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P&I Loss Prevention Bulletin

The Japan Ship Owners'Mutual Protection & Indemnity Association Loss Prevention and Ship Inspection Department

4M5E Analysis

Analysis of Accident Cases

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Vessel A and Vessel B: Collision accident off the port of Kobe

Vessel E: Collision Accident with Bridge

§1 Introduction:
Safety and Casualty Mechanism & Maritime Accident Prevention

In our previous Loss Prevention seminars and Loss Prevention Bulletins, we introduced the definition of "safety", mechanisms behind maritime accidents, how to prevent maritime accidents and so on. (Please see our Loss Prevention Bulletin "Thinking Safety (Vol.35)" published in 2015.

1−1 What Is Safety?

In the world, absolute safety does not exist, and we are always exposed to all hazards. According to the International Basic Safety Standards (ISO/IEC GUIDE 51: 2014), safety is defined as:

"There is no freedom from unacceptable risk."

Also, thinking of "Safety" has been discussed in various different fields, but, in summing them up, "Safety can be defined as the result or evaluation of all danger being avoided."

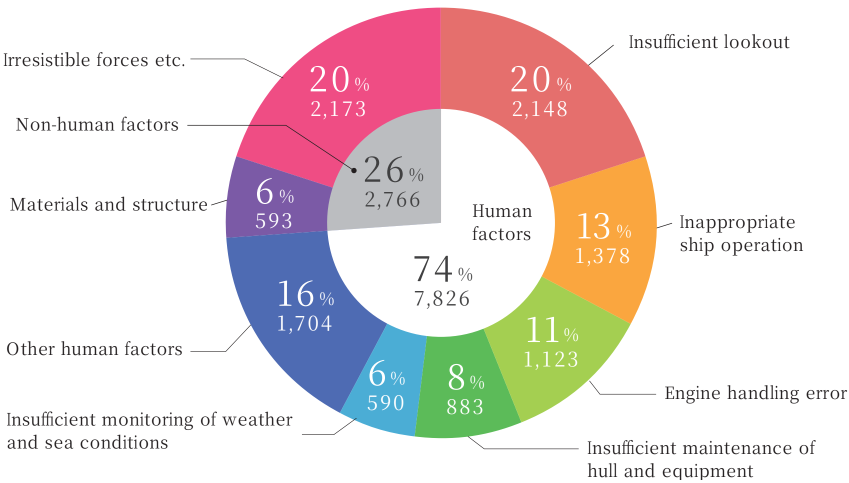
Although each related person, not only those on the vessel but those also working in the offices on land, is always in pursuit of safe operation, unfortunately, "zero marine accidents" have not been achieved yet.

1−2 As a Mechanism behind Maritime Accidents Caused by Human Error

Why then do marine accidents still occur, even though we are aiming to eradicate them every day by taking all possible safety measures? It is necessary to consider the mechanisms that trigger marine accidents.

According to a guidebook called "Facts and countermeasure against maritime accidents in 2017 (provisional translation)" issued by the Japan Coast Guard, the ratio by types of causes as accumulated over the last five years of total maritime accidents reported to the Japan Coast Guard shows that approximately 74% of the causes were those of Human factors. (See Graph 1)

The ratio by type of cause of total accidents as accumulated over the last five years



Graph 1

Reference : Facts and countermeasure against maritime accidents in 2017 (provisional translation)

In addition, those which are caused by Force Majeure (unforeseeable circumstances) are also almost all related to human errors. Then, it may be presumed that 94% of all maritime accidents are caused by human factors.

Therefore, it follows that if there were no human errors, most maritime accidents should not occur. However, unfortunately, it is not possible to realize zero human errors, as the following four aspects are behind the main root cause.

Causes behind Human Error

1 Common characteristics among the people who have acquired advanced skills such as Master, Navigation Officer, aeroplane pilot, medical doctor and so on.

(80th Cultural lecture held by the Japan Captains' Association: Ensuring safety in a proud profession — Why BRM is paramount — from a person with a proud profession (provisional translation.)

These common characteristics of technicians, which are shown in Figure 1, sometimes cause human error.

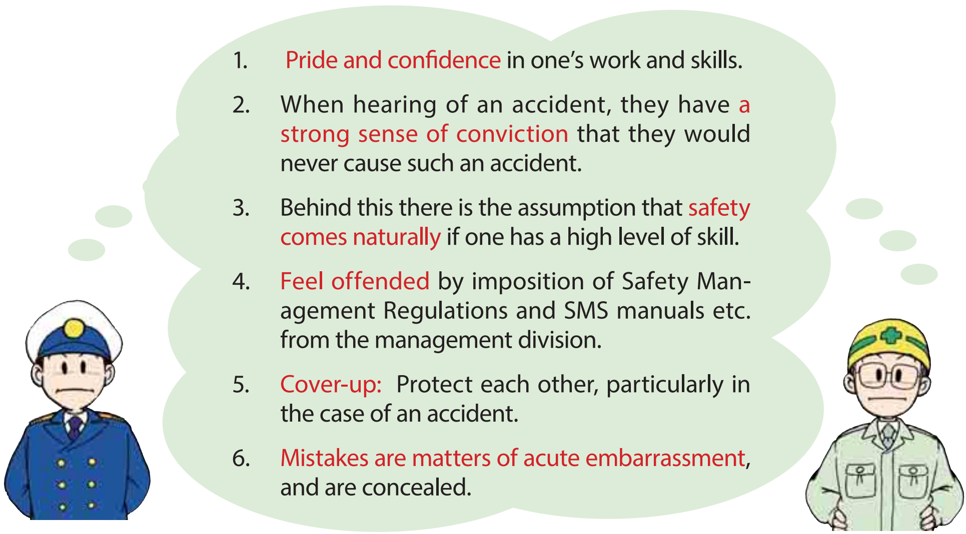


Fig. 1

2 Human characteristics (Nihon VM (Visual Motivation) Centre Co., Ltd from Anzen-no-komado 18 (Safty Loopholes) dated 30 June, 2002 (Provisional translation)

Figure. 2 shows the “human characteristics that everyone has” which are likely to cause human error.

Twelve human characteristics

1. Human beings sometimes make mistakes
2. Human beings are sometimes careless
3. Human beings sometimes forget
4. Human beings sometimes do not notice
5. Human beings have moments of inattention
6. Human beings sometimes are able to see or think about only one thing at a time
7. Human beings are sometimes in a hurry
8. Human beings sometimes become emotional
9. Human beings sometimes make assumptions
10. Human beings are sometimes lazy
11. Human beings sometimes panic
12. Human beings sometimes transgress when no one is looking

Fig. 2

3 Psychological Factors

The following psychological factors mainly induce human error.

① **Psychological reactance (self-efficacy)**

This is when people do not wish to do something that is not of their own volition. They may be inclined to say, “I won’t do what you tell me.”

② **Entrainment, Peer Pressure and Normalcy Bias (justification and cognitive dissonance)**

Anyone else would do the same and the psychology of, “What will the neighbours think?” and “I’m special, nothing can hurt me!”

③ **Confirmation bias**

People are unconsciously prone to believe only “what they want to believe” and “information that supports what they believe” rather than purposefully seeking information to the contrary. They may say something like, “Stop exaggerating!”

④ **Social loafing**

This is when someone does not choose to take the initiative. They may say, "Someone will do it for me."

4 Human Brain Capacity

The reason why we can say that the human brain is a very inefficient organ is because it occupies only 2% body weight, yet consumes 20% of all the energy. Our brains are programmed to save as much energy as possible, while aiming to achieve maximum energy efficiency. The following are examples of its energy-saving mode, and it is these that are responsible for optical illusions and perceptual errors.

Since Neoanthropic man (Cro-Magnon man) was born 40,000 years ago, human beings have been making a living from hunting, pasturage and farming. In 1769, which is just 250 years ago, a Scottish mathematician and engineer, James Watt invented the steam engine, which was epoch making for humanity. In other words, it is thought that the problems in the era of farming and pasturage were mainly only floods, fires, and natural disasters, but now, new disasters can be added to this. It is said that human beings inhabited the earth approximately 40,000 years ago. If this were compressed into 1 year, and human beings started to inhabit the earth from 00:00 on January 1, the industrial revolution would have begun at 17:15 on December 29. Meaning that only 2 days and 6 hours and 45 minutes have passed since human beings came into contact with machines. It is true that technological advances in machinery and equipment are becoming more upgradable and complex, however, we should still think of our DNA and brain capacity as "first-generation processes that cannot keep up with these changes".

- Avoids thinking deeply (it gets tired)
- Is not good at thinking logically
- Forgets and does not remember easily
- Not able to reject our assumptions
- Tends to believe that our choice is correct
- Tends to make choice based on first impression etc.

As a Mechanism behind Maritime Accidents

Unlike traffic accidents that may be caused by a single driver, casualties at sea are seldom caused by one single human error. In most cases, there is a chain of human errors (error chain) that leads to an accident, and unless the error chain is broken, as a result, an accident is likely to occur.

An example of a collision accident is shown in Figure 3. It is understood that an accident occurs when several errors overlap.

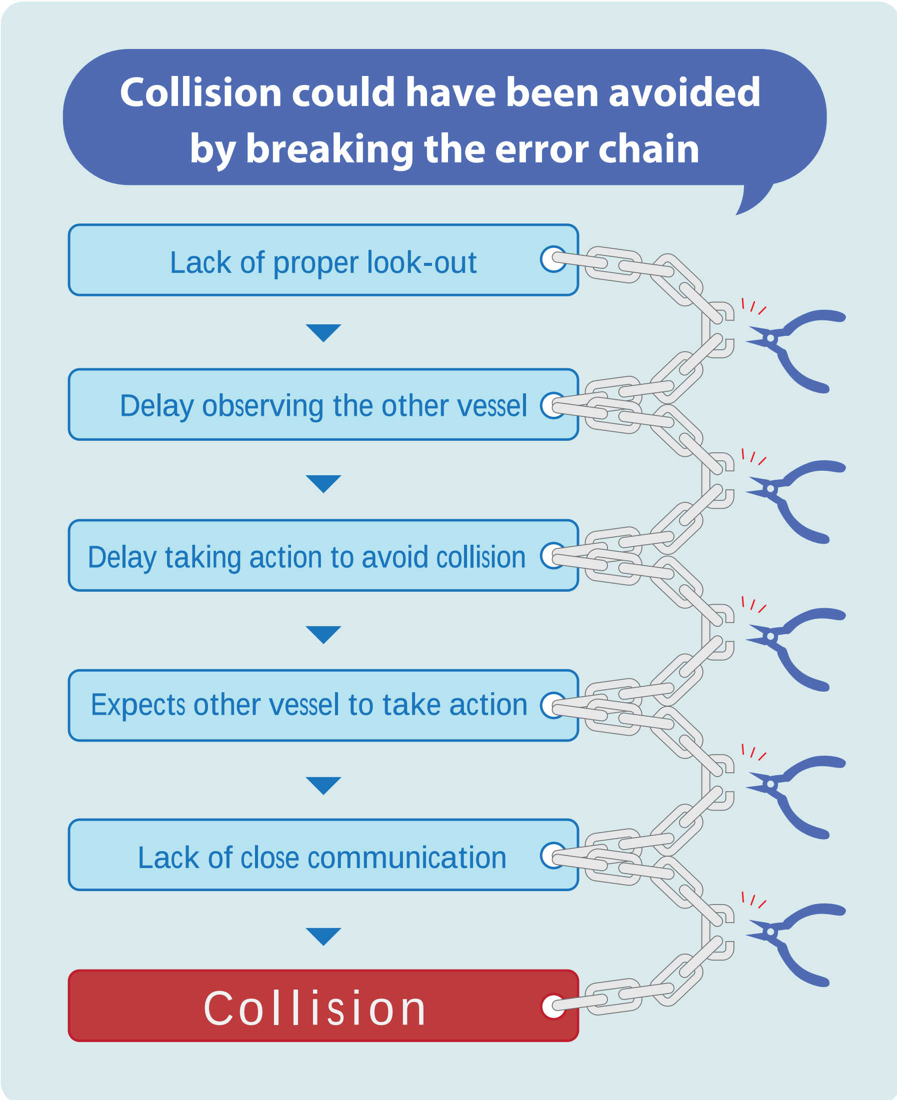

Collision could have been avoided by breaking the error chain
Lack of proper look-out
Delay observing the other vessel
Delay taking action to avoid collision
Expects other vessel to take action
Lack of close communication
Collision

Fig. 3

1—3 Prevention of Maritime Accidents

Basic approach

Herbert William Heinrich (1886-1962). When working as an assistant superintendent of the engineering and inspection division of a non-life insurance company in America, his law Heinrich's Law was derived from his thesis which was published on 19 November, 1929.(Heinrich's Law: Figure 4)

Behind every serious accident or disaster, it is said that there are 29 minor ones and that there are 300 near misses that fortunately do not lead to any accidents. Hazardous "unsafe acts" referred to as "unsafe situations" number in their thousands, meaning that even more dangers lurk in the background.

Thus, if we are able to decrease the several thousands of unsafe conditions and 300 near misses, maritime accidents either minor or major, could definitely be reduced.

