MA2018-2

MARINE ACCIDENT
INVESTIGATION REPORT

February 22, 2018

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

MARINE ACCIDENT INVESTIGATION REPORT

Vessel type and name:	Container Ship ESTELLE MAERSK
IMO number:	9321495
Gross tonnage:	170,794 tons

Vessel type and name:	Container Ship JJ SKY
IMO number:	9347968
Gross tonnage:	9,948 tons

Accident type:	Collision
Date and time:	Around 07:08:54, June 7, 2016 (local time, UTC +9 hours)
Location:	Kobe Chuo Passage, Kobe Section, Hanshin Port Around 015° true bearing, 195m from Kobe Chuo Passage No. 1 Light Buoy (approximately 34°38.7'N, 135°16.0'E)

January 31, 2018

Adopted by the Japan Transport Safety Board

Chairman Kazuhiro Nakahashi

Member Yuji Sato

Member Kenkichi Tamura

Member Toshiyuki Ishikawa

Member Makiko Okamoto

SYNOPSIS

< Summary of the Accident >

While the container ship ESTELLE MAERSK, with the Master, 27 crew members and a pilot on board, was proceeding north toward the South Entrance of Kobe Chuo Passage in the Kobe Section of Hanshin Port under escort by the pilot, and the container ship JJ SKY, with the Master and 21 crew members on board, was proceeding west-northwest toward the South Entrance of Kobe Chuo Passage, the two vessels collided near the South Entrance of Kobe Chuo Passage at around 07:08:54 on June 7, 2016.

ESTELLE MAERSK sustained abrasion damage on the shell plating of her starboard bow, while JJ SKY sustained a pressure collapse on part of her bridge port-side wing. However, there were no casualties or fatalities on either vessel.

< Probable Causes >

It is probable that this accident occurred because, while ESTELLE MAERSK (hereinafter referred to as "Vessel A") was proceeding north and JJ SKY (hereinafter referred to as "Vessel B") west-northwest toward the Passage in the Kobe Section of Hanshin Port in a state whereby they would both enter the Passage at about the same time, Pilot of Vessel A thought that Vessel A would be given priority when entering the Passage and thus continued to proceed north toward the South Entrance of the Passage, while Master of JJ SKY, thinking that Vessel A would navigate astern of Vessel B, increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage, as a result of which the two vessels collided.

It is probable that Pilot thought that Vessel A would be given priority when entering the Passage and continued to proceed north toward the South Entrance of the Passage because (1) Vessel A was a large vessel in the 400m class and he thought that it would be given priority to enter the Passage by passage control, (2) he had made a request for the order of Passage entry, via Port Radio, to the effect that he wished to enter ahead of the vessel navigating from the Osaka (hereinafter referred to as "Vessel D"), Vessel D had accepted this and set an attitude of entering the Passage after Vessel A, and (3) Vessel A was navigating in accordance with the scheduled Passage entry time notified to Port Radio.

It is probable that Master of JJ SKY thought that Vessel A would navigate astern of Vessel B and increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage because (1) he had heard the communication "Follow Vessel B" between other vessels on VHF, (2) the distance to Vessel C which was navigating ahead of Vessel B was about 0.3M, and he therefore thought that it would be dangerous for Vessel A to pass between Vessel B and Vessel C, and (3) he confirmed the presence of Vessel A by radar and thought that Vessel A would be in an attitude of navigating astern of Vessel B as long as Vessel A did not change course. It is probable that the fact that Vessel A and Vessel B were not communicating by VHF when they were in a state of entering the Passage at about the same time contributed to the occurrence of this accident.

1 PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident

While the container ship ESTELLE MAERSK, with the Master, 27 crew members and a pilot on board, was proceeding north toward the South Entrance of Kobe Chuo Passage in the Kobe Section of Hanshin Port under escort by the pilot, and the container ship JJ SKY, with the Master and 21 crew members on board, was proceeding west-northwest toward the South Entrance of Kobe Chuo Passage, the two vessels collided near the South Entrance of Kobe Chuo Passage at around 07:08:54 on June 7, 2016.

ESTELLE MAERSK sustained abrasion damage on the shell plating of her starboard bow, while JJ SKY sustained a pressure collapse on part of her bridge port-side wing. However, there were no casualties or fatalities on either vessel.

1.2 Outline of the Accident Investigation

1.2.1 Setup of the Investigation

The Japan Transport Safety Board (JTSB) appointed an investigator-in-charge and three other marine accident investigators to investigate this accident on June 7, 2016.

1.2.2 Collection of Evidence

June 8, 9, and 14, 2016: On-site investigations and interviews

August 25, November 15, 18, 2016, January 26, and July 14, 2017: Collection of questionnaire

September 15, 16, and December 6, 2016: Interviews

1.2.3 Test and Research by Other Institutes

To investigate this accident, the JTSB entrusted the evaluation of the collision risk level, analysis of the navigational status based on the port entry records, and CREAM analysis which is a method of Human Reliability Analysis to the National Maritime Research Institute of the National Institute of Maritime, Port and Aviation Technology.

1.2.4 Comments from Parties Relevant to the Cause

Comments on the draft report were invited from the parties relevant to the cause of the accident.

1.2.5 Comments from the Flag State

Comments on the draft report were invited from the flag states of the ESTELLE MAERSK and JJ SKY.

2 FACTUAL INFORMATION

2.1 Events Leading to the Accident

2.1.1 The Navigation Track according to the Automatic Identification System

According to the records of the Automatic Identification System (AIS)*1 data (hereinafter referred to as "the AIS record") received by a data company in Japan, the navigation tracks of the "ESTELLE MAERSK" (hereinafter referred to as "Vessel A") and the "JJ SKY" (hereinafter referred to as "Vessel B") from 06:45 to 07:10 on June 7, 2016 were as shown in Table 2.1-1 and Table 2.1-2 below.

Although the positions of the vessels were generally identified with a high degree of accuracy (10m or less), the accuracy of positioning underlined in Table 2.1-2 was low (more than 10m).

The positions of Vessel A and Vessel B refer to the positions of GPS antennas attached to the upper side of the respective bridges. The course over the ground and heading are true bearings (hereinafter the same).

Table 2.1-1 AIS Record of Vessel A (excerpt)

Time (HH:MM:SS)	Ship's position		Course Over the Ground (°)	Heading (°)	Speed Over the Ground *2 (knots [kn])
	Latitude (N) (°-′-″)	Longitude (E) (°-′-″)			
06:45:06	34-34-14.4	135-14-28.2	041.1	040	15.3
06:50:01	34-35-09.7	135-15-17.3	029.5	029	13.0
06:55:01	34-36-05.7	135-15-54.2	019.4	012	12.2
07:00:04	34-37-05.3	135-16-06.7	009.2	009	12.1
07:01:04	34-37-17.3	135-16-08.9	009.2	007	12.1
07:02:04	34-37-29.1	135-16-10.3	003.1	001	11.7
07:03:04	34-37-40.5	135-16-10.2	359.4	359	10.9
07:04:04	34-37-51.0	135-16-09.9	359.4	359	10.3
07:05:04	34-38-01.1	135-16-09.7	359.9	359	9.8
07:06:04	34-38-10.6	135-16-09.4	355.3	352	9.3
07:07:04	34-38-19.4	135-16-07.6	346.4	341	8.7
07:08:04	34-38-27.4	135-16-04.4	340.4	339	8.0
07:08:55	34-38-33.3	135-16-01.7	337.5	336	6.8
07:09:04	34-38-34.2	135-16-01.3	337.0	335	6.5
07:10:04	34-38-38.9	135-15-58.5	332.6	335	4.3

*1 Automatic Identification System (AIS) is a device that each vessel uses to automatically transmit and receive information such as vessel identification code, ship type, name, position, course, speed, destination, and conditions of navigation, and to exchange information with other vessels or land-based navigation aids.

*2 "Speed over the ground" refers to the speed of a vessel as measured against one point on the earth's surface. The speed of a vessel as measured against the water in which the vessel is traveling is called "speed over water".

Table 2.1-2 AIS Record of Vessel B (excerpt)

Time (HH:MM:SS)	Ship's position		Course Over the Ground (°)	Heading (°)	Speed Over the Ground (kn)
	Latitude (N) (°-′-″)	Longitude (E) (°-′-″)			
06:45:01	34-38-08.9	135-19-28.3	255.0	255	13.8
06:50:00	34-37-55.0	135-18-15.7	265.1	272	9.3
06:55:16	34-38-01.1	135-17-34.2	282.2	285	5.7
07:00:16	34-38-07.7	135-17-02.7	284.9	292	5.1
07:01:16	34-38-09.4	135-16-56.6	294.1	300	4.9
07:02:16	34-38-11.7	135-16-50.7	297.4	300	6.2
07:03:06	34-38-14.4	135-16-44.3	299.3	305	7.4
07:04:16	34-38-19.1	135-16-35.4	302.3	305	7.9
07:05:16	34-38-23.5	135-16-27.1	302.4	306	8.1
07:06:16	34-38-28.1	135-16-18.9	305.2	306	8.0
07:07:36	34-38-34.0	135-16-08.8	307.5	308	7.6
07:08:06	34-38-36.4	135-16-05.1	306.0	307	7.3
07:08:56	<u>34-38-43.7</u>	<u>135-15-56.2</u>	312.0	323	6.8
07:09:00	<u>34-38-44.3</u>	<u>135-15-55.6</u>	318.6	323	6.6
07:10:02	34-38-46.0	135-15-53.4	309.1	275	8.5

2.1.2 Information on Voice Communication recorded by VDR

According to records by Voyage Data Recorders[*3] (hereinafter referred to as "VDR") installed in Vessel A and Vessel B, information concerning voice communication and others inside the bridges of both vessels between 06:43:54 and 07:13:23 and the status of communication between Vessel A and Kobe Port Radio[*4] (hereinafter referred to as "Port Radio") using VHF radiotelephone (hereinafter referred to as "VHF") were as shown in Table 2.1-3 below.

Vessels navigating from the Osaka Section of Hanshin Port toward Kobe Chuo Passage (hereinafter referred to as "the Passage") shall be called "Vessel C", "Vessel D", "Vessel E", "Vessel F" and "Vessel G", respectively, and the vessel that was anchored southeast of the Passage shall be called "Vessel H".

(See Figures 2.1-1, 2.1-2 and 2.1-3)

[*3] "Voyage Data Recorder (VDR)" refers to a device that can record a ship's position, course, speed, radar information and other data related to navigation, as well as communications by VHF radio telephone and voice communication on the bridge, among others.

[*4] "Kobe Port Radio" refers to a coastal broadcaster entrusted by Kobe City, as the port administrator, to communicate by VHF with incoming and outgoing vessels and to provide port entry schedules and information on the status inside passages, the status inside ports, and others (the presence of incoming and outgoing vessels, the presence of oncoming vessels, the status of construction works inside the port, etc.) to ships, in order to ensure the safety of navigation by ships whenever necessary. Kobe Port Radio has no authority to organize, restrict or prohibit shipping traffic by vessels, which is undertaken by the harbormaster based on the provisions of the Act on Port Regulations.

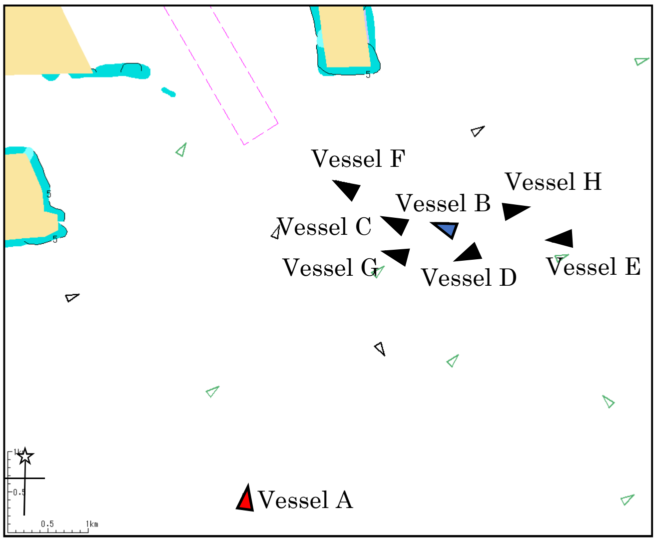

Figure 2.1-1　The situation at around 06:55

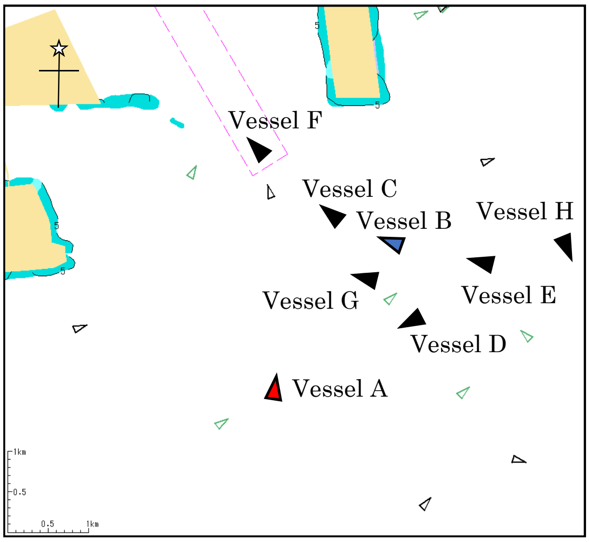

Figure 2.1-2　The situation at around 07:00

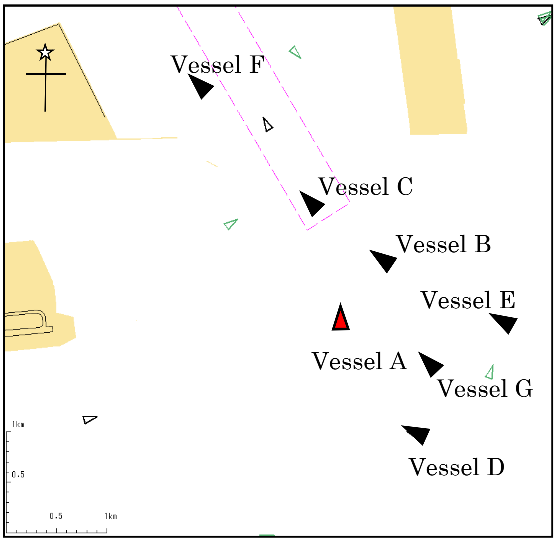

Figure 2.1-3　The situation at around 07:05

Table 2.1-3　VDR Voice Communication, etc. (italics indicate Japanese language)

Time (HH:MM:SS)	Vessel A and Port Radio	Vessel B
06:43:54 - 06:45:40	Pilot (hereinafter referred to as “Pilot A”): *About to arrive outside the port. Will enter the Passage on schedule at 07:10.*	
	Port Radio: *07:10, understood.* *At about that time, five unpiloted container ships will be coming in together from the Osaka direction. All of them will enter the Passage at around 7, would you prefer to wait for them first?*	
	Pilot A: *We will enter the Passage on schedule at 07:10.*	

	Port Radio: *Understood. The unpiloted ships coming from Osaka are likely to enter the Passage at around 7.* *The first will be Vessel F heading for PC-14, followed by Vessel B heading for PC-17, with Vessel D for RC-4 behind that, all in succession.* *We just heard that the piloted Vessel H will soon raise anchor, then enter the Passage at around 07:05 on its way to RC-2.*	
	Pilot A: *We want to enter before the ship heading for RC-4, over.*	
	Port Radio: *You want to enter before that ship, understood. Will instruct that ship to follow you in.*	
06:59:30		Vessel G: Vessel E, this is Vessel G.
06:59:37		Vessel E: Yes, Vessel G, go ahead.
06:59:41		Vessel G: Follow Vessel B, I will follow Vessel H, over.
06:59:46		Vessel E: OK, you'll follow Vessel H, is that correct?
06:59:51		Vessel G: So you just follow Vessel B, thank you sir.
07:00:27	Pilot A: Port 10. Able seaman (hereinafter referred to as "Able Seaman A"): Rudder port 10.	[Conversation on the bridge until around 07:08:50 but content unclear]
07:01:02	Pilot A: Midships. Able Seaman A: Rudder midships sir.	
07:01:15	Pilot A: Slow ahead. Unknown: Slow ahead.	
07:01:46	Pilot A: Dead slow ahead. Unknown: Dead slow ahead.	
07:03:19	Master (hereinafter referred to as "Master A"): [unclear] We try [unclear] enter before him? He waits for us? OK. [unclear] Pilot A: Because we have privilege, big ship. Master A: Priority OK [unclear]. Pilot A: Port control.	
07:04:41	Pilot A: Port 10. Able Seaman A: Port 10.	
07:05:00	Pilot A: Port 20. Able Seaman A: Port 20.	
07:06:04	Pilot A: Midships. Able Seaman A: Midships.	
07:07:04	Pilot A: Stop engine. Unknown: Stop engine.	
07:07:18	Master A: Big ship had priority[unclear] Pilot A: Yah.	

07:07:35	Pilot A: Hard port. Able Seaman A: Rudder hard port, now sir.	
07:07:50	Pilot A: Slow astern. Unknown: Slow astern.	
07:08:02	(Ship's whistle sounded) (continues for about 1 minute) Pilot A: Full astern.	
07:08:26	Pilot A: Full astern. Unknown: Already full astern.	
07:08:54		(Sound of impact)
07:09:52 - 07:10:23	Pilot A: *Ship crossed in front of this vessel from starboard, we collided with stern of that ship, over.*	
	Port Radio: *Vessel B crossed in front and you collided with its stern, understood.*	
07:12:29 - 07:12:53	Pilot A: *Why did you let him enter when passage control was active? Over.*	
	Port Radio: *Yes, Vessel B entered directly as it was an incoming vessel. We're now confirming the movements of Vessel B, which has turned. Please wait a moment.*	
07:13:10 - 07:13:23	Master A: But I don't understand. You said we had priority. Why did he not [unclear. [unclear] So you contact with him [unclear] Pilot A: All [unclear] port control. Master A: Pilot on board? Pilot A: No pilot.	

2.1.3 Events Leading to the Accident according to Statements of Crew Members, etc.

According to statements by Master A, the Chief Officer of Vessel A (hereinafter referred to as "Officer A"), Pilot A, the Master of Vessel B (hereinafter referred to as "Master B"), the Third Officer of Vessel B (hereinafter referred to as "Officer B") and the person in charge of Port Radio as well as the operational report by Port Radio, the events leading to the accident was as follows.

(1) Vessel A

On June 4, 2016, Vessel A departed from Yantien Port in the People's Republic of China bound for Rokko Island Quay RC-5 in the Kobe Section of Hanshin Port, with Master A (nationality: Kingdom of Denmark) and 27 crew members (nationalities: nine from the Kingdom of Denmark, ten from the Republic of the Philippines, five from the Republic of India and three from the Kingdom of Thailand) on board.

At around 04:50 on June 7, Pilot A boarded Vessel A at the pilot station[*5] off to the south of Tomogashima in Wakayama City, Wakayama Prefecture.

Vessel A proceeded north toward the Passage under the guidance of Pilot A, with Master A conning the vessel, Officer A assigned to monitoring radar as well as the Electronic Chart Display and Information System (hereinafter referred to as "ECDIS")[*6], and Able Seaman A

[*5] A "pilot station" is a sea area designated for pilots to meet and board vessels that request piloting.

[*6] "Electronic Chart Display and Information System (ECDIS)" refers to a device that can display a ship's own position on an official electronic chart (Electronic Navigational Chart or Raster Navigational Chart) that meets the standards of the International Hydrographic Organization (IHO), as well as displaying radar, scheduled passages

assigned to hand steering.

At around 05:01, Pilot A informed Port Radio by VHF that Vessel A was due to arrive at the South Entrance of the Passage at 07:10. Port Radio then informed Pilot A by VHF that three tugboats had been prepared for Vessel A, and that Vessel A could enter the Passage after a large vessel had departed. (Hereinafter, "by VHF" will be omitted from descriptions of communication between Pilot A and Port Radio.)

At around 06:43, Pilot A informed Port Radio that Vessel A had arrived outside the port in the vicinity of 135° 1.3 nautical miles (M) from Kobe Oki No. 2 Light Buoy, and would enter the Passage on schedule at around 07:10.

At around 06:55, Pilot A noticed that five vessels including Vessel B (specifically, Vessel B, Vessel C, Vessel D, Vessel F and Vessel G) were heading toward the Passage in succession from the Osaka direction. Thinking that two of those vessels (Vessel F and Vessel C) would enter the Passage ahead of Vessel A while Vessel D would follow aft of Vessel A, Pilot A was focusing attention on Vessel B and one other vessel (Vessel G) 45° ahead on the starboard side.

Pilot A received a report from Officer A that the distance to Vessel B was about 2M and that Vessel B was sailing at a speed (speed over the ground; the same shall apply hereinafter) of about 5kn.

Vessel A adjusted its speed in order to enter the Passage at the scheduled time of 07:10, set the main engine to slow ahead and headed toward the South Entrance of the Passage.

At around 07:00, Master A and Officer A noticed Vessel B, and at around 07:01 Officer A reported to Master A that the DCPA (distance at closest point of approach) to Vessel B was 0.04M (about 74m).

Although Master A could not understand the content of communication between Pilot A and Port Radio as it was conducted in Japanese, he thought that Pilot A was maintaining contact with Vessel B via Port Radio, but sensed the risk of a collision, and so at around 07:01 asked Pilot A about the order of priority when entering the Passage.

Pilot A replied that Vessel A would be given priority when entering the Passage, as Vessel A was navigating such that it would enter the Passage on schedule at 07:10, while Vessel B was due to enter the Passage at 06:50 but its entry was delayed.

After this, Master A again asked Pilot A about the order of priority when entering the Passage, and Pilot A again replied that Vessel A would be given priority when entering the Passage.

