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Abstract

This thesis concentrates focuses on maritime accidents and the reasons behind them. The aim is to compare accidents in Europe and Asia and whether there are differences in the reasons for between them, especially if they are based on human errors and/or cultural differences. In this research, the procedure was undertaken in three separate stages. Firstly, I analysed a selection of recent maritime accident reports as a base for the research. Maritime accidents occurring in the last 20 years (from 2000 onward) with vessels built between 1966 (*Express Samina*) and 2017 (*TS Sola*) were analysed as part of this research. Secondly, different websites, articles, presentations and commercial materials were studied to deepen the research and to support some of the findings. Finally, the available Kongsberg Onboard Advisory-, Onboard Control- and Bridge Zero-products were analysed in conjunction with the cases in terms of accident prevention, product development and sales support.

The conclusion of this research is that, while the main reasons are somewhat similar – there are differences between reasons leading to accidents in Europe and Asia. This could be either cultural (communication) and/or based on differences in training. Most accidents were not caused by one single error, but a sum of multiple errors. Overall it can be said that using Kongsberg Onboard Advisory, Onboard Control and Bridge Zero onboard would have enhanced the situational awareness in all the cases and avoiding the accidents in the majority. While Kongsberg's "autonomous final product" is still in its developing stage, it could still be used as supportive technology onboard to cover for human errors that are bound to happen. This would reduce the fatigue of the Bridge Officers and their focus could be put on more effective use in congestive seas.

Language: English Key words: intelligent navigation, accident prevention, human error, cultural differences

EXAMENSARBETE

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Abstrakt

I detta slutarbete behandlas maritima olyckor samt orsaken till att dessa olyckor har skett. Syftet med slutarbetet är att först jämföra olyckor som skett i Europa och i Asien och därmed granska om det finns olikheter som specifikt beror på mänskliga fel och / eller kulturella olikheter bland besättningen på fartygen. Forskningen har utförts i tre olika skeden. I första skedet har ett antal olycksrapporter från både Europa och Asien analyserats för att kunna bygga upp en bas för själva forskningen. Olyckorna som granskats har skett under de 20 senaste åren (från år 2000 till idag) och gäller fartyg som registrerats mellan åren 1966 (*Express Samina*) och 2017 (*TS Sola*). I andra skedet har olika hemsidor, artiklar, presentationer och kommersiella material studerats för att fördjupa kunskapen i ämnet, och som därmed stöder själva forskningen. I det sista skedet har de olika systemen av Kongsberg analyserats parallellt med de olika olyckorna i ett förebyggande syfte. Detta för att kunna stöda utvecklingen av nya system samt att förebygga framtida försäljning av dessa.

Detta slutarbete kan sammanfattas med att även om huvudorsakerna till olyckorna var mycket lik varandra, framkommer det att orsakerna till att olyckorna skett är lite olika i Europa och Asien. Dessa orsaker är främst kulturella (kommunikationen mellan besättningen) och/ eller skillnader i skolning av besättning. Flesta av olyckorna berodde inte enbart på ett misstag, utan kombinerat av flera olika misstag. Generellt sett kan man påstå att om något av Kongsbergs system varit i bruk på fartygen kunde man ha ökat på situationsmedvetenheten i alla fall och därmed kunde flera olyckor ha undvikits. Även on Kongsbergs system autonoma slutprodukt är fortfarande i utvecklingsskedet kunde detta system med dess teknologi ha fungerat som ett stöd ombord för att undvika mänskliga misstag. Detta system skulle även ha minskat på tröttheten av officerarna på bryggan och därmed skulle deras fokus varit mer effektivt riktat på säker navigering.

Språk: Engelska

Nyckelord: smart navigering, förebyggande av olyckor, mänskligt misstag, kulturell skillnad

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1 Introduction

Even though the research topic changed multiple times there was always one thing that was important to keep me focused – the learning outcome. So, from the initial topic of childhood pirates, then leaning towards a safety officer´s manual to deepening the knowledge of the Colregs - I finally decided to ask my former teacher Anton Westerlund if he had any ideas. Anton had left the teaching world to join the Rolls Royce research facility in Turku, Finland (currently owned and operated by Norwegian based Kongsberg). Already during my basic studies, the interest for reading accident reports was there as they were based on true stories. How could two modern ships equipped with the latest technology in terms of navigating instruments, collide in broad daylight? I continued reading random accident reports occasionally just to learn more and thus avoiding making the same mistakes myself later in my career. Through Anton, I got the possibility to get a deeper view of current Kongsberg products and some insight of the products of the future.

After initial discussions with Anton, that mostly resembled and tennis match – we agreed on a structure that would make the basis for the research. Since that day, it has evolved into a more cohesive research with core structure to follow.

Sailing the oceans has been a way of transportation for ages, long time before the modern age of air transportation. In addition to plain transportation of goods and people, it has also been means to explore and conquer new territorial grounds. From those earliest models of ships and vessels, we have come far in both terms of construction and safety of shipping. In the modern world, 90% of all the trade in the world is performed by the shipping industry (ICS, 2019).

Despite being one of the safest means of transport, the maritime trade is predicted to increase (ICS 2019, figure 33), subsequently so will the hazards and accidents. When we look at the main maritime accidents - collisions, groundings, fires, explosions - human errors are mostly involved. These are the cases we are interested about in this research. Accidents beyond human control, such as unexpected weather conditions and the use of cell phones on the bridge´s also contribute to maritime accidents, but these cases are not in focus in this research.

According to recent studies 75% to 96% of maritime accidents happen due to human errors. This study shows that human intervention is vital in the industry regardless of all the technical progress there has been. This digital age has also created more challenges as it has become even more difficult to keep the crew well trained to operate the new machinery and technology. There are also global issues as all seafarers are not equally trained and certified. To add more diversity to this, there are also cultural differences including communication problems and interpretations (Allianz, 2012). To tackle these challenges Kongsberg has invented new intelligent systems to support and enhance the situational awareness of the bridge crew. The main function is to give more time to evaluate the available data to support the important decision making onboard.

The structure and topics of this thesis are shown in figure 1. After the introduction follows a description of nautical terms, acronyms and abbreviations to make the reader understand what is meant with each term in this thesis. The third chapter will present the case company Kongsberg, the INAV navigation system and its products that are later analysed as part of every accident case in this thesis.

The second part of this thesis is the theory part, which will support the research aim in this thesis. The theoretical part starts with a general description about vessels, what different types of vessels we have and what flag state and flag state of convenience means in shipping. The second part describes maritime accidents, and the third part brings together vessels and accidents. The fourth part is about human errors, which is the area of main interest in this thesis. The last theory part describes EMSA, EMCIP and JTSB. They are relevant in this thesis, because data provided by them on the accidents have been used as a base for analysing. After the theory section of this thesis, the research method is opened in detail. This is followed by analysing the European and Asian accidents. The conclusion, findings and subsequent summary for Kongsberg Maritime sales department are followed to close the research.

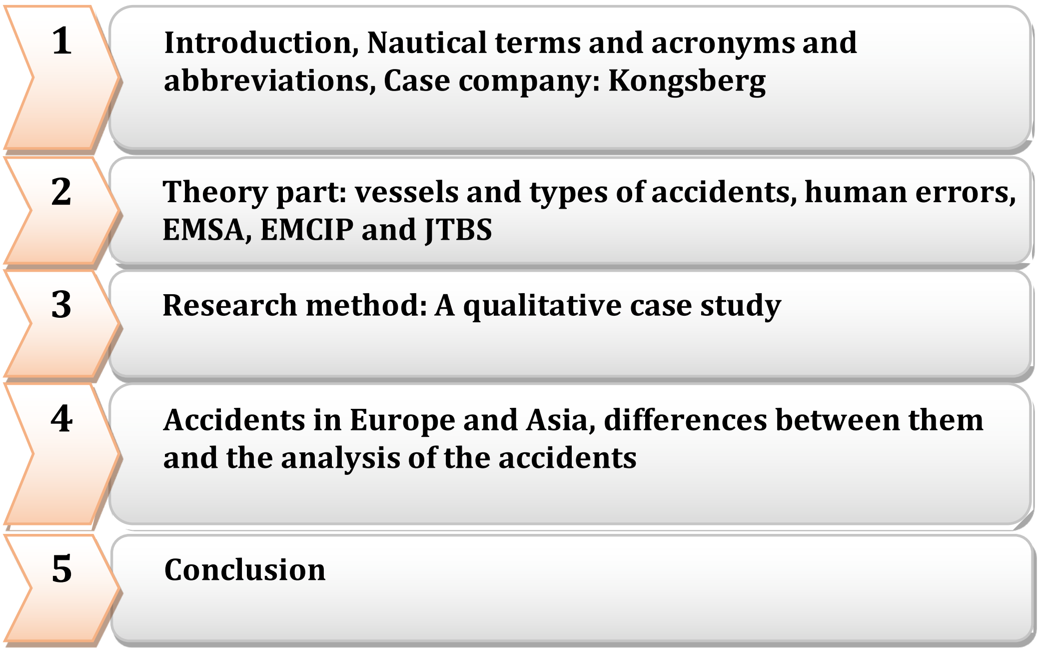

Figure 1. ***Disposition of this thesis.***

2 Nautical terms, acronyms and abbreviations

A list of nautical terms, acronyms and abbreviations that facilitate communication on the seas included in this research are explained in this chapter. This is added to help any reader of this research with interpretation of common terms that are used in the shipping industry. In table 1 are all necessary nautical terms, acronyms and abbreviations for this thesis explained:

Nautical term, Acronym or Abbreviation	*Description*	*Reference*
AB	Able Seaman	*6,13,15*
Adrift	Vessel is not attached to the shore or seabed	*19*
Aft	Back half of the vessel	*19*

AIBF	Accident Investigation Board of Finland	*9*
AIBN	Accident Investigation Board Norway	*4*
AIS	Automatic Identification System	*6,9,13,15*
Abeam	Right angles to the fore-and-aft line	*19*
Anchor	A heavy object attached to a vessel which is thrown overboard to prevent drift	*19*
ANS	Autonomous Navigation System	*20*
ARPA	Automatic Radar Plotting Aid	*9,15*
BCR	Bow Crossing Range	*9,15*
Bearing	A horizontal visual line between two objects	*19*
Bow	The front of a vessel	*19*
BRM	Bridge Resource Management	*6*
BTM	Bridge Team Management	*13*
B0	Bridge Zero (no manning on bridge)	*20*
Cable	Measure of distance equal to 0.1 nautical mile	9
COG	Course over ground	*19*
C/O	Chief Officer	*15*
CoC	Certificate of Competency	*15*
COG	Course over ground	*15*
COLREGS	International Regulations for preventing Collisions at Sea 1972 (as amended)	*6,9,13,15*
CPA	Closest Point of Approach	*9,15*
CRM	Crew Resource Management	*13*
DGPS	Differential Global Positioning System	*19*
DNV	Det Norske Veritas	9
DMAIB	Danish Maritime Accident Investigation Board	3
DWT	Dead Weight Tons	*9*
ECDIS	Electronic Chart Display and Information System	*6,13,15*
ECS	Electronic Chart System	*19*

ECR	Engine Control Room	*2*
E0	Engine room 0 (no manning in the engine room)	*20*
ETA	Estimated time of Arrival	*2*
GMDSS	Global Maritime Distress Safety System	9
GPS	Global Positioning System	*9,15*
GT	Gross tonnage	*9*
GUI	Graphical User Interface	*20*
IA	Intelligent Awareness	*20*
IACS	International Association of Classification Societies	*6*
IAP	Intelligent Auto Pilot	*20*
ICS	International Chamber of Shipping	*13*
IMO	International Maritime Organization - is the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships.	2,6,9,13
INS	Integrated Navigation System	20
ISF	International Shipping Federation	13
ISM Code	International Management Code for the Safe Operation of Ships and for Pollution Prevention	6,9,13
INAV	Intelligent Navigation	20
ISM Code	International Safety Code Management	6,9
JOTD	Junior Officer of the Deck (US Navy Officer assisting the SOTD on the bridge)	18
JTSB	Japan Transport Safety Board	10,12,16,17
Knot (kt)	Speed in nautical miles per hour	9,15
LOA	Length Over All	9
MAIB	Marine Accident Investigation Branch (UK)	1,5,6,8,9,13
MLC	Maritime Labour Convention (2006)	2
MRCC	Maritime Rescue Coordination Center	2,15
MSA	Maritime Safety Administration (P.R. of China)	15
NM	Nautical mile (1NM=1852m)	9,13,15

OOD	Officer of the Deck (US Navy OOW)	18
OOW	Officer of the Watch	9,13,15
OS	Ordinary Seaman	9
PEC	Pilotage Exemption Certificate	6,13
Port (P)	Port Side of ship	19
QMOW	Quarter Master of the Watch	18
Radar	Radio Detection and Ranging	19
Ro-Ro	Roll on – Roll off	9
SAR	Search and Rescue	2
S-band Radar	10cm wave-length radar	19
SMS	Safety Management System	2,6,13
SOG	Speed over ground	15
SOLAS	International Convention for the Safety of Life at Sea 1974, as amended	2,13,15
Sonar	Type of Echo Sounder whose sound propagation can be directed other than straight down	19
SOTD	Senior Officer of the Deck (US Navy OOW)	18
Starboard (SB)	Starboard side of ship	19
STCW	International Convention on Standards of Training, Certification and Watchkeeping	2,6,13,15
Stern	Back of the vessel	19
S-VDR	Simplified Voyage Data Recorder	9
TCPA	Time to Closest Point of Approach	9,15
TSS	Traffic Separation Scheme	9,13
UTC	United Time Co-ordinated	9,13
VDR	Voyage Data Recorder	2,6,9,13,15
VHF	Very High Frequency (radio)	2,6,9,13,15
VTS	Vessel Traffic Services	6,9
WT	Watertight	19
X-band Radar	3cm wave-length radar	19

2/O	Second Officer	19
3/O	Third Officer	15
1. Case Hamburg (MAIB, 2016) *2. Case Costa Concordia (MCIB, 2012)* *3. Case Victoria (DMAIB, 2017)* *4. Case SOLA TS/ KNM Helge Ingstad (AIBN, 2018)* *5.Case Petunia Seaways/ Peggotty (MAIB, 2017)* *6.Case Primula Seaways/ City of Rotterdam (MAIB, 2017)* *7. Case Express Samina (Papanikolaou, D et al, 2015)* *8. Case Red Falcon/ Phoenix (MAIB, 2019)* *9. Case Birka Transporter/ Willempje Hoekstra (AIBF, 2011)* *10. Case Beetle (JTSB, 2017)* *11. Case Sewol (Kwon Y., BAI, 2014)* *12. Case Estelle Maersk/ JJ Sky (JTSB, 2018)* *13. Case Maersk Kendal (MAIB, 2010)* *14. Case Star Kvarven/ Lulanyu 61809 (AIBN, 2016)* *15. Case Sanchi/ CF Crystal (MSA, 2018)* *16. Case Eastern Phoenix/ Keihin Maru No.8 (JTSB, 2018)* *17. Case NOCC Oceanic/ Yujin Maru No.7 (JTSB, 2015)* *18. Case USS Fitzgerald/ ACX Crystal (US Navy, 2017)* *19. Wallin B. Ship Navigation (DOKMAR, 2016)* *20. Kongsberg Business Sensitive Sales & Marketing material (Kongsberg, 2019)* *References written in full in the references section*		

Table 1. Nautical terms, acronyms and abbreviations.

3 Kongsberg

Kongsberg is a world leading technology group with a history that exceeds more than 200 years. Since its humble beginnings that started in Norway, Kongsberg has delivered innovative and high-performance solutions for the constantly changing and demanding global market. As the leading technology provider in the world, Kongsberg operates internationally (also through subsidiaries) to support its customers. The branch that is most relevant to this research is Kongsberg Maritime and its newly acquired product development and testing site in Turku, Finland. Kongsberg A (2019).

3.1 Kongsberg Maritime

The sea environment is not new to Kongsberg. The group has been involved in research and technology of ships, vessels and offshore installations for decades. As the constantly growing shipping trade is vital for the world to function, Kongsberg Maritime has taken on the challenge also to reduce the environmental impact this has globally. Part of this is Kongsberg's mission in developing autonomous ships for the future. Some of the technologies invented towards this, can be utilized onboard already to optimise different functions onboard and to avoid accidents. Kongsberg B (2019).

3.2 Kongsberg products in this research

In this research a comparison has been made between the findings of official accident reports versus the INAV Intelligent Navigation portfolio products. It includes the INAV Advisory-, INAV Onboard Control and Bridge Zero systems. All these systems are trying to unify the diverse sets of equipment onboard – subsequently increasing the SITUATIONAL AWARENESS of the OOW as all relevant information for safe navigation is integrated on one GUI. These systems, smartly used, can/will also reduce fatigue among the deck officers. This will in turn enhance the vigilance while on watch. All these products will assist with intelligent decision support and reduce human error. The human error can be caused by cultural differences, communication, lack of competence and fatigue. (A. Westerlund, personal statement 27.5.2019.)