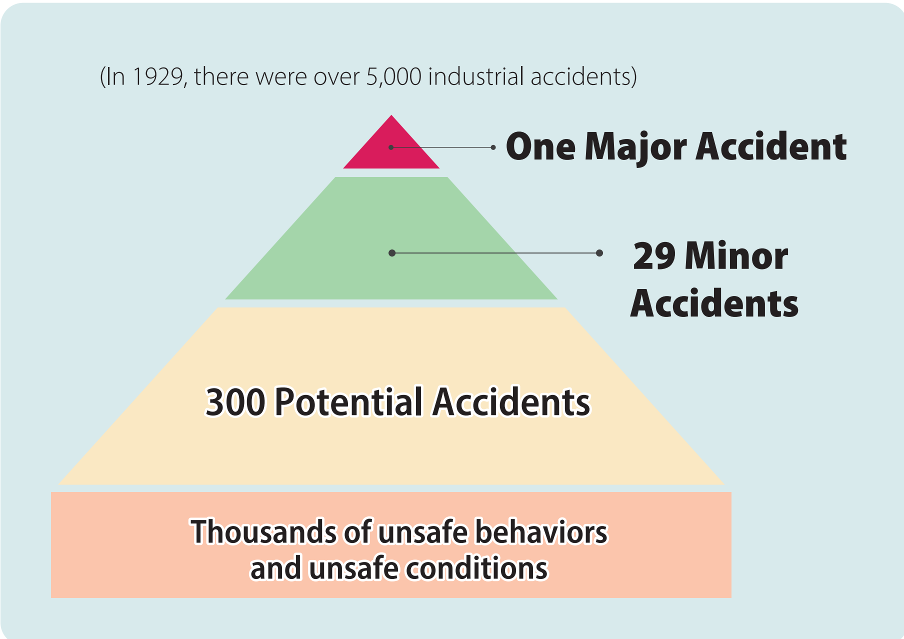


Fig. 4

There can be no "absolute safety" and "Safety can be defined as the result or evaluation of all danger being avoided", as explained above in 1-1. Then, how can we achieve the safe operation of vessels which are always exposed to a variety of dangers? By understanding the Johari Window (see Figure 5) in the field of psychology, we can see that it is possible to "heighten the level of safety".

Considering the scope of activities in vessel operation, there are many dangers lurking in the Johari Window. This consists of four window-panes: ① Known by the person as well as by others (Open Self), ② Information about a person that others know in a group that the person is unaware of (Blind Self), ③ Information that a person knows about themselves that is kept unknown to others (Hidden Self) and ④ Information that is unknown by the person about themselves that is also unknown by others (Unknown Self). The most dangerous area is the "Unknown area". Namely, the unknown area is an area that no one knows about (or a danger that no one notices) where safety measures are yet to be taken.

A requirement that would heighten the level of safety would be to enlarge the Open area. In other words, the Open area specifies that all members within the range of activity, including the vessel and its land management department, are equally aware of the danger, thus proactive measures can be taken.

The "Blind spot" can be narrowed by learning from each other's knowledge and experience, thus expanding the "Open area" of the team. Also, by opening our Hidden areas (what we know that others don't) and by being aware of others' blind spots, the Open area will be expanded, which will in turn bring about improved safety, eventually.

If we remain unaware of the "Unknown" area and its inherent dangers, this will render us defenceless.

However, if we enlarge the Open area, the Unknown area will reduce. At the same time, the Blind spot and Hidden area will also reduce. This means that the level of safety will improve.

Johari Window

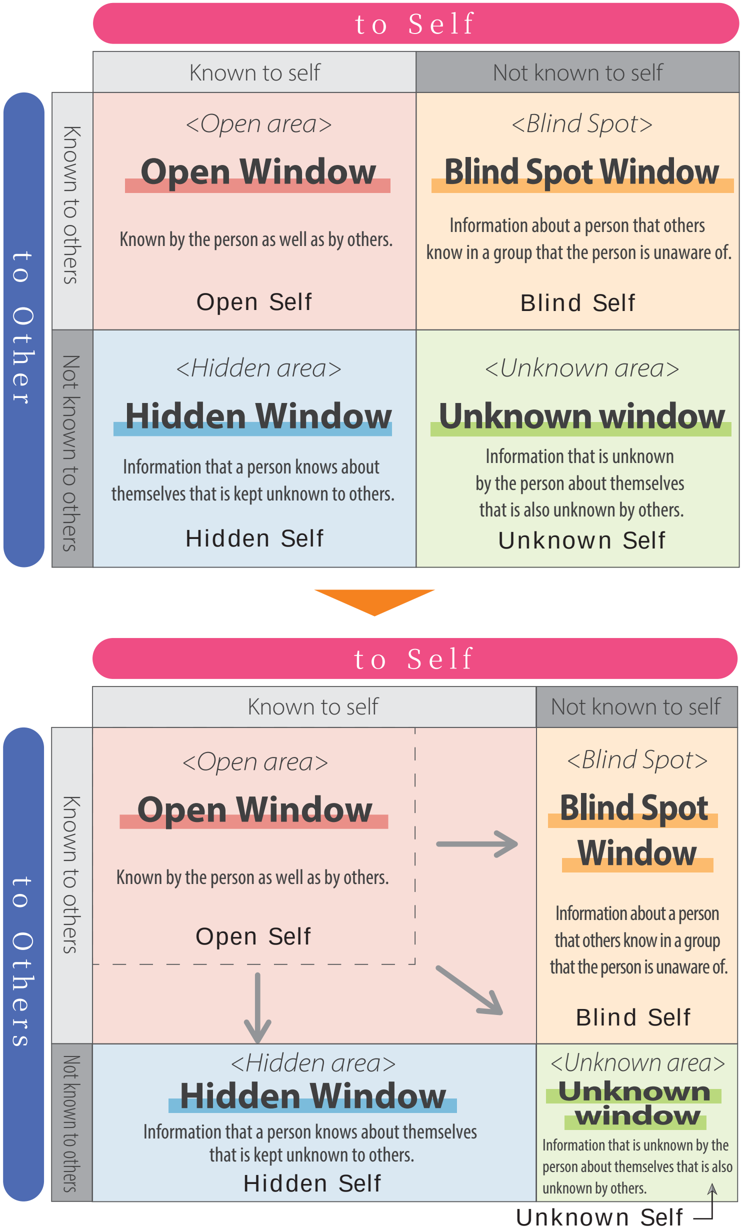


Fig. 5

BRM and ERM

Bridge/Engine Room Resource Management

BRM and ERM have been introduced as methods to prevent maritime accidents from occurring by breaking the chain of human errors (error chain). This method seeks to acknowledge that it is a) impossible not to generate human error, b) that the team unite and work together so that one person's mistake does not create a dangerous situation, c) that mistakes be noticed and corrected in a timely manner, and d) that everyone find a way to support each other and break the error chain.

The concept of BRM and ERM is based on communication with the resources surrounding the subject.（See Figure 6）

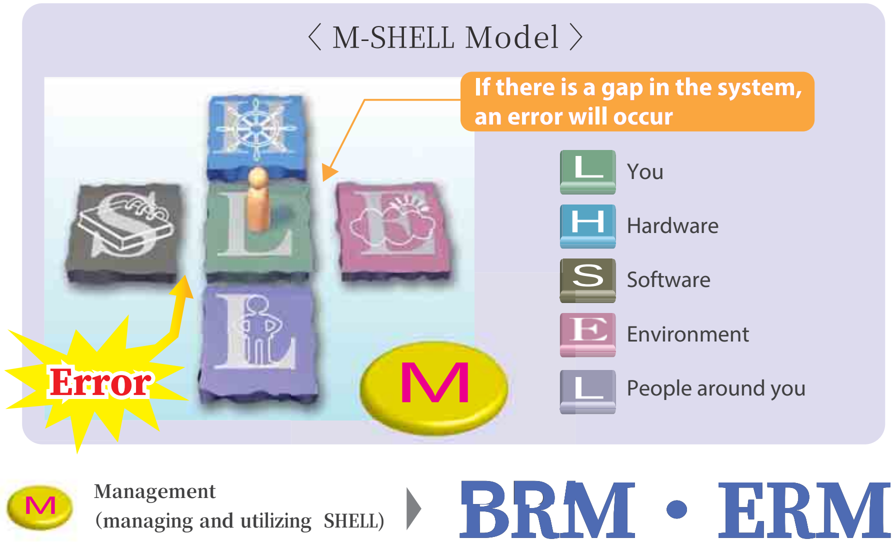


Fig. 6

The person at the centre（L : Person responsible for the accident）is surrounded by those resources such as:（H: Hardware）,（S: Software）,（E: Environment）, and（L: Persons other than the person responsible for the accident）. Each resource is always in a state of change. This situation is shown in terms of quivering rectangles.

If there is insufficient communication and cooperation between the person responsible for the accident (L) and each resource, and if the team does not gel, this will create a gap and safety cannot be established when a human error occurs.
If the squares (H, S, E, L) are well aligned, then even when a person causes a human error (L), the resources surrounding him/her will be aware of it and will communicate this so that L is aware.
BRM and ERM training are effective methods that help us address communication issues, however, there are many who still say that it is difficult to carry this out in practice. The main reason has to do with the difficulty of communication. Figure 7 illustrates this.

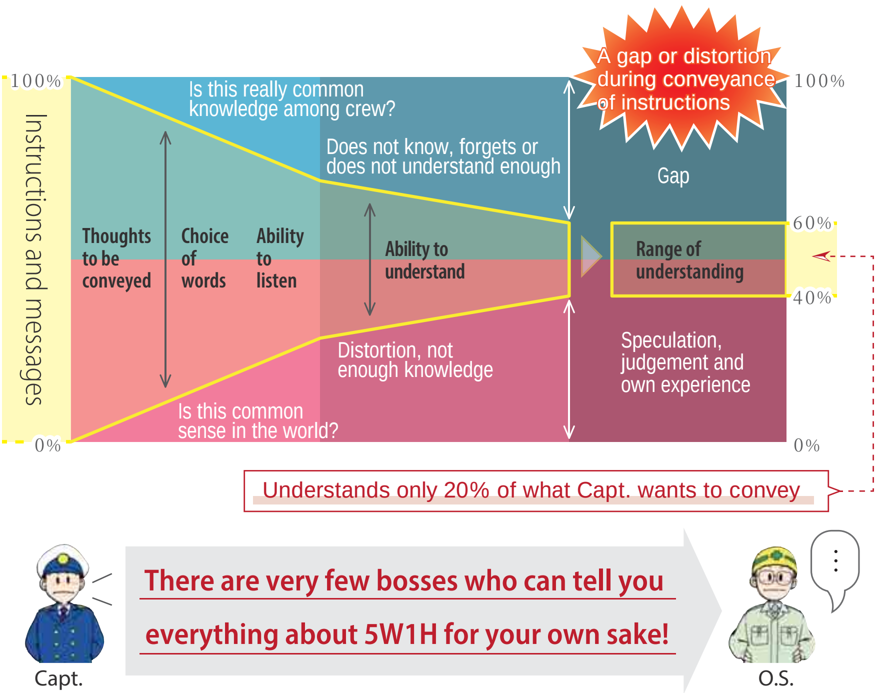


Fig. 7 Problems with oral instructions and communication (difficulty with communication)

The yellow coloured area on the extreme left shows what a Master intends to order or what message he intends to convey (Full understanding is shown as 100%). Even when the Master tries to relay information to an Ordinary Seaman (O/S), only 20% of the information may be understood due to a misunderstanding, a lack of understanding or knowledge that the O/S may think is common sense, a lack of communication, speculation or judgement on the part of the O/S, or he/she may compare what was relayed to their own experience. Why is this the case?

It seems most likely that the reason why information cannot be conveyed successfully is down to a difference in their level of understanding regarding technology. For example, if the Master tries to convey the same message to another Master, his message will be conveyed to the full (100%), because their technical backgrounds are almost the same.

§2 4M5E Analysis

One preventive measure that we can use is the 4M5E Analysis. This model takes into account lessons learned from similar past accidents. This is a countermeasure (method) that seeks to prevent a re-occurrence of the same or a similar accident based on lessons learned, in the event that such an accident should occur.

"Safety" is management's top priority. In order to realize this, it is important to correctly identify "the bud of a potentially new accident" and to prevent a re-occurrence based on the lessons learned. Most accidents at this bud forming stage can be referred to as events that require attention or risky events and are often due to human error. Thus, it would be vitally necessary to analyse such phenomenon thoroughly from a human factor perspective.

This method is derived from an accident investigation method adopted by the US National Transportation Safety Board (NTSB) and has been used in various fields including the industrial arena. With this method, we can not only look at error factors from multiple perspectives but also examine preventive measures from a wide range of viewpoints.

2−1 Errors Made by an Involved Party and Organizational Errors

Although we have established preventive measures for every time an accident occurs, why then has the 4M5E analysis been the subject of recent interest?