At around 07:02, Pilot A noticed Vessel B at about 30° ahead to starboard and at a distance of about 1M, set the main engine to dead slow ahead and reduced the speed to 5-6kn.

Pilot A thought that other vessels would give way and would not dare to come close to Vessel A, as it was a large vessel in the 400m class. At the same time, however, he was aware, from the past maneuvering behavior of Vessel B, that it tended to cut across the courses of other vessels, and therefore thought that Vessel B might accelerate and navigate across the front of Vessel A this time as well.

Pilot A, though concerned over a reduction in rudder effectiveness due to deceleration, noticed that the heading of Vessel B at a distance of about 0.5M had started to change to

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and other information in combination, and also has the function of transmitting warnings when approaching shallows and other hazards.

forward of the bow of Vessel A at around 07:05. Thinking that Vessel B would cut across the front of Vessel A, he sensed the risk of a collision and stopped the main engine.

Pilot A had directed Vessel A toward the west end of the South Entrance of the Passage with the intention of increasing the distance from Vessel B to make it easier for Vessel B to avoid Vessel A, but since the heading of Vessel B changed even more to forward of the bow of Vessel A and it was now in a state of approaching Vessel B, Pilot A set the main engine to full astern at around 07:06.

At around 07:07, Master A sounded a prolonged blast on the ship's whistle.

At around 07:09, the starboard bow of Vessel A collided with the bridge port-side wing of Vessel B.

(2) Vessel B

At around 06:06 on June 7, Vessel B departed from the Osaka Section of Hanshin Port heading for Port Island Quay PC-17 in the Kobe Section of Hanshin Port, with Master B (nationality: People's Republic of China) and 21 crew members (nationality: all from the People's Republic of China) on board.

Vessel B proceeded west toward the Passage, with the Master B conning the vessel, Officer B assigned to monitoring radar and lookout, and an able seaman (hereinafter referred to as "Able Seaman B") assigned to manual steering.

Although Vessel B was due to enter the Passage at 06:50, its entry was delayed because several vessels were in a queue awaiting entry.

At around 06:50, Master B first became aware of Vessel A by radar, while Officer B recognized that the distance from Vessel A was about 3km and Vessel A was sailing at a speed of about 11.0kn at around 06:50, and that the distance was about 1km and that Vessel A was proceeding north having reduced speed to 9.0kn at around 07:00.

At around 07:00, Master B and Officer B sensed the risk of a collision with Vessel A, but because they heard the communication "Follow Vessel B" on VHF, and moreover because the distance to Vessel C, which was navigating ahead of Vessel B and was due to enter the Passage from the Osaka Section of Hanshin Port, was about 0.3M and it would have been dangerous for Vessel A to pass between Vessel B and Vessel C, they thought that Vessel A would navigate astern of Vessel B.

Master B, noticing that Vessel A was reducing speed, set the main engine from dead slow ahead to slow ahead and proceeded west-northwest toward the South Entrance of the Passage to ensure that he did not become separated from Vessel C, which was increasing speed.

At around 07:04, Master B confirmed the presence of Vessel A by radar, and thought that Vessel A would navigate astern of Vessel B as long as Vessel A did not change course.

At around 07:08, Master B set the main engine to half ahead, but became aware that a collision was unavoidable, and so set the rudder hard to port immediately before the collision in order to minimize its impact.

At around 07:09, the bridge port-side wing of Vessel B collided with the starboard bow of Vessel A.

The date and time of occurrence of this accident was around 07:08:54 on June 7, 2016, and the location was around 015° true bearing, 195m from Kobe Chuo Passage No. 1 Light Buoy. (See Annex Figure 1: Estimated Navigation Routes and Annex Figure 2: Navigation Routes

(Enlarged))

2.2 Injuries to Persons

According to the statements of Master A and Master B, there were no casualties or fatalities.

2.3 Damage to Vessels

(1) Vessel A sustained abrasion damage on the shell plating of her starboard bow.

(2) According to a statement by the Port State Control Officer of Kobe District Transport Bureau, Vessel B sustained a pressure collapse on her bridge port-side wing.

(See Photo 2.3-1, Photo 2.3-2)

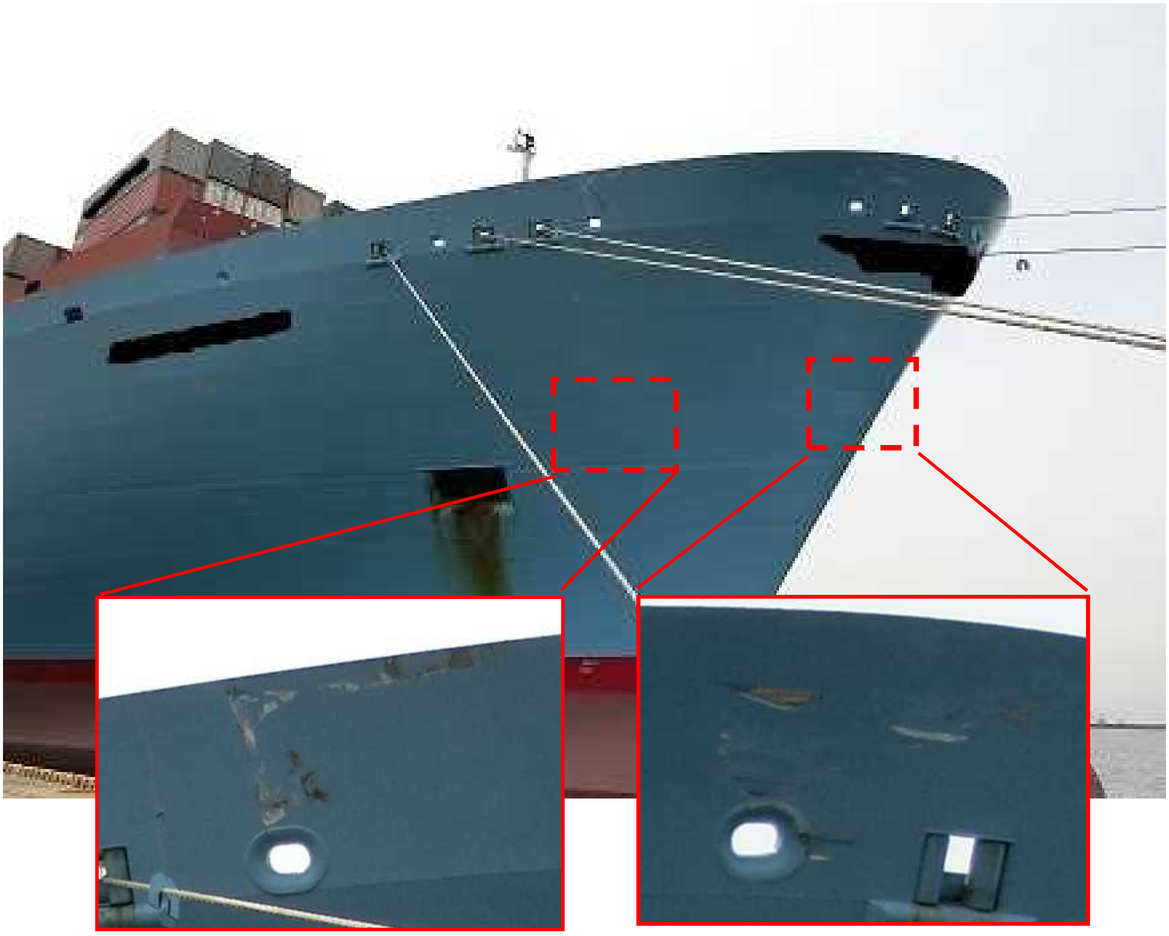

Photo 2.3-1 State of damage to Vessel A

Bridge port-side wing

Photo 2.3-2　State of damage to Vessel B

2.4 Crew Information

(1) Gender, Age, and Certificate of Competence

Master A: Male, 43 years old, national of the Kingdom of Denmark

Master’s License (issued by the Kingdom of Denmark)

Date of Issue: March 11, 2016

(Valid until March 11, 2021)

Pilot A: Male, 72 years old

Osaka Bay Pilot District First Class Pilot’s License

Date of Issue: January 7, 1998

Date of Revalidation: December 4, 2015

Date of Expiry: January 6, 2019

Master B: Male, 43 years old, national of the People's Republic of China

Master’s License (issued by the People's Republic of China)

Date of Issue: November 11, 2014

(Valid until November 11, 2019)

(2) Sea-going Experience, etc.

According to the statements of Master A, Master B and Pilot A and the reply to the questionnaire by Master A and Master B, these were as follows.

1) Master A

Master A was promoted to Master in April 2011, had served on Vessel A as a master since September 2013, and had experienced entering the Kobe Section of Hanshin Port about 20 times, of which two were as a master.

He was in good health at the time of the accident.

2) Pilot A

Pilot A had been employed by the shipping company since 1966, had served on several large container ships, large coal carriers and other vessels as a master, but also had experience of work on land. He then started working as a pilot in Osaka Bay (Bay Pilot[*7]) in January 1998, and had been engaged in piloting work including the work of a harbor pilot since April 2007 (following the integration of piloting districts under the amendment to the Pilotage Act).

He had no health-related problems that would have affected his piloting work at the time of the accident.

3) Master B

Master B joined Vessel B as a master for the first time in January 2014, and had served on Vessel B since May 2016 at the time of this accident. He had experienced entering the Kobe Section of Hanshin Port on more than 100 occasions in total.

He was in good health at the time of the accident.

2.5 Vessel Information

2.5.1 Particulars of Vessel

(1) Vessel A

IMO number:	9321495
Port of registry:	Hellerup, Kingdom of Denmark
Owner:	MAERSK LINE A/S (Kingdom of Denmark) (hereinafter referred to as "Company A")
Management company:	Company A
Classification Society:	AMERICAN BUREAU OF SHIPPING (United States of America)
Gross tonnage:	170,794 tons
L×B×D:	397.71 m x 56.40 m x 30.20 m
Hull material:	Steel
Engine:	Diesel engine x 1
Output:	72,072 kW
Propulsion:	6-blade fixed pitch propeller x 1
Date of keel laid:	April 2006

(See Photo 2.5-1)

(2) Vessel B

IMO number:	9347968
Port of registry:	Hong Kong Special Administrative Region, People's Republic of China
Owner:	BANK OF COMMUNICATIONS HANYANG (SHANGHAI) SHIP CHARTERING CO., LTD. (People's Republic of China)
Charterer:	SUPER FORTUNE SHIPPING S.A. (Hong Kong Special Administrative Region, People's Republic of China)
Management company:	SHANGHAI JINJIANG SHIPPING (GROUP) CO., LTD. (People's Republic of China) (hereinafter referred to as "Company B")
Classification Society:	CHINA CLASSIFICATION SOCIETY (People's Republic of China)
Gross tonnage:	9,948 tons
L×B×D:	147.78 m x 23.25 m x 11.50 m

[*7] "Bay Pilot" refers to a pilot who guides ships from a bay entrance to a point near the port. A pilot who guides ships in and out of the port is called a harbor pilot.

Hull material: Steel
Engine: Diesel engine x 1
Output: 9,730 kW
Propulsion: 4-blade controllable pitch propeller x 1
Date of keel laid: December 2004
(See Photo 2.5-2)

Photo 2.5-1 Vessel A

Photo 2.5-2 Vessel B

2.5.2 Load Conditions

(1) Vessel A

According to the statement and the reply to the questionnaire by Master A, the 20-foot equivalent container loading capacity of Vessel A was 15,500 units. At the time of this accident, Vessel A had 1,119 20-foot containers, 2,732 40-foot containers, and one 45-foot container, while the draught was 11.40m at both bow and stern.

(2) Vessel B

According to the statement and the reply to the questionnaire by Master B, the 20-foot equivalent container loading capacity of Vessel B was 1,114 units. At the time of this accident, Vessel B had 74 20-foot containers and 56 40-foot containers, while the draught was 4.60m at the bow and 7.00m at the stern.

2.5.3 Navigation Equipment, etc.

(1) Vessel A

Vessel A was equipped with a wheel and autopilot device close to the center of the windows on the bow side of the bridge, as well as a main engine remote control panel, a whistle controller, two VHF receivers, radar, ECDIS, AIS display, GPS display, a chart table and other equipment to the starboard side of that, and a gyro repeater, radar, ECDIS, two VHF receivers and other equipment to the port side of the wheel and autopilot device.

According to the reply to the questionnaire by Master A, at the time of this accident, Officer A had set the range of one of the radar units to 6M and that of the other to 3M, respectively, and was monitoring them both.

(See Figure 2.5-1)

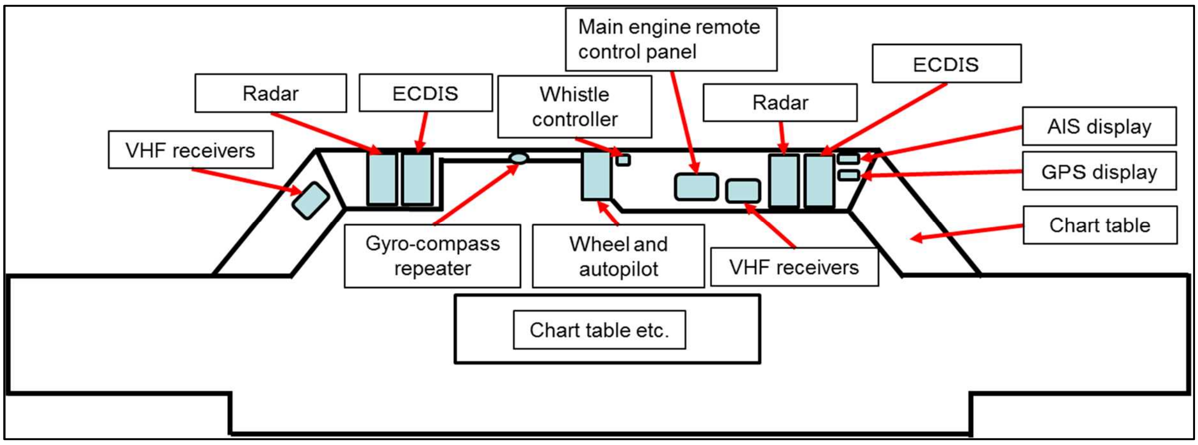

Figure 2.5-1 Bridge of Vessel A

(2) Vessel B

Vessel B was equipped with a main engine remote control panel and a wheel and autopilot device in the center of the bridge, with the No.2 radar, No.2 VHF, whistle controller, GPS display and other equipment on the starboard side and the No.1 radar, No.1 VHF and other equipment on the port side.

According to the reply to the questionnaire by Master B, at the time of this accident, Officer B had set the range of No.2 radar to 1.5M and that of No.1 radar to 3M, respectively, and was monitoring them both.

(See Figure 2.5-2)

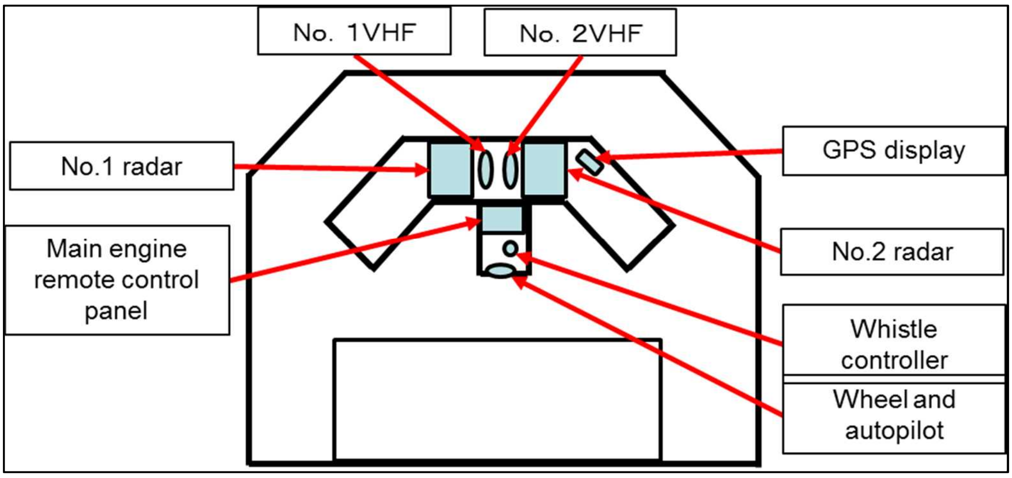

Figure 2.5-2 Bridge of Vessel B

2.5.4 View from the Bridge

There was no structure that would have caused blind spots when looking toward the bow on Vessel A or toward the bow or port-side stern on Vessel B.

2.5.5 Information on Maneuverability

(1) Vessel A

According to the maneuverability characteristics tables of Vessel A, her maneuverability was as follows.

1) Main engine revolutions and speed

Type	Main engine revolutions per minute (rpm)	Speed with load (kn)	Speed without load (kn)
Full ahead at sea	104	25.7	27.5
Full ahead in port	65	16.4	18.1
Half ahead	50	12.4	14.1
Slow ahead	35	8.6	9.7
Dead slow ahead	25	6.0	6.8

2) Time and distance needed until stopping at speed full astern

	With load		Without load	
State when astern order issued	Time (sec)	Distance (m)	Time (sec)	Distance (m)
Full ahead at sea	1,210	7,800	765	5,170
Half ahead	700	2,900	445	1,970

3) Steerageway

With load	About 3kn
Without load	About 3kn

4) Turning characteristics with load

	Main engine revolutions per minute (rpm)	Advance[*8] (m)	Time (sec)	Tactical diameter [*9] (m)	Time (sec)
Starboard turn	90	940	115	995	285
	50	865	190	855	435
Port turn	90	960	120	970	285
	50	835	190	820	410

5) Turning characteristics without load

	Main engine revolutions per minute (rpm)	Advance (m)	Time (sec)	Tactical diameter (m)	Time (sec)
Starboard turn	90	1,120	135	1,410	310
	50	1,035	220	1,215	465
Port turn	90	1,115	135	1,340	305
	50	975	220	1,135	435

(2) Vessel B

According to the maneuverability characteristics tables of Vessel B, her maneuverability was as follows.

1) Control wheel notch and speed

Type	Control wheel notch	Speed (kn)
Full ahead at sea	9.2	18.2
Full ahead in port	8	15.0
Half ahead	6	11.3
Slow ahead	4	7.8
Dead slow ahead	2	4.5

2) Time and distance needed until stopping with speed at full astern

State when astern order issued	Time (sec)	Distance (m)
Full ahead at sea	214	1,098

3) Turning characteristics without load

	Advance (m)	Time (sec)	Tactical diameter (m)	Time (sec)
Starboard turn	488	82	(Not given)	147
Port turn	459	78	(Not given)	136

2.5.6 Other Relevant Vessel Information

According to the statements by Master A and Master B, there was no malfunction or failure in the ship's body, engines or equipment of either Vessel A or Vessel B at the time of this accident.

[*8] "Advance" refers to the distance advanced by a vessel's center of gravity in the direction of the present course when the vessel turns by 90° from the position of its center of gravity during steering.

[*9] "Tactical diameter" refers to the distance of lateral movement by a vessel's center of gravity from the present course when the vessel turns by 180° from the position of its center of gravity during steering.

2.6 Weather and Sea Conditions

2.6.1 Weather and Sea Observations

(1) Weather observations

Observations at the Kobe Local Meteorological Observatory located about 4.1M northwest of the accident site were as follows.

Time	Wind direction	Average wind speed (m/s)	Maximum instantaneous wind speed (m/s)	Precipitation (mm)
06:50	NE	8.3	10.5	None
07:00	ENE	8.4	10.5	None
07:10	NE	8.2	10.8	None
07:20	ENE	7.4	9.9	Less than 0.5

(2) Wave observations

Observations at the NOWPHAS[*10] observation point "Kobe" located about 0.6M east-northeast of the accident site at the time of this accident were as follows.

07:00 Wave height 0.28m, Frequency 3.3 seconds, Wave direction Southeast

07:20 Wave height 0.37m, Frequency 3.6 seconds, Wave direction West

(3) Tide

According to tide tables published by the Japan Coast Guard, the tide in the Kobe Section of Hanshin Port at the time of this accident was in the final phase of a rising tide.

(4) Current

According to Osaka Bay and Harima-Nada tidal current charts and tide tables published by the Japan Coast Guard, the time when the current changed to west-northwest in the Akashi Strait was 07:05, and the tidal current in the accident site at the time of this accident was flowing west-northwest at a speed of 0.3kn.

2.6.2 Observations by Crew

According to the logbook of Vessel B, the weather at 07:09 was cloudy with a northeast wind blowing at force 4.

According to the statement by Pilot A, visibility at the time of this accident was 6M or more.

2.7 Characteristics of the Area

2.7.1 Port Entry Manual

(1) According to the statement by a person in charge of Kobe City, this was as follows.

As the port administration authority, Kobe City had produced a Port Entry Manual and had requested this, via shipping agencies, to be distributed to and kept in vessels entering and leaving the Kobe Section of Hanshin Port. Kobe City had also made announcements about safety measures when entering or leaving the port.

Although the Port Entry Manual was merely an administrative guideline and was not

[*10] "NOWPHAS" (Nationwide Ocean Wave information network for Ports and HarbourS - Ports and Harbours Bureau, MLIT) is a wave information network for Japan's coastlines that was built and is operated through a collaborative effort by the Ports and Harbours Bureau, MLIT; Regional Development Bureaus, MLIT; Hokkaido Bureau, MLIT: Okinawa General Office, Cabinet Office; National Institute for Land, Infrastructure and Management (NILIM); and Port and Airport Research Institute (PARI).

based on any law or ordinance, it had been drawn up and revised as necessary, with the agreement of shipping concerns in the Kobe Section of Hanshin Port.

(2) The Port Entry Manual included statements regarding the method of operational adjustment used by the port administration authority to coordinate the order of incoming and outgoing vessels in advance when congestion was expected. In particular, it included the following statements on coping with sudden congestion.

