account for 438 ships altogether. 19 passenger ships account for 4.34% of the above group. For the 643 ships sailing along the water, 380 ones were under 500GT, 136 ships between 500 to 3,000GT and 127 ships over 3,000GT. 31 passenger ships took a share of 4.63%.

According to the observation station of Wusong VTS, the characteristics of waters near the jetty of Paotai Bay are:

- (1) Relatively high small ship volume in outer fairways and Baoshan Harbor in some period of daytime
- (2) Large ship volume of outer fairways concentrates between 0.5 hours before and 1.5 hours later of Wusong Low Tide.
- (3) Large ship volume of Baoshan Harbor concentrates between 1.5 hours later and 2.5 hours later of Wusong High Tide.

- (4) Loaded and large ships usually enter the fairway of Baoshan Harbor about 1 hour later of Wusong High Tide when it was the end of rising tide or high water.

3.2.2 Navigation Laws of Building Materials Ship near Water of Jetty of Paotai Bay

At present, ships sailing near Baoshan Branch fairway, Jetty of Paotai Bay are generally small vessels, a majority of which come to Shanghai with the loaded yellow sand. The ships are of a small horsepower, so most of them arrive with tide: when they sail from the upstream of the Yangtze River, they take the falling tide; when they navigate against the tide, they would take the rising current. The general navigation rules are:

For ships sailing against water: small motor ships tend to sail toward the south bank. From 4 hours before the end of Wusong High Tide to 3 hours before the initial rising tide, they will leave Wusongkou, pass cruise terminal and sail against the tide in Baoshan branch fairway. After they pass buoy #A76 and #A78, they will sail near Baoshan Main Material Wharf, the beginning of Baoshan fairway(from 2.5 hours before to 2 hours before Wusong High Tide)(Liu, 2008).

For ships sailing along water: about 5 hours before Wusong High Tide(near Wusong Low Tide), small ships sailing along the Yangtze River pass Luoqing Coal unloading Wharf and join in Huangpu River near Wusongkou via cruise terminal. Another patch of ships sail into Huangpu river at the initial rising of Wusongkou 4 hours before Wusong High Tide(about 1 hour later than Wusong Low Tide) after passing Luoqing Coal Unloading berth and sail along the water of Baoshan Branch fairway near cruise terminal(Lei, 2006).

Such small ships sailing between Shanghai and ports of Yangtze River usually pass Baoshan Branch Terminal in a 3 hour period, between 4 to 2 hours before Wusong High Tide. Based on the latest observation, sand ships sailing upstream of Huangpu

River begin to enter Wusongkou before Wusong low tide, and most of them enter Wusongkou a little later during the low tide. During the above mentioned period, small motor ships are filled in the fairway and it is of chaos. Especially when the great wind alarm is released, ships seeking shelter in Taicang and Nantong flood in to sail along Baoshan Branch fairway to enter Huangpu River. Such intensity makes the small ships sail in 3 to 4 rows side by side and they nearly connect each other head to head, which extends for several miles.

Ships approaching Baoshan Harbor Terminals usually arrive at the gate by Baoshan Branch fairway in Wusong High Tide(Neap Tide) and 45 minutes after Wusong High Tide(Spring Tide). Large Ships approaching BaoSteel Comprehensive Wharf usually sail toward the berth 1.5 hours after Wusong High Tide via Baoshan Branch fairway. Ships departing Baoshan Harbor also try to avoid the intense passing period of the gate.

Chapter 4 Impacts of Entry and Departure, Berthing and Un-berthing of Large International Cruises to Navigation Circumstance

4.1 Navigation Circumstance Impact of the Entry and Departure for Large International Cruises

Second Phase of Deep Water fairway for Yangtze River is designed for the two way navigation of container ships 50,000 GT ships which are of the third and fourth generation. At present, the water depth is 12.5m, which can satisfy the need of two way navigation with full tide of the third and fourth generation ships, the 50,000 GT ships and ships of actual draft no more than 11.5m. In addition, the fifth and sixth generation large container ships and loaded 100,000 GT bulk ships and the de-loaded 200,000 GT bulk ships can also pass the fairway with tide.