According to The Hudson Model: Types of Safety Culture (See Figure 8), Safety Culture has been developed as follows:

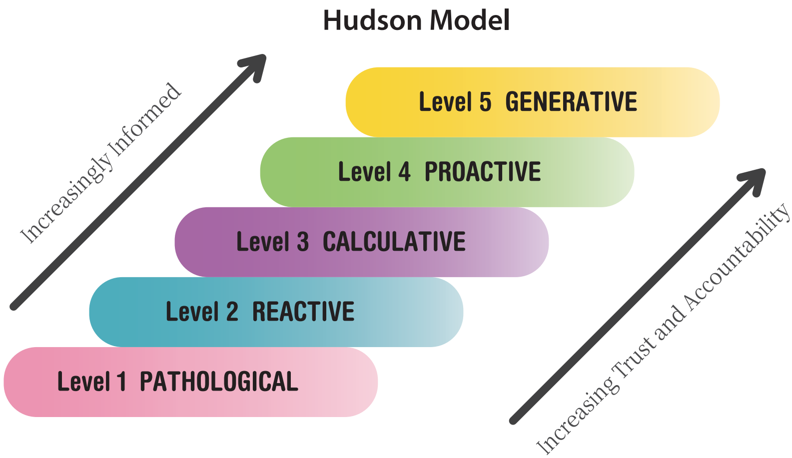


Fig. 8

Level 1 Pathological	Safety problems are caused by the workers. Safety concerns only the Safety department.
Level 2 Reactive	Safety is important, but we activate it only after an incident. Mistakes are punished.
Level 3 Calculative	Safety driven by SMS and safety is improved through PDCA. Emphasis on continuous monitoring using safety measures.
Level 4 Proactive	All staff understand the importance of safety. The organization tries to prevent accidents with proactive measures (manpower, equipment and cost to be included).
Level 5 Generative	Safety is an inherent aspect of a sustainable organization. All staff unconsciously give priority to safety.

In other words, in the past, when an accident occurred, because almost all accident causes were due to human error, the person who caused the accident was identified and the mistakes that led to the accident investigated. Then, the case would have been closed after having reprimanded the individual by saying something like, “Be careful in future” or holding the individual to account by punishing him/her ("grave-post type"). The above Level 1 (Pathological) and Level 2 (Reactive) are applicable to this.

But, we have learned that this kind of preventive measure lacks in efficacy. Therefore, it is a must that we examine the factors behind human error and explore further as to why an individual causes a human error. Then we can take effective countermeasures ("preventive type") to prevent future re-occurrence.
Figure 9 illustrates this. (Why are accidents repeated - the analysis of the human factor written by Akira Ishibashi supervised by Isao Kuroda ; from Japan Industrial Safety and Health Association (JISHA)) (Provisional translation)

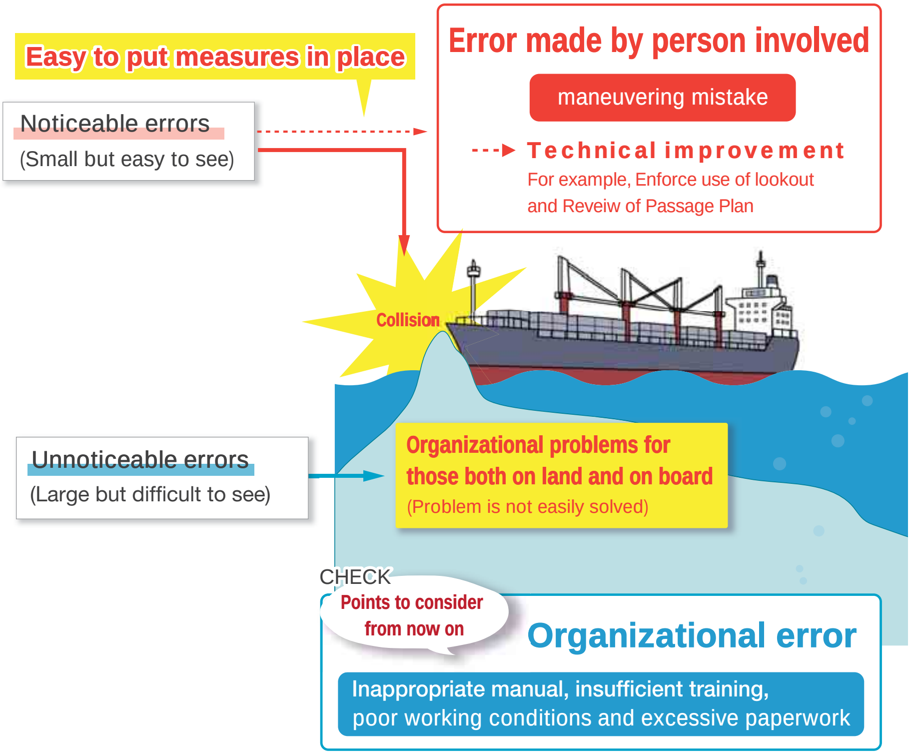


Fig. 9 Why are accidents repeated - the analysis of the human factor written by Akira Ishibashi supervised by Isao Kuroda

Source: Seminar on Analysis and Countermeasures of Accidents Learned from Case Studies, by Japan Industrial Safety and Health Association (JISHA) (Provisional translation)

In the event that an accident is considered to have been caused by human error, it is easy to take remedial measures for visible and technical errors. Moreover, it seems appropriate at first glance that the parties involved should be punished and that the technology should be improved.

For example, as for collision accidents, most of their direct causes are related to human error such as insufficient lookout and non-compliance with the navigation act. As a result, compliance with the 2nd Chapter (Navigation Act) of the Act on Preventing Collision at Sea is followed, and the party involved is punished, then the case is closed.

However, each Master and Navigation Officer who has a seaman's competency certificate fully understands the importance of lookout and compliance with the Navigation act. True preventive measures cannot be established unless we analyse in depth as to why professional qualified mariners "neglected appropriate lookout and could not comply with the navigation act". For example, as organizational errors that are not readily apparent manifest themselves, shown in Figure 9, we must construct recurrence preventive measures by analysing the "Underlying causes", to establish if there are errors in the organization or team, such as an inappropriate manual, insufficient training, poor working conditions and excessive paperwork.

2−2 4M5E Analysis

As mentioned above, the 4M5E analysis considers the cause of the accident to be a result of organizational error. A matrix table of specific causes behind the accident and countermeasures is formulated. The specific causes behind the accident are described (4M), and then countermeasures (5E) in terms of training, technology, reinforcement/enforcement, examples, and environment (organization both within the company and onboard), are added.

4M

Shows specific factors behind an accident

- Man
- Machine
- Media (Environment)
- Management

5E

Reveals countermeasures

- Education
- Engineering
- Enforcement
- Example
- Environment (within company and on-board ship etc.)

When considering the conditions that cause occupational accidents, it can be said that 85.6% occur as a result of a combination of “unsafe behaviour” and “unsafe conditions”. (See Figure 10)

〈When Workplace Accidents Occur〉

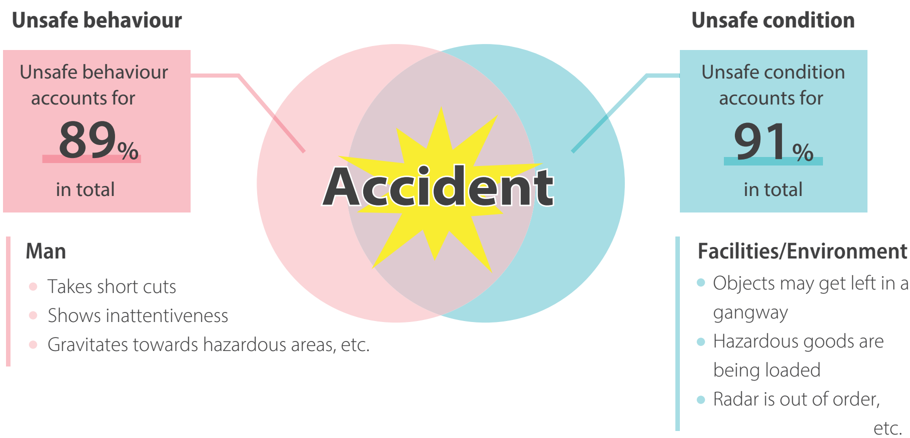


Fig. 10

Source: Seminar on Analysis and Countermeasures of Accidents Learned from Case Studies, by Japan Industrial Safety and Health Association (JISHA) (Provisional translation)

On considering the reasons behind "unsafe behaviour" or "unsafe conditions", the root cause is often found in an "organization's safety management deficiencies". (See Figure 11) for 4M5E analysis, whereby these "root causes" and "direct causes" are organized into a table, analysed, and preventive measures formulated.

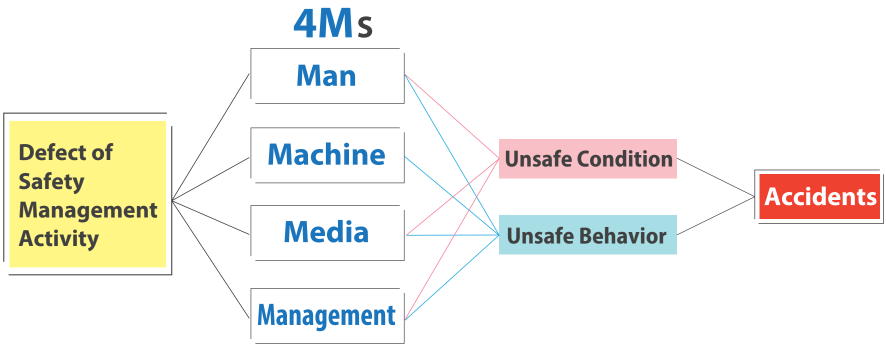
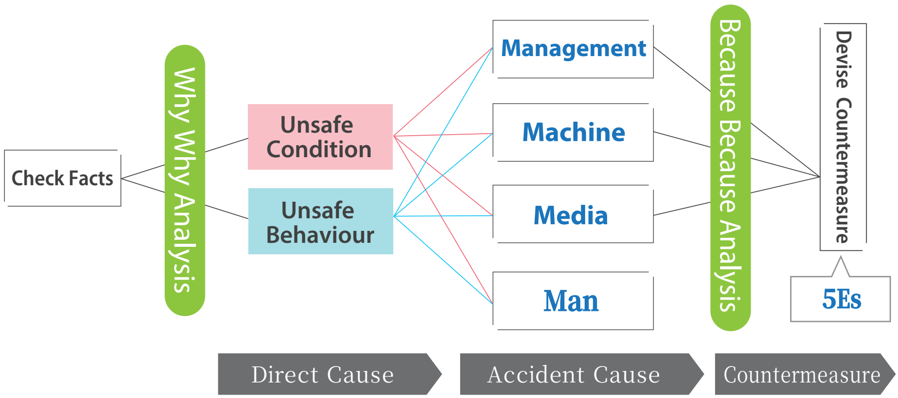


Fig. 11

2－3 4M5E Analysis Plus Why Why Analysis: Investigation, Analysis and Countermeasures

The 4M5E analysis and countermeasure planning workflow is shown in Figure 12.



＊Because it is important to check the facts, countermeasures are not to be made based on own speculation. Conduct a further investigation, if necessary.

Fig. 12

An outline of the analytic procedure will be explained below. (See Attachment 1 P.93)

1. Site investigation

Carry out investigation in as much detail as possible, ideally by a third party (such as a surveyor or marine consultant etc.)

2. Analysis of site investigation report

- Clarify accident cause/s (4M), using a classification table and so on. (See Attachments 2-1, 2-2 and example in Figure 13.)
- Organize these into a matrix to examine the facts (See Attachment 3).

1. Facts extracted from the accident investigation report that caused the accident have been identified and listed under each factor in the table (Figure 13).
2. Classify into Unsafe Behaviour or Unsafe Conditions by factor.
3. After clarifying the accident cause/s, in order to analyse this, assess accident cause by prioritizing according to the scale of the cause.
4. Furthermore, clarify which items need to be inspected/investigated again.

> ＊ Accident Reports
> Ship reports, ship management company reports, survey reports, attorney (maritime auxiliary) reports, transportation security reports, and as much information as possible, such as accident investigation reports of all committees and decisions of the Japan Marine Accident Tribunal, are to be collected.

Example

Vessel superintendent was aware of the low visibility weather forecast, but, as he assumed that the Master also knew, he did not report it.

2 radars were equipped on board, but the magnetron of No.1 radar was to be replaced by the manufacturer at the next port. The Master was requested to navigate using only No. 2 by the vessel superintendent, and agreed despite feeling uneasy about it.

Attachment 3

Maritime Accident Summary of Related Facts

Reference No.	Identified problems from survey findings				Direct cause		Accident cause evaluation	Re-examination necessity
	Date	Time	Caused by	Check facts and problem areas	Unsafe behaviour	Unsafe conditions		
1	Unspecified date	Approx. 3 p.m.	Vessel superintendent	Did not report a forecast of low visibility to the Master	○		4	
2	Unspecified date	Approx. 4 p.m.	Vessel radar	No. 1 radar was out of order	△	○	3	○
3	Unspecified date	Approx. 5 p.m.	Vessel superintendent	Requested the Master to navigate using only No. 2 radar until next port, because arrangement to fix No. 1 radar at the port had been made	○		5	○
4	Unspecified date	Approx. 5 p.m.	Master	Approved navigation to the next port using only one radar.	○		6	
5	Unspecified date	Unspecified time	2/O	Did not report to the Master, although there was the low visibility (less than 2 nautical miles) (According to the Safety Management Code, low visibility is defined as less than 3 nautical miles.)	○		2	
6	Unspecified date	Unspecified time	2/O	Searched for the other vessel at 6.6 nautical miles via radar, but did not notice the image captured on ARPA, because he believed he could pass starboard to starboard	○		1	

Example

Accident cause assessment: Prioritized according to the scale of the cause

At XX:XX (unspecified time), the 2/O knew that there was low visibility of less than 2 nautical miles, but he did not report it to the Master.