5. Safety Measures Associated with Chuo Passage Widening and Passage Control Change

((1) and (2) omitted)

(3) 2) Regardless of operation arrangements, if large vessels are expected to pass each other or enter simultaneously near the passage entrance due to reasons such as schedule change, in addition to contacting Kobe Port Radio regarding the status of ship traffic, and paying close attention to Kobe Port Radio's shipping movement information, exchange communication with other ships via VHF, in order to avoid passing each other or simultaneous entry near the entrance. (rest omitted)

The Port Entry Manual also established two Transit Lines to prevent vessels from approaching each other in such a way that their courses would cross near the South Entrance of the Passage, and stated that incoming vessels should follow a northerly course toward the Passage from the south side of the intersection formed by these two Transit Lines.

(See Annex Figure 3: Safety Information Map in Kobe Section and Adjacent Waters)

(3) According to the statement by Master B, he knew of the existence of the Port Entry Manual, but did not keep a copy on board, and did not know about the Transit Lines.

2.7.2 Basic Principles of the Act on Preventing Collisions at Sea

According to the reference literature*[11], one of the key principles of the Act on Preventing Collisions at Sea is that it regards navigational relationships between multiple vessels as a relationship between two vessels (vessel to vessel), and basically one of the vessels should give way to another vessel. The other key principle is that the vessel with superior maneuverability should give way to the vessel with inferior maneuverability.

2.7.3 Study of Safe Navigation Measures for Large Vessels Entering Kobe Port

According to a report by the Kobe Marine Casualty Prevention Institute compiled in November 2006, this was as follows.

Prior to the first entry into Kobe Port (the name by which the Kobe Section of Hanshin Port was previously known) by a large container ship of the same type as Vessel A, the Kobe Marine Casualty Prevention Institute, under commission from the Kobe Port Terminal Corporation, set up a Safety Measures Investigation Committee (hereinafter referred to as "the Safety Committee"). Consisting mainly of academic and professional experts, the Committee studied navigation safety measures in September and October 2006, including ship maneuvering simulator experiments on port entry and departure.

A ship maneuvering simulator experiment was conducted for a large container ship under the meteorological and sea conditions given in the table below.

As a result, attitude control and safe maneuvering were judged possible by means of

*[11] Reference literature: "Commentary on the Act on Preventing Collision at Sea" (Japan Coast Guard eds., June 2007, publ. Kaibundo, 7th revised edition)

adjusting the course and checking the helm, although a drift of about 0.3m/s was observed due to wind and tidal current.

Wind direction	Wind speed (m/s)	Tidal current (kn)	Speed at the South Entrance of the Passage (kn)
West-southwest	8	East 0.6	7.3

2.7.4 Allocation of Escort Boats and Tugboats

(1) According to the report by the Safety Committee, navigation safety measures are studied in case of port entry by a large container ship of the same type as Vessel A under conditions whereby two escort boats and one tugboat (or, when the wind speed is 10m/sec or more, two tugboats) are allocated.

According to the statement by a person in charge of the Kobe Tug Boat Cooperative, two escort boats (also operated as tugboats) and one tugboat had been allocated to Vessel A at the time of this accident.

(2) According to the statement by Pilot A, he was aware that escort boats had been allocated at the time of this accident, but since there was no plan to use escort boats when piloting Vessel A, he did not give instructions to the escort boats.

2.7.5 Compulsory Pilotage Area and Vessels Subject to Pilotage

According to Article 35 of the Pilotage Act and Article 5 of the Order for Enforcement of the Pilotage Act, the Osaka Bay area (the site of this accident) is designated as a compulsory pilotage area, and masters of vessels with a gross tonnage of 10,000 tons or more must have a pilot on board.

2.7.6 Obligation to Navigate in Passages

According to Article 12 of the Act on Port Regulations*12, when a vessel other than a miscellaneous vessel (i.e. a steam launch, barge, or boat, a ship that is operated solely using oars and paddles, or a ship that is operated mainly using oars and paddles) enters or leaves a Specified Port, it must use a passage prescribed by the Ordinance for Enforcement of the Act on Port Regulations. In turn, Article 8 of the Ordinance for Enforcement of the Act on Port Regulations stipulates that the Passage is a passage in a Specified Port. Moreover, Article 36–3 paragraph 1 of the Act stipulates that a vessel navigating within a waterway prescribed by the Ordinance for Enforcement of the Act on Port Regulations in a Specified Port must comply with signals given by the harbor master at a signal station for controlling traffic. Article 20–2 of the Ordinance for Enforcement of the Act on Port Regulations stipulates the Passage as a waterway in a Specified Port.

According to Article 20–2 of the Ordinance for Enforcement of the Act on Port Regulations, incoming vessels may enter when the signal is a flashing letter 'I'.

According to the reply to the questionnaire by the Kobe Coast Guard Office, at the time of this accident, the signal was alternating between the letters 'X' and 'I', meaning (among others) that it would soon change to a flashing letter 'I', and then changed to a flashing letter 'I' at 6:59.

*12 Article 12 of the Act on Port Regulations was amended on May 18, 2016, coming into effect on November 1 of the same year (after this accident occurred). In the amendment, "miscellaneous vessels" was changed to "steam launches, etc.". This Report uses the expression applicable before the amendment, i.e. "miscellaneous vessels".

2.8 Information on Safety Management by Vessel A

In the Safety Management Manual of Company A, the responsibilities of the Master and the Officer of the Watch when the Pilot is on board were stipulated as follows.

(1) The Master is always responsible for the safety of his vessel and the navigation and the presence of a pilot on board does not relieve the Master or the Officer of the Watch from their responsibilities and duties.

(2) It shall be stressed that the responsibility for the vessel's navigation cannot be transferred to the pilot.

(3) The Master and the Officer of the Watch shall always remain responsible with regard to navigational duties and obligations. The safe progress of the ship as planning should be monitored closely at all times. This will also include track monitoring underkeel clearance.

(4) Verbal orders from the Pilot also need to be checked to confirm that they have been carried out correctly.

2.9 Information on Training for BRM*13

(1) According to the reply to the questionnaire by Vessel A, Master A had undergone BRM training using a simulator in November 2010.

(2) According to the statement by Pilot A, Pilot A had undergone BRM training about two years previously.

(3) According to the reply to the questionnaire by Vessel B, Master B, Officer B and Able Seaman B had all undergone BRM training on May 25, 2016.

2.10 Analysis of Causal Factors

The National Maritime Research Institute of the National Institute of Maritime, Port and Aviation Technology was entrusted with evaluating the collision risk level regarding Vessel A and Vessel B, analysis of the navigational status based on port entry records, and CREAM*14 analysis. The results were as follows.

(See Attachment)

(1) Evaluation of collision risk level

For quantitative evaluation of the risk of collision between Vessel A and Vessel B, the Institute evaluated the collision risk level using three types of evaluation indicator – OZT*15,

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*13 "BRM" is an abbreviation for Bridge Resource Management, and means making effective use of various resources that can be used on the bridge for safe navigation of the vessel, including the crew, equipment and information.

*14 "CREAM (Cognitive Reliability and Error Analysis Method)" is a method of human reliability analysis (HRA) focusing on cognitive aspects of humans. Its characteristics are that it regards accidents as merely the ultimate outcome of various contributory factors lying in the background.

*15 "OZT (Obstacle Zone by Target)" refers to a zone in a vessel's direction of sailing that will be obstructed by other vessels in the near future. Specifically, it refers to waters in which a vessel and another vessel will approach each other at distances within 0.1M in future (set at within 0.1M in the investigation of this accident) at a given time, on condition that the other vessel's course and speed are constant. Since the course of the first vessel is variable, the OZT of the other vessel, as seen from the first vessel, only exists on the other vessel's course. This also means that the OZT of the first vessel as seen from the other vessel will only exist on the first vessel's course, and therefore that the OZT of the two vessels will exist in different waters.

BC[*16] and CJ[*17] – based on AIS records.

1) The occurrence of OZT means that the OZT of another vessel as seen from the first vessel will exist in a range of 10° (the value set in this accident investigation) on either side of the first vessel's course within five minutes, and some action must be taken to avoid the area in which OZT has occurred.

The OZT of these two vessels occurred at around 07:01 for Vessel A and around 07:02 for Vessel B, showing that the distance between the two would enter the dangerous situation of 0.1M or less within five minutes.

2) A rise in the BC value indicates a loss of maneuvering freedom, the maximum value being 1.

The highest value for Vessel A in relation to Vessel B was 0.29 at around 07:00, while that in relation to vessels other than Vessel B was 0.29 at around 06:54. The highest value for Vessel B in relation to Vessel A was 0.49 at around 06:55.

Judging from these trends, BC values rose from around 06:55 in both Vessel A and Vessel B, and although they recovered temporarily at around 07:01, the freedom of maneuver for giving way otherwise remained in a low state.

3) The CJ values calculated in relation to each other's vessels by Vessel A and Vessel B continued to rise, as calculated by Vessel A for Vessel B from around 07:06 and by Vessel B for Vessel A from around 07:03, compared to the CJ values calculated by Vessel A for Vessel C, Vessel D, Vessel E and Vessel F. This reveals that the risk level of a collision between Vessel A and Vessel B was increasing from those respective times.

(2) Analysis of the navigational status

The navigational status of Vessel A at the time of this accident, compared to records of entry to the Passage by 14 vessels of the same type in the past, was standard in terms of both navigational track and speed.

(3) CREAM analysis

1) The following procedure is used for CREAM analysis.

a Facts that actually occurred are described in detail.

b CPC[*18] is specified.

c The chronological details of major events are described.

d All actions requiring attention (e.g. unsafe actions) are selected.

e Error modes[*19] are specified for each action.

[*16] "BC (Blocking Coefficient)" is an indicator showing the degree to which a vessel is blocked by vessels existing in the vicinity when the vessel is giving way by changing speed and course. It is based on the risk level of collision with vessels existing in the vicinity, multiplied by a weighting factor that expresses preference for changing speed or changing course as a means of giving way (i.e. their desirability or expedience as methods of maneuvering).

In this accident investigation, the method of giving way was limited to changing speed, in view of the fact that Vessel A was a large vessel and needed time and space to increase or reduce speed, and that Vessel B was not in a state whereby it could change speed easily, as it was sandwiched between other vessels fore and aft.

[*17] "CJ (Collision Judgement)" is an indicator expressing the collision risk level of two vessels in a one-on-one relationship of correspondence. It is calculated from the relative distance compared to the other vessel and the rate of change in the same, and the relative orientation and rate of change in the same. The risk level increases as the other vessel comes closer.

[*18] "CPC (Common Performance Condition)" is an evaluation of three elements that cause error mode – humans, organizations and technology – and defines nine types (appropriateness of the safety management system, navigation and watch environments, man-machine interfaces, appropriateness of procedures and plans, simultaneously attained targets, margin of time, time zone, ship handler's resources, and sharing of communication and information).

[*19] "Error modes" refer to actions that could lead to accidents and are thought to lie behind the occurrence of accidents.

f The cause of each error mode is traced from related results, and underlying factors are found.

g The entirety of the matter is described and causes are found.

2) The actions requiring attention (unsafe actions) of Vessel A and Vessel B and underlying factors were as follows.

a The actions requiring attention (unsafe actions) of Vessel A were that it could not reduce speed sufficiently (error mode: speed (too fast)) and did not communicate with Port Radio or with Vessel B (error mode: timing (omission)).

The background factors behind these, in common, were that Pilot A expected that Vessel B would give way because Vessel A was a large vessel and assumed that Vessel A could enter the Passage with priority (wrong assumption), and that Master A could not understand the content of communication between Pilot A and Port Radio because it was conducted in Japanese (language).

b The actions requiring attention (unsafe actions) of Vessel B were that it had adopted a course of navigating forward of Vessel A (error mode: direction (wrong direction) and that it did not communicate with Port Radio or with Vessel A(error mode: timing (omission)).

The background factors behind these, in common, were that Master B heard the communication "Follow Vessel B" on VHF, and that he was convinced that Vessel A would navigate aft of Vessel B (preconception).

Error modes are observable, as in the case of timing in "Collisions caused by delayed timing". They are defined in eight categories, namely duration (too long or too short), sequence (reverse order, repetition, failure, interruption), wrong object (wrong action, wrong object), force (too weak, too strong), direction (wrong direction), speed (too fast, too slow), timing (too soon, too late, omitted) and distance-magnitude.

3 ANALYSIS

3.1 Situation of the Accident

3.1.1 Course of the Events

According to 2.1 above, the following events occurred.

(1) Vessel A

1) It is probable that Vessel A departed from Yantien Port in the People's Republic of China bound for Quay RC-5 in the Kobe Section of Hanshin Port on June 4, 2016.

2) It is probable that Pilot A boarded Vessel A off to the south of Tomogashima at around 04:50 on June 7, 2016.

3) It is highly probable that Vessel A was navigating about 2.53M south of the South Entrance of the Passage at around 06:55:01, at a heading of 012° and a speed of 12.2kn.

4) It is highly probable that Vessel A changed course from 009° to 359° with the rudder 10° to port at around 07:00:27 and with the rudder midships at around 07:01:02, set the main engine to slow ahead at around 07:01:15 and to dead slow ahead at around 07:01:46, and navigated while reducing speed from 12.1kn.

5) It is highly probable that Vessel A changed course from 359° to 341° with the rudder 10° to port at around 07:04:41, 20° to port at around 07:05:00, and midships at around 07:06:04, and stopped the main engine at around 07:07:04.

6) It is probable that, although Vessel A set the rudder hard to port at around 07:07:35, set the main engine to slow astern at around 07:07:50, and sounded the ship's whistle while also set the main engine to full astern at around 07:08:02, Vessel A collided with Vessel B while reducing speed at more or less the same heading.

(2) Vessel B

1) It is probable that Vessel B departed from the Osaka Section of Hanshin Port heading for Quay PC-17 in the Kobe Section of Hanshin Port at around 06:06 on June 7, 2016.

2) It is highly probable that Vessel B was navigating about 1.38M east-southeast of the South Entrance of the Passage at around 06:55:16, at a heading of 285° and a speed of 5.7kn.

3) It is probable that Vessel B set the main engine from dead slow ahead to slow ahead at around 07:01, and navigated while increasing speed from 4.9 to 8.1kn.

4) It is probable that Vessel B collided with Vessel A at around 07:08 while navigating with the main engine set from slow ahead to half ahead.

3.1.2 Date, Time and Location of the Accident Occurrence

According to 2.1 above, it is highly probable that the date and time of occurrence of the accident was at around 07:08:54 on June 7, 2016, when the sound of an impact was recorded on the VDR of Vessel B, and the location was around 015° true bearing, 195m from Kobe Chuo Passage No. 1 Light Buoy.

3.1.3 Injuries to Persons

According to 2.2 above, it is probable that there were no casualties or fatalities in either Vessel A or Vessel B.

3.1.4 Damage to Vessels

According to 2.3 above, this was as follows.

(1) Vessel A sustained abrasion damage on the shell plating of her starboard bow.
(2) It is probable that Vessel B sustained a pressure collapse on her bridge port-side wing.

3.1.5 Situation of the Collision

According to 2.1.1, 3.1.1, 3.1.2 and 3.1.4 above, it is probable that the starboard bow of Vessel A collided with the bridge port-side wing of Vessel B while Vessel A was sailing at a heading of about 336° and a speed of about 6.8kn and Vessel B was sailing at a heading of about 323° and a speed of about 6.8kn.

3.2 Causal Factors of the Accident

3.2.1 Situation of Crew Members etc.

According to 2.4 above, the situations of the crew members, etc. were as follows:

(1) Master A and Master B

Master A and Master B possessed legally valid certificates of competence.

It is probable that they were in good health at the time of the accident.

(2) Pilot A

Pilot A possessed a legally valid certificate of competence as a pilot.

It is probable that he had no health-related problems that would have affected his piloting work at the time of the accident.

3.2.2 Situation of the Vessel

According to 2.5.6 above, it is probable that there was no malfunction or failure in the ship's body, engines or equipment of either Vessel A or Vessel B at the time of this accident.

3.2.3 Weather and Sea Conditions

According to 2.6 above, it is probable that, at the time of this accident, the weather was cloudy with a northeast wind blowing at force 4, visibility was 6M or more, waves with a height of about 0.3m were coming from the southeast, the tide was in the final phase of a rising tide, and the tidal current was flowing west-northwest at a speed of 0.3kn.

3.2.4 Analysis of Communication

According to 2.1.2, 2.1.3, 2.8 and 2.9 above, communications were as follows.

(1) Vessel A

(i) It is probable that, on informing Port Radio at around 06:43 that Vessel A had arrived outside the Kobe Section of Hanshin Port and reporting the scheduled Passage entry time, Pilot A was informed by Port Radio that several vessels were due to enter the Passage in the same time band, and knew that Vessel B was due to dock at a quay on the west side of the Passage.

(ii) It is somewhat likely that Pilot A thought, based on the past maneuvering behavior of Vessel B, that Vessel B might accelerate toward the scheduled docking quay and might navigate across the front of Vessel A, but did not communicate with Vessel B using VHF because he thought Vessel A would be given priority when entering the Passage, for the reasons set forth below.

a He thought passage control would give Vessel A priority when entering the Passage, as it was a large vessel in the 400m class.

b When receiving information from Port Radio that several vessels were due to enter the Passage in the same time band, he knew that these vessels were unpiloted, but made a request on the order of Passage entry, via Port Radio, to the effect that he wished to enter before Vessel D. Vessel D accepted this and set an attitude of entering the Passage aft of Vessel A.

c Vessel A was navigating in accordance with the scheduled Passage entry time notified to Port Radio.

(iii) It is probable that, at around 07:03, Master A asked Pilot A about the movements of Vessel B, in a state whereby Vessel A would enter the Passage at about the same time as Vessel B, but did not instruct Pilot A to give way as Pilot A had explained that, as a large vessel, Vessel A would be given priority by passage control.

(2) Vessel B

(i) It is probable that Master B thought that Vessel A would navigate astern of Vessel B, because he had heard the communication “Follow Vessel B” on VHF at around 07:00, and moreover because the distance to Vessel C which was navigating ahead of Vessel B was about 0.3M, and he therefore thought that it would be dangerous for Vessel A to pass between Vessel B and Vessel C.

(ii) It is probable that Master B confirmed the presence of Vessel A by radar at around 07:04, and thought that Vessel A would be in a position of navigating astern of Vessel B as long as Vessel A did not change course.

(iii) It is somewhat likely, judging from (i) and (ii) above, that Master B did not communicate with Vessel A using VHF because he thought that Vessel A would navigate astern of Vessel B.

3.2.5 Situation of Lookout and Maneuvering

According to 2.1, 2.4, 2.5, 2.7.5, 3.1.1, and 3.2.4 above, these were as follows.

(1) Vessel A

1) It is probable that, while Vessel A was heading north toward the Passage, Pilot A was piloting the vessel while Master A and Officer A were keeping lookout by eyesight, radar and ECDIS.

2) It is probable that, at around 06:55, Pilot A noticed that five vessels including Vessel B were heading toward the Passage in succession from the Osaka direction, and thinking that two of those vessels would enter the Passage ahead of Vessel A while Vessel D would follow aft of Vessel A, was focusing attention on Vessel B and one other vessel.

3) It is probable that Master A noticed Vessel B at around 07:00, and, on receiving a report from Officer A at around 07:01 that the DCPA to Vessel B was 0.04M, sensed the risk of a collision, and so asked Pilot A about the movements of Vessel B.

4) It is probable that Pilot A, thinking that Vessel A would be given priority when entering the Passage, set the main engine to slow ahead at around 07:01 in order to enter the Passage at the scheduled time.

5) It is probable that, at around 07:02, Pilot A set the main engine to dead slow ahead and noticed Vessel B, heading toward the Passage from the Osaka direction, at about 30° ahead to starboard at a distance of about 1M.

6) It is somewhat likely that Pilot A thought that Vessel B might navigate ahead of Vessel A toward the scheduled docking quay, but could not change course to starboard because several

vessels on the starboard side were navigating in succession toward the Passage, and so, with the intention of heading toward the western end of the South Entrance of the Passage on the port side, instructed rudder 10° to port at around 07:05 followed by rudder 20° to port, then at around 07:06 instructed rudder midships and proceeded north.

7) It is probable that Pilot A, on noticing that the orientation of Vessel B at a distance of about 0.5M had started to change toward the bow of Vessel A and that Vessel B was in an attitude of cutting across the front of Vessel A, stopped the main engine at around 07:07:04.

8) It is probable that Master A again asked Pilot A, as the situation was contrary to the reported information that Vessel A would be given priority when entering the Passage.

9) It is probable that Pilot A instructed rudder hard to port at around 07:07:35 and subsequently instructed slow astern followed by full astern, because Vessel B was approaching ahead to starboard.

(2) Vessel B

1) It is probable that Vessel B was not boarded by a pilot because it had a gross tonnage of less than 10,000 tons and Master B had experienced entering the Kobe Section of Hanshin Port on more than 100 occasions.

2) It is probable that Master B and Officer B were keeping a lookout by eyesight and radar.

3) It is probable that Master B first noticed Vessel A by radar at around 06:50.

4) It is probable that Master B, thinking that Vessel A would pass astern of Vessel B in a state whereby it would enter the Passage at about the same time as Vessel A, increased speed at around 07:01 in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage.

5) It is somewhat likely that Master B set the main engine to half ahead at around 07:08 and set the rudder hard to port immediately before the collision in order to minimize its impact.

3.2.6 Situation of Lookout and Maneuvering, and Evaluation of Collision Risk Level

According to 2.1, 2.10 and 3.2.5 above, these were as follows.

(1) Vessel A

1) At around 06:55, Pilot A noticed that five vessels including Vessel B were heading toward the Passage in succession from the Osaka direction, and thinking that two of those vessels would enter the Passage ahead of Vessel A while Vessel D would follow aft of Vessel A, was focusing attention on Vessel B and one other vessel.