According to the revision of “Design Code of General Layout for Sea Port”(The Ministry of Communications of PRC, 1999), a typical 100,000 GT bulk ship has an LOA of 250m, breadth of 43m and moulded depth of 20.3m. Plus, its load draft is

14.5m. A 200,000 GT dry bulk ship has an LOA of 312m, the breadth of 50m, the moulded depth of 25.5m and load draft of 18.5m.

The berthing ship of Wusongkou International Cruise Terminal is 80,000 GT, between 150,000 to 160,000 GT. Except for the 80,000 GT large cruise can sail in the Third Phase of Deep Water fairway of Yangtze Estuary, the LOA and the maximum width of the remaining ships cannot satisfy the design requirement of the third phase requirement of deep water estuary.

4.2 Navigation Circumstance Impact to Yuan-yuan sha Guard Zone

Yuan-yuan sha Guard Zone is the junction of several streams of ship flow, and the ship volume density is large especially between 3.5 hours before Changxing High Tide to 0.5 hours after the high tide. To make sure that large passenger ships can pass the Guard Zone safely, temporary traffic control is needed sometimes, which also exerts some influence to the ships passing the Guard Zone.

4.3 Impacts to Other Ships When Passing Waigaoqiao fairway by Large International Cruises

Over 20 large container berths exist in the south side of Waigaoqiao fairway (near Pudong Side). Besides, there are large shipyards, coal terminals of electricity, dangerous cargo terminals and large tanker terminals as well. During the initial rise of tide, the approaching container ships turn left in the berth with the facilitation of tugs. When the tide begins to fall, the departing ship turns to the right with the help of tug.

Due to the limited width of the front water, the ship turning around will occupy the fairway space whether before berthing or after departure.

9 large mooring anchorages lie in the north of Waigaoqiao fairway. Apart from the normal anchorage and ships moored which wait for the tide, many ships enter the

anchorage when a heavy wind is about to come. After the great wind, the above ships leave the anchorage.

When an international cruise passes Waigaoqiao fairway, ships mentioned before have to wait until its departure to resume operation. For the ships sailing according to the stipulated time and those waiting for the tide to leave from Nancao, their captains and pilots may be anxious, which may also hamper the normal operation of ships.

4.4 Impact of Large International Cruises to Ships in Wusongkou Guard Zone

When the international cruises turn portside and pass #60 Light Buoy, they enter the Wusongkou Guard Zone with a length of 3.6 n miles. The upstream of the Guard Zone lies along the Baoshan fairway, with Wusongkou to its south and 4 anchorages in the north(Wang, 2010).

According to the Article 25 of ‘Navigational Safety Management Regulation of Shanghai Huangpu River’, ships in the Wusongkou Guard Zone shall:

- (1) avoid collision of large ships entering and departing Huangpu River
- (2) avoid collision of ships sailing along the water
- (3) small ships should avoid collision of large ships(China MSA, 2010)

When a large ship leaves Wusongkou and sails towards Baoshan fairway via the Guard Zone, or sails from Baoshan fairway along the water to Wusongkou via Wusong Guard Zone, some difficulty will arise.

According to the Annex 1 of “Regulation of Ship Routing in Shanghai Section of Yangtze River”, “the fairway of Shanghai Section of Yangtze River” is mainly for navigation of small ships to sail in the Baoshan Branch fairway.

Since Wusongkou International Cruise Terminal is located in Baoshan Branch fairway, west to the Wusongkou Guard Zone, large cruises cannot prevent the risk of collision with the small ships during the entire navigational process.

4.5 Impact to Ships Sailing in Baoshan Branch Fairway

Small motor ships pass Baoshan Branch fairway from Yangtze River to Shanghai or the opposite direction, and the process is concentrated between the fall and start of the rising Wusongkou Tide. Since the width of this navigational leg is only 250 to 350 m, the ships sailing downstream usually navigate beyond the south boundary of the navigational lane and close to the international cruise terminal. The sailing facilities on board are inferior, the operation is not quite standard, so collisions tend to occur. The berthing cruises are likely to be collided by the ships passing by.