Product	*INAV Onboard Advisory*	*INAV Onboard Control*	*INAV Onboard Bridge Zero*
Description	Advisory system that enhances the situational awareness of the OOW	Navigational control system that incorporates all Advisory system functions and additionally an intelligent autopilot system	Navigational control system with autonomous navigation capabilities. Includes all functions of the INAV Onboard Advisory and INAV Onboard Control systems.
Purpose	To provide prioritized collision avoidance advise that the OOW executes with existing control systems	To navigate along the vessels system track and provide prioritized collision manoeuvres that the OOW approves for execution	During route planning, some predefined legs of the route can be defined as `Bridge Zero´ including applicable safe states. In case of an unsolvable situation the system alerts the OOW to the bridge.
Includes	INAV 3D graphical user interface on a touch screen display	Autodocking as an optional feature	Autonomous control, alarm and safety systems

Table 2. Kongsberg products on-board.

3.2.1 INAV Onboard Advisory system

In the INAV Onboard Advisory system, data from the high-resolution camera, radars, AIS and Integrated Navigation Systems (INS) are fed via the Intelligent Awareness and Autonomous Navigation System processing units to the INAV GUI. Likewise, the route plan is fed from the ECDIS to the same INAV GUI. (A. Westerlund, personal statement 27.5.2019.)

Figure 2. INAV Onboard Advisory flowchart (Kongsberg, 2019)

3.2.2 INAV Onboard Control

Like in the INAV Onboard Advisory system, data from the high-resolution camera, radars, AIS and Integrated Navigation Systems (INS) are fed via the Intelligent Awareness and Autonomous Navigation System processing units to the INAV Onboard Control system´s GUI. Similarly, the route plan is fed from the ECDIS to the same INAV GUI. In addition to that the ship's Propulsion and Steering Control is connected to the Intelligent Auto Pilot processing unit with the VDR. With this setup the INAV Onboard Control system supplies the appropriate speed and heading for navigation or controlled avoidance manoeuvres. (A. Westerlund, personal statement 27.5.2019.)

Figure 3. INAV Onboard Control flowchart (Kongsberg, 2019)

3.2.3 INAV Onboard Bridge Zero

Like in the INAV Onboard Advisory and INAV Onboard Control systems, data from the high-resolution camera/s, radars, AIS and Intelligent Navigation Systems (INS) are fed via the processing units to the INAV Bridge Zero system´s GUI. Similarly, the route plan is fed from the ECDIS to the same INAV GUI. Like in the INAV Onboard Control system the ships Propulsion and Steering Control is connected to the Intelligent Auto Pilot processing unit with the VDR. With this setup the INAV Onboard Bridge Zero system supplies the appropriate speed and heading for navigation or controlled avoidance manoeuvres. With this setup the processing units will supply the appropriate speed and heading for navigation or controlled avoidance manoeuvres as in the INAV Onboard Control System. The INAV Bridge Zero system has also additional sensors connected which provide the system with weather, audio and data from the Sonar. This combination of sensors and processing units can operate the ship with Bridge 0-manning. alerting the OOW whenever necessary. (A. Westerlund, personal statement 27.5.2019.)

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Figure 4. INAV Bridge Zero flowchart (Kongsberg, 2019)

Below, picture 1, is one of the many possible graphical user interfaces from the Kongsberg INAV systems listed in table 2.

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Picture 1. Kongsberg INAV system GUI example (Kongsberg, 2019)

4 Vessels

The world fleet of the modern day consists of many types of ships. Different types of cargo ships are the most common, representing more than 50% of the words fleet. Most of the ships are of relatively young age, but still a third of the fleet are older than 25 years (EQUASIS, 2017). The amount of ships in the world is growing constantly, which is clearly seen in figure 5 (Butt. et al. 2014). This increase of ships eventually increases the risks and adds up to more accidents in the future. The older ships can be a hazard of its own with possibly less updated equipment, problems in keeping the ship in shape and maybe less motivated crew due to poor conditions onboard.

3A. Ship type	Total	
	Amount	%
General Cargo Ships	16246	17,9
Specialized Cargo Ships	318	0,4
Container Ships	5202	5,7
Ro-Ro Cargo Ships	1493	1,6
Bulk Carriers	11748	13
Oil and Chemical Tankers	13431	14,8
Gas Tankers	1979	2,2
Other Tankers	1062	1,2
Passenger Ships	7155	7,9
Offshore Vessels	8338	9,2
Service Ships	5233	5,8
Tugs	18510	20,4
Total	90715	100

3B. Ship age category	Total	
	Amount	%
0-4 years old	11754	13
5-14 years old	33460	36,9
15-24 years old	15482	17,1
+25 years old	30019	33,1
Total	90715	100,1

Table 3a. World fleet 2017 (EQUASIS, 2017)

Table 3b. Number of vessels by age (EQUASIS, 2017).

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Figure 5. How number of vessels have increased (Butt. et al. 2014)

The types of ships, flag states and the flag of convenience is described in more detail below.

4.1 Types of Ships

While there are no universally applicable definitions of ship types, specific descriptions and names are used within IMO treaties and conventions. Some of these ship types are within the scope of my research, either out of interest or due to its high tendency to be part of maritime accidents. The ships are divided into three main groups: 1) Passenger ships 2) Cargo ships and 3) Fishing ships. The ships are categorized and defined in more detail below in table 4 (Encyclopaedia Britannica).

Ship type 1	Passenger ships	A ship with more than 12 passengers (IMO). Multiple versions available.
Ship type 2	Cargo ships	A ship to carry cargo. Multiple versions available.
Ship type 3	Fishing ships	A ship used for fishing. Multiple versions available.

Table 4. Ship types and categorization (Encyclopaedia Britannica, 2019)

4.1.1 Passenger Ships

A passenger ship is a merchant ship, which carries more than twelve passengers on the sea (IMO). Passenger ships include ferries, ocean liners and cruise ships. Cruise ships initially developed from the transatlantic ocean liners. These Cruise ships transport passengers on roundtrips, in which the trip itself and the attractions of the ship and ports visited are the principal draw. They are designed for large number of passengers with high superstructures and multiple amenities onboard. Most ships cruise in the warmer climates, but also the Arctic and Antarctic regions are gaining popularity (Encyclopaedia Britannica). In picture 2 you can see an example of a cruise ship, the Italian flagged *Costa Concordia*, which was lost as a result of poor seamanship and decisions made by the master. This case is later reviewed in more detail in this thesis. Ferries are passenger vessels that can carry passengers and in many cases their vehicles over short passages across the sea. Vessels can vary in size and amenities onboard. Some ferry types have loading ramps for cars just like Roll-on/Roll-off cargo ships. A special type of ferry is the high-speed catamarans usually used on short runs in protected waters where there is no need to carry vehicles (Encyclopaedia Britannica). In picture 3 you can see an example of a high-speed catamaran, the Japanese flagged *Beetle*, who ran into marine life while operating in high speed mode.

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Picture 2. Cruise ship *Costa Concordia* (MIT, 2013)

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Picture 3. High-speed Catamaran *Beetle* (JTBS, 2017)

4.1.2 Cargo Ships

A cargo-ship is a vessel, which main duty is to carry cargo. Some cargo ships can also take onboard a few passengers.

Cargo ships are usually specially designed for the task and they come in all shapes and sizes. Today, they are almost always built by welded steel (aluminium or nickel-steel alloy Invar used for gas transportations in tanks), and with some exceptions generally have a life expectancy of 25 to 30 years before being scrapped. Cargo ships/freighters can be divided into groups, according to the type of cargo they carry (Encyclopaedia Britannica):

1. General cargo vessels as Panama flagged chemical tanker *Eastern Phoenix* shown in picture 4 - carry packaged items like chemicals, foods, furniture, machinery, motor- and military vehicles, footwear, garments, etc. These ships are generally built with deck cranes, which give them a distinct appearance easily recognized from the other specialized cargo ships (Encyclopaedia Britannica). *Eastern Phoenix* collided with Japanese flagged oil tanker *Keihin Maru No 8* later analysed in this thesis.

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Picture 4. Chemical tanker *Eastern Phoenix* (JTSB, 2018).

2. Container ships as Denmark flagged *Maersk Kendal* (picture 5) – carry standardized sizes of containers stacked on each other. They lack cargo handling gear onboard and are usually loaded with cranes at shore terminals. Advantages with containerships is that they are quickly loaded in ports and are usually low in crew numbers onboard, making it economically low cost to run. There is also less pilferage due to the locked containers and hence lower insurance costs. The disadvantages are that less cargo can be taken onboard as the containers itself take space. The containers square shape also does not fill in all the spaces of the ship-shaped hull form, thus not utilizing the ship to full potential. These ships are suitable for long voyages with their high speed of more than 20knots (Encyclopaedia

Britannica). *Maersk Kendal* run into Monggok Reef as a result of poor seamanship, which is later reviewed in this thesis.

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Picture 5. Container ship *Maersk Kendal* (MAIB, 2010).

3. Tankers – specially made for liquid-, oil- or gas transportations. These tankers are usually quite slow, but they have big capacities. The cost of these tankers is quite high as they cannot be made from steel. Cold liquids stored in the tanks would make the steel brittle. Aluminium is widely used, sometimes backed by balsa wood, which is turn backed by steel covering. Invar, which is a special nickel-steel alloy is also used on some ships (Encyclopaedia Britannica). In picture 6 you can spot Malta flagged Oil Tanker *TS Sola* that collided with the Norwegian Navy Frigate KNM *Helge Ingstad*. This interesting case is later reviewed in this thesis.

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Picture 6. Oil tanker *TS Sola* (Shipspotting, 2019).

4. Dry bulk carriers as shown in picture 7 below – are made to transport "loose cargo" such as ore, coal, cement or agricultural products. They have no cargo handling gear, but unlike the tankers they have large cargo hatches. Some bulk-carriers have a large horizontal boom of open truss work for self-unloading (Encyclopaedia Britannica).

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Picture 7. Dry bulk carrier (Safety4Sea, 2019).

5. Multi-purpose vessels as Norwegian (NIS) flagged *Star Kvarven* shown in picture 8 below can carry different classes of cargo – e.g. liquid and general cargo – at the same time (Encyclopaedia Britannica). *Star Kvarven* was involved in a collision with a Chinese flagged fishing vessel *Lulanyu 61809*. This case is later reviewed in this thesis.

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Picture 8. Multipurpose cargo vessel *Star Kvarven* (AIBN, 2016).

6. Reefer ships as the Dole reefer below in picture 9 are specifically designed and used for shipping perishable commodities which require temperature-controlled, mostly fruits, meat, fish, vegetables and dairy products . The Dole Reefer obviously ships bananas. (Encyclopaedia Britannica)

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Picture 9. Reefer ship (Dole, 2019).

7. Ro-Ro ships as Denmark flagged *Primula Seaways* (picture 10) - are loaded through ramps (either built-in or shore based) in the stern, bow or side of the ships – with so called roll on- roll off method. They are specially made to carry wheeled cargo, such as cars, trucks, buses, trailers etc. Cargo without its own wheels, such as containers, train cars, paper rolls can also be rolled onboard using trailers and subsequently rolled off at the departure port (Encyclopaedia Britannica). Some of the Ro-Ro ships also function as passenger-ferries (Ro-Pax), where special cargo, cars and trucks are transported on the lower decks and passengers on the top decks. *Primula Seaways* was collided with Panama flagged car carrier *City of Rotterdam* later analysed in this thesis.

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Picture 10. Ro-ro freight ferry *Primula Seaways* (MAIB, 2017).

4.1.3 Fishing vessels & ships

A fishing ship is used to catch fish whether it is in the sea, or on a lake or river. Picture 11 shows an example of a fishing ship, the Dutch flagged Beam trawler *Willempje Hoekstra* that collided with Finnish flagged Ro-ro vessel *Birka Transporter*. This case is later reviewed in this thesis. Smaller fishing vessels (up to 25 meters or 100 tons) are mainly made of fiberglass, while steel is usually used on ships above that. Ferrocement is also used in artisanal fisheries of developing countries, because of its cheap material costs. There are different types of fishing vessels in use, depending on fishing methods: Trawlers, side trawlers, stern trawlers, beam or outrigger trawlers, wet-fish trawlers, freezer trawlers, factory or processing trawlers, seiners, purse seiners, hand-liners, long liners, pole-and line vessels, multipurpose fishing boats, artisanal fishing boats, mother ships and freshwater fishing boats. *Willempje Hoekstra* is a typical beam trawler used in European waters, where trawls are towed from extending booms supported by a central mast to each side. The booms are strong and take the whole weight of the trawl being towed (Encyclopaedia Britannica).

Picture 11. Beam Trawler *Willempje Hoekstra* (SIA, 2011).

4.2 Flag states and flag of convenience

All merchant ships need to be registered somewhere, under a nations flag. The flag on a ship decides the maritime laws, standards, rules and regulations that are followed onboard and it gives the ship its nationality. Should the ship be involved in an admiralty case, the laws of its flag state would apply. It will also give the owner possible protections and benefits, preferential treatments in terms of taxes, certification and security (ITF, 2019).

Some flag states choose only to ratify some of the international conventions and treaties where the international minimum safety standards are set. It is these countries who attract ship owners that are striving to cut costs even by risking safety of the crew and with little or no concern of the environmental impact of their operations. A flag of convenience refers to a flag of ship, that is different to the ownership of the vessel. The main reason for using a “foreign” flag, would be that the ship owners take advantage of the minimal regulation, cheap registration, low or no taxes and the freedom to choose and use cheap labour onboard. For the workers onboard this can mean lower wages, poor conditions onboard and longer periods of work without proper rest. This can eventually lead to stress, fatigue and potential accidents. Therefore, the flag-state issue has been included in this thesis, as it can easily have partial impacts on accidents. The International Maritime Organisation (IMO) has currently 167 members, but the members performance varies enormously from flag to flag. The worst fleets have casualty rates that are hundred times worse than those of the best (IMO, 2019). IMO itself does not keep track of FOC-countries, but the International Transport Workers´ Federation (ITF) does. As of 2019, this list includes 35 countries (ITF, 2019). The FOC-flagged ships registered in terms of deadweight tonnage (DTW) accounts for a high % of the worlds shipborne carrying capacity as some large shipping nations in terms of DTW are involved (such as Panama, Liberia, Marshall Islands, Bahamas and Bermuda). In the table 5 below, you can see the current states holding a `Flag of Convenience´ status by ITF. If you later look at figure 9 you can see that ships that are FOC-flagged are highly rated in terms of % of losses, which clearly indicates that the flag-state has a significant role in accident frequency.

Flag of Convenience states & registeries	
Antigua and Barbuda	Jamaica
Bahamas	Lebanon
Barbados	Liberia
Belize	Malta
Bermuda (UK)	Madeira
Bolivia	Marshall Islands (USA)
Cambodia	Mauritius
Cayman Islands	Moldova
Comoros	Mongolia
Cyprus	Myanmar
Equatorial Guinea	Netherlands Antilles
Faroe Islands (FAS)	North Korea
French International Ship Register (FIS)	Panama
German International Ship Register (GIS)	Sao Tome and Príncipe
Georgia	St Vincent
Gibraltar (UK)	Sri Lanka
Honduras	Tonga
	Vanuatu

Table 5. Flags of Convenience (ITF, 2019).

5 Types of accidents

This chapter starts with an overview of the main accidents and how they can be categorized. After this follows a more detailed explanation of accidents caused by human errors/factors and possible misunderstandings caused by cultural differences on board. At last, The European Maritime Safety Agency (EMSA), The European Marine Casualty Information Platform (EMCIP) and Japan Transport Safety Board (JTBS) will be presented to raise awareness in their responsibilities and offerings. JTBS has been chosen as Asia does not have a common platform for collecting and analysing Asian accidents. JTBS also offers analytics of the Japanese flagged ships sailing in the Asian waters.

5.1 Accident categorization

For clarity reasons, the MCIP´s own categorization is used in this thesis which are the standard types recognized by the shipping industry. The Asian part of the world is no different in terms of accident types.

The main types of accidents are categorized as shown in table 6.

Accident types	Definition
Collision	Ships striking or being struck by another ship, regardless of ships underway, anchored or moored
Contact	Ship striking or being struck by an external object, floating, fixed or flying. Sea bottom excluded.
Damage to ship/hull failure	Damage to equipment, system or the ship not covered by the other casualty types, including failures effecting structural ship strengh
Fire/explosion	Uncontrolled ignition, fire or explosion of flammables generating heat, smoke, flame, pressure discontinuity or blast wave.
Flooding	Event where the ship is taking water onboard, gradually or abrubt
Foundering	Event where the ship is taking water onboard and eventually sinks
Grounding	Event when a navigating ship, either under command (or not) strikes the sea bottom, shore or underwater wrecks
Loss of control/containment	A total or temporary loss of the ability to operate/manoeuvre the ship, failure of electrical power, or failure to contain onboard cargo

Table 6. Main types of accidents (EMCIP, 2018).

5.2 Types of vessels lost in accidents

As previously mentioned, there are multiple types of vessels around sailing in the oceans, whereas the types scrutinized and focused on in this research are within the scope of passenger ships, cargo ships and fishing ships. As shown in table 6 produced by EMCIP (2018) there are multiple types of accidents categories that can happen due to different reasons. Very rarely there is only one single mistake, more often it is due to series of mistakes based on human error. As seen clearly from figure 6, cargo ships are the most vulnerable type of ship in the terms of accident frequency, but it is in a decline since one of its peak years, 2017. It is also obvious that all ship types except bulk carriers are on the decline since 2017. Similarly looking at figure 7 by the Shipping and Safety review (2019), you can clearly see the same trend in terms of accident types. Foundering seems to be the biggest reason for ship loss, with stranding being the second. Collision is at the lower end of causes for losses. Looking at the high average age of vessels lost (constantly over 20 years and increasing from 1997 to 2011 – figure 8), there is a tendency seen here. It can be that older ships are flagged off to flags of convenience states when reaching a mature age of 20 and when they are no longer able to be classed by a reputable classification society. Ships registered in these flags of convenience states often barely fulfil all international shipping treaties and legislations (ITF, 2020). FOC-flagged ships have also a high cumulative % of losses per registered fleet as clearly seen in figure 9. They also carry multinational crews, where

intercultural differences also contribute to accidents. Human errors and cultural reasons behind accidents will be more opened and discussed in the next chapter.