At XX:XX (unspecified time), Although the 2/O searched for Vessel △△ at approximately 6.0 degrees on their starboard bow in the vicinity of <015> 6.5 nautical miles via radar, he believed he could pass starboard to starboard, but did not notice the image captured on ARPA.

Fig. 13 (Attachment 3)

3. Once the above have been established, compile this information into an accident cause/s matrix (unsafe behaviour and unsafe conditions).

(See Attachments 4 and 5)

Pick out the relevant facts, and compare "unsafe behaviour" and "unsafe conditions" using the 4M classification table and carry out a "Why Why Analysis". Circle the corresponding items.

1. Enter relevant factors into Analysis Tables 1 to XX, and enter why these occurred in (2) to (6) below.
2. Then, circle each applicable column.
3. Enter the sub-item number of each item in the 4M Classification List for Man Machine, Media, and Management.
4. For items requiring re-investigation, circle the corresponding column to the right.

4. Once the above 3 has been completed, analyse and devise countermeasures.

(See Attachments 6 and 7)

- Classify the direct cause and indirect/root cause of the accident referring to the 4M5E table.
- Devise a countermeasure for every 5 item.

1. Copy over the risk factors from the analysis chart (including the applicable numbers).
2. Copy over countermeasures to reduce or improve the risk factors into the 5E table.

Why Why Analysis

The Why Why Analysis method is a way of finding and verifying the efficacy of solutions to a certain problem. By repeatedly asking the question "Why?", the method seeks to identify what caused the problem, what factors led to that cause, and so on.

Method (Figure 14)

- The first stage is to present the problem in question. In order to make a logical progression to the next stage, it is helpful at this point to go through a process of elimination of irrelevant causative factors.
- A list of potential causes can then be created. This is the result of the first "Why?" There may be multiple causes but they must all have a logical connection to the original problem.
- The next stage is to come up with the potential factors which led to those causes. This is the result of the second "Why?" As with the first stage, there may be a number of different factors involved, but each must have a logical connection to the subsequent cause.
- This process is repeated in the same manner with the 3rd and 4th stage of "Why?s".

It is difficult to say at what point it is best to suspend this repeated process, but in practical terms the ultimate goal is to find a logically proven solution whereby removal of the causative factors leads to elimination of the original problem.

During the "Why Why" process, some causative factors, be they a particular phenomena or something of a more systemic nature, may well be deemed unavoidable. In which case, the analytic process should be suspended. Conversely though, through this same process, it is also possible that factors, which were thought to be unavoidable, are actually shown to be no more than a preconception.

〈 Analysis Chart for Incident & Cause Factors（Model）〉

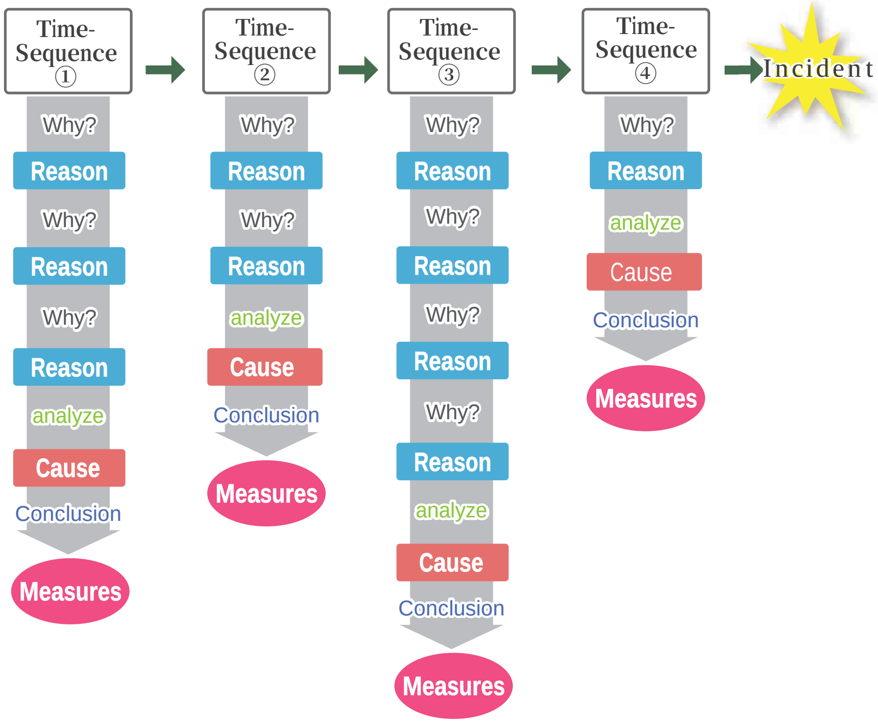


Fig. 14

Devise a countermeasure

Devise a countermeasure for each factor below regarding unsafe behaviour and conditions. The following items from ① to ⑤ are to be extracted from Attachment 6.

❶ **Education :**

Education and training

Measures to improve the competency, awareness and knowledge required to perform the task.

❷ **Engineering :**

Technology and engineering

Technical measures of handling equipment for safety improvement and improvement of equipment etc.

❸ **Enforcement :**

Thorough guidance and enforcement

Measures related to thoroughly enhanced regulation in order to ensure the work done and revision of the SMS etc.

❹ **Examples :**

Case studies, countermeasures and rules

Measures to show specific cases such as lead by example, experience of success, introducing model cases etc.

❺ **Environment :**

Measures related to working environment, office internal management, on-board organization, etc.

Figure 15 shows an example of recurrence prevention countermeasures.

Example

Risk factors (direct cause and indirect/root cause)

↓

It is considered effective to have them attend training programs such as behavioral psychology to learn awareness.

Risk factors (direct cause and indirect/root cause)

Vessel

1. Why wasn't this captured by ARPA?
(1－③,⑧,⑨,⑩,⑪,4－1－③)

2. Why was the problem of poor visibility not reported to the Master?
(1－②,⑥,⑪,⑫,2－①,3－③)

6. Why did he approve navigating with a single radar?
(1－①,⑤,⑥,⑧,⑨,⑪,4－1－③,4－3－②)

Shipowner and ship management company

5. Why did they request a single radar for navigating?
(1－①,⑥,⑦,⑨,⑪,4－1－①,②,③,④,4－2－①,4－3－②,③)

Education and training
Knowledge, skills, consciousness, being given information, etc.

- Training in behaviour psychology
⇒ Learn to notice things
- Education to reinforce habitually that optical illusions/errors and assumptions can cause a risky behaviour

Example
Case studies, countermeasures and rules.
Lead by example, experience of success, introduce model cases, " Hiyari-Hatto " (near misses), etc.

- Gain a sense of experience using navigation simulations, for example

Fig. 15

5. Carry out and verify countermeasures based on the devised example above, and Brush up using a PDCA cycle.

The key is (1) to ensure that the proposed countermeasures are always implemented, (2) that their effectiveness is evaluated and verified and (3) that any defects are corrected. That is to say, PDCA (Plan・Do・Check・Action（for improvement）shall be performed. If this is not done, the hard-earned measures to prevent recurrence will quickly become a mere formality. In the event of a major accident, it will be of value to have a recurrence prevention campaign annually (so as not to forget).

When considering methods of prevention, for example the PDCA cycle mentioned in Attachment 7, be sure to carry out the following to ensure that the intended preventive measures do not become a mere formality.

Enforcement（thorough guidance and enforcement）

Thoroughly clarify procedures for low visibility in the procedure manual.

Plan

Here, we will examine how to ensure that the existing procedures are reviewed and clarified, as well as how to ensure compliance with the revised procedures at sea. In order to achieve this, 4 root causes (Technicians characteristics, Human behavioural traits, Psychological factors and Human brain capacity）described in 1-2 As a Mechanism behind Maritime Accidents Caused by Human Error, shall be considered. For example, a review of training programmes, internal audit frequency, the launching of an evaluation committee etc. could be considered. The most important is annual scheduling. If the scheduling is vague, these kinds of tasks will be easily put off.

Do

It is important to carry out the planned schedule with certainty.

Check (evaluation)

An assessment committee will be held every 3 to 4 months in order to manage the work plan progress and to assess the implementation report. It is important to identify the problems by providing a general overview of the fiscal year at the end of the year.

Action (improvement)

Analyse the problems identified in the evaluation (including the Why Why Analysis), and formulate measures for improvement.

This outcome will be the Plan for the following fiscal year.

§3 Case Study
Collision Accident

Japan Transport Safety Board Report MA2019-6-02
Japan Transport Safety Board Report

The collision accident of the outgoing large size container which occurred off the port of Kobe on XX May, 2018 is to be analysed.

3−1 Accident summary

Date and time (See Figure 16)

XX May, 2018 at approximately 07:02:49 (JST)

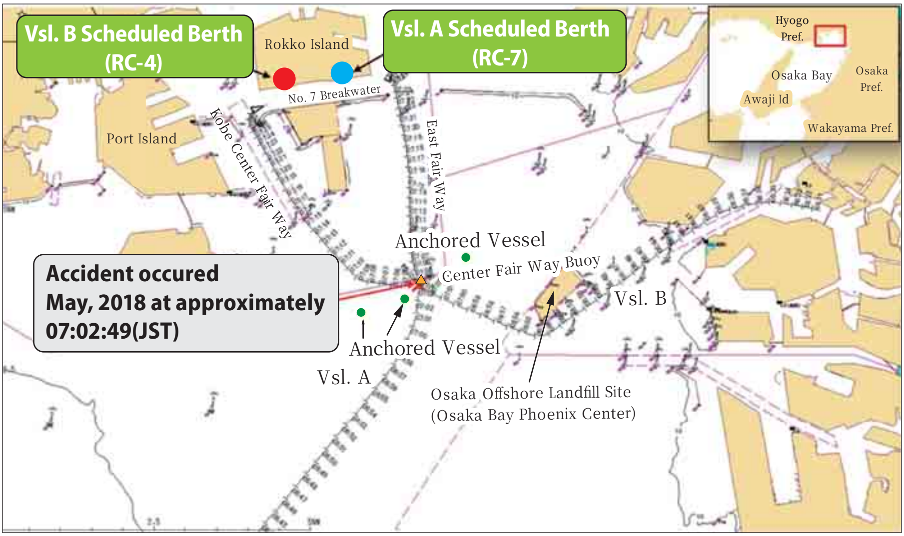


Fig. 16

Point of Occurrence

Near Kobe Rokko Island East Fairway Central FW Buoy

Movement of Both Vessels

Pilot A boards at Tomogashima Channel, and when navigating northeast of Osaka Bay toward RC-7 (Kobe Rokko Island) for mooring, he was trying to head for south of Kobe Rokko Island East Waterway and steered to port side while reducing speed (ship speed: 11.3 knots (approx.).

Vessel B departed Osaka bound for Kobe RC-4 (Kobe Rokko Island) via Kobe Central Fairway. While navigating northwestward and westward, at 13 knots of speed, S/B Full, the starboard bow of Vessel A collided with the accommodation space near the astern port side of Vessel B. (See Figure 17)

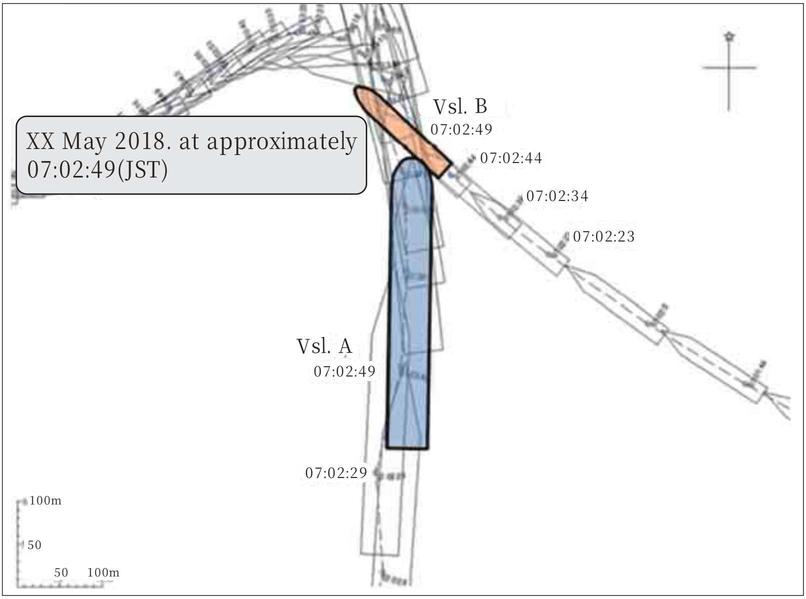


Fig. 17

The weather and sea conditions and visibility at that time were as follows, and did not contribute to the cause of the accident.