It is probable that BC values rose and the freedom of maneuver for giving way started to decrease from around this time.

2) It is probable that the OZT for Vessel A in relation to Vessel B occurred at around 07:01, and that the dangerous situation had arisen whereby the distance between Vessel A and Vessel B was 0.1M or less within five minutes.

3) It is probable that, although Vessel A set the rudder to midships at around 07:06 in a state whereby it would enter the Passage at about the same time as Vessel B, then stopped the main engine, set the rudder hard to port, set to slow astern, sounded the ship's whistle and set to full astern between around 07:07:04 and 07:08:26, CJ values continued to rise from around 07:06, and the risk of a collision continued to increase.

(2) Vessel B

1) It is probable that, while Vessel B was navigating north of the Transit Line set in the Port Entry Manual and was approaching the Passage, the BC value started to rise and the

freedom of maneuver for giving way started to decrease from around 06:55.

2) It is probable that the OZT for Vessel B in relation to Vessel A occurred at around 07:02, and that the dangerous situation had arisen whereby the distance between Vessel A and Vessel B was 0.1M or less within five minutes.

3) It is probable that Vessel B, in a state whereby it would enter the Passage at about the same time as Vessel A, increased speed in an attitude of cutting across the Passage toward the scheduled docking quay to the west of the Passage, but CJ values continued to rise and the risk of a collision continued to increase from around 07:03.

3.2.7 Analysis of Navigational Status

According to 2.1.1, 2.4, 2.5.5, 2.6.1, 2.7 and 2.10 above, it is probable that this was as follows.

(1) Vessel A

1) The navigational status of Vessel A at the time of this accident, when compared to records of entry to the Passage by 14 vessels of the same type in the past, was standard in terms of both navigational track and speed.

2) Since it is probable that the meteorological and sea conditions at the time of this accident were more or less the same as the conditions set for the ship maneuvering simulator experiment conducted by the Safety Committee, their status would not have impacted the attitude control of Vessel A.

(2) Vessel B

1) Master B joined Vessel B as Master in January 2014 and knew of the existence of the Port Entry Manual, but since he did not know of the Transit Line and was late in entering the Passage, he navigated north of the Transit Line, where the distance of navigation to the Passage is short, together with four vessels that were heading toward the Passage in succession from the Osaka direction.

2) Because Vessel B navigated to the north of the Transit Line instead of approaching from the broad expanse of sea to the south of it, it first set an attitude of navigating along the Passage, then did not have sufficient margin of time or space for maneuvering away to the west of the Passage in response to the movements of Vessel A, and therefore navigated setting an attitude of cutting across the Passage diagonally near the South Entrance of the Passage.

3.2.8 Analysis of the Accident Occurrence

According to 3.1.1, 3.1.5, 3.2.4 and 3.2.5 above, this was as follows.

(1) It is probable that Master B, in a state whereby he would enter the Passage at about the same time as Vessel A, thought that Vessel A would navigate astern of Vessel B because he had heard the communication “Follow Vessel B” between other vessels on VHF at around 07:00, and moreover because the distance to Vessel C which was navigating ahead of Vessel B was about 0.3M, and he therefore thought that it would be dangerous for Vessel A to pass between Vessel B and Vessel C.

(2) It is probable that Pilot A, thinking that Vessel A would be given priority when entering the Passage, did not communicate with Vessel B using VHF but set the main engine to slow ahead at around 07:01 in order to enter the Passage at the scheduled time.

(3) It is probable that, at around 07:03, Master A asked Pilot A about the movements of Vessel B in a state whereby Vessel A would enter the Passage at about the same time as Vessel B, but did not instruct Pilot A to give way as Pilot A had explained that, as a large vessel, Vessel A

would be given priority by passage control.

(4) It is probable that Master B confirmed the presence of Vessel A by radar at around 07:04, and thought that Vessel A would be in an attitude of navigating astern of Vessel B as long as Vessel A did not change course.

(5) According to (1) and (4) above, it is probable that Vessel B increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage.

(6) It is somewhat likely that Pilot A thought that Vessel B might navigate ahead of Vessel A toward the scheduled docking quay, but could not change course to starboard because several vessels on the starboard side were navigating in succession toward the Passage, and so, with the intention of heading toward the western end of the South Entrance of the Passage on the port side, instructed rudder 10° to port at around 07:05 followed by rudder 20° to port, then at around 07:06 instructed rudder midships and proceeded north.

(7) It is probable that Vessel A and Vessel B were not communicating by VHF when they were in a state of entering the Passage at about the same time, as a result of which they were unable to confirm each other’s maneuvering intentions and approached each other.

4 CONCLUSIONS

4.1 Probable Causes

It is probable that this accident occurred because, while Vessel A was proceeding north and Vessel B west-northwest toward the Passage in the Kobe Section of Hanshin Port in a state whereby they would both enter the Passage at about the same time, Pilot A thought that Vessel A would be given priority when entering the Passage and thus continued to proceed north toward the South Entrance of the Passage, while Master B, thinking that Vessel A would navigate astern of Vessel B, increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage, as a result of which the two vessels collided.

It is probable that Pilot A thought that Vessel A would be given priority when entering the Passage and continued to proceed north toward the South Entrance of the Passage because (1) Vessel A was a large vessel in the 400m class and he thought that it would be given priority to enter the Passage by passage control, (2) he had made a request for the order of Passage entry, via Port Radio, to the effect that he wished to enter ahead of Vessel D, Vessel D had accepted this and set an attitude of entering the Passage after Vessel A, and (3) Vessel A was navigating in accordance with the scheduled Passage entry time notified to Port Radio.

It is probable that Master B thought that Vessel A would navigate astern of Vessel B and increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage because (1) he had heard the communication “Follow Vessel B” between other vessels on VHF, (2) the distance to Vessel C which was navigating ahead of Vessel B was about 0.3M, and he therefore thought that it would be dangerous for Vessel A to pass between Vessel B and Vessel C, and (3) he confirmed the presence of Vessel A by radar and thought that Vessel A would be in an attitude of navigating astern of Vessel B as long as Vessel A did not change course.

It is probable that the fact that Vessel A and Vessel B were not communicating by VHF when they were in a state of entering the Passage at about the same time contributed to the occurrence of this accident.

4.2 Other Findings of Safety-Related Issues

It is probable that the two Transit Lines shown in the Port Entry Manual were set with the aim of preventing vessels from approaching each other in such a way that their courses would cross near the South Entrance of the Passage, and that navigating along the Passage in the broad expanse of sea to the south of the Transit Lines would give vessels a margin of time and space for maneuvering in order to avoid a collision with other vessels.

5 SAFETY ACTIONS

It is probable that this accident occurred because, while Vessel A was proceeding north and Vessel B west-northwest toward the Passage in the Kobe Section of Hanshin Port in a state whereby they would both enter the Passage at about the same time, Pilot A thought that Vessel A would be given priority when entering the Passage and thus continued to proceed north in an attitude of navigating toward the western end of the South Entrance of the Passage, while Master B, thinking that Vessel A would navigate astern of Vessel B, increased speed in an attitude of cutting diagonally across the Passage toward the scheduled docking quay to the west of the Passage, as a result of which the two vessels collided.

It is also probable that Vessel A and Vessel B were not communicating by VHF when they were in a state of entering the Passage at about the same time, as a result of which they were unable to confirm each other's maneuvering intentions and approached each other.

It is probable that the two Transit Lines shown in the Port Entry Manual were set with the aim of preventing vessels from approaching each other in such a way that their courses would cross near the South Entrance of the Passage, and that navigating along the Passage in the broad expanse of sea to the south of the Transit Lines would give vessels a margin of time and space for maneuvering in order to avoid a collision with other vessels.

Accordingly, implementation of the following measures is necessary to prevent occurrence of a similar accident.

(1) Pilots and Masters should communicate with vessels when there is a risk of colliding by using VHF, escort boats or other means, confirm their maneuvering intentions to each other, and cooperate in efforts to avoid collisions.

(2) Masters should understand regulations and others pertaining to the waters to be navigated, and should observe them correctly.

(3) Port administration authorities should make efforts to ensure that vessels entering and leaving ports understand the purpose of Port Entry Manuals.

5.1 Safety Actions Taken

5.1.1 Safety Actions Taken by Company A

Company A drew up an Accident Investigation Report dated June 28, 2016, in which it identified the causes as over-reliance on the Pilot, poor communication among bridge watch personnel, inadequate assessment of collision risks, and tardiness in taking action to avoid a collision. It also distributed documents urging greater caution to all vessels related to the company.

Company A also instructed officers of vessels related to the company, including Vessel A, to comply with "Navigating with a pilot on board" and "Ship maneuvers" in the Safety Management Manual.

5.1.2 Measures taken by the Osaka-Wan Pilots' Association

The Osaka-Wan Pilots' Association, of which Pilot A is a member, took the following measures after this accident.

(1) Pilot A underwent one-day simulation training, using a simulator based on a vessel of the same type and with the same maneuverability as Vessel A.

(2) Of its two escort boats, it allocated one to a point 1M ahead of the Passage, to warn vessels

and others against crossing in front of incoming vessels.

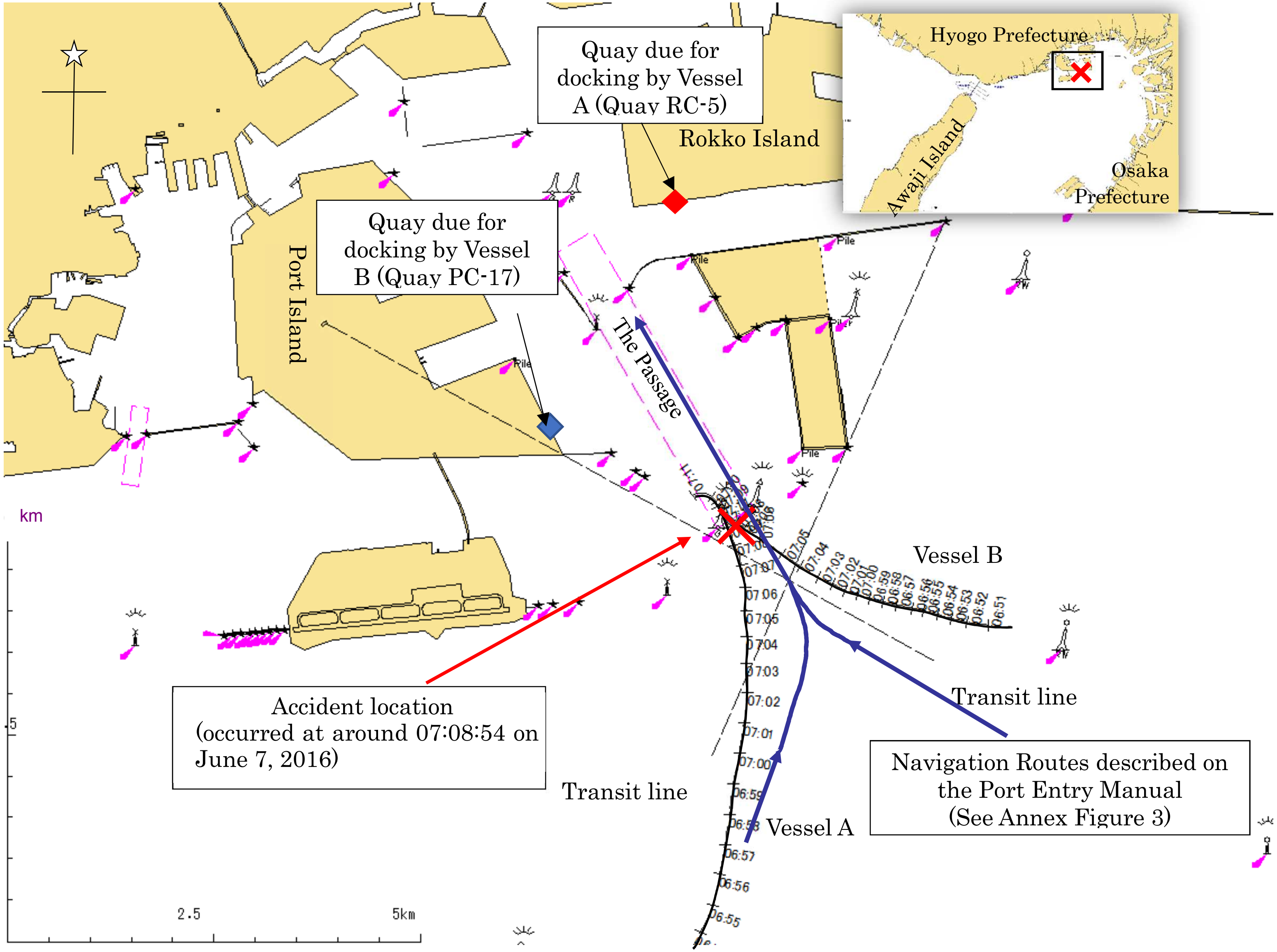
5.1.3 Safety Actions Taken by Company B

Company B identified the causes of this accident as a mistaken belief that Vessel B would enter the Passage first based on incomplete information heard on VHF, an inability to engage in cooperative action for collision avoidance due to a lack of communication with Vessel A, and the fact that Vessel A did not give way. Company B also instructed Vessel B to ensure the safety of navigation by reinforcing its learning of collision avoidance methods, raising safety awareness and maneuvering more carefully, based on the lessons learned from this accident.

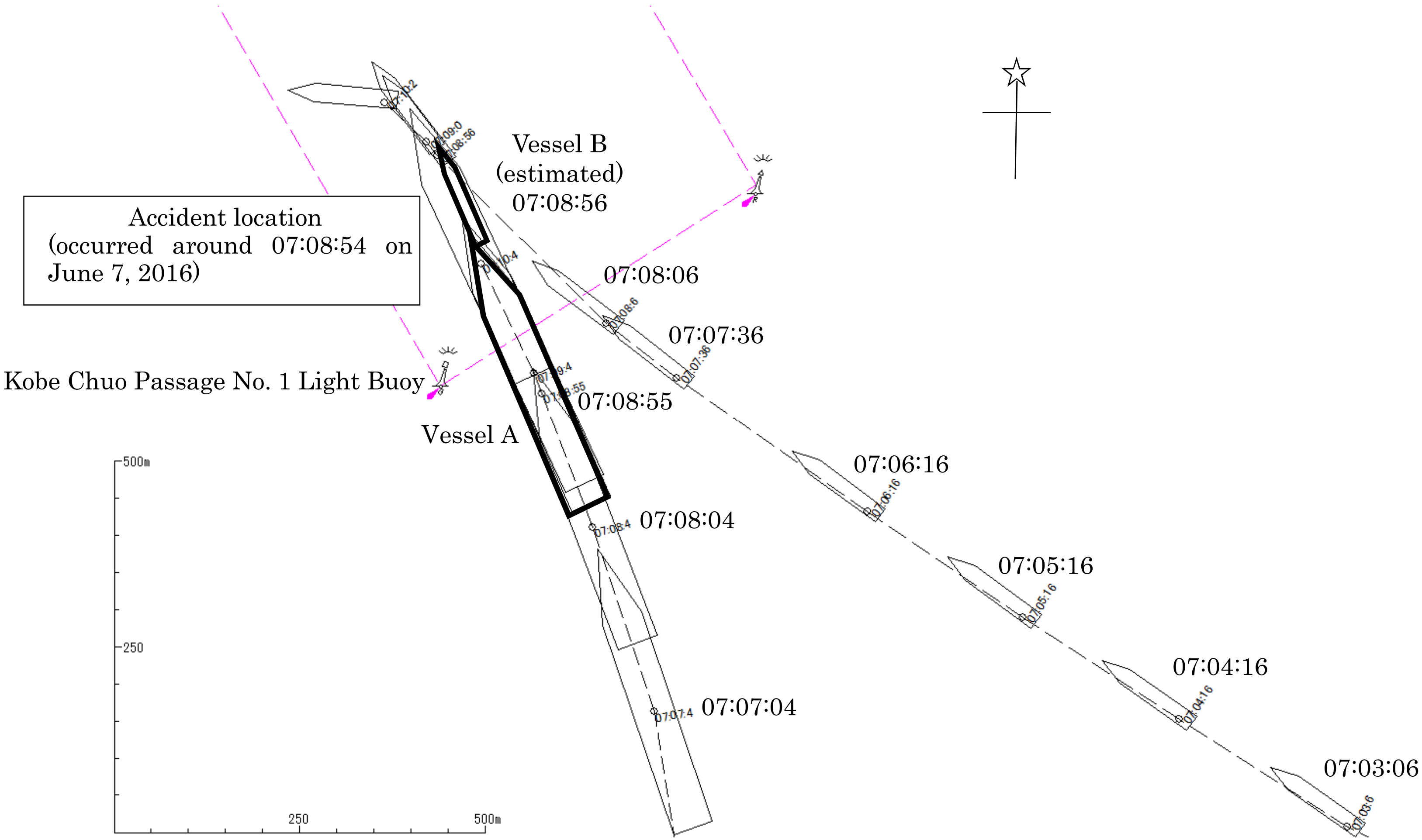
5.1.4 Measures taken by the port administration authority

Kobe City, as the port administration authority, issued a request to relevant shipping agents dated September 15, 2016, urging them to ensure that copies of the Port Entry Manual are always readily available on the bridges of incoming and outgoing vessels and are used by them when entering and leaving the port.

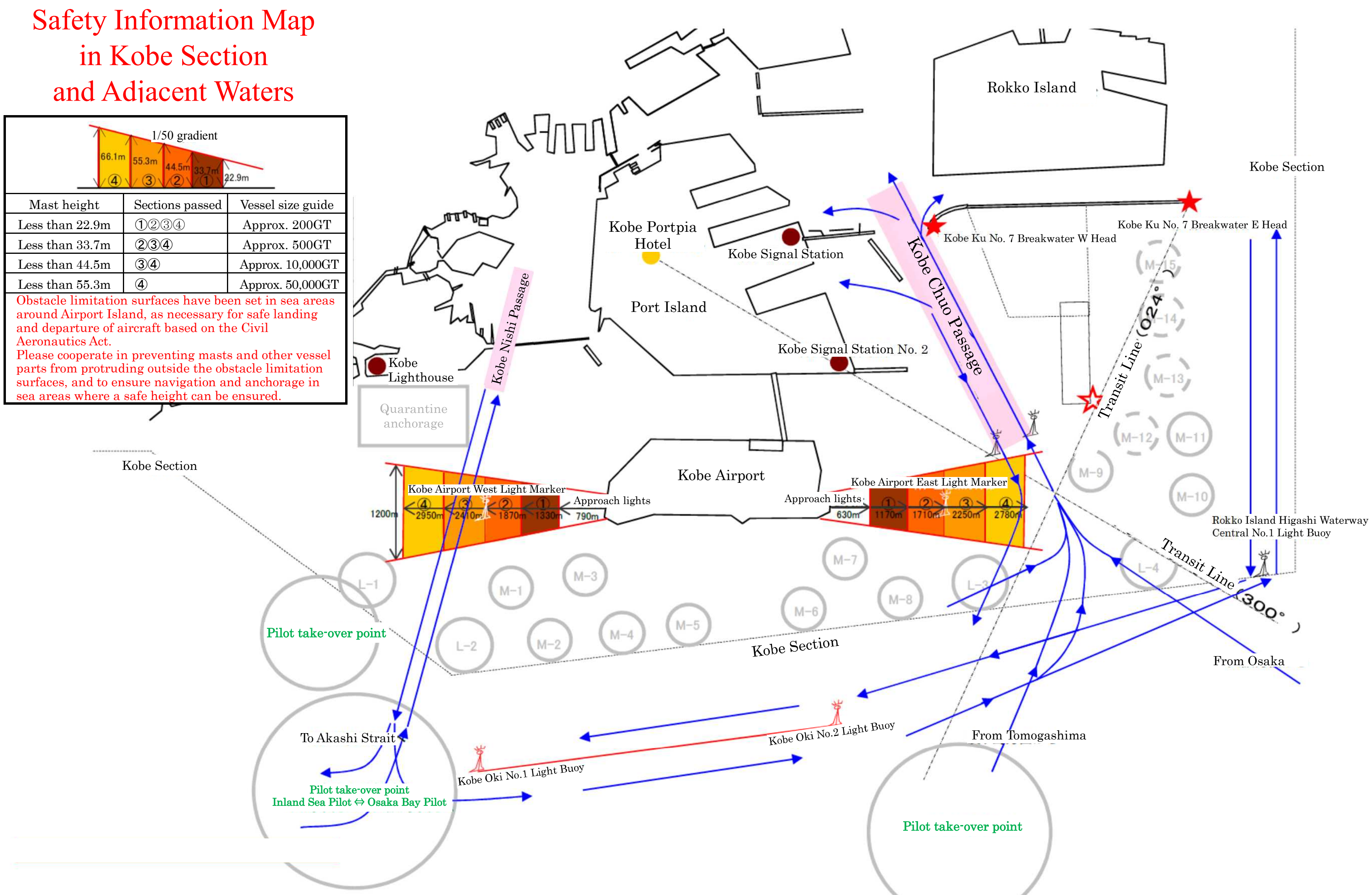
Annex Figure 1 Estimated Navigation Routes



Annex Figure 2 Navigation Routes (Enlarged)



Annex Figure 3 Safety Information Map in Kobe Section and Adjacent Waters



Mast height	Sections passed	Vessel size guide
Less than 22.9m	①②③④	Approx. 200GT
Less than 33.7m	②③④	Approx. 500GT
Less than 44.5m	③④	Approx. 10,000GT
Less than 55.3m	④	Approx. 50,000GT

Attachment

Analytical Investigation of a Collision Accident Involving Container Ships

REPORT

March 2017

National Maritime Research Institute

National Institute of Maritime, Port and Aviation Technology

Table of Contents

1 Introduction

1.1 Purpose of the Investigation

The purpose of this investigation was to contribute to the investigation into the collision accident between the container ship ESTELLE MAERSK (hereinafter referred to as Vessel A) and the container ship JJ SKY (hereinafter referred to as Vessel B) that occurred near the south end of Kobe Chuo Passage at around 07:09 on June 7, 2016. To this end, cognitive support concerning the behavioral status of both vessels leading to the collision was evaluated based on AIS data, the navigational status was analyzed based on the past record of port entry by large vessels, and factors leading to the accident were analyzed by means of CREAM (Cognitive Reliability and Error Analysis Method).