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Figure 6. Type of vessel lost 2009-2018 (Safety and shipping review, 2019).

Figure 7. Causes of losses 2009-2018 (Safety and shipping review 2019).

Figure 8. Average age of vessel losses 1997-2011 (Butt. et al. 2014).

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Figure 9. Losses per flag state of registered fleet in percentage (Butt et al.2014)

5.3 Human factors and errors

The human factor is something that cannot be predicted. All humans are individuals with diverse backgrounds, which leads to different behaviours in dealing with the complex and pressurized workload of a seafarer. This applies not only to accident situations, but also in daily operations. Even with multinational crews, we must work as a coherent team despite working differently in terms of habits and communication. Large shipping losses are now at their lowest level having declined 50% year on year, but the incident numbers remain high. Out of those accidents, the human element covers for 75% of those marine losses. (Global *Safety & Shipping Review, 2019.*)

There has been a boost of new technology recently and simultaneously a lack of integration between them. Most of these systems are used simultaneously and thus creating more pressure on the crew to operate and analyse data from them. Bridge crew must understand which elements of the required tasks are made by machines and what are the expectations of their own performance. Even in a normal operational situation, the OOW can face multiple simultaneous tasks that can escalate into a more stressful situation. New technologies, such as the Kongsberg products simplify the overview thus helping the OOW – by increasing his/her situational awareness.

UK MCA (UK Maritime & Coastguard Agency) have analysed the twelve most common or potential human factors related to accidents. They are collected from near miss reports data from 2003 to 2015. The result of this research unfolded as the `Deadly Dozen´, twelve common or potential human factors. They are shown in figure 10 (UK MCA, 2016).

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Figure 10. The deadly dozen (UK MCA, 2016)

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Figure 11. The deadly dozen in detail (UK MCA, 2016)

1) Situational awareness

One the most important things on the bridge and why not on the whole ship. You need to have an overall understanding of what is happening and why. If you face problems, you need to address them asap and correctly. If you are a team, then get inputs from everyone and communicate properly. (UK MCA, 2016) It is of utmost importance that the navigator has an overall good perception of the ship's situation. In conventional ships this means analysing the data provided by the ship´s instruments. This is mixed with the visual observations of the surroundings. Normally the OOW takes in consideration nautical information, course, speed, depth of water, tides, currents, dangers nearby and ahead. In addition, the OOW should know about aids to navigation, ships in the area, current weather, weather forecasts and the sea state. The navigator should also think ahead where the current situation might develop into (Wallin, B 2016). Kongsberg has taken on this task to help the OOW by integration of the complex bridge technologies and the information they give to one GUI with all the necessary data for safe navigation.

2) Alerting

Even on a perfect day, everything can go wrong. If there is anything suspicious, you need to alert your appropriate colleagues and speak up. There must be a culture, where you feel comfortable to alert senior crew even if you feel uncomfortable about it. (UK MCA, 2016.)

3) Communication

Poor communication is the worst! This can and will happen on any ship but may be more prone on ships with multinational crew. You need also pay attention to body language and gestures, which can/will mean different things in different parts of the world. (UK MCA, 2016.)

4) Complacency

Many days are the same onboard. But it does not mean that everything is ok even though it seems that it is. Repeated pattern of work often creates a false state of mind, but this can pull your leg. Checklists are there for a reason, and do not hesitate to use them to their full potential. (UK MCA, 2016.)

5) Culture

There must be a "Just Culture" onboard where it is easy for the crew to report any safety issues and they are promptly taken care of by the management – to create an accident free workplace for the whole crew. (UK MCA, 2016.)

6) Local practices

There are many standardized procedures and practices onboard that have safely been made to help put the crew. However, there is not a possibility to make written procedures for all shipborne activities. All crew must be vigilant so that no one cuts the corners – thus compromising safety. (UK MCA, 2016.)

7) Teamwork

Is it very important that the whole crew pulls the same string – towards a common goal. A supportive atmosphere is the key to success. (UK MCA, 2016.)

8) Capability

To be able to work onboard ship, you need a good blend of skills. The competence of everyone is important as the failure of technical or non-technical skills can lead to accidents. (UK MCA, 2016.)

9) Pressure

Maritime business is cost effective which affects the scheduling, there are deadlines, route changes etc. All this will put pressure among seafarers. Taking short cuts is no answer to catch up on work, it is always better to speak up and discuss the issue with the master. Overloading yourself will only increase the possibility of mistakes. (UK MCA, 2016.)

10) Distractions

It is easily to become distracted, especially with mobile phones. During pilotage and other difficult areas of navigation, you should be extra focused on the task ahead. Using checklists can be vital not missing out on anything important. (UK MCA, 2016.)

11) Fatigue

Fatigue has safety and long-term physical and mental health implications and long tours of duty (over 6 months) may lead to increased sleepiness, loss of sleep control, reduced motivation which could contribute to accidents (Martha Report, 2017). According to this report, night watch keepers are at most risk from falling asleep, whereas the masters are stressed and fatigued at the end of their contracts. An effective fatigue risk management is very important onboard to prevent near misses and accidents. Figure 12 clearly demonstrates the realities and consequences of fatigue onboard as discovered by the Martha Project. (UK MCA, 2016.)

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Figure 12. Fatigue implications (Martha Report, 2017: 9)

12) Fit for duty

The seafarer does not only have to be clear of alcohol and other drugs but must be generally fit to perform his/her duties. This means also keeping up your fitness and mind while onboard. Crew wellbeing is happily on the rise and contributes positively on the accident statistics. (UK MCA, 2016.)

5.3 Cultural differences

The merchant fleet has become more multicultural and multilingual in crew composition in the last thirty years (Horck, 2005). Currently about two thirds of the world´s marine fleet sail with a combination of mixed crew with different cultural backgrounds. Occasionally this diverse crew mixture can experience behavioural difficulties, that can affect the ship´s safety, pollution prevention and security. This is mainly due to communication issues onboard. Even though it is understood under the revised STCW 78 (STCW 95) that crews must be committed, as in loyal, devoted and dedicated it has been a challenge for the European seafarers – this happening with the recent increased multicultural manning. At the same time, the communication onboard should be free from prejudice, as in discrimination, chauvinism and intolerance. This is not always easy, as you would easily fight to keep your job. This said, a well-trained safety-communicating crew is a prerequisite and mandatory in shipping. Problems arise, when we don't know the values, perspectives and approaches used by the other cultures. Interestingly Nisbett (2003) points out in the "The Geography of Thought that" the main differences between Western and Eastern (Asian) ways of thinking are: westerners believe that the world is linear, stable and mechanic. Simultaneously Asian people think it is complex, changing and organic. So, it is no wonder, that the way of thinking is also far apart.

The presence of power distance, stereotyping and a substandard level of communication may be present on the ship can cause problems, eventually leading to accidents. In ships with multicultural crew, there needs to be a culture onboard that promotes mutual understanding and mixing of the crew. As Knudsen (2004) reports, this can be hard at times. Knudsen (2004) states that in ships with more than four nationalities, there is nobody to claim ownership of the shipboard culture. "The biggest violation of cultural values is a cross-cultural *faux pas*, when we fail to recognize the fellow crewmember's culture". He can have goals, customs, thought patterns and values very different from ours. The communication can therefore be challenging, as some cultures are more straightforward and others quite the opposite (Knudsen, 2004).

To summarize this chapter, communication plays a vital role operating with any type of crew. With multicultural crews this can be a challenge. Lack of proper leadership and failed communication can lead to a decrease of overall moral, which in turn could trigger an accident. But are the master and other senior managers onboard always good leaders? It is essential that the ships management thrive for a cohesive strong culture onboard and that the working language is well understood by all crew members. This is important not only for managing everyday work and safety issues but also for bonding and socializing. In ships with a lesser level of communication and unclear corporate culture there are clearly more risks involved. Regardless of that a multicultural crew also can have advantages, cultural differences are important to keep in mind in the analysing chapter. This is because, the accident reports of today recognise the presence of human factors but are not addressing the possible multicultural misconceptions present at a level that it should.

6 Databases for analysis purposes

There are different places where maritime accidents are collected and statistics available. Accidents happened in Europe is gathered in EMSA and EMCIP, while Asia lacks a common platform for gathering accident data. For the purpose of this research, the Japanese Transport Safety Board´s material have been used.

6.1 European Maritime Safety Agency (EMSA)

EMSA is an EU agency based in Lisbon, Portugal. The main duties are to assist and support the EU (and its member states) in development and implementation of EU legislation on maritime safety, pollution by ships and maritime security. This includes support for the implementation of Directive 2009/18/EC, which establishes the fundamental principles governing the investigation of accidents in the maritime transport sector. They have also an operational role in the field of oil pollution response, long range identification and tracking of vessels. (EMSA, 2019.)

6.2 European Marine Casualty Information Platform (EMCIP)

One part of EMSA´s duties are to maintain and enhance EMCIP (The European Marine Casualty Information Platform), which is an important tool for storage and analysing the casualty data and investigation reports provided by the member states. Information in EMCIP related to marine casualties and incidents involves all types of ships including occupational accidents related to ship operations. It can be used for production of statistics and analysis of the technical, human, environmental and organisational factors in maritime accidents. Some data analysed in this research are detained from EMCIP data through EMSA sources. (EMSA, 2019.)

6.3 Japan Transport Safety Board (JTSB)

JTSB´s mission is to contribute to the prevention of accidents by objective, transparent and scientific investigations into the accident and its root causes. While it is important to find the essential errors that caused the accident, including organizational factors, JTBS´s principles include that they do this without apportion blame and liability. JTBS contributes the maritime industry with recommendations, opinions and information on accidents and its causes whenever there is a reason. JTBS also provide up to date accident data through their website that can be used for research purposes. (JTSB, 2019.)

7 Research method

In this chapter, the chosen research method will be discussed, and why it is chosen and why it fits this thesis. The data gathering method will also be presented in this chapter.

7.1 Qualitative case study

The aim of the research decides which research strategy will be chosen, and how data will be gathered (Silverman, 2006). The qualitative research method has been chosen, because the aim is to get a deeper understanding about the maritime accidents already taken place in Europe and Asia and to identify how Kongsberg´s products could have prevented these accidents (Silverman, 2006). The qualitative research method is also suitable, when the research and analyse is not based on numbers, which this research is not.

According to Silverman (2006) a qualitative case study gives answers on questions “how and why”, but also on “what” with a deeper view. As the goal of this thesis is to gather deep and information rich data for the case company, Kongsberg, the selected research strategy, case study, fits well here. Patton (2002) points out that information rich data is gathered via case studies, which strengthens the reason for choosing case study.

But to remember, case studies are not suitable for generalization, as the amount of cases, accidents in this research, are not that many (Patton, 2002; Gummesson, 2000). The timeframe for this research is tight, and this is the reason why only a limited amount of 18 different (nine in European waters and nine is Asian waters) accidents have been analysed.

7.2 Selection of case companies

In this research a handful (18) of maritime accidents in both Europe and Asia will be analysed. As the interest in this research is in accidents caused by human errors and cultural differences, there are accidents from both Europe and Asia chosen. This selection will give some data and an opportunity to compare the data from Europe and Asia but will also give feedback for the Kongsberg Maritime product development and sales department. The cases were chosen with the aim to contain as many vessel types and varieties of human errors as possible to maximise results. The timetable and the size of the research set some limits to the number of the case studies.

7.3 Data collection

In this research, both primary and secondary data were collected. Primary data were collected via interviews and observations, while secondary data were collected via literature reviews (Gummesson, 2000). What makes this analyse process easier is my pre-knowledge, collected through my own work experience. Gummesson (2000) points out that having not enough of background information (specific knowledge about some specific things) might cause problems when analysing the gathered data. The knowledge gained from being a rating, my OOW experience and my earlier interest in accident reports has been the basic method used to analyse the data.

The interviews have been done as unstructured interviews, which are more like discussions with people in the field to gain more insight of the complex reasons behind different accidents. During my work hours as Watchkeeping Officer, continuous observations and unstructured interviews have been done of possible situations at sea, and especially situations which could have led to close encounters with other ships. These different scenarios have been discussed with able seamen, chief officers and masters onboard to further understand the way things might escalate towards an accident. (Jamshed, 2014.)

7.4 Summary

As conclusion, this research will be carried out as a qualitative case study. In figure 13 is summarized how this research will be done, and with help of which data collection methods the expected result will be achieved.

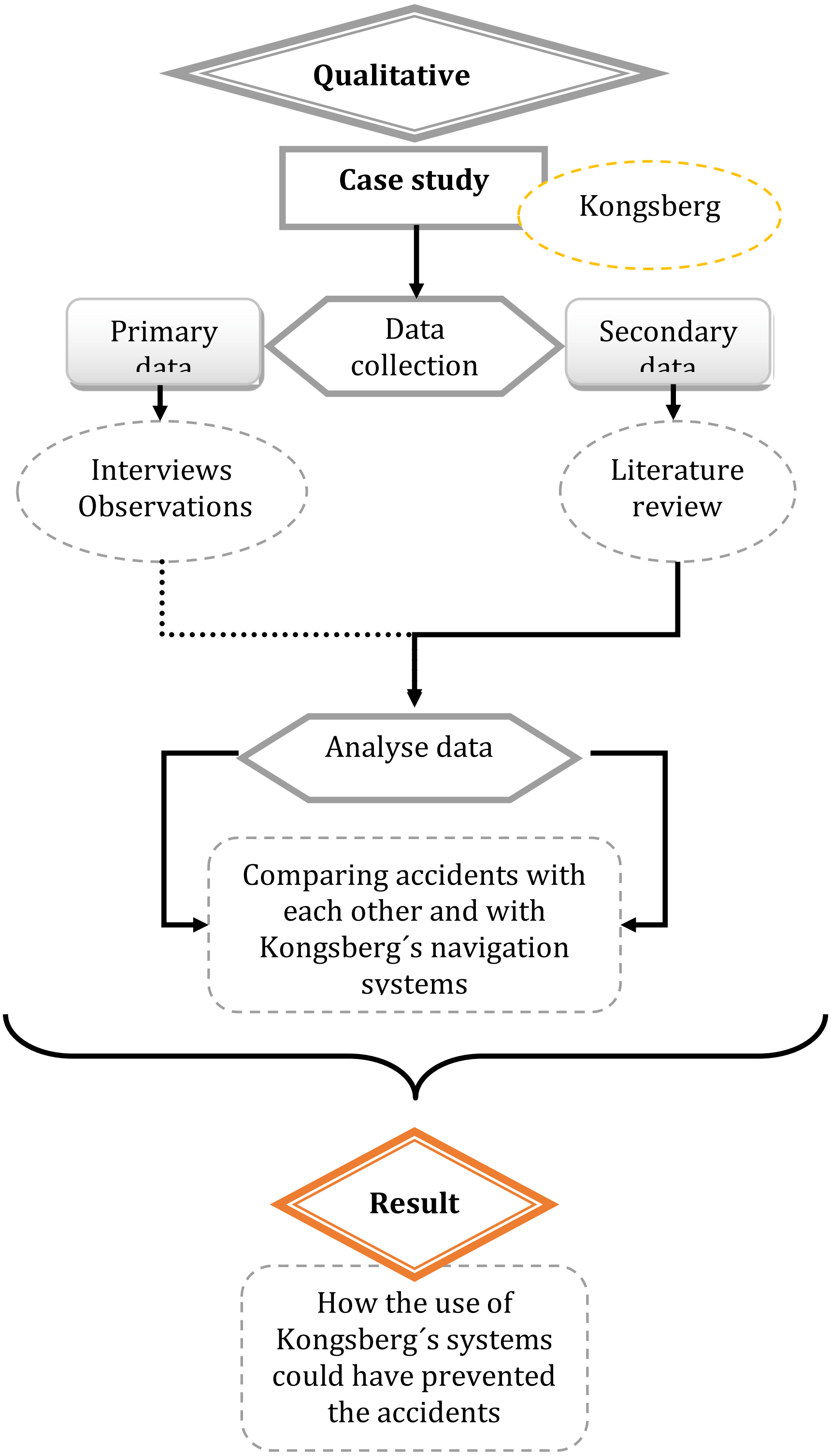

Figure 13. Summary over how the research will be carried out.

8 Accidents in Europe and Asia

In this chapter, different accident cases from Europe and Asia will be explained. First accidents from Europe, and then accidents taken place in Asia. Figure 14 shows losses of ships between years 2009 and 2018 and in which regions they have taken place. As we are interested in Europe and Asia in this research, we can see from figure 14 that these among the main accident hotspots in the world. In Annex I there is a breakdown of all the accident particulars in terms of what type of accident it is, what type of ships are involved, under which flag the ships are sailing and the age of the ships.

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Figure 14. Losses of ships (Safety and shipping review 2019).