05:06 Fine SW ～ WSW 3.8 ～ 4.1m/s (wind force 2 ～ 3) Visibility 30km or more (more than 16 nautical miles)

Container Vessel A Summary

Photograph 1

Gross tonnage	:	97,825GT
L×B×D (Length) (Breadth) (Depth)	:	338m×46m×25m
Port of origin	:	Singapore
Port of destination	:	Kobe RC-7
Cargo	:	20FT CTNR×1,360 40FT CTNR×2,441
Draft	:	Fore 12.85m Aft 13.35m
Crew arrangement	:	3 Croatian, 2 Russian, 16 Filipino, 2 Indian, 1 Romanian and 2 Chinese Subtotal 26 crewmembers ＋ 3 accompanying passengers (Indian) and 1 Pilot Total of 30 crewmembers on board
Ship's Bridge on duty personnel at the time of the accident	:	Master A, Pilot A, 3/O A, AB A and Cadet A
Master A	:	Croatian nationality at the age of 54 : Captain since 2003, boarded the vessel on March 2018 and had 8 times experience of entering Hanshin Port of Kobe as Master
Pilot A	:	Japanese nationality at the age of 70 has been an active Pilot since 2002 (15 times per month)
3/O A	:	Filipino nationality at the age of 24
Cadet A	:	Chinese nationality at the age of 25

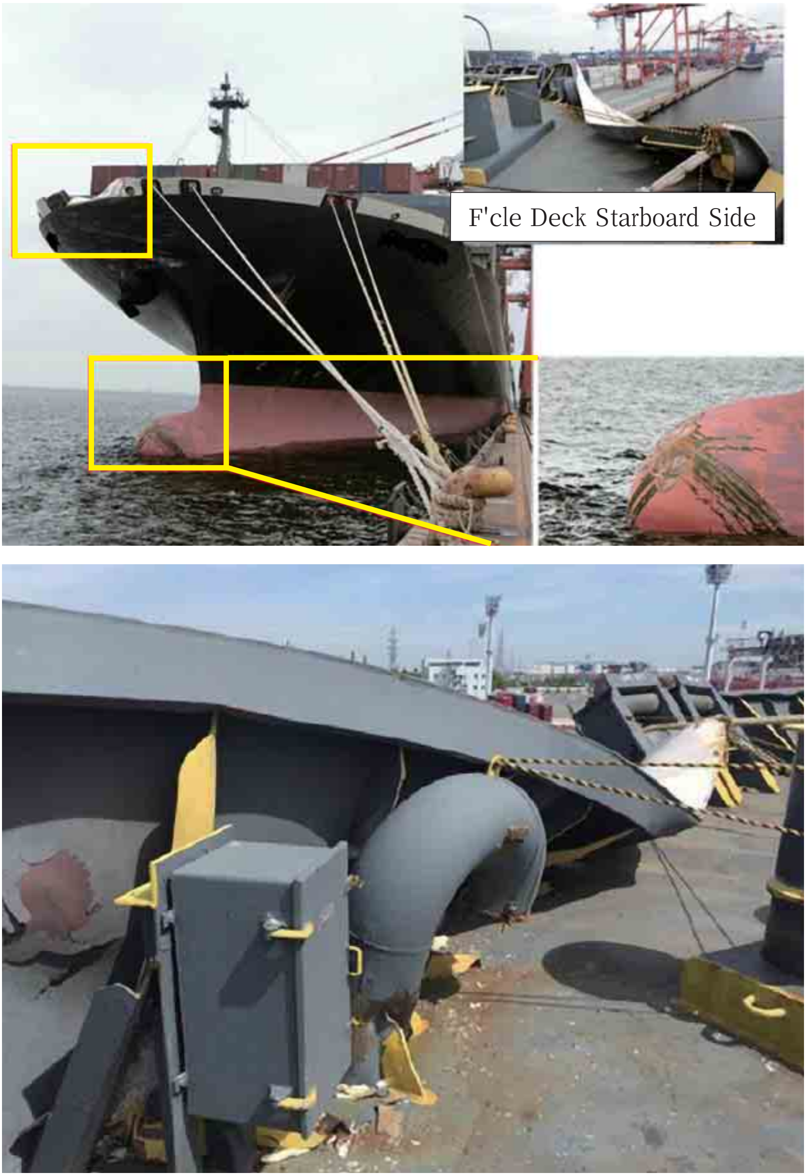
Container Vessel B Summary

Photograph 2

Gross tonnage	:	9,566GT
L×B×D (Length) (Breadth) (Depth)	:	141m×23m×12m
Port of origin	:	Osaka
Port of destination	:	Kobe RC-4
Cargo	:	20FT CTNR×197 40FT CTNR×208
Draft:	:	Fore 5.19m Aft 7.05m
Crew arrangement	:	Master and 17 other crew members, all Chinese nationals
Ship's Bridge on duty personnel at the time of the accident	:	Master B, Navigation Officer B and AB B
Master B	:	Master B was at the age of 45 with experience as Master since 2002. He boarded the Vessel on November 2017 and had more than 100 times experience as Master of calling at Hanshin Port in the Kobe area.

Damage

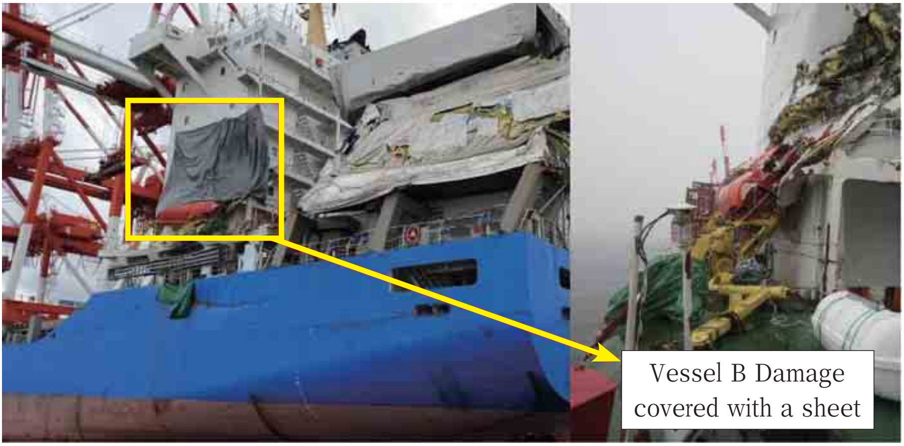
■ Vessel A was damaged due to a bent and dented bulwark at the starboard bow with scratched shell plating and concave loss on the bulbous bow. (Photograph 3)



Photograph 3

Photograph 4

■As for Vessel B, her accommodation spaces at the astern of port side and the shell plating on the port side was cracked.（Photograph 5）



Photograph 5

3－2　Events that Led to the Accident

In the table of events leading up to the accident (Attachment 9), items related to the accident cause are shown in red.

Ship handling to be applied

Although the conclusion is not yet known, as the decision of the Marine Accident Inquiry is still currently being deliberated (while the author is writing this Guidebook), relative position which seems to be applicable to a Crossing Situation (Article 15 of the Act on Preventing Collisions at Sea) would appear to be the case. However, considering the fact that both Vessel A and B frequently changed headings, increased or decreased speed, etc., and given the outcome of similar accidents, there is a high possibility that "Article 39 of the same law: Liability for negligence of caution, etc. (Managing officer of a seafarer)" will be applied. For reference, a crossing situation, actions by the give-way vessel and stand-on vessel, text regarding Crew responsibilities related to the Act on Preventing Collisions at Sea and the Act on Marine Accidents Inquiry Article 1 (Purpose) will be shown below:

Reference: Extracts from the Act on Preventing Collisions at Sea and the Act on Marine Accidents Inquiry

The Act on Preventing Collisions at Sea

■ (Crossing Situation)

Article 15

When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel. In this case, the vessel that must avoid the course of the other vessel shall not cross the bow of the other vessel unless it is unavoidable (Provisional translation).

■ (Action by give-way vessel)

Article 16

In accordance with the provisions of this Act, every vessel which is directed to keep out of the way of another vessel (stand-on vessel defined in the following article) shall, as far as possible, take early and substantial action to keep well clear.

■ (Action by stand-on vessel)

Article 17

(i) Where one of two vessels is to keep out of the way the other shall keep her course and speed.

(ii) The latter vessel (hereinafter, "stand-on vessel" in this Rule) may however take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules. In this case, if the requirements of Rule 15.1 apply to these vessels, the stand-on vessel shall turn to port unless impossible.

(iii) When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take the best possible cooperative action to avoid a collision.

■ **(Neglect of duties: Crew responsibilities)**

Article 39

This article stipulates that in the event of any consequences resulting from neglect of any of the following listed below, neither the vessel structure or materials, or vessel owner, or Master, or crew will be exempt from responsibility: appropriate navigation, observance of any lights or shapes displayed, the sending of signals, or any of the duties of the crew, be they either routine or those required in special circumstances.

Tha Act on Marine Accidents Inquiry Law

Article 1 (Purpose)

This article stipulates that in the event of any marine accidents caused either in the course of duties or through negligence, disciplinary proceedings against either maritime officers, or small vessel operators, or pilots, shall be determined at a maritime tribunal established by the Ministry of Land, Infrastructure, Transport and Tourism. The main purpose of which will be to help prevent further accidents from happening again.

3−3 Causes behind Maritime Accidents

By extracting the accident causes from the Japan Transport Safety Board Report (MA2019-6-02), the parts considered as the accident cause are highlighted in red. (See Attachment 9)

Container Vessel A

▶ 05:00 (approx.) Pilot A

Boarded Vessel A at Tomogashima pilot station. After conducting the information exchange about Vessel A and its port entry work with Master A, he started his pilotage of Vessel A. Through his pilotage on various vessels, he felt that the crew of Vessel A had received thorough training in BRM and assumed them to be trustworthy. Also, he assumed that Master A had a shared understanding of the navigation plan.

▶ 06:44 (approx.) Pilot A

Informed port radio via VHF No. 2 in Japanese as follows:

- He had arrived outside Hanshin Port of Kobe area, and
- planned to pass through the breakwater to RC-7 of Hanshin Port Kobe at approximately 07:20

The Pilot also heard that a vessel would pass Vessel A's bow from port radio; that " Vessel B would enter Kobe Central Fairway at approximately 07:15. " The Pilot visually confirmed Vessel B, but did not inform the Master.

▶ 06:53 (approx.) Master A

After visually confirming Vessel B on starboard bow at a distance of approximately 3.0 nautical miles, he also confirmed Closest Point of Approach (CPA) (hereinafter, DCPA) with Vessel B via No.1 Electronic Chart Display and Information System at 0.84 nautical miles (approx. 1,556 meters). Because Vessel B was heading in a southwest direction, and his Vessel was going to steer to port, the Master thought he could pass starboard to starboard with ample distance.

But, he did not mention the movement of Vessel B to Pilot A. Also, because

Pilot A did not mention the movement of Vessel B as well, near the sea chart table, he started discussing port entry work with C/O A.

▶ 06:55 (approx.) Pilot A

Because Master A appeared to be keeping lookout via radar, Pilot A kept a visual lookout for Vessel B's movements. At approximately 06:55, although he felt that there was no change of bearing between Vessel A and Vessel B, he assumed that the crew of Vessel A were paying attention to the movement of Vessel B, because Master A and 3/O A were watching the radar (ARPA) and ECDIS. Also, because he visually pointed to Vessel B. Then he instructed the vessel to steer to port side in order to head for Kobe Rokko Island East Waterway (hereinafter East Fairway).

▶ 06: 57 (approx.) Pilot A

Cadet A reported to Pilot A, Master A and 3/O A, because he was worried about a risk of collision with Vessel B.

Although he could not predict where Vessel B was heading immediately after she steered to starboard, he visually confirmed Vessel B's relative position. Vessel B would pass the bow of Vessel A, and he continued to steer to port side while reducing speed. Therefore, he kept manoeuvring, believing that his instruction regarding navigation in preparation for port entry work had been approved by Master A. In addition, Cadet A confirmed the risk of collision with Vessel B via radar and reported it to Pilot A (by saying "Closer!! Closer!!"), but the Pilot did not notice Cadet A's report.

▶ 06:57 (approx.) Master A and 3/O A

Did not notice the Cadet reporting. * Cocktail-party effect

Note: Cocktail-party effect (psychology terminology)

Please imagine a situation such as being at a job-well-done party or wedding after party. An example of this would be the way in which a person at a lively party is able to filter out all of the surrounding background noise and still hear their own conversation. They will even notice if their name is called out from across the room, because they can focus on the talk that interests them most. Thus, it is thought that humans have the ability to segregate different sounds and re-arrange them in order of priority. In psychology, this is known as the "cocktail-party effect". It may be that he did not pay attention to Cadet A's reporting on a routain basis.

▶ 07:02 (approx.) Pilot A, Master A and 3/O A

Did not respond to Vessel B's VHF call. He might have got into a panic as the Vessel was about to collide.

Container Vessel B

▶ 06:50 (approx.) Master B

Confirmed Vessel A (at bow and distance of approximately 4.0 nautical miles) and started lookout both via radar and visually. Then, at 06:52 (approx.), he steered to starboard heading for Kobe Central Fairway.

▶ 06:54 (approx.) Master B

Recognized crossing point with Vessel A and that Vessel B was the stand-on vessel. He was concerned about the decreasing DCPA of approximately 06:57, but assumed that vessel B could pass the bow of Vessel A without trouble, according to Vessel's A predicted course on the radar (ARPA). Also, if the speed had been increased to Nav. Full, he assumed that the vessel would reach port too quickly.

3－4 Accident Causes

Taking the above 9 factors into account, the Japan Transport Safety Board summarised the accident causes as follows:

Container Vessel A

Headed for the entrance of Kobe Rokko Island East Waterway and started steering to port side while reducing speed, Pilot A thought that Vessel A could pass the bow of Vessel B, which became the direct cause.