4.6 Impact to Ships in the CSC Ship Base

The width of west gate in CSC Ship Base is only 300m, and the navigational water width is less than 200m. If the ship does not operate with great caution, such a narrow gate is likely to cause collision for the large cruise ships near the gate.

When a large cruise is anchored in the berth, the high station hinders the view of ships entering and departing the CSC Ship Base. Vessels that would like to leave the west gate cannot watch the dynamics in Baoshan Branch fairway, and ships that would like to enter Baoshan Branch fairway cannot watch the ships within the base, either, which enhances the insecure factors unconsciously.

4.7 Impact to the Navigating Ships

When ships come from the outer sea to approach the berth, they have to pass Wusongkou Guard Zone, enter and pass Baoshan Branch fairway to berth without turning around. During the end of falling and the initial rising, ship density is quite big near the water. In this sense, it is quite hard for a large international cruise to pass through waters with so many ships. Under this circumstance, navigation not only influences itself, but also influences other ships in motion, such as ships in Baoshan Branch fairway, as well as ones passing through Wusongkou and Baoshan fairway.

When a ship enters during the rising tide, it must turn around before berthing (The ships previously berthed during the falling tide have to turn starboard in Baoshan Branch fairway to get out). Since there is no sufficient water in front of the wharf,

the water in the fairway has to be utilized. In addition, if the water depth still cannot meet the turning requirement of large international cruises, they have to utilize some deep water beyond the north boundary of Baoshan Branch fairway.

The approach and departure of large cruises will affect the navigation of many ships passing Baoshan Harbor, Baosteel Comprehensive Berth and the Baoshan Branch fairway.

Chapter 5 Problems in the Navigation Safety of International Cruises

According to the joint feasibility analysis of technology security of Wusongkou International Cruise Terminal by Shanghai Navigation Association (Aug 2008), Shanghai Haiping Technical Consulting Service Company (Jan 2009) and Shanghai Maritime University (Apr 2009), a series of hidden dangers lurks for cruises to sail from the water of Wusongkou International Cruise Terminal to the wharf.

5.1 Potential Risks Near the International Cruise Terminal

5.1.1 Relatively Large Intersection Angle between the Wharf Front and the Water Direction

The intersection angle of upstream wharf of Jetty of Paotai Bay is $113.5^{\circ}\sim 293.5^{\circ}$, while for the downstream is $120.5^{\circ}\sim 300.5^{\circ}$.

According to the measured data provided by of Hydrology and Water Resources Measurement Bureau of Yangtze Estuary in May 2009(a P-2 Line is set in the middle of the berth).

Table.5 – Water Direction of Wharf Front

Spring Tide				Neap Tide			
Rising Tide		Falling Tide		Rising Tide		Falling Tide	
Flow Angle	Flow Speed	Flow Angle	Flow Speed	Flow Angle	Flow Speed	Flow Angle	Flow Speed
308°	1.5m/s	121°	1.6m/s	311°	0.71m/s	129°	0.9m/s

Source: Shanghai Institute of Navigation. (2010). *Research of Water Safety Management for Wusong International Cruise Terminal Operating*. Shanghai: Author.

Table.6 – Comparison of Water Direction and Intersection Angle with the Wharf

Spring Tide			Wharf Location	Neap Tide		
Tide	Direction	Variance of the Angle		Tide	Direction	Variance of the Angle
Rise	308°	14.5°	Upstream: 113.5°~293.5°	Rise	311°	17.5°
Fall	121°	0.5°	Downstream: 120.5°~300.5°	Fall	129°	8.5°

Source:Shanghai Institute of Navigation. (2010). *Research of Water Safety Management for Wusong International Cruise Terminal Operating*. Shanghai: Author.

Since the intersection angle is over 10°, so when there is heavy rain, rapid current or wind no less than 7 degrees, if one hawser is loose in the bow or aft, then the bow or aft will be affected by the overlay effects and flow away from the terminal and form a insecure acute angle. What's worse, this angle will increase with the greater wind, which makes it even more unsafe.