Out of the 18 maritime accidents studied in this thesis, 8 crews were mixed crew (2 of these were mixed Scandinavian), 11 with one nationality onboard and 8 with unknown crew composition. The crew composition table 7 shown below shows the breakdown of the crews in each case. It is fair to say that looking at the below table, there is an indication that mixed crews are more common in the European waters and respectively one nationality crews in the Asian waters. The only two one nationality crews in the European cases are KNM *Helge Ingstad* (NOR) and *Birka Transporter* (FIN). KNM *Helge Ingstad´*s crew composition is easily explained as you would expect a Navy Frigate to hold only crew of that flag country. The OOW of *Birka Transporter* was alone on the bridge, subsequently *Birka Transporter* is classified as one nationality crew.

MIXED	ONE NATION	UNKNOWN
Hamburg (Bahama - FOC)	KNM Helge Ingstad (Norway)	TS Sola (Malta - FOC)
Costa Concordia (Italy)	Birka Transporter (Finland)	Peggotty (N/A)
Victoria (Portugal - Madeira FOC)	Beetle (Japan)	Express Samina (Greece)
Petunia Seaways* (Denmark)	Sewol (South Korea)	Red Falcon (UK)
Primula Seaways* (Denmark)	JJ Sky (Hong Kong/P.R.China)	Phoenix (N/A)
City of Rotterdam (Panama - FOC)	Star Kvarven (Norway NIS)	Willempje Hoekstra (Netherlands)
Estelle Maersk (Denmark)	Lulanuy 61809 (China)	Yujin Maru No.7 (Japan)
Maersk Kendal (Denmark)	CF Crystal (Hong Kong/P.R.China)	Keihin Maru No.8 (Japan)
Sanchi (Panama - FOC)	NOCC Oceanic (Marshall Islands - FOC)	
Eastern Phoenix (Panama - FOC)	USS Fitzgerald (USA)	
*Scandinavian crew	ACX Crystal (Philippines)	

Table 7. Crew composition table

8.1 Europe

In this chapter focus is on accidents in European waters. There are nine different cases, involving passenger ships, various types of cargo ships (an oil tanker, a container ship, Ro-ro vessels, a car carrier), a navy frigate, a fishing vessel, a historic launch and a private motor yacht. These ships have either grounded or collided with another ship. Table 8 shows the cases in focus. Out of the fourteen (14) ships involved in the European accidents, five (5) are with affirmed mixed multicultural crews (which if two is of mixed Scandinavian nationalities), two with one nationality crews and seven (7) with unknown crew composition. There is a clear trend here being multicultural crew favoured in Europe. The youngest ship in the Europe fleet was 1year old Maltese flagged Oil tanker *TS Sola* and the oldest being 72-year-old Historic motor launch *Peggotty* (no flag state). Maybe because of *Peggotty*´s mature age, the average age for all ships (14) involved in the European cases was 18,9 years.

Ship type	Name	Accident type
Cruise ship	*Hamburg*	Grounding
Cruise ship	*Costa Concordia*	Grounding
Container	*Victoria*	Grounding
Oil tanker & Navy Frigate	*TS Sola* & KNM *Helge Ingstad*	Collision
Ro-ro & Motor launch	*Petunia Seaways* & *Peggotty*	Collision
Ro-ro & Car carrier	*Primula Seaways* & *City of Rotterdam*	Collision
Ro-ro	*Express Samina*	Grounding
Ro-ro & Motor yacht	*Red Falcon* & *Phoenix*	Collision
Ro-ro & Fishing vessel	*Birka Transporter* & *Willempje Hoekstra*	Collision

Table 8. European accident cases and types

8.1.1 Passenger ship case/s

HAMBURG

ACCIDENT PARTICULARS	
SHIP	Hamburg
TYPE	Passenger
FLAG	Bahamas (FOC)
BRIDGE	Master - Portuguese
CREW	2nd Officer - Italian
	Cadet - nationality not known
WIND	SW occational gale force
SEASTATE	Moderate
VISIBILITY	Moderate
RESULT	Propeller cropped, propeller shaft distorted, port rudder stock displa-
	ced, hull plating heavily indented, internal bottom structure damaged

Table 9. Accident particulars case *Hamburg* (MAIB, 2016)

The Bahamas flagged passenger vessel *Hamburg*, left Bremerhaven on the 4th of May 2015 heading on at cruise around England, Ireland and Scotland. First stop was London but as a fishing net got entangled around its starboard propeller, the scheduled London port call was cancelled. The net was eventually removed in Southampton by divers and the trip could continue as planned. As the ship was heading towards Tobernary from Dublin, there was a gale warning issued for the Irish Sea area which would worsen during the following day. This resulted in the master deciding to proceed with the best possible speed towards Tobernary to be able to anchor in the shelter of Tobernary Bay before the weather got any worse. When *Hamburg* was approaching Tobernary Bay, they received information from Tobernary Harbour Association (THA) that there were already two smaller cruise ships anchored and that *Hamburg* had to wait for them to leave before entering the area. At 0933 on the accident day, the master of *Hamburg* was informed that one of the two ships anchored in the bay – The *Hebridean Princess*, was expected to leave at 1215. Shortly later at 1036 when *Hamburg* approached Ardmore point, the master of *Hamburg* decided that they would continue towards Tobernary Bay and keep drifting in the northern parts of the Sound of Mull. This was communicated to the OOW but neither made any alterations to the passage plan. As *Hamburg* proceeded into the Sound of Mull, the lashings to both anchors were cleared ready to use. The bridge was also cleared of passengers and extra crew. The stabilizer fins were stowed, the engine was on standby and steering was on manual. *Hamburg* was ready in all senses of a normal approach to a port. (MAIB, 2016)

At 1200 *Hebridean Princess* left their anchored position. Simultaneously *Hamburg* was on a south-easterly heading, now drifting in the northern part of the Sound of Mull. The south-westerly wind of force 6 to 7 Beaufort had gusting winds up to 40kts created a moderate swell. *Hamburg* periodically adjusted to maintain their position but generally the engine controls were set to stop. (MAIB, 2016)

The other cruise ship anchored in the bay, *Sea Explorer 1*, was scheduled to leave the anchor area at around 1300. At the same time, *Hamburg* was slowly proceeding with 1,11kts speed towards Tobernary Bay. At 1321 both the OOW and the cadet plotted the vessels position on the paper chart (which they did irregularly). As the cadet found out that his plotted position was some distance away from the OOW´s, he erased his position from the chart without consulting the OOW as he assumed that his position was wrong. (MAIB, 2016)

As *Sea Explorer 1* was heading out the bay as *Hamburg* was about to enter, the two ships decided to pass green-to-green. Shortly after another two ships, motor yacht *Nahlin* and bulk carrier *Yeoman Bridge* contacted *Hamburg*. *Nahlin* was approaching the New Rocks buoy from south-east with a north-westerly course and *Yeoman Bridge* was approaching from north-west. The expected CPA's between the three vessels remained very close at about 0,2NM. As the master was occupied with the traffic ahead, he was aware that *Hamburg* was closing in on the New Rocks buoy. At 13:28 the safety officer (present on the bridge) went to take the bearing to the buoy. On his arrival to the bridge, *Hamburg´*s port quarter grounded to the north-east of the New Rocks buoy with a speed of 6,37kts (SOG). (MAIB, 2016)

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Picture 12. Accident site *Hamburg* (MAIB, 2016).

Hamburg shook violently as it grounded but it did not get stuck on the rocks. After visual inspections of the internal spaces and assuring there was no water ingress, *Hamburg* continued crippled with one engine towards the bay. As the master noticed that the bay was congested with smaller boats on moorings, he decided that he would anchor in the entrance rather than in the pre-planned position. *Hamburg* was anchored close to Calve Island and the five shackles of anchor chain did not hold. Luckily the OOW noticed the drifting and they aborted the anchoring. While leaving the position, *Hamburg* was only 0,1NM of Calve Island and was very close to a second grounding. As the weather was worsening, the master decided to heave-to in the Irish Sea before continuing passage to Belfast for repairs. (MAIB, 2016)

Hamburg is a flagged to Bahamas; therefore, we cannot rule out any FOC-related issues in this case. As we can see from Figure 9 Bahamas flagged ships are on the accident % per fleet list at a medium level (between 1 to 2% % of the fleet). Table 8 below shows the main reasons for why Passenger Ship *Hamburg* run aground on entry to Tobernary Bay.

Main reasons for the accident
➢ The bridge crew did not recognise that they were approaching the New Rocks buoy from an unsafe direction ➢ No or minimum team work on the bridge ➢ Navigation practises were not on top level onboard ➢ Crew relied entirely on paper charts and did not utilize the ECDIS at all ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision ➢ The ship failed to comply with Colregs Rule 8 Action to avoid collision

Table 10. Main reasons case *Hamburg* (MAIB, 2016)

The reason for the accident was a combination of poor bridge team management and bad navigational practices. The passage plan was not amended or re-evaluated on re-entry to Tobermory Bay and the result was an unsafe approach. The cadet did not challenge his plotted position towards the OOW´s so there was no common confirmation on the ship´s position. On top of that the EDCIS was not used to its full potential. There was a mixed crew on the bridge, so there is a possibility that the communication was not running fluently between the crew. At least teamwork was at a minimum level.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As not all aspects are not readily given in the original accident report, some causal factors have been added or left out based on the overall picture received by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 11.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD5 - culture
DD7 - lack of teamwork
+ *possible cultural differences/power gap*

Table 11. Causal attributes case *Hamburg*

To conclude the *Hamburg* case, a modern ship with multiple officers on the bridge can run aground if the situational awareness is lost. The use of different Kongsberg INAV system products could have prevented this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the shallow waters around New Rocks buoy and the nearby ships *Sea Explorer 1*, *Nahlin* and *Yeoman Bridge*. The passing of all ships and the shallow area could have been made in a safe manner, *if the master and 2/O would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would also have led to not losing the situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a better approach to Tobernary Bay.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating past the New Rocks Buoy and the nearby ships pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters in mind, ending up in safe passing of all dangers on the ship´s course.

Table 12. Kongsberg analysis case *Hamburg*

COSTA CONCORDIA

ACCIDENT PARTICULARS	
SHIP	Costa Concordia
TYPE	Passenger
FLAG	Italy
BRIDGE	Master - Italian (takes the con before the accident)
CREW	1st Deck Officer - Italian
	2nd Officer - not confirmed but most likely Italian
	Helmsman - Indonesian
	Cadet
	Hosted guests
WIND	E-NE/ 17 kn
SEASTATE	Rough
VISIBILITY	Partly cloudy
RESULT	Very serious accident. Total loss of ship, 32 dead or missing, 157 injured.

Table 13. Accident particulars case *Costa Concordia* (MCIB, 2012)

Italian luxury cruise liner *Costa Concordia* left the port of Civitavecchia shortly after seven (19:18) in the evening and was heading for Savona, Italy on January 13th, 2012. Only two hours into the trip, the 1st officer contacts the master and he´s ordered to stay 6 nautical miles off Giglio Island – just reconfirming the instructions that he was given already at departure. According to the original planned course, the ship was supposed to reach the waypoint passing Giglio at 21:39. At 21:34 the master arrives at the bridge and directly orders the helmsman to change to manual steering. The 1st officer still has the con for a couple of minutes and during this time he orders the helmsman to execute a new heading of 285 and subsequently 290. After five minutes on the bridge and after been reassured on the phone of the safe distance to pass the island, the master takes the command of the ship. At the time the speed was 3,15kts and the heading 290. The master orders a new heading to 300 and increase speed to 16 knots. Simultaneously the helmsman's orders were to gently pull to heading 310. Until this point the ship was still on its original course. Soon after this the master orders "bows", as to execute an "inchino", a kind of courtesy sail by to commemorate an old colleague. After a series of heading orders to the helmsman, which were not always clear- the master changes to rudder angles in his orders. The ship ends up to close to the coast than planned and when the helmsman just before impact steers the rudder 20 degrees to starboard instead of port, it steers the ship even closer. The helmsman executes the last command hard to port correctly but by then it was already too late, the ship runs aground at 21:45 on the port side (left) of the ship. The speed decreases to 8,3knots, *Costa Concordia* loses propulsion and starts drifting. Despite the seriousness of the situation, with two flooded compartments – master Schettino does not sound the general alarm. This is done only at 22:36. At 22:55 the ship runs aground again with a 20 degrees list to starboard. This listing eventually increases to 30 degrees within 15 minutes of impact. As a result of master Schettino´s inchino, a total of 32 persons were lost (27 passengers and 5 crewmembers) and the ship was declared a total loss. It was later recovered and scrapped.

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Picture 13. Accident site *Costa Concordia* (MIT, 2013)

Costa Concordia was flagged to Italy, so FOC-related matters were not analysed for the ship. As can see from Figure 9 that Italy is listed on the accident % per fleet list at a low level (under 1% of the fleet). Table 9 below shows the main reasons for why Passenger Ship *Costa Concordia* run aground while making a close sail-by of Giglio Island.

Main reasons for the accident
➢ Master´s decision to pass Giglio Island at an unsafe distance at high speed ➢ Using an inappropriate chart for the approach (wrong scale) ➢ No handover between master and C/O occurred ➢ The master was distracted by extra persons on bridge ➢ Master´s orders to helmsman were inconsistent (Compass course/rudder angle) ➢ Bridge team passive attitude resulting in no assistance to the master ➢ Helmsman´s mistakes understanding orders ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision

Table 14. Main reasons case *Costa Concordia* (MCIB, 2012)

This close approach on Giglio was an inchino, a form of a salute to a colleague. This was accepted by the company on their whole fleet as something that was part of the entertainment package. This time master Schettino used this accepted form of salute to `wow` his guests onboard the bridge. Master resumed control of the ship from the Chief Officer without clearly taking the con. Subsequently the whole bridge team stays passive and does not even help the master with the navigation. No one plots the position (which was the 2/O responsibility) or warns the master of the shallow waters ahead. On top of that, a wrong scale chart is used for the approach. The master is also disturbed by a phone call to the bridge, if the guests were not enough to distract his mind. master was unsure of the depth of the shoreline and his answer is to call someone ashore? He had his whole bridge team at his disposal and this option was not used. So, with his guests on the bridge, master Schettino decides to approach the shore with high speed even knowing how deep the waters are close to the shoreline. Lastly the W/T doors were not closed when this manoeuvre was executed. *Costa Concordia´s* bridge was an Italian flagged vessel with Italian officer´s. Only the helmsman was from Indonesia, which caused communication problems and subsequent misunderstandings in the orders. The helmsman made mistakes and should have been removed from his duties after the first mistake, in a delicate approach like this close to the shoreline. Just before the accident, *Costa Concordia´s* management applied to the Flag state that the operating language would be changed to Italian. There were 46 nationalities onboard, with English as a common language, even if this was at a poor level. So, by the time of the accident, orders were given in two languages, which confused a lot of crew. We can fairly assume that forty-five (45) different nationalities would not pick up the Italian language quickly enough to operate a ship safely.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As not all aspects are not readily given in the original accident report, some causal factors have been added or left out based on the overall picture received by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 15.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD5 - culture
DD7 - lack of teamwork
DD10 - distractions
+ *possible cultural differences/power gap*

Table 15. Causal attributes case *Costa Concordia*

To conclude the *Costa Concordia* case, a modern ship with multiple officers on the bridge can run aground if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the shallow waters around Giglio Island. The passing of the shallow area could have been made in a safe manner, *if the master, 1/O and 2/O would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a better sail-by of Giglio Island.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating past the Giglio Island pending the OOW´s approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time*. The close sail-by of the island would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters in mind, ending up in safe passing of all dangers on the ship´s course.

Table 16. Kongsberg analysis case *Costa Concordia*

8.1.2 Cargo ship case/s

VICTORIA

ACCIDENT PARTICULARS	
SHIP	Victoria
TYPE	Cargo - container (fully cellular)
FLAG	Portugal (Madeira - FOC)
BRIDGE	Master - Polish
CREW	Chief Officer - Romanian
	AB - Philippino
WIND	E 8-10 m/s
SEASTATE	1,0 m
VISIBILITY	Good
RESULT	50m indentation on ship´s bottom, 100m3 fuel ois was spilled. Minor
	environmental damage to wildlife and coastline

Table 17. Accident particulars case *Victoria* (DMAIB, 2017)

The Portuguese flagged container ship *Victoria* was on its way from Antwerp, Belgium to Fredericia Port in Denmark. They went aground in Kattegat at the entrance to the deep-water channel Lillegrund on the 10th of February 2017. *Victoria* was a frequent visitor to Danish waters and knew the waters well. It was not compulsory to take pilot onboard on this type of vessel. *Victoria* also used different passage plans on its trips to Fredericia depending on the ship's draught and schedules. This time the navigational officer made the passage plan based on an older plan and chose the shortest route. This was not the traditional route towards the deep-water channel (even VTS commented on that and the shallow waters ahead) and resulted in that the ship had to make a heavy course change at 16knots in the dark, with a westerly current (and wind) drifting the ship towards the shallow area. The bridge crew (master and chief officer, who was in con) was concentrating on making the turn and not on the shallow area ahead. The Isolated danger mark was in the middle of the shallow area, but it did not steer the crew to think there was also shallow waters on the eastern side of the mark. They were too much concentrating on the turn. This was also not visible (wrong scale used) on the ECS which was "primary" used for navigation instead of the official paper charts onboard. Additionally, the alarm from the echo sounder was deactivated however with this speed the alarm would not have made any difference in avoiding the grounding. The result of the minor grounding was that the bottom hull was breached in several places along the SB side damaging fuel oil tanks. On top of deformed plating on the bottom, five propeller blades had to be replaced. As a result, some oil was spilled and washed ashore on Island of Endelave and other municipalities and had to be later removed.