Although Pilot A continued to steer to port side along with reducing speed gradually in preparation for port entry, he assumed his vessel could pass the bow in relation to Vessel B which was visually confirmed, but apparently he did not realize there was a risk of collision with Vessel B.
Furthermore, Master A visually confirmed Vessel B at the point of 3.5 nautical miles in the distance, without confirming the movement of Vessel B with Pilot A. Judging by his vessel's relative position, before Vessel B steered to starboard side (had already passed Vessel B's bow), there is the possibility that he assumed that Vessel B would pass starboard to starboard and that there would be no risk of collision.

Container Vessel B

While heading for the entrance of Kobe Central Fairway, he continued manoeuvring believing that he could pass the bow（front）of Vessel A, which we consider to be the direct cause.
From Vessel A's sailing route and predicted course via radar (ARPA data), Master B assumed that Vessel A would follow her original course. (In fact, Vessel A started steering to port side).
He confirmed the ARPA data via radar（vector diagram and DCPA and TCPA digital display), but there is a possibility that he believed that Vessel B was to be the stand-

on vessel at the crossing point with Vessel A. This is why he completely believed that Vessel B could pass the bow of Vessel A without the need to confirm visually.

Information exchange via VHF

Another cause behind the accident could be that neither communicated one another's sailing route at an early stage using VHF.

Although Vessel A obtained the other vessel's information from port radio, neither paid attention to each other's Vessel's movements. Mutual communication might have prevented the accident.

3－5　Transport Safety Board Report ＝ Recurrence Preventive Measures ＝

The Japan Transport Safety Board Report (MA2019-6-02) summarises preventive measures to be taken as follows:

Pilot

- A constant watch must be kept both visually, and by means of radar and ECDIS navigation instruments.
- When another ship is passing in close proximity, the risk of collision must be considered. VHF contact should be made to the other vessel with a request for their co-operation to avoid such an outcome.
- The respective officers of the watch of the two vessels should verbally clarify each other's manoeuvres and headings.
- Communication should be in the local language (Japanese), and the contents relayed to the Ship's Master.

Photograph 6 courtesy of the Japan Captains' Association, DVD

Master A and Master B: Common characteristics of both vessels

- Together with the pilot, the respective officers of the watch should verbally clarify each others' manoeuvres and headings.
- Even when there is a pilot on board, both the crew and the Master himself must be aware that navigation is ultimately the responsibility of the Master and that constant surveillance must be maintained.
- When coming into close proximity to another vessel, both the Master and the Pilot must be aware that the "distance of closest approach" (DCPA), which is based on the location of each vessel's GPS antenna, does not take into account the length and width of either vessel. Sufficient separation must be maintained for both vessels to safely pass each other.
- To safeguard the storage of objective data in the event of any accident, the Master must ensure that the crew are fully competent with operating the VDR.

Vessel A switched off its VDR immediately after the accident in order to preserve the data, however the vessel set off on its next voyage before the data could be extracted (Kobe to Nagoya). The VDR was again switched on and the previous data overwritten and deleted.

Photograph 7

§4 4M5E Analysis of a Case Study Collision Accident

4−1 Summary of Related Facts

Related facts from the previous chapter “3-3 Events That Led to the Accident” were summarised in the “Maritime Accident Summary of Related Facts.” This brings us to the following:

- There is nothing applicable to Unsafe conditions.
- Rather a number of unsafe behaviours of Pilot A are examined.
  Bias and assumptions are particularly noticeable.

Attachment 10 Vessel A and Vessel B Collision Accident Summary of Related Facts

Reference No.	Identified problems from survey findings				Direct cause		Accident cause evaluation	Re-examination necessity
	Date	Time	Caused by	Check facts and problem areas	Unsafe behaviour	Unsafe conditions		
1	XX May	05：00 Approx.	Pilot A	Felt that the crew of Vessel A had received thorough training in BRM and assumed them to be trustworthy. Also, assumed that Master A had a shared understanding of the navigation plan.	○		4	
2	XX May	06：44 Approx.	Pilot A	Visually confirmed Vessel B, but did not inform the Master of port radio information (Vessel B bound for RC-7).	○		3	
3	XX May	06：53 Approx.	Master A	Assumed that Vessel B would keep its distance when passing the starboard side of Vessel A.	○		5	
4	XX May	06：53 Approx.	Master A	Did not mention the movement of Vessel B to Pilot A. Also, as Pilot did not talk to him about Vessel B, he started discussing port entry work near the sea chart table with 1/O A.	○		6	
5	XX May	06：55 Approx.	Pilot A	Although he felt that there was no change of bearing between Vessel A and Vessel B, he assumed crew of Vessel A were paying attention to the movement of Vessel B, because Master A and 3/O A were watching the radar and ECDIS. Pilot A himself confirmed Vessel B visually by pointing.	○		1	
6	XX May	06：57 Approx.	Pilot A	Assumed that Vessel B would pass their bow, and continued to steer to port side.	○		2	
7	XX May	06：57 Approx.	Pilot A	Did not notice the Cadet reporting.	○		7	
8	XX May	06：57 Approx.	Master A and 3/O A	Did not notice the Cadet reporting earlier.	○		8	
9	XX May	07：02 Approx.	Pilot A, Master A and 3/O A	Did not respond to Vessel B's VHF call.	○		9	
10	XX May	06：57 Approx.	Master B	Was concerned about decreasing DCPA, but assumed that vessel B could pass the bow Vessel A, according to the predicted course Vessel A on the radar.	○		10	
11	XX May	06：57 Approx.	Master B	Assumed that the vessel would reach port quicker if speed was increased to Nav. Full.	○		11	
12			Master B and ship management company B	Did not instruct navigation officer to report and lookout thoroughly. (BRM is was not implemented)	○		12	○
13			Pilots' Associations	Were the pilots obliged to take BRM training periodically?	○		13	
14			Master A	Non-compliance with Safety Management Code	○		14	○
15			Ship management company A	Non-compliance with Safety Management Code	○		15	○

Accident cause assessment: Prioritized according to the scale of the cause

Fig. 18 (Attachment 10)

Regarding the examined behaviours in the list of related facts, each unsafe behaviour will be summarised while carrying out a Why Why Analysis.

4−2 “Analysis of Unsafe Behaviour” for Pilot A

After carrying out the Why Why Analysis regarding Pilot A’s unsafe behaviour which was extracted from the “Maritime Accident Summary of Related Facts”, we can see that the causes of the unsafe behaviour are mostly associated with “Man” of the 4M. (Figure 19)

In addition, in this situation, Management stipulates that Pilot A, as a member of the BRM structure, should exchange information, but this was not adhered to. Thus, there is a necessity to investigate as to whether the Pilots associations have such policies and operation manuals, and if so, ascertain as to why Pilot A could not follow them.

	Cause (Unsafe behaviour)	Man																				
		Human factor (The vessel, shipowner and ship management company)																				
		1 Psychological												2 Emotional					3 Organizational			
	In ①, write down a direct cause which was investigated based on the facts After ②, write down the root cause using the Why Why Analysis. Then, circle each applicable cause. Regarding items other than Man (Human factors), enter the sub-item number of each item in the 4M Classification List.	① Impulsive action	② Forgetful	③ Habituation behaviour	④ Personal problems	⑤ Unconscious acts	⑥ Sense of urgency and sensitively	⑦ Mental shortcuts	⑧ Cuts corners	⑨ Judgement based on speculation	⑩ Mistakes and perceptual illusion	⑪ Habituation phenomenon	⑫ Personality	① Fatigue	② Lack of sleep	③ Alcohol, medicine or disease	④ Physical ability	⑤ Ageing	① Desire and willingness	② Leadership and teamwork	③ Communication	④ Commitment (responsible intervention)
Pilot A																						
1	1. Why was it assumed that the crew of vessel A had been thoroughly trained in BRM and that Master A had a shared understanding of the Passage Plan?									○		○									○	
②	Was there not enough time to confirm?	○		○					○													
③	Was it because the vessel belonged to his affiliated shipping company?									○	○											
2	2. Why was information on Vessel B not reported to Master A?								○	○										○	○	
②	Assumed that the Master understood because he also checked Vessel B.							○	○	○											○	○
5	5. Why did he think the crew were paying attention to Vessel B?							○	○	○										○	○	
②	Why did he assume confirmation was not needed because the crew were monitoring the ECDIS?	○				○			○	○										○	○	○
6	6. Why did he assume that Vessel B would pass their bow, and continued to steer to port side?			○				○	○	○	○	○										
②	Why did he not check the change of relative bearing or DCPA?	○								○		○										
7	7. Why did he not notice Cadet A reporting?			○		○			○											○	○	
②	Why did he not pay attention to Cadet A as well?									○												
③	Why did believe that Cadet A's skills were insufficient?			○						○												
9	9. Why did he not respond to Vessel B's VHF call?	○																				
Total number of circled items		4		4		2		3	7	10	2	3								4	6	2

	Cause (Unsafe behaviour)	Man														Machine						Media					Management												Necessity of re-investigation
		Human factor (The vessel, shipowner and ship management company)														Mechanical factors such as machinery not working properly or being out of order						Media connecting Man with Machinery					Management factors and organization												
		4 Individual skills												5 Management of health and working environment		Mainly on the vessel						The vessel, shipowner and ship management company					On the vessel						Shipowner and Ship management company						
		4-1 Inadequate knowledge					4-2 Inadequate skills			4-3 Poor work ethic																													
		① Inadequate or inappropriate knowledge about the work to be carried out	② Work content not understood or misunderstood	③ Lack of a sense of urgency and awareness	④ Mistakes regarding work procedure/ forgetfulness	⑤ Lacks basic knowledge of the work	① Unaccustomed to work, inexperienced, inadequate skills	② Not enough training	③ The belief that the work done is satisfactory, when objectively it is inadequate	① Not "ready" to work	② Intentionally dishonest regarding work, and breaks the rules	③ Covers up or tolerates dishonest work	④ Protective wear not worn	① Health check not implemented prior to working	② Tool box meeting was not implemented	① Design flaw in the machinery	② Defective protection against hazards	③ Lack of fundamental safety (design and ergonomic arrangement)	④ Lack of consideration regarding ergonomic factors	⑤ Lack of standardization	⑥ Lack of machinery and facility maintenance, etc.	① Lack of information regarding work to be carried out	② Work preparedness/inadequate working conditions	③ Inappropriate work method	④ Inadequate work space	⑤ Poor working environment conditions	① Inadequate management/ organization	② Inadequate/incomplete regulations and procedure manual	③ Inadequate safety management planning	④ Lack of education and training	⑤ Inadequate layout arrangement	⑥ Inadequate supervision of his/her subordinates	① Inadequate management/ organization	② Inadequate/incomplete regulations and procedure manual	③ Inadequate safety management planning	④ Lack of education and training	⑤ Inadequate layout arrangement	⑥ Inadequate supervision of his/her subordinates	
Pilot A																																							
1	1. Why was it assumed that the crew of vessel A had been thoroughly trained in BRM and that Master A had a shared understanding of the Passage Plan?																											①							①						
②	Was there not enough time to confirm?																																						
③	Was it because the vessel belonged to his affiliated shipping company?																																						
2	2. Why was information on Vessel B not reported to Master A?																																						
②	Assumed that the Master understood because he also checked Vessel B.																																						
5	5. Why did he think the crew were paying attention to Vessel B?																																						
②	Why did he assume confirmation was not needed because the crew were monitoring the ECDIS?																																						
6	6. Why did he assume that Vessel B would pass their bow, and continued to steer to port side?																																						
②	Why did he not check the change of relative bearing or DCPA?																																						
7	7. Why did he not notice Cadet A reporting?																																						
②	Why did he not pay attention to Cadet A as well?																																						
③	Why did believe that Cadet A's skills were insufficient?																																						
9	9. Why did he not respond to Vessel B's VHF call?																																						
Total number of circled items																												1							1						

Fig. 19 (Attachment 11)

Looking at Human factors, it is possible to see that there is a concentration of factors that fall under 1 Psychological Factors ⑧ Cutting corners and ⑨ Judgement based on speculation. In addition, there are many issues related to ② Leadership and teamwork and ③ Communication, in 3 Organizational factors.

It is understandable that it may be difficult to exchange information with other members of the Bridge including the Master of the vessel because of such pilotage conditions in Osaka Bay where traffic is congested. However, ⑪ Habituation phenomenon and ⑤ Unconscious acts and Judgement based on speculation and so on, and each item applicable to the list here all contribute to the chain of human errors.

In addition, Cadet A reported the movement of Vessel B shortly before the collision, but they did not notice. "People are unconsciously prone to believe only what they want to believe" and "information that supports what they believe rather than purposefully seeking information to the contrary" from ③ Psychological factors on "1-2 As a Mechanism behind Maritime Accidents Caused by Human Error" of which Confirmation bias (psychology terminology) might have contributed as well.

4—3 " Analysis on Unsafe Behaviour " for Master A and Master B

In the same way as Pilot A, the Why Why Analysis will be carried out here regarding the unsafe behaviour of Master A and Master B.