The group of vessels besides Vessel B that were navigating toward the Kobe Chuo Passage from the Osaka direction shall be referred to Vessel C, Vessel D, Vessel E, and Vessel F.

1.2 Outline of the Investigation

(i) Evaluation of cognitive support

To quantify the risk of collision between the two vessels that collided (Vessel A and Vessel B), the level of collision risk between the two vessels was assessed using three evaluation indicators (OZT (Obstacle Zone by Target), CJ (Collision Judgement) and BC (Blocking Coefficient) values) based on AIS data at the time of the accident. As well as this, the level of collision risk in the group of vessels including the two vessels that collided was also assessed and the situation at the time of the accident was objectively analyzed.

Finally, the result of CPA (Closest Point of Approach) analysis using the center of the vessels as a datum point was compared with the result of CPA taking into account the size of the vessels, and assessment of the level of collision risk was studied, taking account of vessel length.

(ii) Navigational status based on past record of port entry by large vessels

Speeds and navigational tracks when passing several gate lines were analyzed based on AIS data, using a total of 15 port entry records by large vessels since September 2015 supplied by the Japan Transport Safety Board.

(iii) CREAM analysis

Cognitive factor analysis was carried out using the CREAM method, which is a method of Human Reliability Analysis, based mainly on interview research with ship handlers and others supplied by the Japan Transport Safety Board.

2 Evaluation of Cognitive Support

2.1 Time-related Changes in the Quantitative Status of Vessel A and Vessel B

Time-related changes in the quantitative status of the two vessels that collided were analyzed based on AIS data at the time of the accident. Fig. 1 and Fig. 2 show changes in the quantitative status of Vessel A and Vessel B. The top part of Fig. 1 shows the rate of change in relative bearing, while the bottom part shows the distance between the vessels. The top part of Fig. 2 shows the Time to Closest Point of Approach (TCPA), while the bottom part shows the Distance of Closest Point of Approach at the bottom (DCPA).

Relative bearing

This shows that the rate of change was virtually zero in both Vessel A and Vessel B until around 6:50.

DCPA

After briefly falling to almost zero at 6:55, DCPA remained at about 0.1NM continuously thereafter, indicating a state of risk.

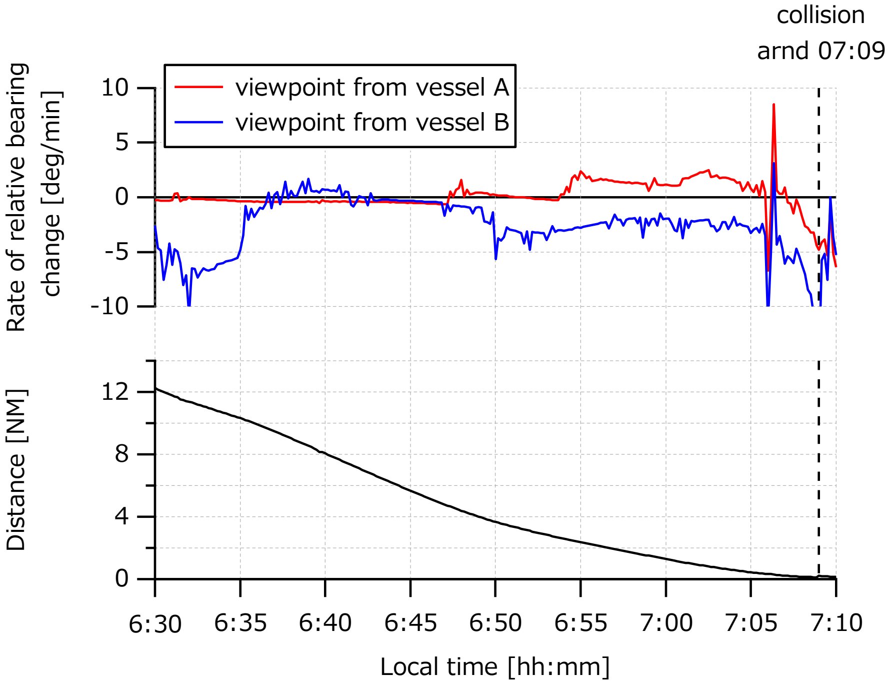


Fig. 1　Time-related changes in relative bearing and distance

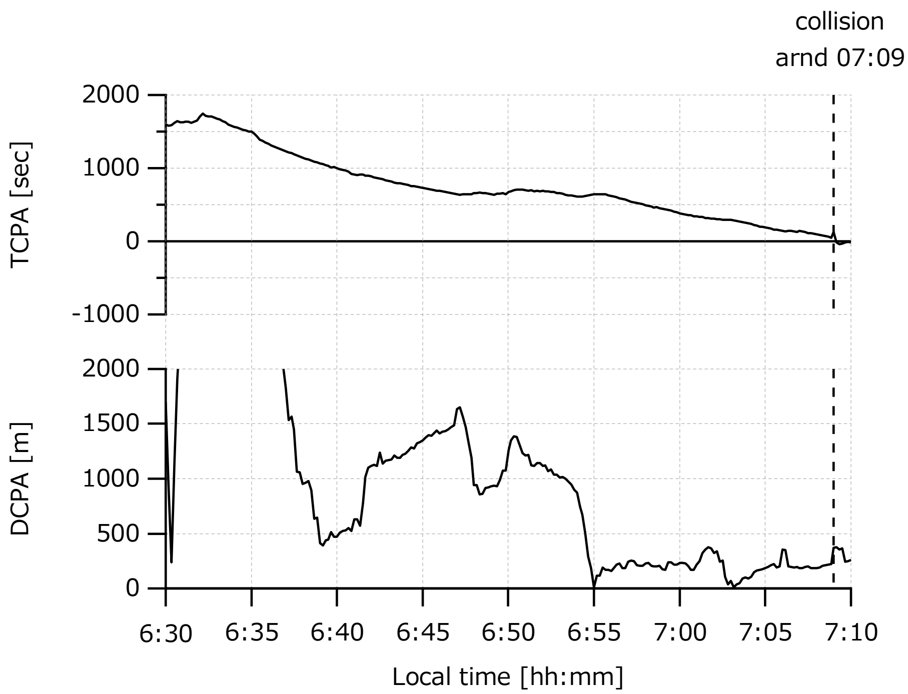


Fig. 2　Time-related changes in TCPA and DCPA

2.2　Location of OZT Occurrence

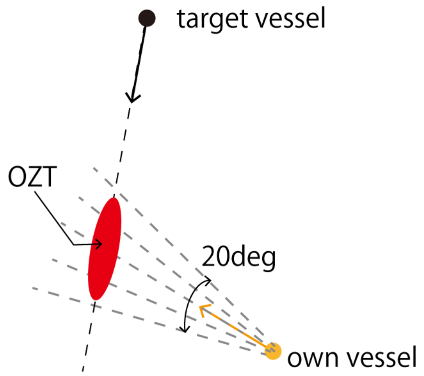
OZT[1)] indicates an area in the direction of navigation of a vessel (the "own ship") that is likely to be obstructed by another vessel (the "target ship") in the near future. If this area exists ahead, when seen from the viewpoint of the own ship, it becomes an element that impacts the maneuvering behavior of the own ship. If the area is right in front when seen from the own ship, some kind of action must be taken to avoid the area. Based on this concept, the conditions for OZT areas regarded as causing maneuvering difficulty above a certain level were set as shown below.

Conditions for OZT evaluation

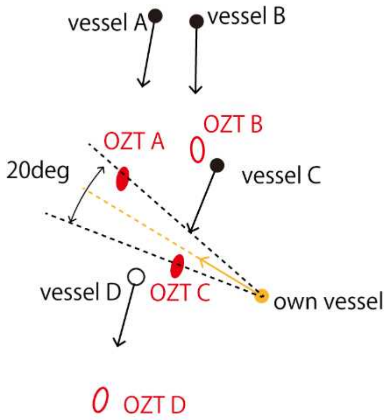
- ✓ OZT shall be taken to occur when the minimum safe navigating distance between two vessels falls to 0.1NM or lower.
- ✓ Evaluation shall apply to vessels approaching within 3NM.
- ✓ The time until arrival at the OZT point shall be five minutes or less.
- ✓ OZT shall apply to an area within 10 degrees to port or starboard of the own ship's course (the evaluation area) (Fig.3(a))

Examples of OZT evaluation

For example, let us consider a situation in which four other vessels are navigating in the vicinity of the own ship, as shown in Fig. 3(b). Since two OZT areas exist within the evaluation area (i.e. within 10 degrees to port or starboard of the own ship's course), namely A and C, OZT can be said to occur for the own ship.



(a) Between two vessels



(b) Between several vessels

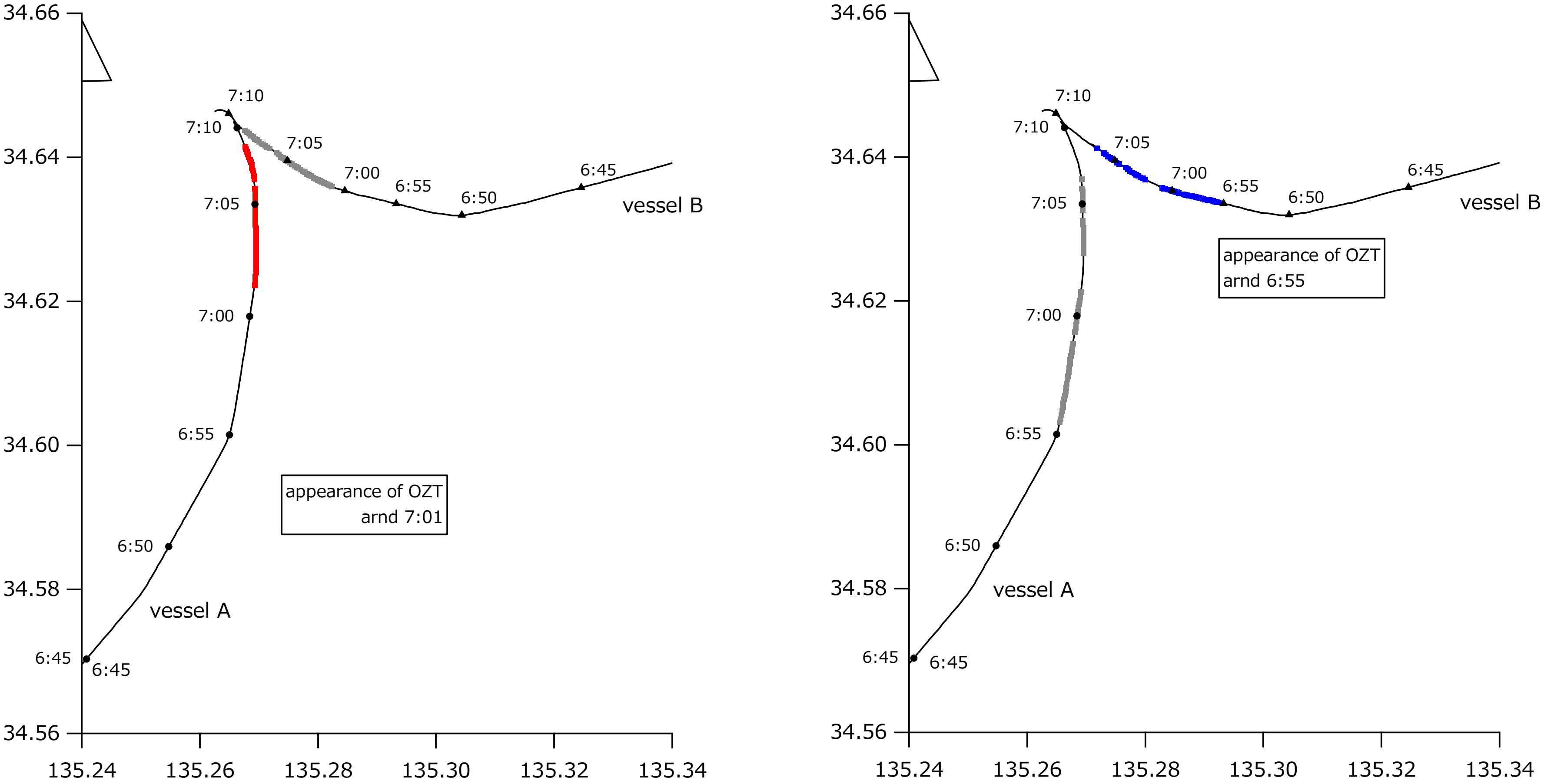
Fig. 3 The concept of OZT

Analysis of the OZT occurrence point

Fig. 4 shows the positions of the vessels superimposed on their navigational track chart when the course of the own ship has been obstructed by OZT. Fig. 4 shows the positions of the own ship, with the relevant times, when the course has been obstructed by an OZT arising between the two vessels Vessel A and Vessel B.

The time at which the course of the own ship is obstructed by the OZT is around 7:01 for Vessel A and around 6:55 for Vessel B. That is, if the course and speed are constant, at these respective times the vessels were falling into a dangerous situation in which the distance between the two vessels would decrease to 0.1NM or less within five minutes of that.

Meanwhile, Fig. 5 shows the position of Vessel A, with the relevant times, when its course has been obstructed by Vessel B, Vessel C, Vessel D, Vessel E and Vessel F. Though differing in scale from Fig. 4 (a), the time of OZT occurrence and the location of OZT are the same. In other words, at all times the OZT has been caused by Vessel B, but no OZT arises with the other four vessels (Vessel C, Vessel D, Vessel E and Vessel F).



(a) Situation when own ship is Vessel A

(b) Situation when own ship is Vessel B

Fig. 4 Own ship's position when its course is obstructed by another vessel

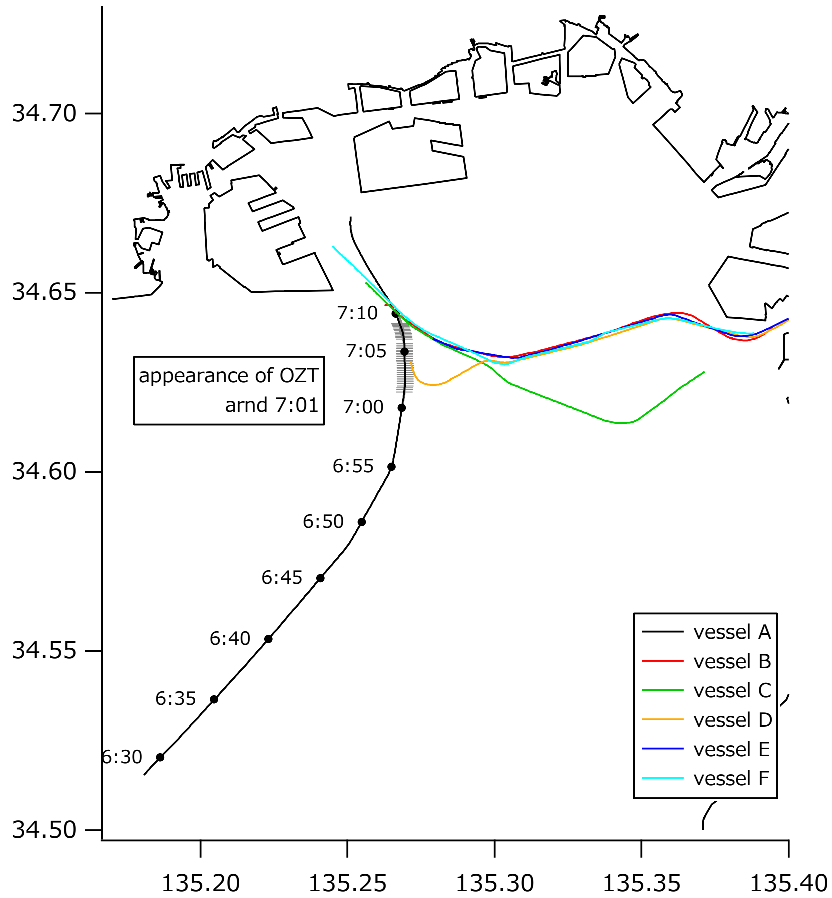
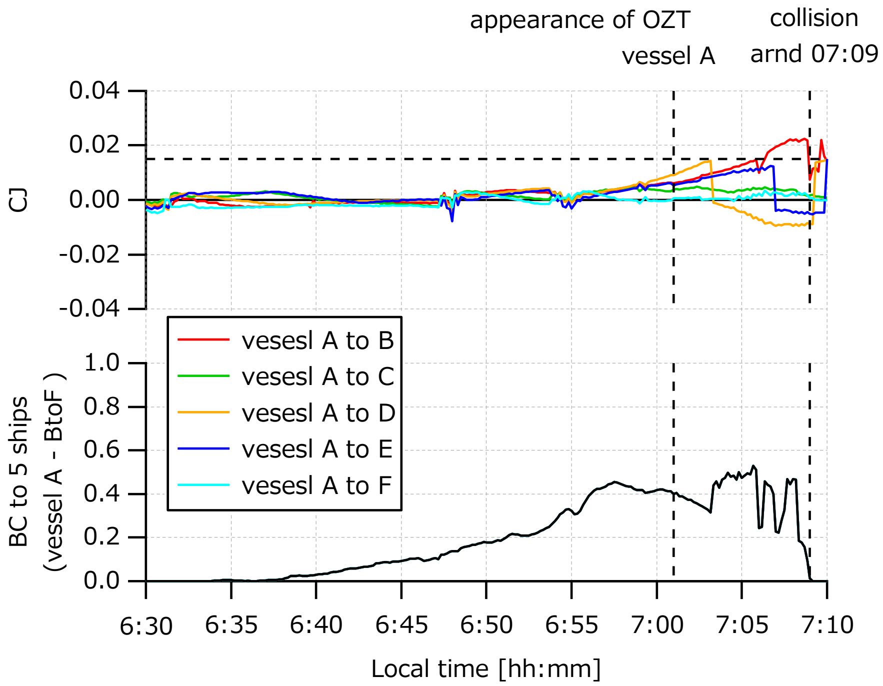


Fig. 5　Own ship's position when the course of Vessel A is obstructed by a group of five vessels

2.3 Time-related Changes in Collision Risk Level

Time-related changes in collision risk level were analyzed based on AIS data at the time of the accident.

Fig. 6 shows the result of assessment of the collision risk level between Vessel A and Vessel B,



B, while Fig. 7

Fig. 7shows the result of assessment of the collision risk level with a group of vessels as seen from the viewpoint of Vessel A.

What is CJ (Collision Judgement)[2)]?

CJ is an indicator showing the level of collision risk between two vessels in a one-on-one matching relationship. The collision risk level is calculated from the distance relative to the other vessel and the rate of change in it, as well as change in the bearing relative to the other vessel and the rate of this change. CJ can be within the range from - ∞ to ∞.

What is BC (Blocking Coefficient) [3)]?

BC is used to calculate the degree to which the own ship is blocked by the risk of collision with other vessels existing in the vicinity. Specifically, it uses the risk level of collision with vessels existing in the vicinity when the own ship is giving way by changing speed and course, multiplied by a weighting factor that expresses preference for changing speed or changing course as a means of giving way. BC can be in the range of 0 to 1. When BC is 1, it means that the TCPA is extremely small and cannot be avoided by any maneuvering.

In this accident investigation, the method of giving way was limited to changing course when using BC for evaluation. This was because Vessel A was a massive vessel that needed time and distance to increase or reduce speed, while Vessel B was in a situation in which it could not change speed easily as it was sandwiched between other vessels fore and aft.

Evaluation based on CJ

Fig. 6 shows CJ values rising from around 6:55 for both Vessel A and Vessel B. In addition, Fig. 7 shows that the CJ values of the other vessels, seen from the viewpoint of Vessel A, started to rise from around 6:55 for each vessel, just as in Fig. 6.The timing of the sharp decrease in CJ values after the rise shown in Fig. 7 corresponds to the point after the Closest Point of Approach (CPA) had been passed. Moreover, the difference in collision risk level between Vessel B, which collided with Vessel A, and the group of vessels other than Vessel B, which did not collide, is reflected as a difference in maximum CJ values. Considering this, the threshold CJ value for judging that there was a risk of collision in this accident is thought to be 0.015 (or higher). This threshold value of 0.015 was exceeded by Vessel A at around 7:06 and by Vessel B at around 7:03. In Fig. 6 and Fig. 7, the threshold CJ value of 0.015 is represented by dotted lines.

Evaluation based on BC

According to Fig. 6, the BC value between Vessel A and Vessel B, seen from the viewpoint of Vessel A, was greatest at around 7:00, when it was 0.29. According to Fig. 7, the BC value of the group of vessels including Vessel B was 0.29 at around 6:54, the same as the maximum value between the two vessels, and it is probable that it was somewhat difficult for Vessel A to maneuver owing to the vessels navigating in the vicinity. It is probable that Vessel A then had even greater difficulty in maneuvering, since the BC value continued to rise and remained at a high level from around 6:55 until the collision. As for Vessel B, Fig. 6 shows that the BC value rose sharply at around 6:55, reaching a peak value of 0.49 throughout all points in time until the accident. Up to around 6:54, however, the BC value had hardly risen at all and the freedom of maneuvering is thought to have been at a high level. According to Fig. 6, on the other hand, the BC values of both Vessel A and Vessel B had decreased at around 7:01, and the freedom of maneuvering is thought to have been at a relatively high level for a short time.