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Picture 14. Accident area *Victoria* (DMAIB, 2017)

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Picture 15. Accident site *Victoria* (DMAIB, 2017)

Victoria is flagged to Portugal (Madeira - MAR); therefore, we cannot rule out any FOC-related issues in this case. As we can see from Figure 9 that Portugal (including ships registered in Madeira) is not listed on the accident % per fleet list. Table 10 below shows the main reasons for why Container ship *Victoria* run aground entering the Lillegrund Channel.

Main reasons for the accident
➢ The bridge team was navigating by visual means only ➢ The change of passage plan made it necessary to make a 45- degree change within a short distance to shallow waters. ➢ The course change was planned to be made at speed of 15kts which required the turn to be made with precise timing. ➢ The drift of the ship made it seem to the bridge crew that the ship was further east than it was ➢ The ECS did not clearly bring the bridge crew´s attention to the shallow water area ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision

Table 18. Main reasons case *Victoria* (DMAIB, 2017)

This accident shows that navigating a ship safely is a combination of different tasks made by a team of people to be made during the voyage. The passage plan is usually made by the navigating officer, position fixes along the route is made by the OOW´s and different manoeuvres are made by everyone. Communication is held with other ships, VTS operators with the aim to arrive in time at the destination port. All these complex interactions need focusing and it is hard to be equally on the map with each task. This leads to a prioritization process and task-specific decisions for the OOW to make. As there can be many things which distract the OOW, some information or tasks may not be recognized or done completely. The bridge of *Victoria* had three nationalities present which could have caused lack of communication between the parties.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 19.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD6 - lack of local practices
DD7 - lack of teamwork
DD9 - pressure
+ *possible cultural differences/power gap*

Table 19. Causal attributes case *Victoria*

To conclude the *Victoria* case, a modern ship with multiple officers on the bridge can run aground if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the shallow waters around the entry to Lillegrund Channel. The passing of the shallow area could have been made in a safe manner, *if the master and C/O would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a better approach to the channel.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating through Lillegrund Channel pending the OOW´s approval*. *The system would also have automatically chosen the safest option to navigate past the targets in case the OOW had failed to activate his choice in ample time*. The passing of the isolated danger mark and the channel would have been made in a safe manner by INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters in mind, ending up in safe passing of all dangers on the ship´s course.

Table 20. Kongsberg analysis case *Victoria*

SOLA TS/ KNM Helge Ingstad

ACCIDENT PARTICULARS		
SHIP	TS Sola	KNM Helge Ingstad
TYPE	Cargo - oil tanker	Navy Frigate
FLAG	Malta (FOC)	Norway
BRIDGE	Pilot - Norwegian	Duty Officer - Norwegian
CREW	Captain*	Bridge crew of 7 - Norwegian
	OOW*	(incl. 2 trainees)
	Helmsman*	
WIND	Unknown	
SEASTATE	Unknown	
VISIBILITY	Clear sky, good visibility	
RESULT	Entensive damage to the frigate and minor damage to the tanker	
	MGO leaked with little impact on the marine environment	
* TS Sola was leaving port so this crew composition is most likely. Nationalities unknown		

Table 21. Accident particulars case *TS Sola*/ KNM *Helge Ingstad* (AIBN, 2018)

The Norwegian Navy Frigate KNM *Helge Ingstad* was cruising on a southerly course in inshore waters of Bergen, Norway on the 8th of November 2018. As they entered the Fedje VTS area at 02:40 at 17 knots they reported normally and the VTS operator was given the intended route. *Helge Ingstad´*s AIS was set on receiver mode only, so the OOW on the frigate could see other AIS-objects, but they were not seen by the other parties – except as a normal radar target. As KNM *Helge Ingstad* was making its way southbound, there were three other ships sailing on a northerly course. All these ships were monitored and plotted on the navy frigate. The OOW on *Helge Ingstad* was also listening to the VTS working channel 80 in the area. Just before 03:00 a pilot boarded Oil Tanker *TS Sola*, a Malta flagged ship that had been loading crude oil at Sture Terminal. As they were leaving the port, Fedje VTS confirmed that there were only three ships on northerly course in the area – leaving KNM *Helge Ingstad* out of the scope. At 03:57 the pilot onboard *TS Sola* noticed the radar echo of KNM *Helge Ingstad* as a ship on a southerly course, on a collision course with *TS Sola*. At 03:58 the pilot called the VTS to inquire about the ships name, but the VTS-operator could not recognize the ship in question. The bridge crew also used an Aldis lamp to try to contact the frigate. At this point, the pilot requested the master to make a 10-degree course change from 350 to 000. At 04:00 the VTS-operator called back the pilot to tell that the ship was most probably KNM *Helge Ingstad*. A tight sequence of calls was made between the VTS, *Helge Ingstad* and the pilot onboard *TS Sola*. At a very late stage, the navy frigate tried to make an avoidance manoeuvre, but it was too late. The two ships collided and KNM *Helge Ingstad* sustained heavy damage, drifted ashore and grounded in shallow waters. *TS Sola* only gained minor damages.

It was a clear night so all navigation lights on ships should have been seen from 2-3 miles away. Both KNM *Helge Ingstad* should have known others existence just by listening to the VTS channel 80 (most likely also on *TS Sola* at 02:40 when *Helge Ingstad* reported to VTS). KNM *Helge Ingstad* could also see *TS Sola´*s AIS. The VTS operator overall control of the area was not at a high level as this situation could happen. On *TS Sola*, there was the pilot, the master and one AB. Only at a very late stage, the pilot noticed the large frigate as an echo on the radar. No one saw the navigation lights, so proper lookout was not done. On KNM *Helge Ingstad*, they performed navigation training and should thus have been more alert. They had plotted the three northerly ships but ignored the AIS-target leaving Sture Terminal. They must have heard *TS Sola* pilot´s conversation with VTS as it was ready to leave port. This is a complex case, but eventually all parties failed in some extent. The VTS operator, *TS Sola*´s master and the OOW on board KNM *Helge Ingstad*.

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Picture 16. Accident site *TS Sola*/KNM *Helge Ingstad* (Wiudwingblogspot, 2018)

TS Sola is flagged to Malta, so we cannot rule out any FOC-related issues in this case. As we can see from Figure 9 Malta is listed on the accident % per fleet list at a high level (between 2 to 3% of the fleet). KNM *Helge Ingstad* was flagged to Norway (NOR), so FOC-related matters were not analysed for the ship. We can also see from Figure 9 that Norway is not listed on the accident % per fleet list. Table 22 below shows the main reasons for why Oil Tanker *TS Sola* collided with Navy Frigate KNM *Helge Ingstad* in the inshore waters of Bergen.

Main reasons for the accident
➢ Situational awareness on both bridges was low or non-existent. ➢ Navigation level unsatisfactory on KNM *Helge Ingstad* ➢ Officer of the watch on KNM *Helge Ingstad* was unexperienced ➢ Handover on KNM *Helge Ingstad* was insufficient ➢ Training mode on KNM *Helge Ingstad* reduced the capacity to monitor the traffic situation ➢ Starboard lookout position was unmanned on Helge Ingstad ➢ The bridge team on KNM *Helge Ingstad* may have been affected by fatigue ➢ KNM *Helge Ingstad* sailed with the AIS in passive mode, which affected the safety as many other players largely use AIS as their primary (ant to some extent only) source of information ➢ *TS Sola* was not plotted on KNM *Helge Ingstad´*s radar ➢ Lack of proper communication between pilot and bridge crew on *TS Sola* ➢ Pilot o/b *TS Sola* was not vigilant enough to spot the risk of collision ➢ OOW and master o/b *TS Sola* did not help the pilot with navigation with their own feedback and checks (KNM *Helge Ingstad* was not plotted on radar) ➢ The deck lights were lit on *TS Sola* after departure, which made the navigation lights and *TS Sola´*s ALDIS lamp hard to spot ➢ KNM *Helge Ingstad* was in the belief that they were communicating with some other ship they were monitoring on the radar. ➢ The VTS operator did not warn ships in the area of KNM *Helge Ingstad´*s receiver (silent) mode. KNM *Helge Ingstad* was not plotted on radar. ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ KNM *Helge Ingstad* failed to comply with Colregs Rule 15 Crossing situations ➢ KNM *Helge Ingstad* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *TS Sola* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 22. Main reasons case *TS Sola*/ KNM *Helge Ingstad* (AIBN, 2018)

It was a clear night so all navigation lights on ships should have been seen from 2-3 miles away. Both KNM *Helge Ingstad* should have known others existence just by listening to the VTS channel 80 (most likely also on TS Sola at 02:40 when KNM *Helge Ingstad* reported to VTS). KNM *Helge Ingstad* could also see *TS Sola´*s AIS. The VTS operator overall control of the area was not at a high level as this situation was able to happen. On *TS Sola*, there was the pilot, the master and one AB. Only at a very late stage, the pilot noticed the large frigate as an echo on the radar. No one saw the navigation lights, so proper lookout was not done. On KNM *Helge Ingstad*, they performed navigation training and should thus have been more alert. They had plotted the three northerly ships but ignored the AIS-target leaving Sture Terminal. They must have heard *TS Sola* pilot´s conversation with VTS as it was ready to leave port. This is a complex case, but eventually all parties failed in some extent. The VTS operator, *TS Sola´*s master and the OOW on board KNM *Helge Ingstad*. In terms of the Colregs, KNM *Helge Ingstad* was the give-away vessel and *TS Sola* the stand-on vessel. To start with *TS Sola* should have kept her course and KNM *Helge Ingstad* make avoiding actions in ample time. As the navy frigate did not comply with its obligations, *TS Sola* should have made her own in ample time to avoid the collision.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 23.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD5 - culture
DD6 - lack of local practices
DD7 - lack of teamwork
DD8 - lack of capability
DD9 - pressure
DD10 - distractions
DD11- fatigue
+ *possible cultural differences/power gap*

Table 23. Causal attributes case *TS Sola*/ KNM *Helge Ingstad*

To conclude the *TS Sola*/KNM *Helge Ingstad* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the bridge team(s) of the nearby ships. The navigation in the area could have been made in a safe manner, *if the pilot on TS Sola and the OOW(s) on both ships would have followed the guidance (visual track given as per set safety parameters) provided by their respective INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team(s) of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge(s). The INAV system would have given the OOW/SOTD/bridge team(s) more time to assess the risks ahead, evaluate and execute better manoeuvres to avoid all nearby ships.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the area and past the nearby ships pending the OOW(s) approval*. *The systems would also have automatically chosen the safest option to navigate past targets in case the OOW/SOTD had failed to activate their respective choices in ample time.* The passing of the area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team(s) could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship(s) would have been INAV system-operated with all the safety parameters of the ship(s) in mind, ending up in safe passing of all dangers on the ship(s) course(s).

Table 24. Kongsberg analysis case *TS Sola*/ KNM *Helge Ingstad*

PETUNIA SEAWAYS/ PEGGOTTY

ACCIDENT PARTICULARS		
SHIP	Petunia Seaways	Peggotty
TYPE	Ro-ro freight	Motor launch
FLAG	Denmark	UK
BRIDGE	Master - Danish, with PEC	Master - UK national who
CREW	for Immingham since 20years	was an Off - duty HUMBER pilot
	Chief Officer - Swedish	Potential byer´s representa-
		tive with seafaring experience
WIND	Light airs	
SEASTATE	Calm	
VISIBILITY	Dense fog	
RESULT	Petunia - scratches to paintwork, Peggotty - total loss	

Table 25. Accident particulars case *Petunia Seaways/ Peggotty* (MAIB, 2017)

The early morning of 19th on May 2016 the visibility on Humber River was very poor, with a dense fog hanging over it. The owner of the historic motor launch *Peggotty* was ready sell the vessel and had the prospective new buyers' representative to come over for a test drive on the way to the survey site, where *Peggotty* was due to be surveyed. When arriving at the berth at 03:15 in the morning, *Peggotty*´s batterie s were flat and had to be restarted with the help of the master's car batteries. To be able to sail the launch under a low road bridge *Peggotty*´s mast had to be lowered and stowed in its cradle on the main deck. With the radar's scanner mounted to the mast, the radar could not be used. The buyer's representative noticed also that the port side sidelight was not working. He tried to fix it with the use of the bulb from the headlight, but he could not get it to function. He decided to accept the situation, although *Peggotty* was in no shape to operate in dense fog without working set of lights and radar. The master had also told him that the fog would soon lift after the sunrise. At 04:00 *Peggotty*´s engine was running, and it was ready to proceed into the foggy river with only the starboard sidelight illuminated. With only an Ipad with a navigation application as the primary source of navigation, the two gentlemen proceeded through the lock at Royal Dock onto the River Humber. Their destination was Hull.

The Danish registered ro-ro vessel *Petunia Seaways* was at this time ready sail from Immingham towards Gothenburg, which they did at 04:11. The master sounded the fog signal once, sounding a long blast for other ships in the vicinity but the automatic fog-signal was not switched on.

At 04:33 *Petunia Seaways* C/O called VTS Humber informing that it was passing buoy 9 Alpha and that the visibility was zero.

At the same time, *Peggotty* and the vehicle carrier Sea Cruiser 1 were clear of the Royal Dock as they transited outbound to River Humber. *Peggotty*´s master called VTS, but the reply was never heard onboard *Peggotty* – due to the poor readability of the handheld VHF-radio in use. When *Peggotty* entered the inshore area of Grimsby with the north-easterly course and the speed of 6kn, the fishing vessel Northern Star was also in the area, proceeding with an easterly course using a similar speed. After exiting the lock, *Peggotty*´s masters Ipad navigation application had ceased to function, which resulted in very poor or no possibility to assess *Peggotty*´s position or nearby traffic. In and around the area was the dredger UKD Bluefin (dredging in the area) and City of

Sunderland, which was heading inbound for Grimsby. When 04:38 *Peggotty* again contacted VTS but the readability was not even worse, and it was rapidly closing in on *UKD Bluefin*. *Peggotty´*s master saw UKD Bluefin close on the starboard side and subsequently changed his course onto a north-westerly course. *Peggotty* continued with the same course and when at 04:44 the launch passed the southern buoy line, *Peggotty* entered the main shipping channel. Shortly after, Northern Star´s master contacted the VTS to request permission to cross the channel. Also, the OOW onboard bulk carrier Cape Star interrupted the conversation several times. The conversation with Northern Star that included the information that *Petunia Seaways* was proceeding in the channel with 14 knots, was never heard onboard *Peggotty*.

While listening to the VTS operators' conversations with Cape Star, *Petunia Seaways* master noticed a small radar target on his starboard beam (using his S-band radar) – something he could not recognise as a navigational mark. This was not seen on the Chief Officer's radar as he was using the X-band radar. The master sounded the fog-signal and changed his course 5 degrees to port. After sounding the second fog-signal, the master started slowly to turn the ship back to its original planned course.

On *Peggotty* the buyer's representative tried his best to plot the position without any plotting instruments. Even without them, he estimated that *Peggotty* was somewhere in the middle of the shipping channel. *Peggotty´*s master heard *Petunia Seaways*' fog signal but was unaware of from which direction the signal came from. *Peggotty´*s master tried to contact VTS, but the call was never heard. *Peggotty* was not directly ahead of *Petunia Seaways*' bow. As a last-minute manoeuvre, the master tried to steer *Peggotty* away from the evident collision, but it was too late. *Peggotty´*s master turned off the engine, shouted to the byers representative and ducked back into the cabin.

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Picture 17. Accident site *Petunia Seaways*/ *Peggotty* (MAIB, 2017)

Petunia Seaways is flagged to Denmark, so FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Denmark is not listed on the accident % per fleet list. *Peggotty* was a small historic Motor Launch with no relevant flag state. Table 25 below shows the main reasons for why Ro-ro Ship *Petunia Seaways* collided with Motor Launch *Peggotty* in the Humber River.

Main reasons for the accident
➢ *Peggotty*´s master lost his situational awareness totally relying only on navigation by an Ipad navigation tool. No use of radar was considered despite of heavy fog. ➢ *Peggotty* did not show the correct navigational lights ➢ VTS did not monitor small vessels effectively to deconflict traffic ➢ *Peggotty* was visible on both the *Petunia Seaways* and VTS Humber´s radars. Neither one acquired the target nor attempted to plot it ➢ *Petunia Seaways* had a 98-metre blind spot ahead, due to the bridge position on ship. In heavy fog, the visibility ahead was very poor or zero. ➢ Both ships did not sound the fog horns as they should have ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ Both ships failed to comply with Colregs Rule 19 Restricted weather ➢ *Peggotty* failed to comply with Colregs Rule 20 Application ➢ *Peggotty* failed to comply with Colregs Rule 23 Lights displayed by power-driven vessels underway ➢ Both ships failed to comply with Colregs Rule 35 Sound signals to be used in restricted visibility

Table 25. Main reasons case *Petunia Seaways*/ *Peggotty* (MAIB,2017)

A classic example on how many mistakes or wrongdoings can escalate into a collision. *Petunia Seaways* was proceeding with normal high-speed despite of the heavy fog and visibility of 100 metres. They had a blind spot up to 98 meters, so they were practically blind. There was traffic around, but the automatic fog signal was never switched on. At the same time an off-duty Humber Pilot leaves the port with an unseaworthy vessel with faulty navigation lights. The radar was not in use as the antenna was in retracted position. With only his local knowledge and an Ipad navigation tool, the owner/operator of *Peggotty* leaves the port and gets disoriented in the dense fog. He loses his situational awareness totally and by the time the potential byers representative plots the position on the chart (without navigation tools) they realize that they are in the middle of the channel. The Scandinavian bridge crew of *Petunia Seaways* were sailing under Danish flag so we can assume that there were no communication issues there. For some reason *Peggotty*´s radar image was not acquired, and the high speed was kept despite of the trafficked channel and heavy fog. A reduction of speed would have allowed *Petunia Seaways* master more time to assess the radar target ahead of him.