5.1.2 Turn-round of Ship Occupies the Navigation Water

The cruise terminal is located in the south of Baoshan Harbor and the actual navigational route of Baoshan Harbor. The front line of the cruise terminal lies in 100 to 180m to the south boundary of the actual navigational route of large ships passing Baoshan Harbor. Since the width of this leg in Baoshan Branch fairway is 250 to 350m, thus the wharf front line is in 370(430)m to 470(530)m to the north boundary of Baoshan Branch fairway.

5.1.3 Dense Ships Affects the Safe Approaching and Departure of the Cruises

Sand used by the construction industry of Shanghai is almost obtained from the middle of Yangtze River and transport to Shanghai by water. Since the last decade of the last century, sand quantities increases dramatically owing to the prosperous development of infrastructure, construction and real estates. During the specific period, when the front water of the international cruise terminal is filled with the yellow sand construction material ships in chaos, there exists great potential risk of serious accidents.

5.2 Potential Risks and Hazards in Navigation

5.2.1 Intersection Problems in Yangtze Deep Water Fairway

The design standard for deep water fairway in Yangtze Estuary is “Satisfy the need of two-way passing for full-load 50,000 GT container ships (with draft ≤ 11.5 m), and also satisfy the need for the 100,000 GT dry bulk ships and 200,000 GT dry bulk ships to pass with rising tide”.

Whether the deep fairway cruise can intersect with the 50,000 GT container ships is assessed and analyzed by Shanghai MSA and experts. The conclusion is: The 80,000 GT cruise will intersect with the 50,000 GT class ships in the deep water fairway of Yangtze Estuary while the 150,000 GT class cruise will not(Shanghai Institute of Navigation, 2010).

5.2.2 Issues of Traffic Jam in the Waigaoqiao Fairway

The total length of Waigaoqiao fairway is about 8.8 n miles with a width of 1060m to 900m and most of the fairway is as wide as 900m. The center line of the fairway is the separation line, with the right side (north side) separating the entry navigation and the left side (south side) separating the departure navigation. The right side (north side) of the entry lane is the main shipping lane and small ships enter from the north side, to its north lies the anchorages from No.1 to No.7; while on the left side (south side) of the departure lane is the coastal lane of Waigaoqiao, to its south lies the wharf clusters of Waigaoqiao(including First Phase to Fifth Phase terminals of Waigaoqiao Wharf Company, Waigaoqiao Power Factory, Waigaoqiao Shipyard and sewage Terminals of Large Ships).

Since Waigaoqiao Shipping Lane is the throat to access the ports in Yangtze River, Luoqing Port, BaoSteel Terminal, Baoshan Harbor and Huangpu River(the inner port of Shanghai Port).

According to the requirement of tide and current for the berth and operation of large ships to pass the shallow, ships approaching Luoqing Port, BaoSteel Terminal, and the middle and downstream of Huangpu River need to approach during the wait for Waigaoqiao fairway. At the same time, ships going to the ports located along Yangtze River and upstream of Huangpu River need to pass quickly. Ships usually pass the anchorage or enter or depart the Waigaoqiao terminals. As a result, many large importing ships wait for the tide in the fairway, causing detention and ships sailing with dripping water. Under such circumstances, when large ships enter and depart the north anchorage or operate near the south terminals, the sailing order in the fairway will be extremely complicated, and the ships destined for ports of Yangtze River and upstream Yangtze River cannot pass quickly, so the cruise may not arrive at the berth on time. What' worse, the ship shall miss the best safety berthing period.

5.3 Countermeasures

5.3.1 Countermeasures in Navigation

5.3.1.1 Intersections Problems in Yangtze Deep Water Fairway for 150,000 GT Cruises

Since 150,000 GT cruises cannot intersect with the 50,000 GT ships in the deep water fairway, so it has to be outlined as a single issue for discussion. Before the arrival of the 150,000 GT cruiser comes to the international cruise terminal, the ship shall declare to the MSA 20 days before with the materials of the ship details, arrival plan, departure plan, etc.

The MSA shall assess and investigate the safety measures concerning the cruise materials, arrival plan and departure plan with staff from pilotage, wharf, shipping agents and supervisory body.