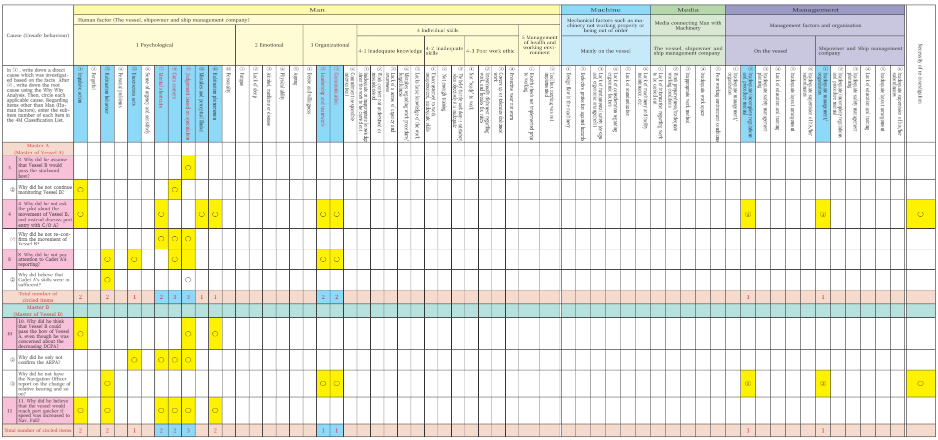


Fig. 20 (Attachment 12)

Master A

We can see that the causes of unsafe behaviour are mostly associated with “Man” of the 4M. As shown in Figure 31 and on close examination, we can see that there is a tendency for ⑦ Mental shortcuts, ⑧ Cutting corners and ⑨ Speculation and judgement in 1 Psychological factors. Also, similarly to Pilot A, problems can be identified in ② Leadership and teamwork and ③ Communication in 3 Organizational factors.

Vessel B’s movement was confirmed only once. However, it was before Vessel B changed her direction bound for Kobe RC-4 (Kobe Rokko Island) and, at that point, the stem of the Vessel B was facing a southwesterly direction（Tomogashima Channel direction). This is why he believed Vessel B was an outgoing ship from Osaka Bay and that he could pass starboard to starboard.

As introduced in “ 4 Human Brain Capacity ” in “P.7 1-2 As a Mechanism behind Maritime Accidents Caused by Human Error”, once he/she may have had a bias, we understand the difficulty in thinking differently about something once it set in one’s mind.

He let Pilot A take care of the manoeuvring, and started discussing port entry work with C/O A. It must be said that he neglected his top priority of keeping lookout, which shows that the prioritizing of work proved to be challenging.

We presume that the importance of BRM is stated in the SMS manual at the ship management company. But as this is still unknown, we circled the column Re-examination necessary regarding: ① Inadequate management/organization, ② Inadequate/incomplete regulations and procedure manual, ③ Inadequate safety management planning, and ⑥ Inadequate supervision of his/her subordinates, in the items under Management.

Master B

Similarly to Master A, it is possible to see that there is a concentration of factors that fall under Man (Human factors) in 1 Psychological Factors ⑦ Mental shortcuts, ⑧ Cutting corners and ⑨ Judgement based on speculation. In particular, he was distracted in order to not be delayed for the port arrival time which caused him to neglect monitoring Vessel A. Also, another reason as to why he did not pay attention to the movements of Vessel A was because he neglected to confirm visually as a result of solely relying on the ARPA（CPA/TCPA) system.

4－4 Countermeasures for“ Unsafe Behaviour ” for Pilot A

As there were no related facts applicable to unsafe conditions, regarding the unsafe behaviour of Pilot A and the pilots' association, we are going to consider measures with "Analysis using 4M5E and Countermeasure List (Unsafe behaviour)".

On listing up the examined factors, it is possible to ascertain countermeasures.

The root causes can be identified in the following:

- Human beings face difficulty thinking differently about something once they have it set in their mind.
- Lack of awareness that the pilot is also a member of the BRM structure.

Recurrence Prevention Countermeasures

- BRM re-training
- Training in psychology (mental state of mind)

The Pilots' Associations, as organizations, also need to take preventative measures

- Creation or review of the procedure manual
- Introduce BRM training and training that covers mental state of mind

Attachment 13 **Vessel A and Vessel B Collision Accident Analysis using 4M5E and Countermeasure List (Unsafe behaviour): Pilot A**

	Man	Machine	Media	Management	
	The vessel, shipowner and ship management company	Mainly on the vessel	The vessel, shipowner and ship management company	On the vessel	Shipowner and ship management company
Risk factors (Direct cause and indirect/ root cause)	1 Psychological 1. Why was it assumed that the crew of vessel A had been thoroughly trained in BRM and that Master A had a shared understanding of the Passage Plan? (1- ① , ③ and ⑧〜⑪) 2. Why was information on Vessel B not reported to Master A? (1- ⑦〜⑨) 5. Why did he think the crew were paying attention to Vessel B? (1- ① , ⑤ and ⑦〜⑨) 6. Why did he assume that Vessel B would pass their bow, and continued to steer to port side? (1- ③ , ⑤ , ⑧ and ⑨) 7. Why did he not notice Cadet A reporting? (1- ③ and ⑨) 9. Why did he not respond to Vessel B's VHF call? (1- ①) 3 Organizational Related Facts 1, 2, 5, 5, 7 and 9 ② Why could he not exert leadership as a conning officer? ③ Why could he not communicate with the Master?			13. Incomplete BRM including pilot (2- ①)	13. Incomplete BRM including pilot (2- ①) 13. Not enough training about psychological factors invites human error (2- ①)
Education Education and training Knowledge, skills, consciousness, being given information, etc..	Cause ・Human beings face difficulty thinking differently about something once they have it set in their mind. ・The pilot is also a member of the Bridge. It would have been naive not to have considered him part of the BRM structure. Recurrence Prevention Countermeasures ・BRM re-training ・Training in psychology (mental state of mind)				
Engineering Technology and engineering Engineering countermeasure					
Enforcement Thorough guidance and enforcement Standardization, proceduralization, alerting, reward and punishment KYT, Campagnes etc..					Recurrence Prevention Countermeasures ・Thorough guidance and creation of procedure manual for pilotage regarding BRM (Pilots' associations)
Examples Case studies, countermeasures and rules Lead by example, experience of success, introduce model cases, "Hiyari-Hatto" (near misses), etc.					Recurrence Prevention Countermeasures ・Introduce model cases, BRM training and training that covers mental state of mind(Pilots' associations)
Environment Working environment, office internal management, onboard organization, etc.					

Each item number (bold and red coloured) corresponds to the Summary of Related Facts No. in the Attachment 3
The number applies to the number in Attachment 2-2 (Maritime Accidents 4M Classification List)

Fig. 21 (Attachment 13)

After transcribing the results of the analysis in 4-2 "Analysis of Unsafe Behaviour" for Pilot A into the risk factors column (in the column of Direct and indirect/root causes (coloured in pale yellow) of "Analysis using 4M5E and Countermeasure List (Unsafe behaviour)", the Why Why Analysis will be carried out here regarding each risk factor. The root causes can be identified in the following two points:

- **Human beings face difficulty thinking differently about something once they have it set in their mind.**
- **Lack of awareness that the pilot is also a member of the BRM structure.**

Psychological Factors : Man

The following numbers correspond with Attachment 10.

1 Pilot A assumed that the crew of vessel A had been thoroughly trained and that Master A had a shared understanding of the manoeuvring.

Although not stated in the report by the Japan Transport Safety Board, Vessel A's operation and ship management were both managed by the shipping company from where Pilot A belonged.
He might have assumed that the BRM training had been thoroughly carried out.

2 06:45 (approx.) He visually confirmed Vessel B and checked the movement of Vessel B with port radio, but he did not report this to Master A.

Resource management via communication with " resources surrounding the subject " (See Figure 6), which is based on the concept of BRM, was not sufficient. This generated a gap between the subject and other people except the subject which is the most important resource where human error would be caused.
Not informing the movement of Vessel B to Master A, 3/O A, Cadet A and A/B A is applicable to the " Hidden area: Imformation that a person knows about themselves that is kept unknown to others " in the Johari Window (See Figure 5). Had such information been shared appropriately, this would have been changed to an Open area, which would have allow the ship's bridge on duty personnel of Vessel A to have kept paying attention to the movement of Vessel B and to report it to Pilot A. This exchange of information might have made it possible to make a give-way manoeuvre prior to being in a dangerous situation.

5 He thought that the crew were paying attention to Vessel B.

06:55 (approx.) Assumed crew of Vessel A were paying attention to the movement of Vessel B, because Master A and 1/O A were watching the ECDIS (Electronic Chart Display Information System). They also confirmed Vessel B visually by pointing.
However, Master A and C/O A moved away from the ECDIS just prior to this, and they started discussing port entry work beside the sea chart table. Lookout was neglected.

6 06:55 (approx.) Headed for the entrance of the East Fairway and continued to steer to port, assuming that Vessel B would pass their bow

He instructed the vessel to reduce speed in preparation for port entry and docking work, but he did not allow the crew to report the actual speed, and did not check it himself. He assumed that the vessel could pass the bow of Vessel B owing to his pilotage experience.

7 Did not notice Cadet A reporting

06:57 (approx.) Cadet A reported“ Closer ”to mean that Vessel B was too close. The timing of the report was a little too late, however, since it was around five minutes prior to the collision, this would have been the crucial moment to have given way. It cannot be denied that not enough attention was paid to the report that was made by the cadet.

9 Did not respond to Vessel B's VHF call

Shortly before the collision, VHF calls were made twice by Vessel B, but non were returned. This presumably was not noticed because a collision was imminent and he panicked.

Workplace Factors: Man and Management

The root causes were (1) both Master A and Pilot A did not adequately perform their leadership duties as conning officers and (2) could not communicate with Vessel A’s bridge on duty personnel. Pilot A well understood the importance of BRM, but it is presumed that he could not carry it out in reality.

Recurrence Prevention Countermeasures

Pilot A felt deeply responsible for causing the accident. However, as mentioned above, the root cause behind the chain of human errors was caused by Psychological factors. Even though there were several chances to break such a chain of errors after having boarded Vessel A until the accident occurred, resource management (the foundation of BRM) was ineffective and the error chain could not be broken as a result, which inevitably lead to the collision accident. Because it was unknown as to what kind of safety measures had been implemented by the Pilots' Associations, we raised the issue that a Re-examination was necessary.

Recurrence Prevention Countermeasures through Education (education and training) in 5E for Pilot A

After removing the above risk factors, the following two preventive measures remain.

- **BRM re-training**
- **Training in psychology (mental state of mind)**

After Pilot A took above mentioned training and lecture, had he have taken actions such as Self-analysis and told other pilots around him about his experiences, this may have been helpful in preventing a recurrence.

Management (Pilots'Associations) : Preventive measures by Management

According to the Japan Transport Safety Board’s report, Pilot A took BRM training 3 years prior to the accident (in 2015). We naturally assume that accident prevention activities are appropriately implemented by Pilots' Associations. However, it is still unknown if such accident prevention measures pertaining to Management were sufficient or not, therefore, it would be necessary to review the accident prevention measures through Re-examination. Thus, we have identified Re-examination necessary in the countermeasure list.

4−5 Countermeasures for“ Unsafe Behaviour ”for Masters A and B

The root causes can be identified in the following three points:

- Human beings face difficulty thinking differently about something once they have it set in their mind.
- Lack of awareness that pilot is also a member of the BRM structure. Collapse of communication (the foundation of BRM) Master A starts discussing port entry work with C/O A.
- Mistakes regarding work prioritization.

Recurrence Prevention Countermeasures

- BRM re-training
- Re-training of Safety Management System (SMS)

The Company, as organizations, also need to take preventive measures.

- Reviewand make the work procedure.
- Introduce BRM training and traing that covers mental state of mind.

Attachment 14 Vessel A and B Collision Accident Analysis using 4M5E and Countermeasure List (Unsafe behaviour): Master A and Master B

	Man	Machine	Media	Management	
	The vessel, shipowner and ship management company	Mainly on the vessel	The vessel, shipowner and ship management company	On the vessel	Shipowner and ship management company
	Master A 1. Psychological 3. Why did he assume that Vessel B would pass the starboard bow, without continuously monitoring Vessel B? 4. Why did he start discussing port entry work with C/O A? 8. Why did he not pay attention to Cadet A's reporting? (1- ①, ③, ⑤ and ⑦∼⑪) 3. Organizational factors (Related Facts No. 3, 4, 8 and 9) ② Why could he not exert leadership as a			Vessel A 14. Why did he not comply with the Safety Management Code? (2-①) 4. Why did he interrupt lookout duty to start discussing port entry work with C/O A in the middle of S/B? (2-①)	Ship management company A 15. Why did he not comply with the Safety Management Code? (1-③) 4. Why did he interrupt lookout duty to start discussing port entry work with C/O A in the middle of S/B?

Fig. 22 (Attachment P. 14)

Let's take a closer look at the preventive measures for unsafe behaviour of both Master A and Master B. Just as with Pilot A, Analysis using 4M5E and Countermeasure List (Unsafe behaviour) will be used here. It is clear to see that the root cause underlying Psychological factors and Organizational factors has to do with Man on both sides.

Psychological Factors Regarding Master A: Man

The root causes can be identified in the following three points: Each number corresponds with a Summary of Related Facts No.

3 He assumed that Vessel B would pass the starboard bow, without continuously monitoring Vessel B.

06:53 (approx.) Master A visually confirmed Vessel B, but Master A did not watch continuously.

At this moment, Vessel B's bearing was <068> and her distance at approx. 3.4 nautical miles and steering to starboard, but she would have been heading in a southwest direction. Also, the ARPA showed Closest Point of Approach (CPA) to be 0.22 nautical miles on the starboard side and TCPA displayed 6.5 minutes later. Together with those and the vector, Master A assumed that Vessel B was an outgoing vessel from Osaka Bay and completely believed that he could pass starboard to starboard.