Maybe the C/O was overconfident navigating with the master as he was a PEC holder in this Humber area. Still the C/O should have challenged the master to reduce speed, use the foghorn and proceed with more care in the area. Nor did they try to contact the VTS for more information on the nearby traffic. We can fairly say that if *Petunia Seaways* had the Kongsberg INAV systems onboard the system would have automatically done the acquiring/plotting of *Peggotty*´s radar target which was not done by humans as it should have. This would have alerted the bridge crew to act accordingly.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 27.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD6 - lack of local practices
DD7 - lack of teamwork
DD8 - lack of capability
DD9 – pressure

Table 27. Causal attributes case *Petunia Seaways*/ *Peggotty*

To conclude the *Petunia Seaways*/*Peggotty* case, a modern ship with multiple officers (with the master holding a PEC for the area) on the bridge can collide with a motor yacht mastered by an off-duty pilot if the situational awareness is lost on the bridge(s). The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable. Kongsberg systems do not recognize "restricted weather" conditions, so there is a need for human presence and decision to reduce speed and sound the appropriate sound signals as per Colregs. *Petunia Seaways* bridge was well manned but still proper signals were not executed.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the reminding the bridge team of the nearby ships including *Peggotty*. The passing of *Peggotty* could have been made in a safe manner, *if the master and C/O onboard Petunia Seaways would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the bridge team more time to assess the risks ahead, evaluate and to pass *Peggotty* at a safe distance.
INAV Onboard Control	Accident prevention with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the area and past the nearby ships pending the Petunia Seaways master´s approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the restricted visibility area and *Peggotty* would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for any possible human intervention at any time of choice. In this case to adjust speed (and min CPA) to safe speed according to the prevailing circumstances.
INAV Onboard Zero	Accident prevention. The ship(s) would have been INAV system-operated with all the safety parameters of the ship, ending up in safe passing of all dangers on the ship´s course.

Table 28. Kongsberg analysis case *Petunia Seaways/ Peggotty*

PRIMULA SEAWAYS/ CITY OF ROTTERDAM

ACCIDENT PARTICULARS		
SHIP	Primula Seaways	City of Rotterdam
TYPE	Ro-ro	Car carrier
FLAG	Denmark	Panama (FOC)
BRIDGE	Master - Swedish	Pilot - UK, Humber pilot for 14 years
CREW	(River Humber PEC since 2011)	Master - Bulgarian
	2nd Off - UK national	3/O - Filippino
	AB - Danish	AB - Filippino
WIND	SSW up to 40 kts	
SEASTATE	Unknown	
VISIBILITY	Dark with clear skies, good visibility	
RESULT	No pollution, no serious injuries, damage to both ships	

Table 29. Accident particulars case *Primula Seaways/ City of Rotterdam* (MAIB, 2017)

The pure car carrier *City of Rotterdam* departed Immingham Dock, UK on December 3, 20:15 in the evening. Onboard the bridge was the pilot, the master and a helmsman (AB). As they departed, the pilot and the master discussed the effect of the gusting winds (up to 40kn south-south-west) as the ship was high-sided and in ballast. The pilot also anticipated that the ship would drift due to tidal streams once it had passed Grimsby, where it was more exposed. At 19:59, *City of Rotterdam* had passed and was clear of the Immingham lock. The vessel sailed on a south-easterly heading with manual steering and a speed of 12kn. The tidal stream had an effect of 1,5kn. Passing the 9A buoy, VTS was contacted and the ship continued its passage down the channel. The pilot mainly monitored the ships position by eye, but occasionally checked the ECS and portside radar to verify the sightings. Simultaneously the Danish flagged ro-ro ship *Primula Seaways* was on its way in the opposite direction in the outer approaches of the River Humber, heading for Immingham. On *Primula Seaways* bridge were the master, 2/O and an able seaman. The master had the con. *City of Rotterdam* was navigating north to its intended track and could now see *Primula Seaways*. The pilot onboard *City of Rotterdam* made 5-degree increments from 125 to 95 and informed the master that the ships would pass each other port to port. The VTS operator monitoring the area, noted *City of Rotterdam´s* northerly track and subsequently informed the VTS watch manager – who was not too concerned as he thought that the pilot would have enough time for corrective action. At 20:34 *Primula Seaways* master contacted VTS Humber to enquire about *City of Rotterdam*'s intentions. At this point the two ships were 2,8NM apart. At 20:35 the pilot onboard *City of Rotterdam* reported the ships position to the VTS after some time waiting for his turn on the VHF. He used the VHF sited to starboard of the centreline for the transmission. As the ships sailed closer the master and the 2/O on *Primula Seaways* grew more concerned that *City of Rotterdam* still was on its northerly course. So did the VTS watch manager. They both contacted *City of Rotterdam* in sequence, and the pilot responded. Again, using the starboard side VHF, not aligned with the centreline. VTS and the two ships were discussing twice on the VHF and the pilot onboard *City of Rotterdam* agreed to bring the ship as far to the south as possible. During the last conversation, *Primula Seaways* master reduced the speed to 9,4kn. *City of Rotterdam* ordered 20degrees to SB and as it hit 125, then midships and lastly 135. Now the car carrier´s master expressed concern over what was happening, but the pilot explained that both ships were going to experience drift. When at 20:39 when *Primula Seaways* master noticed that *City of Rotterdam* was not turning to starboard as quickly as needed, they changed to manual steering and applied full starboard helm. The engine was also put to full astern. When at 20:39 *City of Rotterdam*'s pilot ordered 150 and the helmsman applied 5 degrees to SB, the master reacted with "what is he doing?". The ships were now 0,27NM apart. At this very late stage the VTS contacted *Primula Seaways* with the information that *City of Rotterdam* seems unable to come more south. Primula was already turning full to starboard, so they had little room for any other manoeuvres. *City of Rotterdam* never replied to the last effort to contact them. At 20:40 the master of *City of Rotterdam* shouted, "go to starboard", then midships and lastly hard to port. Some fourteen seconds later the two ships collided, port bow to port bow. (MAIB, 2017.)

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Picture 18. Accident site *Primula Seaways*/ *City of Rotterdam* (MAIB, 2017)

Primula Seaways is flagged to Denmark, so FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Denmark is not listed on the accident % per fleet list. *City of Rotterdam* is a Panama flagged ship so we cannot rule out any FOC-related issues. As we can see from Figure 9 Panama flagged ships are very high on the accident % per fleet list. Table 30 below shows the main reasons for why Ro-ro Ship *Primula Seaways* collided with Car Carrier *City of Rotterdam* in the Humber River.

Main reasons for the accident
➢ The pilot of *City of Rotterdam* lost his (situational and) spatial awareness due to the position of the SB side VHF creating `relative motion illusion´ ➢ Apparent over-reliance on the pilot onboard *City of Rotterdam* ➢ No intervention by the passive bridge team on *City of Rotterdam* despite of knowing the potential disorientation when conning from a position away from the centreline ➢ VTS did not intervene to suggest more robust actions ➢ *Primula Seaways* actions were taken too late to be effective ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ Both ships failed to comply with Colregs Rule 14 Head on situations ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 30. Main reasons case *Primula Seaways/ City of Rotterdam* (MAIB, 2017)

The main reason for this accident is the loss of spatial awareness of the pilot onboard *City of Rotterdam*. Due to the unconventional bridge design (Picture 29) the pilot was affected by `relative motion illusion´ when conning away from the centreline of the bridge. The mixed bridge team of *City of Rotterdam* did little to challenge the pilot or keeping track on where the ship was heading. Hence, no alerting or challenging of the pilot´s decisions were made. Looking back at the Dirty Dozen (Picture 10) by MCA (2016), we can clearly see that loss of situational awareness, alerting, maybe teamwork, complacency and lack of proper communication were part of this accident. As mentioned earlier in the cultural differences section, there could always be an issue in the communication flow due to cultural bounders. The Swedish master of *Primula Seaways* would most likely have an easy communication flow with the fellow Scandinavian AB. Likewise there would probably not have been any communication issues with the UK national either. Onboard *City of Rotterdam* on the other hand, the pilot was a UK local, the master from Bulgaria and the 3/O and AB from Philippines. The multinational combination on *City of Rotterdam* could have had communication and cultural causes. As *City of Rotterdam* was drifting towards north in the channel due to the pilot´s actions (and lack of the bridge teams challenging), the mixed (Scandinavian) bridge team did little onboard to avoid the collision. They finally reduced speed two minutes before impact but these actions were too late to avoid the collision.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 31.

DD1 - loss of situational awareness
DD2 - lack of alerting
DD3 - lack of communication
DD4 - complacency
DD5 - culture
DD6 - lack of local practices
DD7 - lack of teamwork
DD8 - lack of capability
DD9 - pressure
+ *possible cultural differences/power gap*

Table 31. Causal attributes case *Primula Seaways/ City of Rotterdam*

To conclude the *Primula Seaways/City of Rotterdam* case, two modern ships with multiple officers navigating can collide if the situational awareness is lost on the bridge(s). The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the bridge team(s) of the nearby ships. The navigation in the area could have been made in a safe manner, *if the Pilot on City of Rotterdam and both bridge teams would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team(s) of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW(s)/bridge team(s) more time to assess the risks ahead, evaluate and execute better manoeuvres to avoid nearby ships.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the area and past the nearby ships pending the OOW(s) approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the channel area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team(s) could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship(s) would have been INAV system-operated with all the safety parameters of the ship(s) and the operating area in mind, ending up in safe passing of all dangers on the ship(s) course.

Table 32. Kongsberg analysis case *Primula Seaways/ City of Rotterdam*

BIRKA TRANSPORTER/ WILLEMPJE HOEKSTRA

ACCIDENT PARTICULARS		
SHIP	Birka Transporter	Willempje Hoekstra
TYPE	Ro-ro	Fishing vessel
FLAG	Finland	Netherlands
BRIDGE	Chief Officer - Finnish	No info available
CREW	No lookout	
	present	
WIND	SE 12 m/s	
SEASTATE	1,0 m	
VISIBILITY	Good	
RESULT	Minor damage to both ships	

Table 33. Accident particulars *Birka Transporter*/ *Willempje Hoekstra* (AIBF, 2011)

Birka Transporter (FIN), a Ro-Ro ship sailing under Finnish flag was on its way to Amsterdam from Sweden on 14th of February 2011, when it collided with a Dutch fishing trawler *Willempje Hoekstra* (NED). The accident happened outside the Dutch coast, on the southern lane of the TSS, some 18 nautical miles of Texel island. The trawler had left Port of Den Helder at 01:35 for fishing in the North Sea.

The weather was good. As *Willempje Hoekstra* was on its way to the fishing grounds and not fishing, it was classified (only) as a power-driven vessel in terms of the Colregs. So, in this case the trawler was the give-away vessel (Colregs Rule 15/ crossing situations) towards the Ro-Ro ship.

The imminent reason for the collision was the trawler's inadequate, unclear and late responses to avoid collision (Colregs Rule 8/ action to avoid collision and Rule 16/ The give-away vessel). As *Willempje Hoekstra* failed to comply with its responsibilities as a give-away vessel, *Birka Transporter* should have responded by all means available and in ample time to avoid collision (Rule 2/ responsibility and Rule 17/ The stand-on vessel). Reasons that had an impact on the accident was the sleepiness (AIBF, 2011) of the OOW on *Birka Transporter* and the fact that the outlook was missing from the bridge (Colregs Rule 5/ Look-out). It is unclear but there was a possible lack of lookout on the trawler as well, maybe due to the crew could have been rigging up the fishing gear.

This is a classic case, where both parties did not comply with the Colregs in good weather conditions despite both vessels knew there was a risk of collision (Colregs Rule 7/ Risk of collision). Both vessels are EU flagged ships, where the master is by EU-laws of European origin. It is unknown whether the bridge team onboard was multicultural at the time of the incident, thus cultural misunderstandings cannot be ruled out.

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Picture 19. Accident site *Birka Transporter*/ *Willempje Hoekstra* (AIBF, 2011)

Birka Transporter is flagged to Finland and *Willempje Hoekstra* to Netherlands, so FOC-related matters were not analysed for either ship. As we can see from Figure 9 that Finland is not listed on the accident % per fleet list. Netherlands is listed at a low level (under 1% of the fleet). Table 34 below shows the main reasons for why Ro-ro Ship *Birka Transporter* collided with Fishing Vessel *Willempje Hoekstra* in the TSS outside the Dutch coast.

Main reasons for the accident
➢ *Birka Transporter*s OOW was alone on the bridge, no lookout ➢ The events leading to the accident onboard *Willempje Hoekstra* are unknown due to lack of information available, thus causal attributes contributed by *Willempje Hoekstra* cannot be evaluated in full. ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Actions to avoid collision ➢ *Willempje Hoekstra* failed to comply with Colregs Rule 15 Crossing situations ➢ *Willempje Hoekstra* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *Birka Transporter* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 34. Main reasons case *Birka Transporter*/ *Willempje Hoekstra* (AIBF, 2011)

Willempje Hoekstra was a fishing vessel, but it was not fishing. So, in terms of the Colregs it is treated as a motor-driven vessel. If you look at Rule 10 of the Colregs. As *Willempje Hoektra* had *Birka Transporter* on its SB side, it was acting as the give-away vessel. *Willempje Hoekstra* should have made avoiding actions and *Birka Transporter* should have kept her course and speed. As *Willempje Hoekstra* was not complying to the Colregs, the OOW of *Birka Transporter* should have acted in ample time to avoid the collision. The Chief Officer was alone on the bridge of Birka Transporter so there was no lack of communication or cultural misunderstandings present. His actions to reduce speed and crash stop were too late to avoid the collision. *Willempje Hoekstra* did not even have an AIS or VDR onboard, as it was not mandatory at this point.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 35.

DD1 - loss of situational awareness DD4 - complacency DD5 - culture DD6 - lack of local practices DD10 - distractions DD11 – fatigue

Table 35. Causal attributes case *Birka Transporter/ Willempje Hoekstra*

To conclude the *Birka Transporter/Willempje Hoekstra* case, two ships can collide if the situational awareness is lost on the bridge(s). The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the fishing vessel ahead. The passing of *Willempje Hoekstra* could have been made in a safe manner, *if the C/O onboard Birka Transporter would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the OOW of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW more time to assess the risks ahead, evaluate and execute a better avoiding manoeuvre to pass *Willempje Hoekstra* at a safe distance.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the past the nearby ship pending the Birka Transporter OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the *Willempje Hoekstra* would have been made in a safe manner with INAV system-controlled manoeuvres. The OOW could have been on monitoring mode for any possible human intervention at any time of choice.
INAV Onboard Zero	**Accident prevention**. *Birka Transporter* would have been INAV system-operated with all the safety parameters of the ship, ending up in safe passing of all dangers on the ship´s course. The INAV Onboard Zero system could have been activated onboard *Birka Transporter* and subsequently the OOW could have been on monitoring mode and acting partly as the lookout who was missing from the bridge at the time of the accident.

Table 36. Kongsberg analysis case *Birka Transporter/ Willempje Hoekstra*

RED FALCON/ PHOENIX

ACCIDENT PARTICULARS		
SHIP	Red Falcon	Phoenix
TYPE	Ro-ro	Motor cuiser
FLAG	UK	N/A
BRIDGE	Master*	Owner - skipper*
CREW	Chief Officer*	3 adult guests
WIND	Unknown	
SEASTATE	Unknown	
VISIBILITY	Sunny, good visibility	
RESULT	Phoenix seriously damaged ->total loss	
*nationalities unknown		

Table 37. Accident particulars case *Red Falcon*/ *Phoenix* (MAIB, 2019)

The British flagged Ro-Ro vessel *Red Falcon* and a small privately-owned motor cruiser *Phoenix* collided in the Thorn Channel (on their way to Cowes in the Isle of Wight) on the 29th of September 2018. *Red Falcon´s* bridge team did not see the motor cruiser on the starboard side as it was entering the channel at a shallow angle. The owner of *Phoenix* with his limited knowledge of the Colregs also failed to comply with having proper lookout while navigating into the channel. The weather was clear with the sun brightly shining. As the bridge team on *Red Falcon* remained seated on the bridge with sun screens up and possibly some blind arcs, they did not see *Phoenix* approaching on their starboard side. This resulted in a collision, where *Phoenix* was pinned against the *Red Falcon´s* bow for 18 seconds thus being seriously damaged. There was no damage to Red Falcon. The 182 passengers and 20 crew on *Red Falcon* were not harmed, nor did the crew of four onboard *Phoenix*.