As shown in Fig. 6, the BC value from the viewpoint of Vessel B was only evaluated in relation to Vessel A. However, since the four vessels from Vessel C to Vessel F were navigating in the same direction fore and aft of Vessel B, Vessel B is thought unlikely to have suffered a significant loss of freedom of maneuvering by changing course to accommodate vessels navigating in the vicinity. As such, it is probable that the two vessels started to lose freedom of maneuvering at around 6:55, and that although they temporarily recovered somewhat at around 7:01, their freedom of maneuvering was otherwise at a low level.

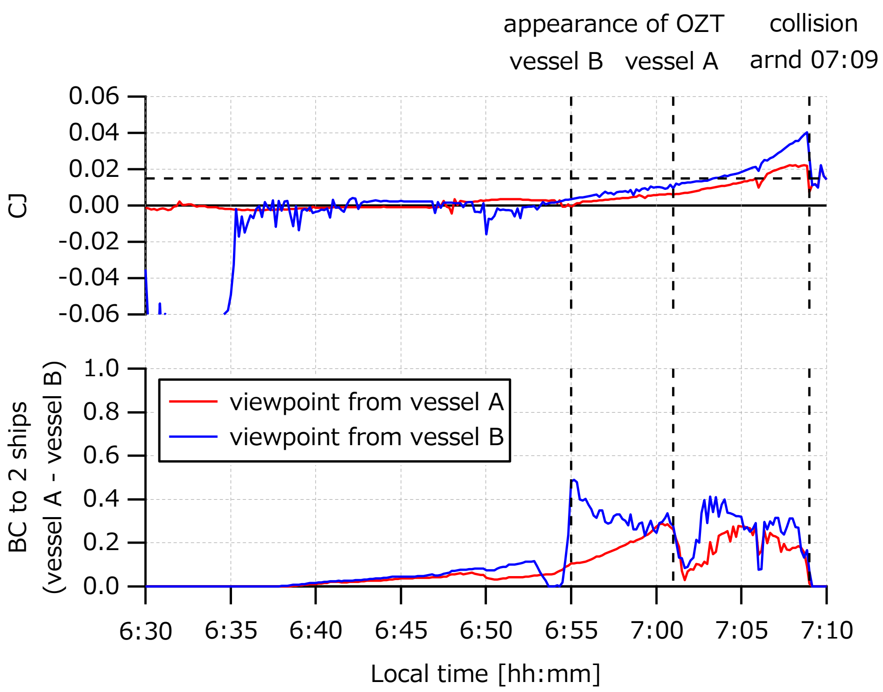


Fig. 6　Time-related changes in collision risk level (Vessel A and Vessel B)

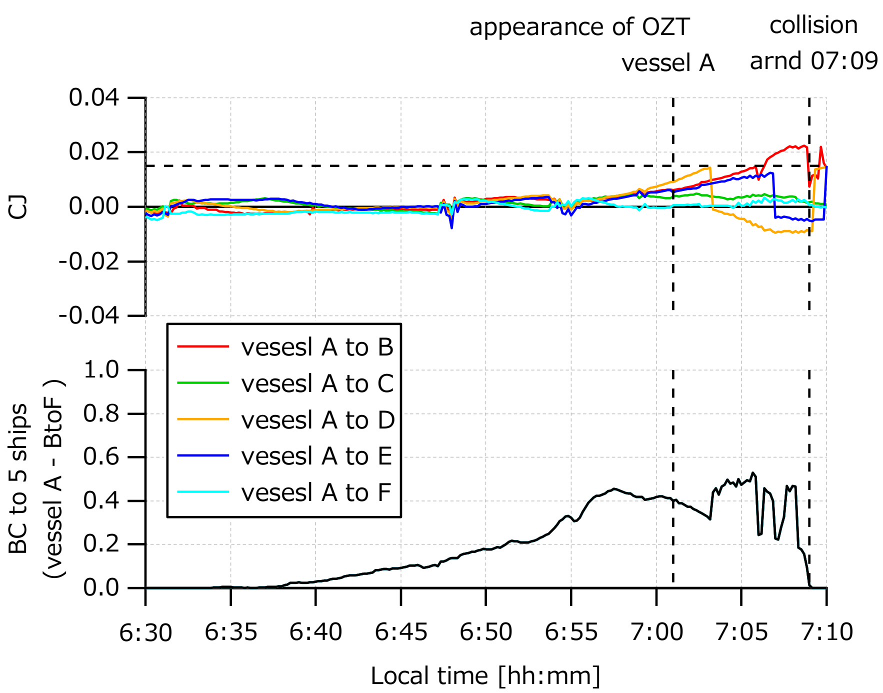


Fig. 7　Time-related changes in collision risk level (Vessel A and the group of five vessels)

2.4　CPA Analysis Taking Account of Vessel Length

To analyze the impact when taking account of vessel size, CPA analysis was carried out using the points where the vessels collided as datum points for calculation at five-minute intervals, from 6:50 (about 20 minutes before the collision) until 07:08 (just before the start of turnaround caused by the collision). Table 1 shows the collision points, while Table 2 and Fig.8 show the results of CPA analysis when vessel centers and collision points are used as datum points.

Evaluation of the impact of vessel length

Since both Vessel A and Vessel B were turning course during the time subject to evaluation, DCPA values changed with the passage of time. The DCPA difference when the vessel centers and collision points are used as the datum point for calculation peaked at around 6:50, and DCPA is evaluated about 190 m shorter when taking vessel length into account. This figure corresponds to about half the vessel length of Vessel A and about 1.3 times that of Vessel B. Moving the datum point for calculation forward from the vessel center makes TCPA smaller when taking account of vessel length, giving rise to a maximum difference of about 1.5 minutes. As a result, although depending on the state of the two vessels, it is probable that TCPA and DCPA are significantly impacted by vessel length, and when vessel length is large this trend becomes more pronounced.

Table 1 Collision points taken as datum points

	Distance from vessel center [m]	
	Forward	To starboard
Vessel A*	189.43	23.5
Vessel B	-62.69	-11.625

* Datum points for Vessel A were taken as the centers of the two areas of abrasion damage.

Table 2 Comparison of CPA analysis when taking vessel length into account

	DCPA [m]			TCPA [sec]		
	vessel center	Collision point	Difference	vessel center	Collision point	Difference
6:50:00	1258	1072	(-186)	677	660	(-17)
6:55:00	10	138	(128)	640	608	(-32)
7:00:00	233	342	(109)	382	345	(-37)
7:05:00	184	14	(-170)	189	144	(-45)
7:08:00	187	38	(-149)	96	4	(-92)

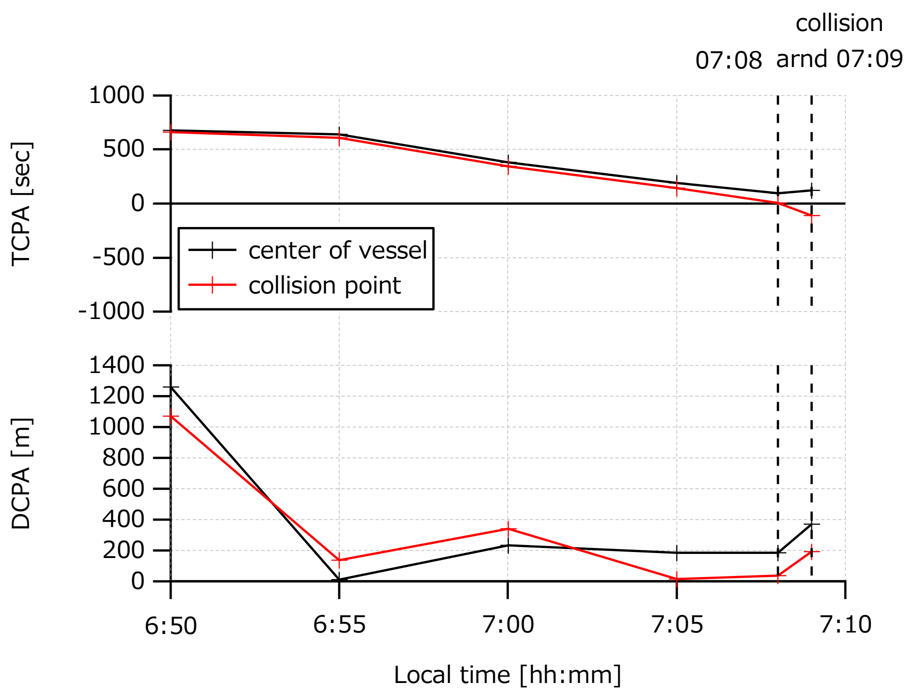


Fig. 8 Comparison of CPA analysis when taking vessel length into account

2.5 Summary

The results of the above analysis concerning cognitive support may be summarized as follows. First, since the degrees of change in relative bearing and DCPA values were almost zero, it is probable that it was easy to judge a risk of collision in the period of time from 6:55. Next, since the time of OZT occurrence was earlier in Vessel B than in Vessel A and the BC value from the viewpoint of Vessel B changed significantly around the time of OZT occurrence, it is probable that Vessel B was able to become aware of the risk earlier than Vessel A, and that this occurred at around 6:55. Judging from the BC values, moreover, it is probable that the two vessels started to lose the freedom of maneuvering from around this time owing to the other vessels navigating in the vicinity, and that although this briefly recovered to a certain extent at around 7:01, their freedom of maneuvering was otherwise in a low state. Finally, it was confirmed that, although the positions of the vessel centers were used as datum points for the vessels in these calculations, caution is therefore required as these may differ when calculating the actual collision point. The results of situation analysis on these various elements are shown below.

Situation analysis based on time-related changes in quantitative status

As the degree of change in relative bearing was small from around 6:30 to around 6:54, from the viewpoint of Vessel A, and from around 6:30 to around 6:47 from the viewpoint of Vessel B, a risk situation would have arisen if this status quo had been maintained. However, since the distance between the two vessels was about 2.5NM, TCPA was about 10 minutes, and DCPA was about 0.5NM even by the time of around 6:54, it is probable that there was still a relatively good margin of time and space at this stage.

Considering the navigational tracks, moreover, the positional relationship between the two vessels was changing from moment to moment in the time before 6:54, since both vessels were turning course around toward the Passage entrance. It is probable that it was somewhat difficult to recognize this as a situation in which they must give way.

On the other hand, since the DCPA remained extremely small from 6:55 even though the degree of change in relative bearing increased somewhat, it is probable that it was relatively easy to recognize this as a situation in which they must give way.

Situation analysis based on indices of collision risk level

Judging from the fact that OZT appeared in front of Vessel A at around 7:01 and in front of Vessel B at around 6:55, and the two vessels were in a situation whereby the distance between them would fall into a dangerous state of 0.1NM or less within five minutes, it is probable that they could both have recognized the risk of a collision at around this time.

Judging from the fact that, based on the evaluation of collision risk level using CJ, Vessel B passed the threshold value of 0.015 for judging that there is risk of a collision at around 7:03, and Vessel A did the same at around 7:06, it is probable that they were both able to recognize the risk of a collision at around this time.

Judging from the fact that, based on the evaluation of collision risk level using BC, the two vessels maintained high BC values from around 6:55 until the collision, it is probable that they had fallen into a state in which it was difficult to maneuver. However, BC values became somewhat lower at around 7:01, and the vessels could be said to have been temporarily in state with a relatively high freedom of maneuvering.

Situation analysis based on the impact of vessel length

When evaluating CPA, and particularly DCPA, the calculation results differ significantly between cases when the collision point of vessels is used as a datum and those when a GPS antenna or similar is used for this purpose. This difference is particularly conspicuous when the vessel length is large. In this accident case, similarly, it was confirmed that a difference in DCPA values arose.

3 Navigational Status Based on Past Records of Port Entry by Large Vessels

3.1 Port Entry Records

Table 3 shows past port entry records by a total of 15 vessels of more or less the same type as Vessel A (including Vessel A in this accident), as supplied by the Japan Transport Safety Board.

Table 3 Port entry records

	Vessel	Date of port entry
1	Vessel G	9/23/2015
2	Vessel H	11/10/2015
3	Vessel G	12/8/2015
4	Vessel A	1/5/2016
5	Vessel I	1/12/2016
6	Vessel H	1/28/2016
7	Vessel J	2/2/2016
8	Vessel G	2/23/2016
9	Vessel A	3/22/2016
10	Vessel I	3/29/2016
11	Vessel H	4/12/2016
12	Vessel J	4/19/2016
13	Vessel G	4/26/2016
14	Vessel K	6/1/2016
15	Vessel A	6/7/2016

3.2 Navigational Track When Entering Port

The navigational tracks of Vessel A when entering the Kobe Chuo Passage will now be compared. Fig. 9 shows the navigational tracks of Vessel A (black line) on the date of the accident, superimposed together with the navigational tracks when Vessel A and other similar vessels entered port in the past (red lines). In the navigational track at the time of the accident, the angle of approach to the Passage entrance was large compared to a situation of standard navigation, but there are records of vessels approaching the port at a similar angle. Of the 15 records of port entry, Vessel A on this accident navigated more to the west of the Chuo Passage than any of the others.

The movements of vessels in the vicinity (including Vessel A) at this time will now be analyzed. As shown in Fig. 10, several vessels that were scheduled to enter the Chuo Passage from the Osaka direction were navigating in the vicinity. Fig. 11 shows the positions of vessels that were present in the same sea area at 06:55, when Vessel A is thought to have started its approach to the Chuo Passage. At this time, anchored vessels M and N lay on the approach course to the Chuo Passage, while Vessel D was due to enter the Passage from the south of anchored vessel N, following aft of Vessel A.

Considering these various circumstances, it is highly probable that Vessel A adopted a large angle of approach and navigated generally to the west side in order to take a course toward the western side of the Passage entrance. This was because, owing to the presence of anchored vessels M and N, it had difficulty in setting a direct course into the Chuo Passage from outlying waters and needed to pass between anchored vessels L and N, and moreover because it needed to avoid vessels entering the Chuo Passage from the Osaka direction.

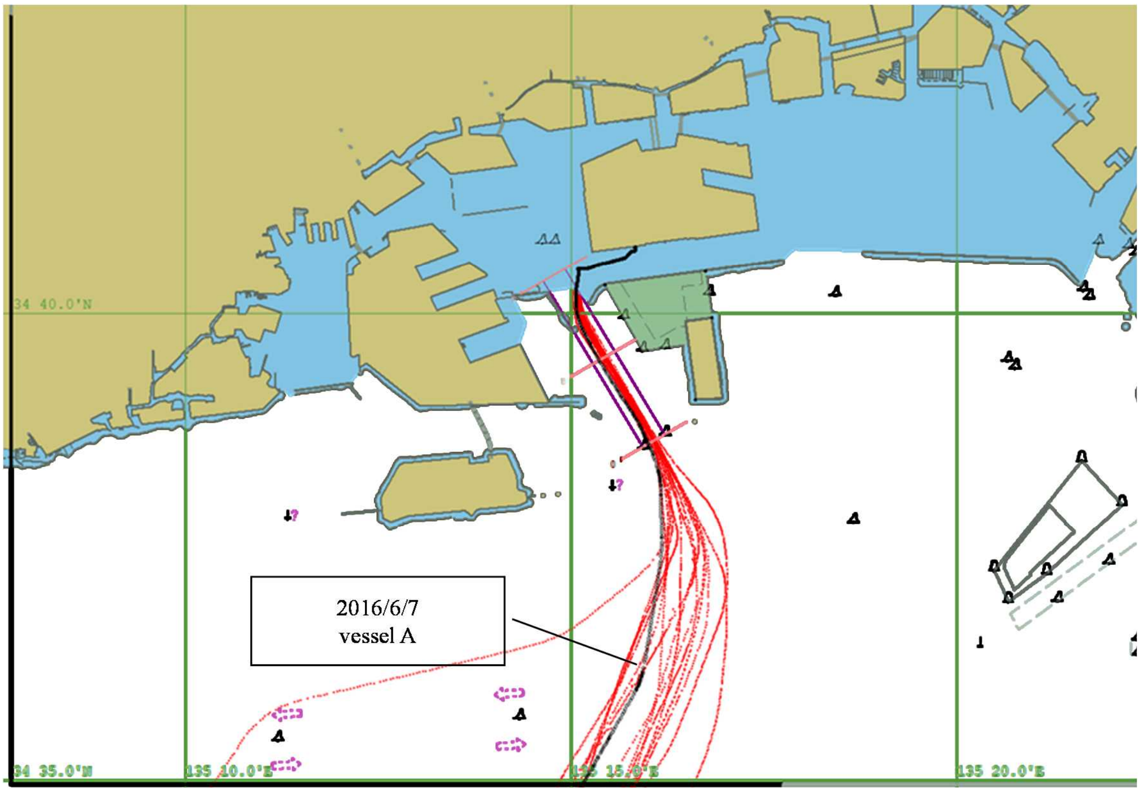


Fig. 9　Navigational tracks of Vessel A and similar vessels when entering port

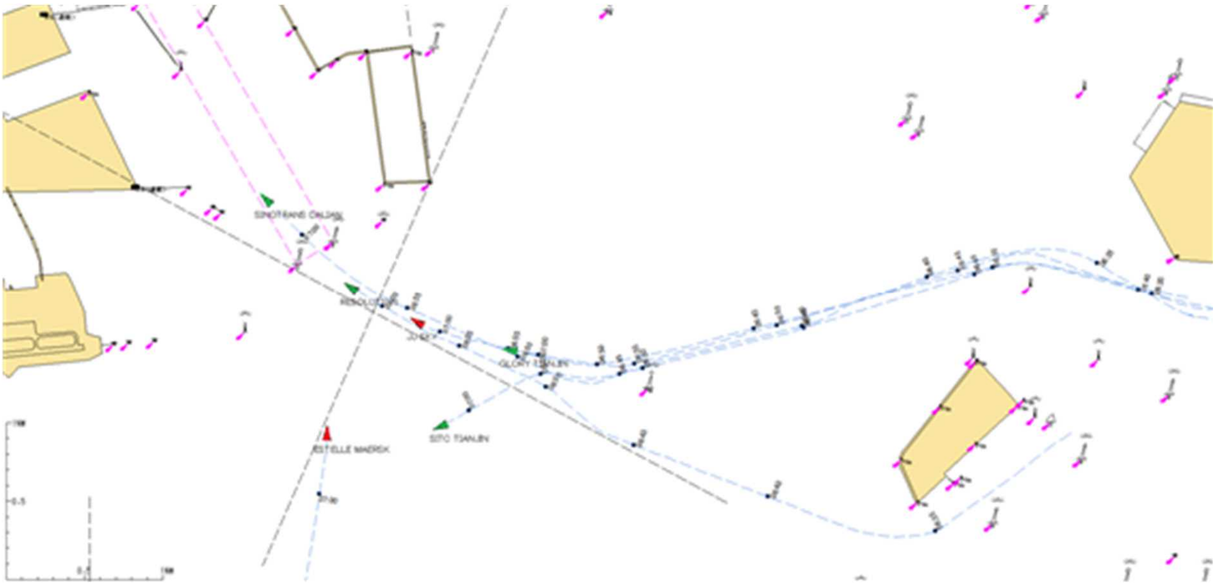


Fig. 10 Navigational tracks before the accident
(from data provided by the Japan Transport Safety Board)

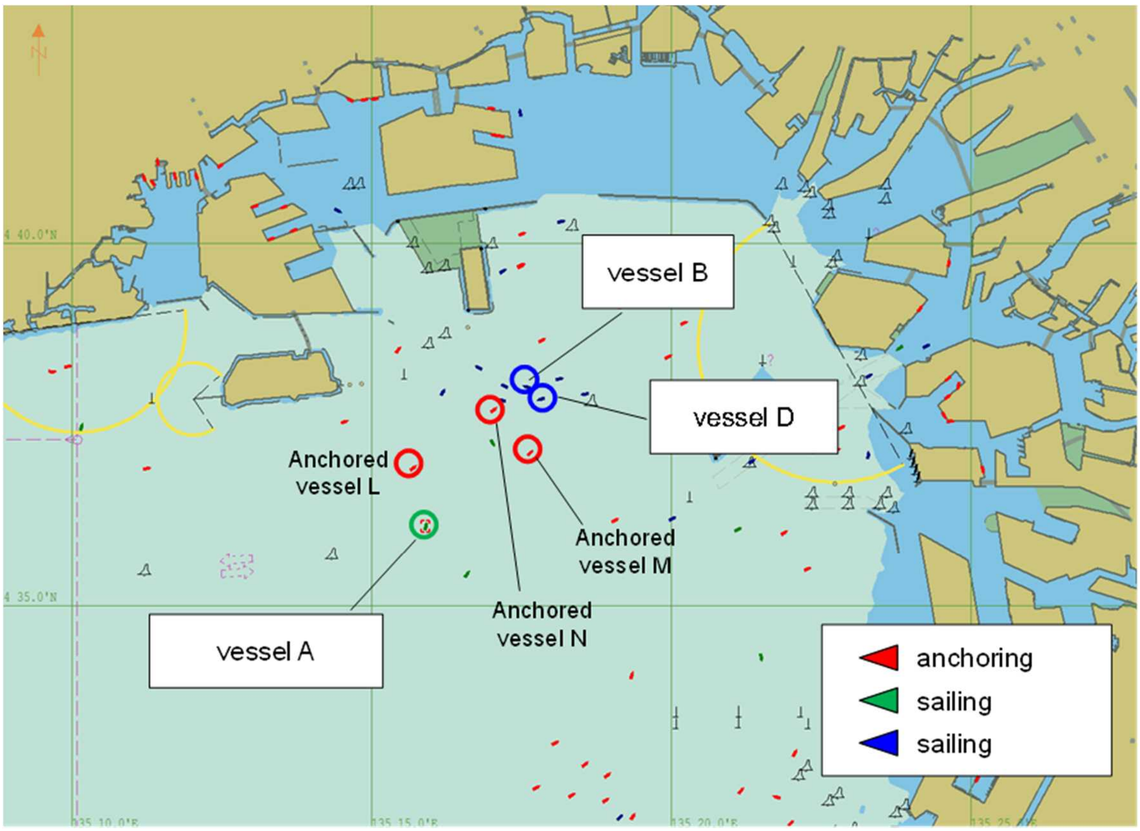


Fig. 11 Positions of vessels based on AIS data at 06:55 on June 7

3.3 Speed when Entering Port

As shown in Fig. 12 and Table 4, twelve hypothetical gates were established from north latitude 34°35′00″ to just before the pier docking berth of Vessel A, and the speeds of vessels when passing the gates were analyzed. The results are shown in Fig. 13. The blue line shows the average speed sailed by vessels according to the 15 port entry records. It is probable that the speed at which Vessel A was navigating at the time of the accident was a standard speed compared to the speeds of vessels when entering port at past.