However, Pilot A was in contact with port radio via VHF at approx. 06:45 and understood that Vessel B was a shifting ship between Osaka Bay and Kobe RC-4.

Port radio communications with Pilot A was conducted in Japanese and Master A did not understand the contents. But, he would have noticed that Pilot A was using VHF to relay information. At that point, if he had confirmed with Pilot A what he was talking about, the chain of errors could have been broken at this stage.

4 He started discussing port entry work with C/O A.

06:53 (approx.), he let 3/O A man the bridge to take over from 1/O A and started discussing port entry work with C/O A beside the sea chart table. It is important that discussion immediately prior to work be conducted, so it is also known that the most important work to be done during S/B in a congested area like this is lookout. Errors regarding work prioritization.

8 Did not notice Cadet A reporting

Similarly to Pilot A, it cannot be denied that not enough attention was paid to the report that was made by the cadet. As usual, and not just on this occasion, he did not notice the Cadet reporting.

Workplace Factors Regarding Master A: Man

Even when a Pilot is on board, the Master is ultimately responsible as navigator. But, just as with Pilot A, (1) leadership duties were not adequately performed, (2) communication with the vessel's bridge on duty personnel including Pilot A was insufficient. These underlay the root cause. It is considered that BRM was infeasible.

Risk Factors Regarding Management of Master A and Ship Management company A

The ship management company of A's SMS Manual clarifies the procedures during port entry work. Why was this not adhered to? Also, as mentioned earlier, why did he neglect to carry out important lookout work and management of the ship's bridge on duty personnel to start discussing port entry work with C/O A?

It is apparent that both Master A and the Safety management company are fully aware that compliance with the Safety Management Code is a top priority. However, why were they unable to realize this? As further examination and analysis to clarify the reason is necessary, we have designated this as Re-examination necessary.

Psychological Factors Regarding Master B: Man

The root causes can be identified in the following two points:

10 He thought that Vessel B could pass the bow of Vessel A, even though he was concerned about the decreasing DCPA. In addition, he checked ARPA data only and did not confirm it visually.

Furthermore, whilst Master B did appear to pay attention to the movements of Vessel A, he neglected to make a visual confirmation and believed blindly in the ARPA (CPA/TCPA) data alone. In addition, 3/O B on the bridge did not give the order to monitor the movements of Vessel A. When focusing on ship handling in congested sea areas, it is possible to lose sight of the surrounding circumstances, because it is very difficult for crew to perform 3 or 4 different tasks simultaneously. To deal with this problem, the bridge personnel need to form a team which can exert efficient BRM and raise the level of safety. However, this did not happen on this occasion.

11 Assumed that the vessel would reach port delayed or quicker if speed was decreased or increased

Although he believed that the vessel could have just passed the bow of Vessel A, based on the relative bearing of A, and if the speed was maintained, it would have been problematic to do such a manoeuvre using only ARPA data in such close quarters.

In addition, the Master steered to starboard while increasing speed just prior to the collision. The author understands that DCPA will increase when speed is increased, but it is impossible to rapidly increase speed for a large-sized vessel.

The author believes that Master B did his very best given the somewhat stressful circumstances and understands that he may have used the engine for better rudder effect due to there being more than 1 nautical mile to Kobe Central Fairway, but believes that his testimony regarding his concern as whether speed should have been increased (or decreased) to be questionable.

Recurrence Prevention Countermeasures

Recurrence Prevention Countermeasures through Education (education and training) using 5E for Master A

The Master is expected to handle the ship in congested areas until the Pilot arrives on board. However, there is a tendency due to language difficulties to just hand over responsibility to the pilot upon their arrival.
This author has also experienced entry into Kobe port on many occasions. Typically we would pick up the pilot at 04:00 in the morning, which would require some time rescheduling from around 23:00 the previous night at Cape Muroto or off the coast of Cape Shiono (adjustment of engine speed, change of course etc.). At this point I would take command of the bridge. However, it is said that the average human concentration span is around 40-50 minutes, with 90 minutes being an absolute maximum. Under busy continuous working conditions, that span begins to fade and become even shorter. The tendency to leave it all up to the Pilot when he comes on board is therefore understandable given the level of mental and physical fatigue of the crew.

That said though, the command of ship handling is not something which should be simply handed over to the Pilot. The Master must retain responsibility until safely docked at port. Exercising good BRM, including management of the Pilot, is one of the duties of the Master.

With this in mind, the measures needed to be taken by Master A, to prevent recurrence of this danger, can be summarised in the following two points.

- **BRM re-training**

  When the pilot boards, is enough information exchanged, or would there have been enough information exchanged regarding a head-on situation like this?
  The pilot checked port radio for the movement of Vessel B via VHF.

Although he knew that Vessel B was communicating in Japanese and that he could not understand what was being said, he could see that the pilot was communicating via VHF. At the time once they had finished speaking, he should have proactively asked the pilot if there was any information that needed to be shared with him.
Also, when he started discussing port entry work with C/O A, he let 3/O A take over from 1/O A immediately after he ascended and started manning the bridge. Was he really aware of the surrounding situation when he took over?
Although he took BRM training, he was unable to practise it in reality, which is the root cause behind the accident. Thus, he is required to take BRM re-training.

・Re-training of Safety Management System (SMS)

Details including the importance of BRM regarding duties on departure and entry, congested areas, reduced visibility would be written in the Safety Management System (SMS). Master A had also seemingly received training in the Safety Management System (SMS) several times. Still, it is necessary to analyse as to why he could not practice this on board and to recommend re-training.

Recurrence Prevention Countermeasures through Management (management and organization) Applying 5E to Ship Management Company A

The ship management company proactively provided the crew with BRM training and seminars on the Safety Management System(SMS). We have identified this as Re-examination necessary, because we do not know the contents of the program.
In other words, crew (those who attended lectures and training) vary in levels of competency, and, consequently, may not be able to apply such training to actual circumstances, thus leading to an accident.
This is the reason why there needs to be further investigation as to why the Safety Management System (SMS) was not adhered to and, furthermore, the following

countermeasures need to be examined and implemented if necessary.

Countermeasure through Guidance and Enforcement (Enforcement)

Review, disseminate, and carry out training of Safety Management System (SMS) procedures for Pilot duty when the Pilot is on board. Also, VDR data was overwritten, thus data at the time of the accident is not available. VDR operation skills and a review of the procedure manual may be required.
In addition, for the time being, it will be of value to continuously carry out internal audits and hold collision recurrence prevention campaigns. Moreover, the Master must realize that he is in charge even when a pilot is on board. However, he must also understand that it may be difficult to supervise a pilot as intended. The ship management company should check with the Pilots' Associations for any relevant improvements.

Recurrence Prevention Countermeasures through Education (education and training) Applying 5E to Master B

Similarly to Master A, one of the contributing root causes Psychological factors: Human beings face difficulty thinking differently about something once they have it set in their mind. Another contributing root cause would be the collapse in communication, such as bridge on duty personnel management and the exchange of information externally, which are the foundations of BRM. Therefore, the following have been identified as recurrence prevention countermeasures:

• BRM re-training

Similarly to Master A, although Master B appears to have taken BRM training, he was unable to practise this in reality. BRM re-training is one recurrence prevention countermeasure that could prove to be effective for those not ready to carry it out in practice.

・Re-training of Safety Management System (SMS)

It appears that the vessel was not able to carry out port departure and entry work in accordance with Safety Management System(SMS), and similarly to Master A, re-training will be necessary.

Recurrence Prevention Countermeasures through Management (management and organization) Applying 5E to Ship Management Company B

As in the case of Company A, the following recurrence prevention countermeasures could be considered: (1) to analyse why the Safety Management System(SMS) was not adequately performed at sea, and if necessary, (2) to review the Safety Management Code regarding duties on departure and entry, narrow channels, reduced visibility and so on, and (3) to disseminate and carry out training for improvement.

4-6 Accident Analysis from the Perspective of Human Factors and Human Error

Attachment 15 Vessel A and B Collision Accident Human Behavioural Traits and Human Error (Psychological Analysis)

Time	Movement	Who?	Behaviour	Human characteristics	P sychology
06 : 10	Vessel A After passing Tomogashima Channel, changed course to the northeast for Kobe Rokko Island Berth.	Pilot A	From past experience as a pilot, he assumed the crew of Vessel A to be trustworthy.	⑨ Human beings sometimes make assumptions	③ Confirmation bias People unconsciously collect information that supports what they believe.
		Pilot A	Assumed that Master A had a shared understanding of the navigation plan.	⑨ Human beings sometimes make assumptions ⑩ Human beings are sometimes lazy. Did not explain procedure sufficiently enough to the Master after boarding.	② Normalcy bias Assumed everything would be fine, because this method had been fine up until now. ③ Confirmation bias Only collected information that supported what what he/she believed.
06 : 45 Approx.		Pilot A	Informed port radio via VHF of the approximate time he	③ Human beings sometimes forget	④ Social loafing [illegible]
	Vessel B Steered north-westerly heading for the entrance of Kobe Central Fairway	Master B	Concerned about decreasing CPA, but assumed that the vessel could pass the bow, according to the vector indicated on ARPA.	⑨ Human beings sometimes make assumptions ⑤ Human beings have moments of inattention ⑩ Human beings are sometimes lazy. ⑥ Human beings are sometimes only able to see one thing at a time Only confirmed information via ECDIS and ARPA	② Normalcy bias People ignore negative information and underestimate phenomena saying "I'm special, nothing can hurt me!"

Fig. 23

The "Human Characteristics" column on figure 23 lists the item numbers from figure 2 (Human characteristics), and the "Psychology" column lists number from 3 Psychological Factors.

For example, at 06:10 (approx.) Pilot A thought that he had shared his understanding of manoeuvring with Master A, but they never actually communicated with each other in reality. We can assume that information exchange using the Pilot Card in accordance with the procedure manual was all but a formality. This can be analysed as follows:

Human characteristics

⑨ Human beings sometimes make assumptions, and

⑩ Human beings are sometimes lazy

He did not explain the procedure sufficiently enough to the Master after boarding, as he assumed it would not be necessary, despite the fact that the circumstances at that time were unknown. As a result, he probably simplified his usual explanationtion.

Psychological factors

② Normalcy bias

Psychologically, he assumed that everything would be fine, because this method had been fine up until now.

Did he not underestimate the importance of exchanging information?

Psychological factors

③ Confirmation bias

According to human behavioural characteristics, could it be that when he quickly observed Master A and other bridge personnel, that he may have had the bias that the crewmembers were all conversant in BRM?

Although mentioned earlier above, Master A visually confirmed Vessel B at approximately 25.0 degrees on its starboard bow at approx. 06:53. However, because Master A did not hear from the Pilot that Vessel B would head for Kobe Central Fairway, he assumed that there would be no risk of collision judging by his vessel's relative position with the other ship: that it would be heading in a southwest direction (Outgoing Osaka Bay). He also neglected paying attention to the movement of Vessel B afterwards. This, too, can be applied to human characteristics and psychological factors as follows:

Human Characteristics

⑤ Human beings have moments of inattention,
⑨ Human beings sometimes make assumptions and
⑩ Human beings are sometimes lazy.

Tracing the chain of human errors, it is possible to see that he neglected to keep monitoring the movement of Vessel B.

Psychological factors

② Normalcy bias

People unconsciously collect information that supports what they believe.

Psychological factors

③ Confirmation bias

He only collected information that supported what he believed by thinking everything was fine because she crossed the stem of Vessel B.

Psychological factors

④ Social loafing

Assumed that Pilot A would take care of the entire procedure.

In addition, as for Master B, at 06:52 (approx.), he steered to starboard for Kobe Central Fairway without checking the movement of Vessel A visually. This was also the result of the following human characteristics and psychological factors which contributed to the chain of errors.

Human Characteristics

④ Human beings sometimes do not notice,
⑤ Human beings have moments of inattention,
⑥ Human beings are sometimes only able to see one thing at a time,
⑦ Human beings are sometimes in a hurry.

He understood that the relative position would be risky, if he steered to starboard, but he was concerned about entering port late if he was to follow the originally scheduled course, and neglected to keep visual confirmation of Vessel A.

Psychological factors

② Normalcy bias

People ignore negative information and underestimate phenomena saying : " I'm special, nothing can hurt me! "

He simply confirmed the ARPA only.

As compiled in Attachment 15, when looking chronologically at the course of events, it is possible to see how each factor contributes to the chain of human errors. This accident might have been prevented had the chain been broken at some point. It can be said that BRM was not operational.

When analysing other collision accidents, it is possible to observe "accident analysis from the perspective of human factors and human error". These are almost identical to "4M5E Analysis". In other words, the root causes that led to the collision accident can be found in the following Human Characteristics: ⑨ Human beings sometimes make assumptions, ⑤ Human beings have moments of inattention, ⑩ Human beings are sometimes lazy and ⑦ Human beings are sometimes in a hurry. There are also 4 psychological factors that are connected which make it impossible to eradicate human error.

Thus, even if the person "L", who is the centre of the M-Shell Model (Figure 6) makes a mistake, the surrounding resources will notice and point it out via communication without hesitation. This is important, because it will break the chain of errors to prevent an accident, namely: practising BRM effectively.