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Picture 20. Accident site *Red Falcon*/ *Phoenix* (MAIB, 2019)

Red Falcon is flagged to the UK, so FOC-related matters were not analysed for the ship. As we can see from Figure 9 that UK is listed on the accident % per fleet list so the % at a low level (under 1% of the fleet). *Phoenix* was a small Motor Cruiser with no relevant flag state. Table 38 below shows the main reasons for why Ro-ro Ship *Red Falcon* collided with Motor Cruiser *Phoenix* in the Thorn Channel.

Main reasons for the accident
➢ *Red Falcon* was navigating with visual lookout only ➢ *Red Falcon´*s bridge crew were focusing on the sailing boat on their port bow ➢ *Red Falcon´*s view was obscured by the sun´s glare and SB side window frames ➢ *Red Falcon´*s bridge team never checked blind spots or radar ➢ *Phoenix* owner/operator had little knowledge of the Colregs ➢ *Phoenix* owner/operator only looked ahead ➢ *Phoenix* was not equipped with AIS or VHF ➢ No actions to avoid collision was taken on either vessel ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Actions to avoid collision ➢ *Red Falcon* failed to comply with Colregs Rule 13 Overtaking ➢ *Red Falcon* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *Phoenix* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 38. Main reasons case *Red Falcon/ Phoenix* (MAIB, 2019)

This accident is a combination of poor navigation on both ships. The owner of *Phoenix* did not have knowledge of the Colregs and concentrated only on what was happening in front of him. The bridge team had blind spots to the SB due to the window framing. The bridge team was seated all the time and only navigating visually. They did not take time to check the radar and the blind spots at some intervals.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 39.

DD1 - loss of situational awareness
DD3 - lack of communication
DD4 - complacency
DD6 - lack of local practices
DD7 - lack of teamwork
DD8 - lack of capability
DD10 - distractions

Table 39. Causal attributes case *Red Falcon/ Phoenix*

To conclude the *Red Falcon*/*Phoenix* case, two modern vessels can collide if the situational awareness is lost on the bridge(s). The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the bridge team of *Red Falcon* of the closing motor yacht *Phoenix*. The navigation in the channel area could have been made in a safe manner, *if the master and chief officer on Red Falcon would subsequently have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the bridge team more time to assess the risks ahead, evaluate and execute better manoeuvres to avoid nearby ships.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the area and past the nearby ships pending the OOW(s) approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The OOW could have been on monitoring mode for any possible human intervention at any time of choice.
INAV Onboard Zero	**Accident prevention**. The *Red Falcon* would have been INAV system-operated with all the safety parameters of the ship ending up in safe passing of all dangers on the ship´s course.

Table 40. Kongsberg analysis case *Red Falcon/ Phoenix*

EXPRESS SAMINA

ACCIDENT PARTICULARS	
SHIP	Express Samina
TYPE	Passenger
FLAG	Greece
BRIDGE	Apparently no bridge manning as crew were watching
CREW	a soccer game. Greek crew.
WIND	Fair 5-6 Bf
SEASTATE	Unknown
VISIBILITY	Cloudy, visibility 7-10 nm
RESULT	Damages on ships hull, total loss due to sinking.
	80 passengers and crew lost. Port officer on duty
	died of heart attack and shipping company´s CEO
	committed suicide two weeks after the accident

Table 41. Accident particulars case *Express Samina* (Papanikolaou, D et al, 2015)

A Greek Ro-ro vessel built in 1966 left the port of Piraeus towards Paros with some 533 people onboard. The intended trip was 90,5NM long that was planned to operate with an average speed of 18,5kn. The weather was fair, with a fresh to strong breeze (17-27kn) and a cloudy sky. There was no rain and a reported visibility of 7-10NM. In terms of weather, it was not too bad to operate in. After passing the island Kefalos, the ship was set on autopilot for the remaining time of the trip. The SB stabilizer fin was unfolded to calm down the ship's motions. With the combination of the stabilizer fin, waves and wind the ship eventually drifted away from the intended course and eventually hit the rocky Portes islet some 0,4NM away. It is obvious that the Officer of the watch did not have control of the navigation and his situational awareness was far off what is should have been. The Officer did notice the rocky Portes and tried to do a last-minute manoeuvre, but it was already too late. The ship hit the rocks on the SB side which resulted in 3 different cracks on the hull. The SB stabilizer that was out, penetrated the hull like a knife which resulted in the flooding of the engine department. What eventually sunk the ship in 52 minutes after the collision was that only two (2) out of eleven (11) watertight (WT) doors were closed in the flooded compartments. The crew was also unable or did not do any efforts to close the doors manually. The remote-control station on the bridge and the platform deck, where this could also have been made was out of order. (Papanikolaou et al. 2003.)

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Picture 21. Accident site *Express Samina* (NTUA-SDL, 2003)

Express Samina was flagged to Greece, so FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Greece is listed on the accident % per fleet list at a medium level (between 1 to 2% % of the fleet). Table 42 below shows the main reasons for why Passenger Ship *Express Samina* run aground on Portes Islet.

Main reasons for the accident
➢ The bridge was empty for a long time, the ship was navigating by autopilot alone ➢ The port side stabilizer was folded so only the SB fin was out and contributed to the ship´s failing to keep original course ➢ The OOW´s last minute manoeuvres were too late and not efficient enough ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision

Table 42. Main reasons case *Express Samina* (Papanikolaou, D et al, 2015)

It is very clear that there was a lack of proper lookout (Rule 5 Colregs) and the OOW relied to solely on the autopilot for navigation in his absence. Had the WT doors been closed initially after departure or closed manually (or by remote control, should the system have been in operation) swiftly after the contact, the ship could have been saved alongside with the 81 persons eventually lost in this tragedy.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 43.

DD1 - loss of situational awareness DD2 - lack of alerting DD4 - complacency DD5 - culture DD6 - lack of local practices DD8 - lack of capability DD10 - distractions

Table 43. Causal attributes case *Express Samina*

To conclude the *Express Samina* case, it is no brainer that a modern ship with multiple officers onboard can run aground if no one is present on the bridge to navigate. The use of different Kongsberg INAV system products (only Onboard Control and Onboard Zero would have avoided the accident to 100%) could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Possible accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the shallow waters around Portes Islet. The passing of the area could have been made in a safe manner, *if the OOW would have been on the bridge and subsequently followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge team (if present) of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team (*if present*) more time to assess the risks ahead, evaluate and execute a better approach to the destination.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating past the Portes Islet pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The navigation through the area would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course. This mode would have been optimal mode in this case as the whole crew were watching a soccer game and the OOW was not constantly present on the bridge.

Table 44. Kongsberg analysis case *Express Samina*

8.1.3 Fishing ships' case/s

The only accident case involving a fishing vessel in Europe is the collision between the Ro-ro vessel *Birka Transporter* (FIN) and the fishing vessel *Willempje Hoekstra* (NED). This case was reviewed in the previous cargo ship chapter.

8.1.4 Summary of European Accidents

In this chapter the European cases are summoned together as shown in table 45 to find common grounds or reasons behind the accidents. Out of these nine cases, which involved 14 ships 6 had mixed crew. Out of these 6 mixed crew ships 3 were FOC-flagged and 2 ships carried a mixed Scandinavian bridge crew onboard. 2 ships were of one nationality only and 6 crew compositions were unknown. We can clearly see that mixed crew are favoured to some extent in the European waters maybe because of the current economics of the trade. Use of crew from cheaper countries can enhance the shipping company's competition and allowing for better profits. This also brings new challenges onboard mainly in terms of communication that is vital for both operations and safety and cultural differences. One good example is the *Costa Concordia* case, where the company applied permission from the flag state to change the operational language from English to Italian. The 46 nationalities onboard operated the ship initially using English as a common language. The crew with their limited knowledge of English, had to start learning Italian to be able to safely run a large cruise liner. At the time of the accident, there was orders given in two languages! There is no possibility in the world that this transition was going to happen easily, within a short period of time and at an acceptable level of safety with a multinational crew.

Almost half of the European accident cases involved FOC-flagged ships so we cannot rule out that FOC-related issues had a partial impact on these accidents.

Looking at the Dirty Dozen reasons (Figure 11), the European cases are much alike each other. All accidents analysed had some sort of loss of situational awareness, complacency and lack of proper local practices. Most accidents had lack of alerting, lack of communication, lack of safety culture and lack of teamwork. More than half of the accidents had lack of capability and distractions. Some accidents had pressure and fatigue as causal attributes.

Fit for duty were not reported as causal attribute in the European accidents, but it cannot be fully excluded in real life.

Generally speaking, the use of different Kongsberg systems would have supported the OOW through its Automation Awareness in all cases and eventually could have avoided most if not all of the accidents. Kongsberg systems do not recognize "restricted weather" conditions, so ships need a human presence and decision to reduce speed and sound the appropriate sound signals as per Colregs whenever conditions so require (case *Petunia Seaways*/ *Peggotty*).

CASE	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	CD	FOC
HAMBURG														
COSTA CONCORDIA														
VICTORIA														
SOLA TS/HELGE INGSTAD														
PETUNIA SEAWAYS/PEGGOTTY														
PRIMULA SEAWAYS/CITY OF ROTTERDAM														
EXPRESS SAMINA														
RED FALCON/PHOENIX														
BIRKA TRANSPORTER/WILLEMPJE HOEKSTRA														

Table 45. Causal attributes Europe cases

8.2 Asia

In this chapter focus is on accidents in Asian waters. There are nine different cases, involving a passenger ship (fast catamaran), various types of cargo ships (a ro-ro ship, container ships, bulk cargo ship, a chemical tanker, a car carrier), a navy destroyer a and a fishing vessel. These ships have either foundered, grounded or collided with another ship. Table 46 below shows the cases in focus. Out of the 15 ships involved in the Asian accidents, four (4) are with affirmed mixed multicultural crews, nine (9) with one nationality crews and only (2) with unknown crew composition. There is a clear trend here with one nationality crew being favoured in Asia. The two unknown crews were Japanese flagged and possibly/most likely also of one nationality.

The youngest ship in the Asian fleet was 1year old Marshall Island flagged car carrier *NOCC Oceanic* and the oldest two being 26year old Japanese flagged ships Passenger catamaran *Beetle* and Oil tanker Keihin Maru No.7. The average age for all ships (15) involved in the Asian cases was 10,9 years.

Ship type	Name	Accident type
Fast catamaran Passenger ship	Beetle	Collision
Ro-ro/Ro-pax	Sewol	Foundering
Container ship & Container ship	Estelle Maersk & JJ Sky	Collision
Container ship	Maersk Kendal	Grounding
Bulk cargo & Fishing vessel	Star Kvarven & Lulanyu 61809	Collision
Oil tanker & Bulk carrier	Sanchi & CF Crystal	Collision
Chem tanker & Oil tanker	Eastern Phoenix & Keihin Maru No.8	Collision
Car carrier & Fishing vessel	NOCC Oceanic & Yujin Maru No.7	Collision
Navy destroyer & Container ship	USS Fitzgerald & ACX Crystal	Collision

Table 46. Asian accident cases and types

8.2.1 Passenger ship case/s

BEETLE

ACCIDENT PARTICULARS	
SHIP	Beetle
TYPE	Passenger (fast catamaran)
FLAG	Japan
BRIDGE	Master - Japanese
CREW	Chief Engineer - Japanese
	1st Engineer - Japanese
WIND	NW 10 m/s
SEASTATE	1,8 m
VISIBILITY	Clear blue skies, good visibility
RESULT	Serious injuries to 3 passengers,
	damage to ship´s shock absorbers

Table 47. Accident particulars case *Beetle* (JTSB, 2017)

The Japanese passenger ship *Beetle*, carrying 184 passengers and 7 crew left the Port of Busan after two hours of departure work at 09:30 on January 8, 2016. All crew members were Japanese, except one – who was of Korean descent. The ship quickly accelerated to foilborne mode, reaching a speed of 40kn at 09:45 after leaving the harbour limit of the Port of Busan. As the sea state was rough, the master set the hydrofoils to an arbitrary position (depth handle) in order to avoid influence of breakers over the hull and making sure a seawater inlet was not exposed. The C/O left the bridge for a routine patrol, leaving the master, the C/E and 1/E seated on their respective seats. The ship soon entered the "the decelerating area" previously set up by the company for implementation of decelerating manoeuvres as part of the safety actions against collisions with marine mammals. As *Beetle* was heading towards the Port of Hakata at 09:54 with the course of 145 on a standard course line, the 1/E noticed marine life in the form of a fin-like projection close to the starboard bow. The shouted to inform the master and prepared himself for impact. The master turned the ship to starboard (assuming that the 1/E warned about marine life on the course of the ship) resulting in a strong impact with a marine mammal. The impact was taken by the starboard hydrofoil, where after the speed of the ship decreased. Subsequently the ship went to hull borne mode after the speed decreased. As a result of the collision, *Beetle´*s shock absorbers on the hydrofoils (both port and starboard side) got damaged. Three of the 184 passengers were seriously injured and four on a minor scale. Additionally, two of the seven crew members got minor injuries (JTSB, 2017).

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Picture 22. Accident site *Beetle* (JTSB, 2017)

Beetle is flagged to Japan, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Japan is listed on the accident % per fleet list at a low level (under 1% of the fleet). Table 48 below shows the main reasons for why Passenger Ship *Beetle* collided with marine life on its way to Port of Hakata.

Main reasons for the accident
➢ No proper lookout (C/E was possibly entering engine data into company systems, 1/O was on patrol, 1/E was performing lookout duties while monitoring engine operation data) ➢ Too high speed for the area as the master did not lower the speed at the company´s setup reduction area ➢ The company had not established operating guidelines of cetacean-cautious manoeuvres ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision

Table 48. Main reasons case *Beetle* (JTSB, 2017)

The master was pressed for time already at departure. Sad but true, but this is very common in the trade that due to commercial pressures speeds are kept at a maximum. The schedules are made tight to keep the ships making money as effectively as possible and if the ship departs late for some reason, this time must be made up somewhere. So, the master of *Beetle* made the decision not to decelerate to catch up with the schedule. This high speed and the misunderstanding with the 1/engineer's marine life spotting caused the accident. The right decision would have been to lower the speed and posting an extra lookout in this area. This would have increased the situational awareness of the bridge team, most likely preventing the accident. No system could have prevented the accident, if the master insisted on keeping up the high speed.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 49.

DD1 - loss of situational awareness DD3 - lack of communication DD4 - complacency DD5 - culture DD6 - lack of local practices DD7 - lack of teamwork DD9 - pressure

Table 49. Causal attributes case *Beetle*

To conclude the *Beetle* case, a modern ship with multiple officers on the bridge can collide with a marine mammal if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the company´s decelerating area. The passing of the area could have been made in a safe manner *if the master would subsequently have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of the possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the bridge-team more time to assess the risks ahead, evaluate and execute better manoeuvres to avoid the marine life.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving safe options for navigating through the company´s decelerating area *pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the area would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention.** The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course.

Table 50. Kongsberg analysis case *Beetle*

SEWOL

ACCIDENT PARTICULARS	
SHIP	Sewol
TYPE	Passenger
FLAG	South Korea
BRIDGE	3/Officer - South Korean
CREW	Helmsman - South Korean
WIND	SE 2-3 kts
SEASTATE	1-2 feet
VISIBILITY	Up to 20 nm
RESULT	Capsizing of ship and subsequent total loss.
	304 of passengers and crew perished as a result

Table 51. Accident particulars case *Sewol* (Kwon Y., BAI, 2014)

Sewol, the Korean flagged passenger ship left the Port of Incheon two hours late of its original departure time in the evening on the 15th of April 2015. *Sewol* was on its way to Port of Jeju also in South Korea. Onboard there was 476 passengers, 124 cars, 56 trucks and 1157 tons of cargo. The improperly secured amount of cargo was twice the limit they were allowed to carry. *Sewol* was also carrying only 761 tons of ballast water, which was less than half of the required 1703 tons. The next morning, the weather was fine with a 2 to 3 knots south-westerly wind and temperature of 15 degrees C. The visibility was very good, the sea was calm with only 1 to 2 feet waves. At 08:48, the ferry was heading with a 135-degree course. The OOW first changed the heading to 140, and then subsequently to 145. The strong currents in the Maenggol Channel required that course changes needed to be less than 5 degrees at a time. This was also important because *Sewol´*s restoring force was known to be very low. The OOW had previously received instructions from the regular master to keep this in mind. As the helmsman executed the OOW´s orders, he possibly turned first to 145 and then to 155. It is not clear if the helmsman correctly executed the OOW´s final order to "turn in the opposite direction" but it seemed too late. The ship listed 20 degrees (mainly due to the second 10-degree course change) into the water which made the improperly secured cargo to shift in the cargo hold. As the remaining cargo shifted in the holds, the ferry started to lose its restoring force and eventually took in water through the bow and stern doors. At 08:50, the listing was already 30degrees to port. By this time, the chief engineer stopped the engines on based on his sole decision. The master soon arrived on the bridge and ordered the OOW to start the anti-heeling pumps, but the pumps were not working. At 08:54 the master ordered the chief engineer go to the engine room but failed to give any clear orders on what he should do. Maybe to check the generator connected to the anti-heeling pumps. As the Chief Engineer proceeded to the engine room, he met his engineers in the accommodation corridor on the third deck. They all stayed there because the ships listing prevented them from entering the engine room. At 08:52, one of the students onboard made the first emergency call reporting that *Sewol* was capsizing. Still when at 09:16, when the on-scene-commander tried to contact *Sewol* – there was no answer. At 09:25, the ships listing was already 50 degrees to port. As the ship started to capsize, the ferry´s PA system announced that all passengers should stay put. This was a personal judgement of the Guest Services desk officer on duty, without the permission from the master. The other Service desk worker tried frantically to contact the bridge, trying to ask if there was an evacuation plan that needed to be announced. The stay put announcements started at 08:52 and continued for one hour, even when water began flooding passenger compartments and cabins. Even the master ordered the passengers to stay put at a later stage. Only at 09:27, the master orders the evacuation. The second mate contacted the Guest Services using a handheld two-way radio transceiver but never checked if they received the message. At 09:37, the ship was listing 60-70 degrees to port. The passengers were told to evacuate on port side but there were still announcements made that they should stay put. Two helicopters arrived at the scene at 09:32 and 09:45 and they started to evacuate passengers from the deck. Two rafts were dropped in the water by a crewmember of a Patrol vessel who boarded the ship. The rest of the rafts could not be dropped due to the listing. Slowly the ship started to list more and finally by 1118 the bow and the stern were submerged, leaving a section of the hull above the water. Before the capsizing, about 150 to 160 passengers jumped into the water to be rescued. As a result of the capsizing, only 172 out of the 476 survived.