- (1) Determine the safety period of the cruise to berth
- (2) According to the time of berth, work out the arrival period within which there are fewer departing ships to avoid intersection in the fairway
- (3) Navigational alert is released by the MSA
- (4) Coordination between different parties to avoid intersection in the deep water fairway and carry out volume control when necessary
- (5) Make out the emergency measures in case of intersections
- (6) Determine the cooperative tug powers to facilitate the cruise
- (7) Determine the measures to work together with the alert yacht
- (8) Enhance the guarantee measures and requirement of the VTS system
- (9) The cruise should report the dynamic situations through VHF and exchange its meaning. Give signals during intersection with other ship

5.3.1.2 Preventing the Ship Traffic Jam in Waigaoqiao Fairway

At present, the measures taken by the MSA include:

Wusong VTS releases the time for the cruise to pass Waigaoqiao fairway which requires the detained and dripping ships voluntarily avoid the collision and give way to the cruise. Ships receiving approaching and departing services or entering or

departing the anchorage that affect the normal navigation of the cruise should pause their work and resume operation after the pass of the cruise.

The cruise arriving at Waigaoqiao fairway should report its dynamics through VHF and asks for the avoidance from other sailing and operating ships.

The patrol boat should maintain good traffic order and make sure that the fairway is order and clear.

5.3.2 Countermeasures of the Cruise Berthing

5.3.2.1 Suggestions for Cruises During Approach and Departure by Turning Around

(1)The wharf should apply to the MSA for publication of safety navigation rules concerning the turning around for cruises during Approach and Departure by turning around.

(2)Select a period with less ship volume. For example, 2 to 3 hours after Wusong Hide Tide or approach at the end of rise or the beginning of the falling tide.

(3)The cruise should inform the dynamics of the ship by VHF 15 minutes earlier before departure, and voluntary evasion of other ships can be required.

(4)VTS should release the dynamics of water in the cruise terminal 15 minutes earlier than berthing, and provide danger alerts and safety reminder in time.

(5)Apply alert yacht to maintain traffic order in the upstream and downstream of the cruise terminal. During the turning around of the cruise, the alert yacht should conduct the evasions of ships in the fairway when the fairway is occupied.

(6) The cruise terminal should establish a system involving the stakeholders before the operation of the terminals to transfer information periodically. The annual cruise

approaching plan should be informed, ship dynamic inform system and safety measures shall be set up to obtain priority from the stakeholders.

5.3.2.2 Countermeasures to Prevent Impact of Large Angles Formed by Water Direction and Terminal

“Safety Manual” provided by the wharf staff to the cruise should clarify that a certain angle exists for the terminal and the current. So when the current is rapid, the ship should take the following safety measures:

Sailors on watch should check the looseness of the strips diligently. Once he finds that the string is loosened, certain measures must be taken and tugs assistance shall be applied when necessary.

The clerk on watch of the wharf should check whether the strips are tight at the same degree diligently and inform the people on watch in time. He or she should report to the wharf immediately when necessary, and emergency measures shall be taken when the problem is serious.

Tugs can be applied in advance in case of flood and heavy rain.

Chapter 6 Conclusions, Potential Risks and Suggestion

6.1 Conclusions

When the international cruise sails from deep water fairway, Waigaoqiao fairway and Wusong Guard Zone to Wusongkou International Cruise Terminal, some difficulty and unsafe risks lurk during the navigation and turning around.

The 80,000GT cruise can sail through the deep water fairway of Yangtze River towards Wusongkou International Cruise Terminal regardless of the limit of ship size and water depth of the fairway, but cruises over 100,000GT have to be approved by the authority and with the safety measures taken.

The best berthing and departing time for the cruise is the end of the rise and the initial fall (2 to 3 hours after Wusong High Tide). The period a little inferior is the initial rise (2 hour to 1 hour before Wusong High Tide).

The patrol boat should be applied in advance during the turn around and approach to make sure that the ships sailing in fairway are quite in order.

6.2 Potential Risks

The width of wharf front water cannot satisfy the need of large cruises.

During north wind and northeast wind, large cruises are affected by the large hit space, thus the hull is likely to be crushed when collided to the wall of the wharf.

Since the port is greatly influenced by the current and ships move with the currents. During the end of falling tide and initial rise, ship density near the wharf cruises is extremely large, therefore the approaching berthing in the morning cannot be realized sometimes.