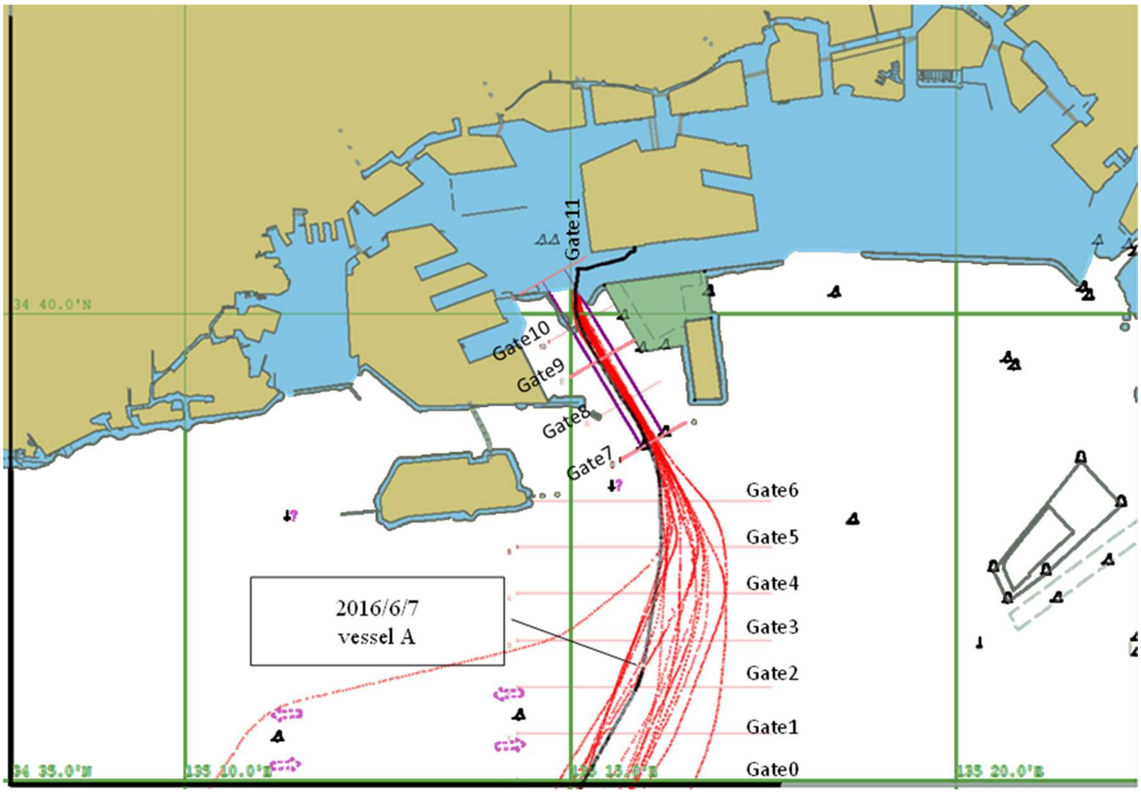


Fig. 12 Gate positions

Table 4 Gate settings

Gate No.	Start point		End point	
	Lat	Lon	Lat	Lon
0	34°35′00.0″N	135°14′19.1″E	34°35′00.0″N	135°17′36.6″E
1	34°35′30.0″N	135°14′19.1″E	34°35′30.0″N	135°17′36.6″E
2	34°36′00.0″N	135°14′19.1″E	34°36′00.0″N	135°17′36.6″E
3	34°36′30.0″N	135°14′19.1″E	34°36′30.0″N	135°17′36.6″E
4	34°37′00.0″N	135°14′19.1″E	34°37′00.0″N	135°17′36.6″E
5	34°37′30.0″N	135°14′19.1″E	34°37′30.0″N	135°17′36.6″E
6	34°38′00.0″N	135°14′19.1″E	34°38′00.0″N	135°17′36.6″E
7	34°38′26.0″N	135°15′38.9″E	34°38′50.0″N	135°16′30.1″E
8	34°38′52.7″N	135°15′19.5″E	34°39′16.7″N	135°16′10.7″E
9	34°39′19.4″N	135°15′00.1″E	34°39′43.4″N	135°15′51.3″E
10	34°39′42.2″N	135°14′43.6″E	34°40′06.2″N	135°15′34.9″E
11	34°40′39.9″N	135°15′16.2″E	34°40′10.8″N	135°15′16.2″E

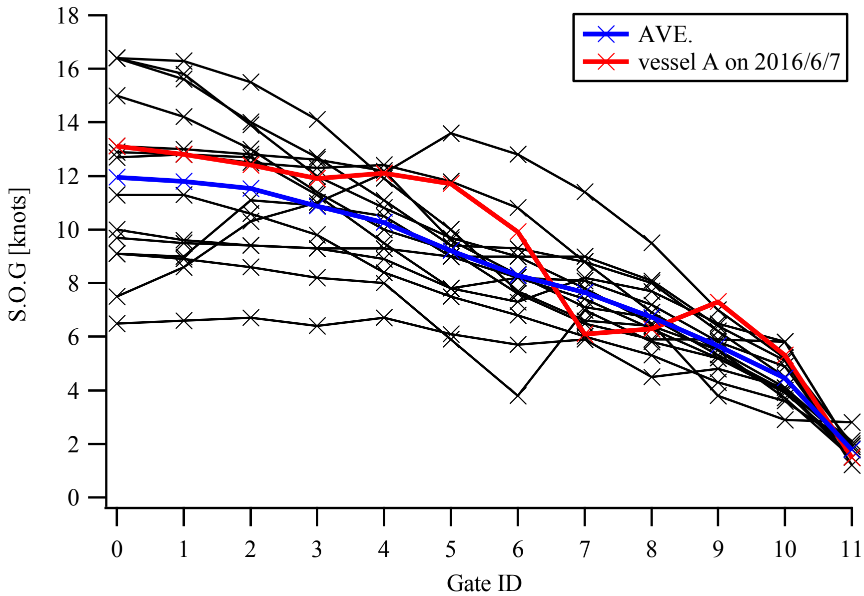


Fig. 13 Speed when passing gates

3.4 Summary

Compared to past records, it is probable that the position of navigation was somewhat to the west, under the influence of vessels navigating westward from the Osaka direction as well as anchored vessels, but that vessel A was navigating in a standard position, and that its speed at the time of the accident was also standard.

4 CREAM Analysis

4.1 The CREAM Analysis Method

CREAM (Cognitive Reliability and Error Analysis Method) is a method of HRA (Human Reliability Analysis) that focuses on cognitive aspects of human beings. In the classic HRA method, the cognitive processes of workers are not taken into account, and analysis is directed instead at skill-based and rule-based actions. As such, errors by workers who cause accidents are identified as the cause of the accidents. By contrast, a characteristic of CREAM, as the 2nd generation method of HRA, is that it takes an accident as merely the ultimate result, and examines various background factors lying behind it[4)].

First, this method focuses on unsafe actions and others observed in the process of accident occurrence, and makes these the starting point of analysis as actions requiring attention. To initiate a search for background factors, these actions requiring attention are matched with types of deviation, otherwise known as "error modes." The following eight are defined as general error modes.

- Duration (too long or too short)
- Sequence (reverse order, repetition, failure, interruption)
- Wrong object (wrong action, wrong object)
- Force (too weak, too strong)
- Direction (wrong direction)
- Speed (too fast, too slow)
- Distance (too far, too short)
- Timing (too soon, too late, omitted)

Besides these, three elements are seen as causative factors lying behind error modes, namely "Individuals (general functions, specific functions)", "Organizations (organization, communication training, ambient conditions, working environment)", and "Technology (equipment, procedures, interfaces)." These are evaluated under the concept of Common Performance Conditions (CPC). The following nine types of CPC have been defined.

- Adequacy of safety management system
- Navigation and watch environment
- Man-machine interface (MMI)
- Adequacy of ship handling manual
- Number of simultaneous goals
- Available time
- Time of day
- Resources of ship handlers
- Communication and information sharing

Conclusions about the cause of the accident subject to analysis are reached by combining the result of CPC evaluation with background factor analysis based on error modes. Next, the steps undertaken in CREAM analysis are as shown below.

① Describe in detail the events that actually occurred.
② Specify CPC.
③ Describe temporal relationships between major events.
④ Identify all actions that require attention.
⑤ Specify error modes for each action.
⑥ Find a cause-and-effect link related to each error mode.
⑦ Describe the whole and find the cause.

4.2 Accident Progression

The temporal relationships regarding the occurrence of the accident will now be described.

4.2.1 Outline

Fig. 14 shows the movements of the vessels based on AIS data at around the time when the accident occurred. The figure also shows steering and engine operations, awareness of other vessels, and the time and vessels' positions when a risk of a collision was sensed.

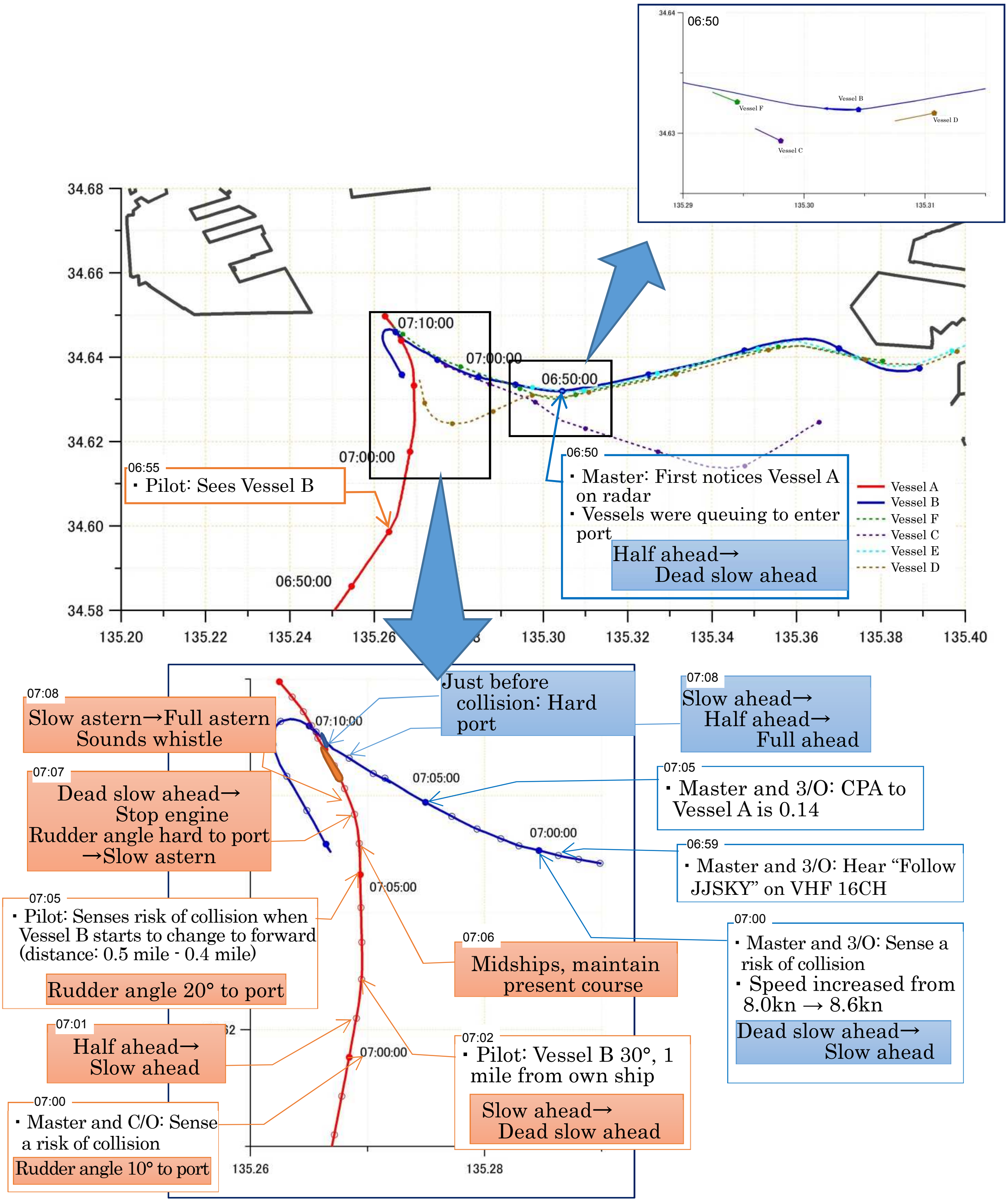


Fig. 14　Movements of vessels at the time of the accident

4.2.2　Temporal Progression

Tables 5 to 8 show the progression of the accident compiled on the basis of statements, VDR and operational reports of Port Radio (hereinafter referred to as "PR").

Black text indicates situations confirmed from statements and VDR, red text indicates the awareness of ship handlers and others based on statements, and blue text indicates information based on PR operational reports.

Table 5 Accident progression (June 7, 04:50-06:50)

Time June 7	Vessel A (ESTELLE MAERSK)	PR (Port Radio)	Vessel B (JJ SKY)
04:50	Pilot boarded the vessel off Tomogashima Had a meeting with the Master		
05:01	Pilot) Contacted PR to notify scheduled time of arrival outside port (06:50) and scheduled time of Passage entry (07:10).	Report from Vessel A	
	Information from PR	Gave information to Vessel A (may enter port after Vessel P leaves the Passage at 06:10)	
06:20		Report from Vessel B	Master) Departure from Osaka Port and scheduled time of port entry (06:50).
		Gave information to Vessel B (two container ships heading toward the Passage)	Information from PR
06:43	Arrived at pilot station		
	Vessel A) About to arrive outside the port. Will enter the Passage on schedule at 7:10. PR) Five ships will be entering port together from the Osaka direction. All of them will enter port at around 7. Would you prefer to wait for them before entering? Vessel A) We will enter the Passage on schedule at 7:10. PR) 7:10, understood. Unpiloted ships coming from Osaka are likely to enter the Passage in succession at around 7. The first will be Vessel F heading for PC-14, followed by Vessel B heading for PC-17, with Vessel D for RC-4 behind that. (part omitted) Vessel A) We want to enter before the ship heading for RC-4.		
06:47		Gave information to Vessel D (message requesting it to follow aft of Vessel A)	
		Report from Vessel D (follow Vessel A, understood)	
06:49			Master) Changed course toward the Passage
06:50			Master) First noticed Vessel A on radar. Although it was the scheduled time for entering port, it was delayed owing to the presence of many other vessels. Vessels were queuing to enter port. Master) Reduced speed from Half ahead → Dead slow ahead 3/O) Distance to Vessel A about 3km, Vessel A sailing at a speed of about 11kn.

Table 6 Accident progression (June 7, 06:55-07:04)

Time June 7	Vessel A (ESTELLE MAERSK)	PR (Port Radio)	Vessel B (JJ SKY)
06:55	Pilot) Saw Vessel B at 45° about 2 miles from dead ahead and confirmed by radar. Pilot) Recognized Vessel B as a vessel that tended to navigate across the Passage.		
06:59			Master and 3/O) Hearing the communication “Follow JJ SKY” on VHF radio 16CH, understood that Vessel A would enter the Passage following aft of Vessel B. Master) Felt it would be difficult for Vessel A to pass between Vessel B and the vessel navigating ahead, as the distance to the vessel ahead was between 0.3 and 0.4 miles.
0700	Pilot) Port 10. Master) Started to sense the risk of a collision with Vessel B. One of the four vessels that concerned him was Vessel B. Master) Reduced speed from half ahead to slow ahead to prepare for entering port. C/O) First noticed Vessel B. Was concerned as the vessel’s course was strange.		Master) Changed speed from Dead slow ahead → Slow ahead Master and 3/O) Sensed the risk of a collision. 3/O) Distance to Vessel A about 1km, Vessel A heading north at a speed of about 9kn. 3/O) Thought to increase speed as port entry was delayed. Increased speed of own ship from 8kn to 8.6kn in order to pass in front of Vessel A. Could not increase speed more than this as there was a vessel ahead.
07:01	Pilot) Midships Slow ahead C/O) Reported to the Master that the CPA of Vessel B was 0.04. Master) Asked the Pilot whether Vessel A had priority.		
07:02	Pilot) Vessel B was positioned 30° and 1 mile from own ship Master) Dead slow ahead (instruction to the Pilot)		
07:03	Pilot) “Because we have privilege, big ship” (reply to Master’s question at 07:01) Pilot) Vessel B had increased speed, so at this point it was not a situation in which the whistle should be sounded (i.e. in which there was a risk of a collision).		Master) Increased own ship speed because the vessel navigating ahead had also increased speed.
07:04	Pilot) Port 10.		Master) Confirmed on radar, and thought that Vessel A could pass aft of his own ship as long as Vessel A did not change direction.

Table 7 Accident progression (June 7, 07:05 until accident occurrence)

Time June 7	Vessel A (ESTELLE MAERSK)	PR (Port Radio)	Vessel B (JJ SKY)
07:05	Pilot) Port 20 Pilot) Sensed the risk of a collision as Vessel B started to change course to forward (distance: 0.5 miles-0.4 miles) Pilot) As there were no reports from the Master or C/O, thought that they didn't seem to sense a risk. Pilot) As the VHF was too far away from the standing position in the center of the bridge and he had to keep watching the other vessel, thought that it was impossible for him to handle the vessel while repeatedly going to the VHF and back.		Master and 3/O) Confirmed that CPA to Vessel A was 0.14.
07:06	Pilot) Midships, maintain present course		
07:07	Pilot) Stop engine. Master) Asked the Pilot if Vessel A had priority. Pilot) Replied "Yah." Pilot) Hard port Slow astern Master) Sensed the risk of a collision. Thought it could be avoided if Vessel A changed course to port and Vessel B also changed course.		
07:08	Pilot) Full astern Master) Sounded ship's whistle		Master) Changed speed from Slow ahead → Half ahead → Full ahead.
	Pilot) Full astern (Already full astern)		Master) Hard port just before the collision (to reduce impact)
07:09	– Collision – (visibility 10 miles or more, northwest wind, wind force 3, no waves)		

Table 8 Accident progression (June 7, After the collision)

Time June 7	Vessel A (ESTELLE MAERSK)	PR (Port Radio)	Vessel B (JJ SKY)
07:09	Pilot) Accident report to PR		
07:10	Pilot) Slow ahead. Hard port. (It already was hard to port.) Master) Changed to dead slow ahead after confirming that Vessel B had passed. Pilot) Contact with PR about the position of the collision		
07:11	Pilot) Port 10.	Report from Vessel A (Points of collision on Vessel A, confirmation of damage, docking possible)	
07:12	Pilot) Replied to PR with details of collision position (starboard side). Said the vessel could dock as it was.	Questions to Vessel B (Was there contact? Contact position, extent of damage, OK to enter port?)	Asked by PR to confirm fact of accident occurrence
	Pilot) Asked PR why Vessel B was permitted to enter port when Vessel A was supposed to be the control vessel	Replied to Vessel A (Because Vessel B was the vessel entering port)	
	Pilot) Midships, and steady		
07:13	Master) Asked the Pilot whether Vessel B was piloted. Pilot) Replied "No Pilot."		

4.3 CPC Evaluation

The impact of the nine Common Performance Conditions (CPC) on the actions of ship handlers and others will now be evaluated and the reasons for the evaluation explained.

4.3.1 Result of CPC Evaluation of Vessel A

Summarized evaluations of the Master, Chief Officer, able seaman and Pilot, who were on the bridge at the time of the accident, are shown in Table 9.

Table 9 Result of CPC evaluation of Vessel A

	Operating environment with positive effect	Operating environment with no effect		Operating environment with adverse effect		Reason for CPC Evaluation
Adequacy of safety management system	Very efficient	✔ Efficient		Inefficient	Deficient	The Master, C/O, able seaman and the Pilot were aware of their roles and fulfilled their duties. No impropriety was seen in the handling of the vessel.
Navigation and watch environment	Advantageous	✔ Compatible		Incompatible		The inside of the bridge was tidy, and there was nothing that would cause noise or restrict visibility.
Adequacy of MMI	Supportive	Adequate		✔ Tolerable	Inappropriate	Two electronic charts had been installed and the equipment was substantial. It was impossible to handle the vessel while repeatedly going to the VHF and back, as the VHF was too far away from the Pilot's standing position in the center of the bridge and he had to keep watching changes in the bearing of the other vessel.
Availability of procedures / plans	Appropriate	Acceptable		✔ Inappropriate	Deficient	There was no radio communication with Vessel B. The whistle was only used just before the collision, thus its effect as a warning was limited. The pilot thought it is impossible for him to communicate by VHF, as the VHF was too far away from the Pilot's standing position. The pilot did not have the plan to use escort boats.
Number of simultaneous goals		Fewer than capacity	✔ Current capacity	More than capacity		No workload exceeding capacity was generated.
Available time	✔ Adequate	Temporarily inadequate		Continuously inadequate		The time of port entry was as scheduled.
Time of day		✔ Day-time (adjusted)		Night-time (unadjusted)		Around 7:00 a.m.
Resources of ship handlers	✔ Very good	Good		Not good		Had abundant experience of entering Kobe Port.
Communication and information sharing	Very efficient	Efficient		Inefficient	✔ Deficient	The Master thought that the Pilot was communicating with Vessel B.