6.3 Suggestions

(1) Though only 2 berths in Wusongkou International Terminals run the international cruises business at present, the support from the related authorities is indispensable to the process. To reduce their losses, it's best not to increase the cruise berths before any improvement of the current fairway and ship volume density achieved. Only after more experience is obtained; the layout of the fairway and the ship volume is bettered; the risk degree is decreased after investigation, shall the expansion of the berths be carried out step by step as appropriate.

(2) Sweeping approximate 1,500-meter-long and between 850-meter to 900-meter wide body of water which is from apron to the linking line of Light Buoy #66 to #68 is absolutely necessary to the turning around of cruises. Besides, the water depth should be no less than 1.2 times of the loaded draft of the design vessel type.

Reference

Chen, X, H., & Zhan, H, D. (2009). Discussion About Navigation Rules of Yuan-yuan sha Guard Zone in Shanghai Harbor. *Marine Technology*, 3. Retrieved from World Wide Web:<http://www.doc88.com/p-09692145548.html>

China MSA, (2010). *Regulation for Navigation Safety Management of Deep Water fairway of Yangtze River (12.5m depth)*, Retrieved June 13 2014 from World Wide Web: <http://www.shmsa.gov.cn/UserFiles/File/20100311124727.pdf> (2010).

Ji, L., Gong, H.F. & Lou, F. (2010). Preliminary study on navigation function orientation of Hengsha Passage at Yangtze Estuary. *Port & Waterway Engineering*, 12, 104-108. Retrieved May 23, 2014 from World Wide Web: http://wenku.baidu.com/link?url=LHBzlpJ8zHnLvsNzcmGxjpGgOolfq721gDvoVTY7gtNHTUbmhf_Zv8z0GliZECRu7peOQ8Vs52S5D9C3g3r8nhtECSYqjdZ8cPPrbgWEWO3

Lei, H.Z. (2006). *Ship Navigation Safety Assessment in Shanghai Port*. Unpublished master's thesis, Wuhan University of Technology, Wuhan, China.

Liu, G.R. (2008). Discussion of Ship's Routeing in Shanghai and Jiangsu Water Area. *Marine Technology*, 2, 32-33.

Navigational Safety Management Regulation of Shanghai Huangpu River, China Ministry of Transport, (2005).

Shanghai Hongkou District People's Government. (2012). *2011-2012 China Cruise Industry Development Report*. Shanghai. Shanghai Pujiang Education Press.

Shanghai Institute of Navigation. (2010). *Research of Water Safety Management for Wusong International Cruise Terminal Operating*. Shanghai: Author.

Shanghai Maritime Safety Administration. *Navigation Circumstance of Shanghai Port*. Retrieved June 15, 2014 from World Wide Web:<http://www.shmsa.gov.cn/>

[NewsList.aspx?CatalogId=f7ee1038-4328-4a9a-9c58-a19dbd5a74c9](#)

Shanghai MSA. (2007). *Tide Table of Shanghai Port and Hangzhou Gulf in 2008*. Beijing: China Communication Press.

Sun, C., Xia, D., Zhang, J.P. & Hu, S.P. (2012). Risk Assessment of Navigational Environment of Waigaoqiao Water. *Navigation of China*, 35, 68-71.

Tang, Y. Q. (2012). *Cruise Practice*. Published Teaching material, Higher Education Press, Beijing, China.

The Ministry of Communications of PRC. (1999). *Design Code of General Layout for Sea Port*. (Publication No. 1999-221).

Wang, C.F. (2010). *Assessment and Research of Cruise Safety Navigation Environment in Wusongkou Water*. Unpublished master's thesis, Shanghai Maritime University, Shanghai, China.

Zhang, Z.Y., & Li, Q. (2007). *Analysis on the Vessel Traffic Management of Wusongkou Area*. Retrieved May 26, 2014 from World Wide Web: http://wenku.baidu.com/link?url=_dlkpgAPoSoksxiP-PtyMjy2j9xdVpb_WofpW56K6HcYCtrKC8ne3ID8beY46ufMn5CC0BfvccM27osCgVyojuJZ9hHg1scJLzRjUuIKyK