4.3.2 Result of CPC Evaluation of Vessel B

Summarized evaluations of the Master, 3rd Officer and able seaman, who were on the bridge at the time of the accident, are shown in Table 10.

Table 10 Result of CPC evaluation of Vessel B

	Operating environment with positive impact	Operating environment with no impact	Operating environment with adverse impact	Reason for CPC Evaluation
Adequacy of safety management system	Very efficient	✔ Efficient	Inefficient / Deficient	The Master, 3/O and able seaman were aware of their roles and fulfilled their duties. No impropriety was seen in the handling of the vessel.
Navigation and watch environment	Advantageous	✔ Compatible	Incompatible	The inside of the bridge was tidy, and there was nothing that would cause noise or restrict visibility.
Adequacy of MMI	Supportive	✔ Adequate	Tolerable / Inappropriate	Radar and other navigation equipment was arranged in a fan-like formation in the center of the bridge, and was efficiently laid out.
Availability of procedures / plans	Appropriate	Acceptable	✔ Inappropriate / Deficient	The Port Entry Manual issued by the port administration authority was not readily available on the bridge. There was no awareness of the Transit Lines. There was no radio communication with Vessel A.
Number of simultaneous goals		Fewer than capacity / ✔ Current capacity	More than capacity	No workload exceeding capacity was generated.
Available time	Adequate	Temporarily inadequate	✔ Continuously inadequate	Port entry by Vessel B was later than the scheduled time owing to a delay in port departure by other vessels.
time of day		✔ Day-time (adjusted)	Night-time (unadjusted)	Around 7:00 a.m.
Resources of ship handlers	Very good	✔ Good	Not good	Had abundant experience of entering Kobe Port.
Communica-tion and information sharing	Very efficient	Efficient	✔ Inefficient / Deficient	The Master, 3/O and able seaman all spoke the same language and stood close to each other, thus communication between them is thought to have been easy. There was no communication with Vessel A.

4.4 Analysis of Background Factors

Error modes were identified and background factors analyzed with regard to the Pilot of Vessel A, the Master of Vessel A, the Master of Vessel B, and PR.

4.4.1 Pilot of Vessel A

The following error modes were identified and background factors for each mode were analyzed with regard to the Pilot of Vessel A.

○ Identified error modes

<u>Speed (too fast)</u>

- 07:07 Was too late in changing to astern, and could not reduce the vessel's speed sufficiently.

<u>Timing (omission)</u>

- From 06:55 Did not communicate with PR or Vessel B.

<u>Timing (omission)</u>

- From 06:43 Did not ascertain the arrangement positions of the escort boats. Had no intention to use the escort boats.

Fig. 15(a)(b) show the results of background factor analysis. On sighting Vessel B at around 06:55, the Pilot was aware that it was a vessel that tended to navigate dangerously. However, he did not expect Vessel B to force its way in, because he assumed that PR would coordinate port entry and because his own ship was a large vessel with poor rudder effectiveness that could only respond by adjusting speed. At around 07:03, therefore, he did not sense the risk of a collision. He was not maintaining communication with Vessel B or PR, although it is probable that this was because he thought that the VHF was too far away from the Pilot's standing position. Similarly, he also tended not to communicate very much with the watch personnel inside the bridge. Although he was aware that escort boats and tugboats had been arranged, and he had ascertained the positions of tugboats as he was planning to take a tug line, he had felt no need to use them. The Kobe Marine Casualty Prevention Institute had made it standard for massive vessels in the 400m-class to use two escort boats and one tugboat when entering the port.

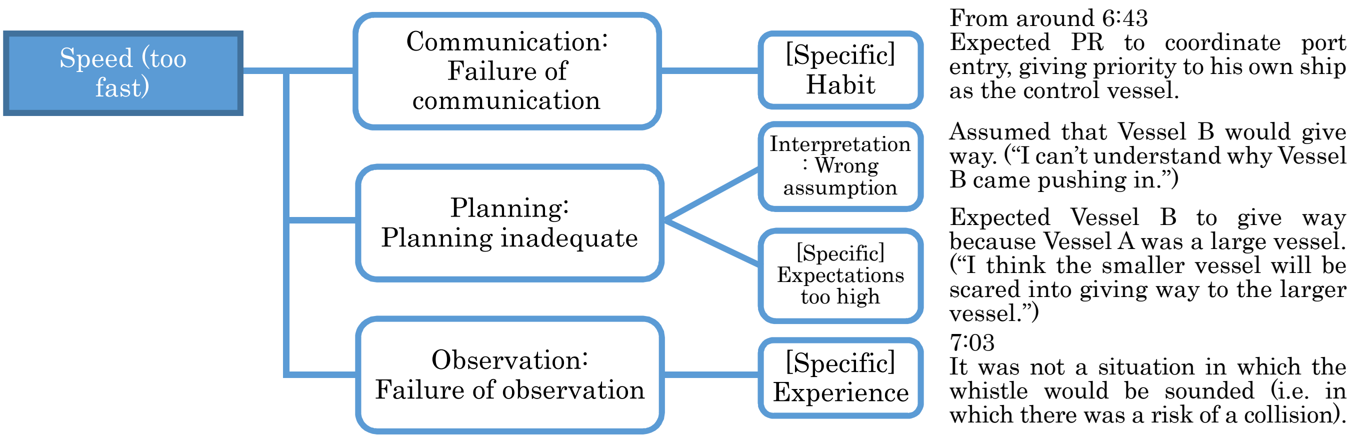


Fig. 15(a) Result of background factor analysis on the Pilot of Vessel A

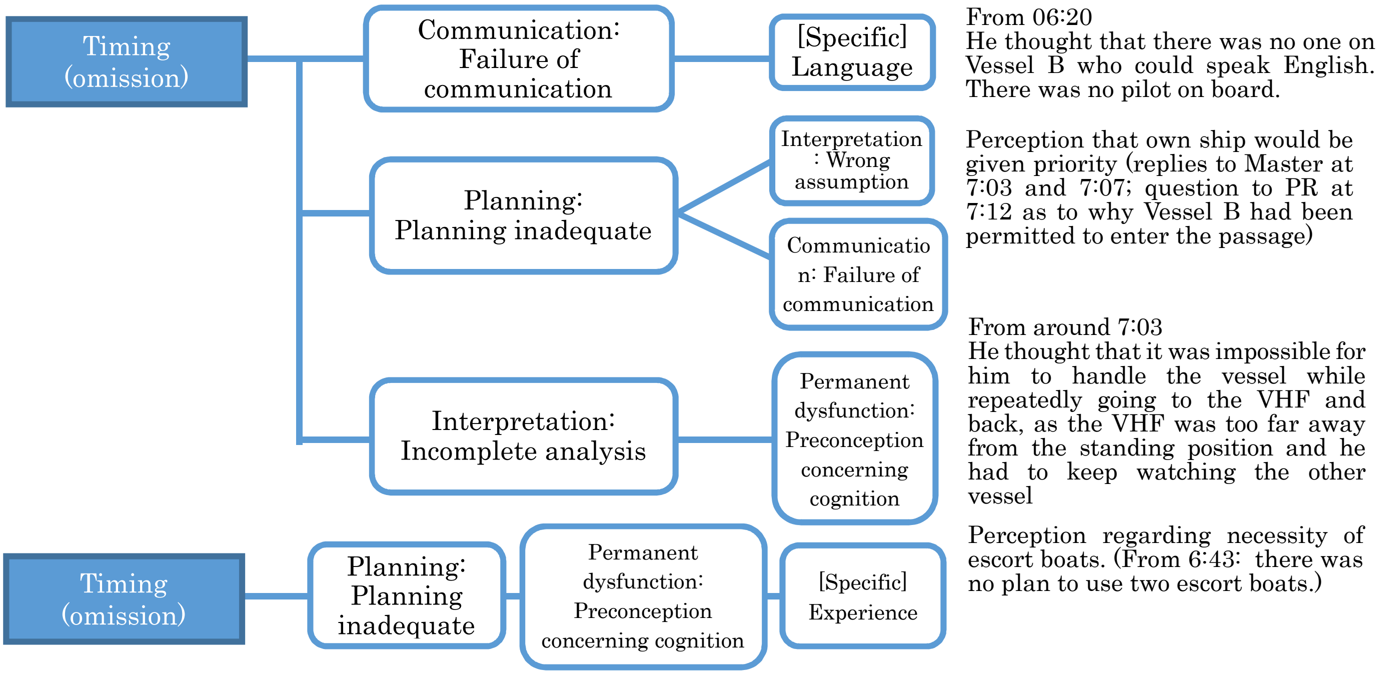


Fig. 15(b) Result of background factor analysis on the Pilot of Vessel A

4.4.2 Master of Vessel A

The following error modes were identified and background factors for each mode were analyzed with regard to the Master of Vessel A.

○ Identified error modes

<u>Speed (too fast)</u>

- 07:01 Was too late in changing to astern, and could not reduce the vessel's speed sufficiently.

<u>Timing (omission)</u>

- From 07:00 Did not confirm with the Pilot whether or not there was a common awareness between PR and Vessel B that his own ship would have priority when entering the port.

<u>Wrong object</u>

- From 07:01 May have mistaken PR for a port authority possessing control functions.

Fig. 16 shows the result of background factor analysis. Although the Master had difficulty in grasping the situation because the Pilot and PR were communicating in Japanese and he could not understand what they were saying, he did not compensate for this by communicating with the Pilot. Due to his experience of entering ports outside Japan, moreover, he may also have mistaken Port Radio for a port authority possessing control functions, and he thought that, as a large vessel, his own ship would be given priority when entering the port. Although he checked this point with the Pilot, the answer was ambiguous due to inadequate communication.

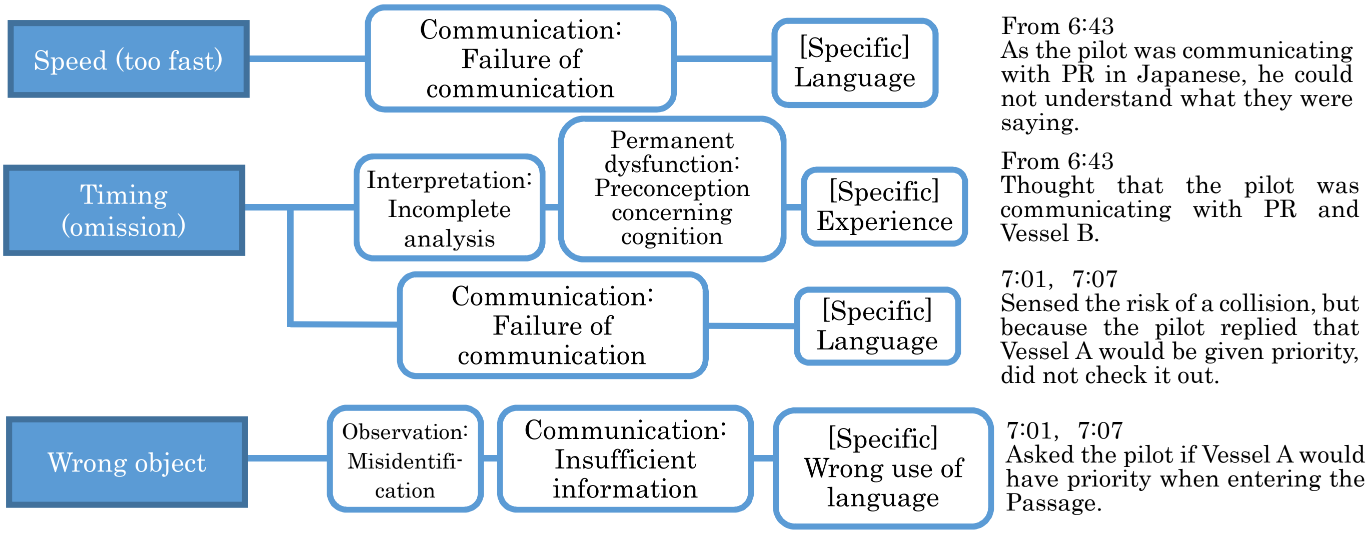


Fig. 16 Result of background factor analysis on the Master of Vessel A

4.4.3 Master of Vessel B

The following error modes were identified and background factors for each mode were analyzed with regard to the Master of Vessel B.

○ Identified error modes

<u>Direction (wrong direction)</u>

- From around 06:50 Took a course that would pass in front of Vessel A. Also increased speed in order to pass in front of the bow of Vessel A.

<u>Timing (omission)</u>

- From 07:00 Sensed the risk of a collision but did not contact Vessel A.

<u>Timing (omission)</u>

- From 06:20 Omitted to navigate along the Passage, but headed for his destination on a course that would cross the Passage diagonally.

Fig. 17 shows the result of background factor analysis. The Master was accustomed to navigating between Osaka Port and Kobe Port on a weekly basis. He had also navigated diagonally across the Passage before, in the same way as at the time of the accident, but had not previously experienced an accident. In the case of this accident, he had adopted the course of passing in front of the bow of Vessel A because he perceived the communication "Follow JJ SKY," which he heard on VHF radio, as meaning that "Vessel A will enter the Passage following aft of your own ship." Also, partly because the time of port entry was delayed, he increased speed and tried to pass in front of the bow of Vessel A. Besides this, he had seen the Port Entry Manual but had not sufficiently grasped its content; for example, he did not know about navigating between the Transit Lines.

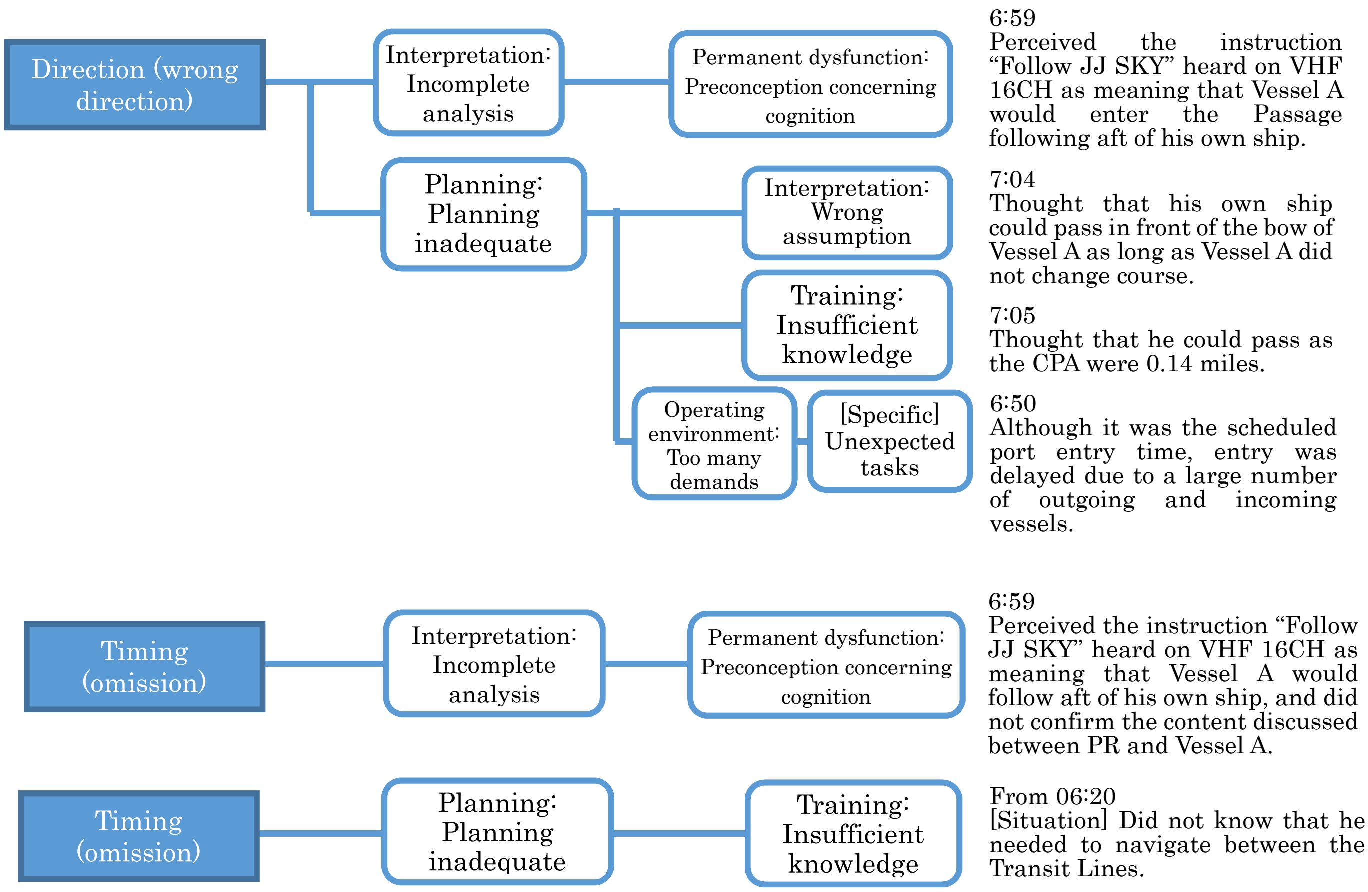


Fig. 17　Result of background factor analysis on the Master of Vessel B

4.4.4　PR (Port Radio)

The following error mode was identified and background factors were analyzed with regard to PR.

○ Identified error mode

<u>Timing (omission)</u>

- 06:43　The Pilot's reply to PR's question was not as intended, but no attempt was made to confirm it.

Fig. 18 shows the result of background factor analysis. PR tended to reserve to the pilot.

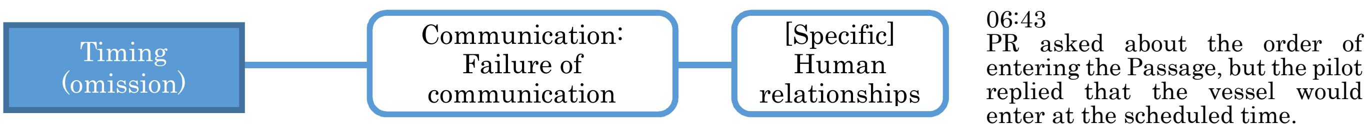


Fig. 18　Result of background factor analysis on PR

4.5　Discussion

Here, the connection between causative factors obtained from the CPC evaluation results concerning Vessel A and Vessel B and the analysis of background factors will be discussed.

○ Vessel A

According to the CPC evaluation results, the following three topics were identified as elements of an operating environment with adverse impact.

- Adequacy of MMI (arrangement of VHF from the Pilot's standing position)
- Availability of procedures / plans (lack of radio communication with Vessel B, timing of whistle use, etc.)
- Communication and information sharing (between the Master and the Pilot, the Pilot and PR, and the Pilot and Vessel B)

The direct causes targeted in the analysis of background factors and the background factors that caused them were as follows. Here, the analysis of the Pilot and the Master will be shown collectively.

As direct causes, the following three were identified.

(i) The timing of the change to astern was too late, and speed was not sufficiently reduced.

(ii) No contact was made with Vessel B. With PR, meanwhile, the only communication (about entering port) was made at the pilot station.

(iii) Escort boats were not used.

The background factors were as follows. Parentheses show the relevant direct cause.

- Due to a failure of communication, both the Pilot and the Master could not correct the mistaken perception that their own ship would have priority when entering the port. (⇒(i) , (ii))
- The Master could not easily state his opinion because the Pilot had taken command of maneuvering the vessel. (⇒(i))
- The Pilot and PR spoke in Japanese, the Vessel A watch personnel in English, and Vessel B in Chinese. (⇒(i), (ii))
- It is probable that the recognition affected. The recognition is that the pilot could not use the VHF while handling the vessel under the urgent situation because the VHF was too far away from his standing position. (⇒(ii))
- It is probable that the pilot felt no need to use the escort boats, because he had not used them when entering port on the previous occasion. (⇒(iii))

These five points cited as background factors were consistent with the topics deemed to have an adverse impact in the CPC evaluation. Information was not shared owing to a lack of communication due to differences in the language used and the arrangement of VHF equipment, while the mistaken perception that Vessel A would have priority when entering the port was not corrected.

○ Vessel B

According to the results of CPC evaluation, the following three topics were identified as elements of an operating environment with adverse impact.

- Availability of procedures / plans (lack of radio communication with Vessel A, the Port Entry Manual not kept on board, no knowledge of the Transit Lines)
- Available time (delay of Vessel B in entering port)
- Communication and information sharing (communication with Vessel A)

The direct causes targeted in the analysis of background factors and the background factors that caused them were as follows.

As direct causes, the following three were identified.

(i) Vessel B adopted a course that would pass in front of Vessel A. It also increased speed in order to pass in front of the bow.

(ii) No contact was made with Vessel A.

(iii) Vessel B headed for its destination by navigating diagonally across the Passage.

The background factors were as follows. Parentheses show the relevant direct cause.

- The Master understood “Follow JJ SKY” as meaning that Vessel A was to follow aft of Vessel B. (⇒(i), (ii))
- He thought that he could pass in front of Vessel A as long as Vessel A did not change course. (⇒(i))
- The time of port entry was delayed. (⇒(i))
- The Master did not know that he needed to navigate between the Transit Lines. (⇒(iii))

In Vessel B, similarly, the four points cited as background factors were consistent with the topics deemed to have an adverse impact in the CPC evaluation. Although there was a mistaken perception regarding the method of passing Vessel A based on the content heard on VHF radio, Vessel B was unable to correct this perception owing to a lack of communication with Vessel A.

4.6 Summary

The CREAM method was used to conduct CPC evaluation, identify error modes and analyze background factors. Several causative factors were identified for both Vessel A and Vessel B, and in particular, it was highly probable that a failure of communication was the main cause.

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