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Picture 23. Latest AIS position of *Sewol* (OpenSeaMapTeam, 2014)

Sewol was flagged to South Korea, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 South Korea is listed on the accident % per fleet list at a medium level (between 1 to 2% % of the fleet). Table 52 below shows the main reasons for why Passenger Ship *Sewol* run into trouble navigating in the Maenggol Channel, eventually sinking the ship.

Main reasons for the accident
➢ Improper loading and lashing ➢ Overloading ➢ Modifications had made *Sewol* unstable ➢ OOW´s orders and Helmsman´s subsequent executions were not controlled actions ➢ C/Engineer stop the engines by own judgement. ➢ Heeling pumps were not working as the generator running it was not working ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 6 Safe speed

Table 52. Main reasons case *Sewol* (Kwon Y., BAI, 2014)

A chaos. To start with the OOW lacked experience in manoeuvring the ship. The ship was also overloaded, wrongly loaded and lacked proper lashing. The OOW´s and helmsman's wrongly executed manoeuvres made the ship to list, the cargo started to shift, and the ships list grew. Water started to ingress and the ship eventually lost its stability due to the heavy list. To add up the C/Engineer stopped the engines by his own decision and never went down to the engine room to check on the generators running the heeling pumps. Call it a cultural thing or whatever, but it seems that no one was thinking with their own brain and everyone was just waiting for orders from the master. Had *Sewol* used Kongsberg INAV systems, the manoeuvres in the Maenggol Channel could have been done in a safe way despite of the overloaded ship.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 53.

DD1- loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD5 - culture DD6 - lack of local practices DD7 - lack of teamwork DD8 - lack of capability DD9 - pressure

Table 53. Causal attributes case *Sewol*

To conclude the *Sewol* case, a modern ship can capsize if the ships stability is compromised. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Possible accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving safe options for navigating through the Maenggol Channel pending OOW´s approval. The passing of the area could have been made in a safe manner, *if the OOW (and the helmsman) would subsequently followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a better passage through the channel.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating past the Maenggol Channel pending the OOW´s approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The navigation through the area would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course.

Table 54. Kongsberg analysis case *Sewol*

8.2.2 Cargo ship case/s

ESTELLE MAERSK/ JJ SKY

ACCIDENT PARTICULARS		
SHIP	Estelle Maersk	JJ Sky
TYPE	Container	Container
FLAG	Denmark	Hong Kong (P.R.of China)
BRIDGE	Pilot - local	Master - Chinese
CREW	Master - Danish	OOW - Chinese
	OOW	Helmsman - Chinese
	Helmsman	Lookout - Chinese
WIND	NW 7-8 m/s	
SEASTATE	0,3 m	
VISIBILITY	Good	
RESULT	Both ships sustained minor damages	

Table 55. Accident particulars case *Estelle Maersk/ JJ Sky* (JTSB, 2018)

The Danish flagged container ship *Estelle Maersk* departed Yantien Port in China on the 4th of June 2016. The vessel was heading for Hanshin Port, Kobe Section in Japan. Three days later, the pilot boarded the ship at 04:50 south of Tomogashima in Wakayama City. The ship was due to arrive at the South Entrance of the Passage at 07:10. Shortly before entering the passage, at 06:55 – the pilot noticed five vessels heading towards the Passage from the Osaka direction. This was from the starboard side of *Estelle Maersk*. The pilot was focusing on two of these vessels, one of being the Hong Kong flagged container ship *JJ Sky*. At 07:00 both the master and the deck officer on the bridge noticed that *JJ Sky*´s CPA was only 0,04NM. Even though the pilot was speaking in Japanese on the VHF which the master could not understand, he thought that the pilot was maintaining contact with *JJ Sky* regarding priority to enter the Passage. Sensing the risk of collision, he asked the pilot of the priority at 07:01. The pilot answered that *Estelle Maersk* would have priority and was due to enter at 07:10. This was regardless of that *JJ Sky*´s was late to enter, as it should have entered the Passage at 06:50. Once hearing this, the master repeated his question on priority, again the answer was the same. *Estelle Maersk* would be given priority. As *JJ Sky* was only 1,0NM away on starboard side, the pilot reduced the speed to 5-6knots. The pilot thought that other ships would give way, as *Estelle Maersk* was a large vessel in the 400m class. He knew from past experiences that *JJ Sky* had a reputation to cut across other ship's courses, so he was still aware of possible risks. When the CPA was down to 0,5NM at 07:05, the pilot noticed that *JJ Sky* started to change course forward to the bow of *Estelle Maersk*. Sensing the risk of collision, the pilot stopped the main engine. A minute later as *JJ Sky*´s changed even more towards *Estelle Maersk* bow, the pilot set the engine to full astern. At 07:07 the master sounded a prolonged blast on the ship´s whistle. Two minutes later *Estelle Maersk*´s starboard bow hit *JJ Sky*´s port-side wing.

The leading events before the collision onboard *JJ Sky*; The Hong Kong flagged container ship *JJ Sky* left Hanshin Port in the early morning of 7th of June. At around 06:50, the master of *JJ Sky* first became aware of *Estelle Maersk* by radar. At around 07:00 the master and the other officer on the bridge sensed that there is a risk of collision, but because of the misleading communication they heard on the VHF, they thought *Estelle Maersk* would follow them and navigate astern of them. Noticing that

Estelle was reducing speed, the master increased speed from dead slow ahead to slow ahead. At around 07:04 the master confirmed Estelle´s position on the radar and was still convinced that Estelle would pass astern of them should they keep their course. Four minutes later at 07:08 the master put the engine half ahead, but he soon realized that the collision was unavoidable. A last-minute course change, hard to port was made to minimize the impact. At 07:09 the ships collided.

As a result of the collision, *Estelle Maersk* sustained damage on her shell plating and *JJ Sky* a partly collapsed bridge wing. There were no pollution or injuries on either ship´s crew.

Picture 24. Accident site *Estelle Maersk* (JTSB, 2018)

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Picture 25. Accident timeline *Estelle Maersk*/ *JJ Sky* (JTSB, 2018)

Estelle Maersk was flagged to Denmark, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Denmark is not listed on the accident % per fleet list. *JJ Sky* was flagged to Hong Kong (P.R. of China), so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Hong Kong (P.R. of China) is listed on the accident % per fleet list at a low level (under 1% of the fleet) (Pls note that Hong Kong has bigger % than mainland China). Table 56 below shows the main reasons for why Container Ship *Estelle Maersk* collided with Container Ship *JJ Sky* on entry to Hanshin Port.

Main reasons for the accident
➢ Pilot on *Estelle Maersk* and the master on *JJ Sky* had different views on who would be allowed to enter the Passage first ➢ Specially set Transit Line were not used by *JJ Sky* ➢ The pilot of Estelle spoke Japanese, the bridge team English and *JJ Sky*´s bridge team Chinese -> lack of communication between the ships ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ *Estelle Maersk* failed to comply with Colregs Rule 15 Crossing situations ➢ *Estelle Maersk* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *JJ Sky* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 56. Main reasons case *Estelle Maersk*/ *JJ Sky* (JTSB, 2018)

The different views of entry priority and subsequent lack of proper communication between the pilot onboard *Estelle Maersk* and *JJ Sky* was the main reason for this accident. There was a risk of collision and both ships continued to sail towards the port. Knowing their ships manoeuvrability's and responsibilities in terms of the Colregs, both ship´s masters should have taken earlier action to avoid a collision. When entering a port, the INAV Advisory system could have been activated. If used, it would have given the bridge crew´s an overview on what is happening, keeping the situational awareness at a safe level. Despite of the lack of communication due to cultural gaps, this accident could possibly have been avoided. Kongsberg INAV system could also have covered for parts of the lack of teamwork and helped with challenging the masters/pilot's decisions on the bridges.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 57.

DD1 - loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD6 - lack of local practices DD7 - lack of teamwork

Table 57. Causal attributes case *Estelle Maersk*/ *JJ Sky*

To conclude the *Estelle Maersk/ JJ Sky* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the bridge team(s) of the nearby ships. The navigation in the area could have been made in a safe manner, *if either or both bridge teams would have followed the guidance (visual track given as per set safety parameters) provided by the INAV systems.* The use of INAV Onboard Advisory system would have alerted the bridge-team(s) of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge(s). The INAV system would have given the OOW(s)/bridge team(s) more time to assess the risks ahead, evaluate and execute better manoeuvres to avoid nearby ships.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating in the area and past the nearby ships pending the OOW(s) approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team(s) could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship(s) would have been INAV system-operated with all the safety parameters of the ship(s) and the operating area in mind, ending up in safe passing of all dangers on the ship(s) course(s).

Table 58. Kongsberg analysis case *Estelle Maersk/ JJ Sky*

MAERSK KENDAL

ACCIDENT PARTICULARS	
SHIP	Maersk Kendal
TYPE	Container
FLAG	Denmark
BRIDGE	Master - British
CREW	Chief Officer - Indian
	Helmsman - Filippino
WIND	Light
SEASTATE	Unknown
VISIBILITY	Good
RESULT	Damage to fore peak, bow thruster room, no.1
	and no.1 ballast tank, hull plating/internal frames

Table 59. Accident particulars case *Maersk Kendal* (MAIB, 2010)

The UK flagged container ship *Maersk Kendal* left the Port of Laem Chabang, Thailand on the 14th of September 2009 on her way to Tanjung Pelepas in Malaysia. This was only a short trip as the estimated time of arrival was only two days away. At 03:00 on the 16th of September the master arrived on the bridge to assist the bridge team in transiting the busy Singapore Strait. At that time the second officer had the con and the master was only assisting him. After the watch change at 04:00, the chief officer took over the conning responsibilities from the 2nd Officer and the master continued with the supporting role on the bridge. At 06:15, the master informed the chief officer that he would take the con of the vessel. At 06:30 *Maersk Kendal* crossed from VTIS sector 9 (east sector) to sector 8 (central sector). Shortly after seven (07:03) VTIS called Maersk to slow down as three (3) ships were coming out of the Jong Channel. VTIS also advised *Maersk Kendal* to exercise caution, which was acknowledged by the chief officer. The master responded by setting the telegraph to half ahead. At this time the vessels course was recorded as 257 degrees and the speed 20,7 knots. The master assessed the situation on the radar as he could identify three vessels approaching on the starboard side – these being the *Kota Delima*, *Bright Pacific* and *Samho Jewelry*. Ace Dragon, which was almost right ahead was discounted. The helm was changed to manual mode and the course changed to starboard as to pass on the stern side of *Kota Delima* and *Bright Pacific*. No trial manoeuvre functions were utilized to understand where the situation was heading. VTIS was assisting in collision avoidance by proving information to all the ships involved. *Maersk Kendal* was repeatedly told to slow down but even though the master of *Maersk Kendal* set the telegram on slow ahead the speed did not slow down enough. When the master continued to alter the course to starboard at 07:08, the speed was still 19 knots. *Maersk Kendal*´s intention was to pass on the astern of *Samho Jewelry* but while positioning to do so by multiple alterations to starboard (with its high speed) they had ended up too far north. At 07:13, when *Maersk Kendal* was still proceeding with 16,2 knots the VTIS warned *Maersk Kendal* of the shallow area ahead. After *Samho Jewelry*´s passing ahead, the master started to follow the stern of the other vessel to port. The master´s orders being first, port 10, then port 20 and finally hard to port. He soon went onto the starboard wing to assess if the ship was clear of the beacon on Monggok Reef. Soon after returning to the bridge, the ship ran aground on the reef at a speed of about 14,2 knots. The ship sustained extensive damage to the hull (and damage to electrical equipment in the bow thruster room) and subsequently some 120 tonnes of steel was renewed before the ship resumed service some two months later.

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Picture 26. Accident site *Maersk Kendal* (MAIB, 2010)

Maersk Kendal was flagged to Denmark, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Denmark is not listed on the accident % per fleet list._Table 60 below shows the main reasons for why Container Ship *Maersk Kendal* run aground on Monggok Sebarok reef in the Singapore Strait.

Main reasons for the accident
➢ Misplaced confidence by the master and chief officer ➢ Lack of use of all means especially the trial manoeuvre function ➢ Lack of early and substantial reduction of speed, together with appropriate alteration of course ➢ Lack of situational awareness ➢ Lack of plotting the ships position at frequent intervals in confined waters as per normal good seaman´s practise and company procedures ➢ Chief Officer´s cultural reluctance to challenge the master ➢ Chief Officer´s lack of crew resource management or bridge team management training ➢ Lack of recognising the VTIS assistance it was clearly able to provide ➢ The ship failed to comply with Colregs Rule 2 Responsibility ➢ The ship failed to comply with Colregs Rule 5 Look-out ➢ The ship failed to comply with Colregs Rule 6 Safe speed ➢ The ship failed to comply with Colregs Rule 7 Risk of collision ➢ The ship failed to comply with Colregs Rule 8 Action to avoid collision

Table 60. Main reasons *Maersk Kendal* (MAIB, 2010)

The master and C/O on the bridge of *Maersk Kendal* lost their situational awareness and were distracted by the VTIS, who was trying to help them by giving important information. They also interpreted wrongly the information they were given, resulting in more confusion and irritation. The master had the intention to reduce speed by switching the engine telegraph from full ahead to half ahead, but it had no effect on the speed. To avoid the ships and Monggok Reef, a combination of an early and substantial reduction of speed with the addition of appropriate course changes would have been needed. As the mixed bridge team did function together in terms of communication nor navigational matters, it can be said that the mixed crew was a causal factor of the accident.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As not all aspects are not readily given in the original accident report, some causal factors have been added or left out based on the overall picture received by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 61.

DD1 - loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD7 - lack of teamwork DD8 - lack of capability DD10 - distractions + possible cultural differences/power gap

Table 61. Causal attributes case *Maersk Kendal*

To conclude the *Maersk Kendal* case, a modern ship with multiple officers on the bridge can run aground if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding of the shallow waters around New Rocks buoy and the nearby ships. The passing of all ships and the shallow area could have been made in a safe manner, *if the OOW would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system.* The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a better approach to Tobernary Bay.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for navigating past the Monggok Reef and the nearby ships pending the OOW´s and master´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the area and ships would have been made in a safe manner with INAV system-controlled manoeuvres. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention.** The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course.

Table 62. Kongsberg analysis case *Maersk Kendal*

STAR KVARVEN/ LUHANUY 61809

ACCIDENT PARTICULARS		
SHIP	Star Kvarven	Lulanyu 61809
TYPE	Mixed cargo	Fishing
FLAG	Norway	P.R.China
BRIDGE	OOW (3/O) - Filippino	All chinese
CREW	Helmsman - Filippino	
WIND	SE 13-14 m/s	
SEASTATE	2,0 m	
VISIBILITY	Good	
RESULT	Damage to Star Kvarven´s bulb	
	Lulanyu total loss with all of the crew of 8	

Table 63. Accident particulars case *Star Kvarven/ Lulanyu 61809* (AIBN, 2016)

The Norwegian (NIS) flagged mixed cargo (bulk/container) ship *Star Kvarven* left the Port of Lianyungang, China at 10:18 on the 27th of November 2014 carrying 4920 tonnes of ceramic proppants. It was on its way to Pohang in South Korea. *Star Kvarven* was making way with an economic cruising speed of 12,5kn during the whole day and afternoon. At 20:00 there was a change of watch and the new OOW was the third officer. At the time of the changeover, the master was in the radio room close by with the chief engineer – where he remained for the next two hours. Just after the changeover, he notified the third officer that he should be informed if there was dense traffic ahead or if he had any possible questions.

After finishing with the work with the chief officer, the master joined the third officer on the bridge and got updated on the traffic situation ahead. Almost simultaneously the lookout observed the fishing vessel *Lulanyu 61809* on the starboard side of the course line. The fishing vessel was returning to Lanshan Port with a speed of 8,3kn after a fishing trip in the area. The OOW noticed that the CPA was 0,29NM given that the two ships would keep their course and speed. The master notified the OOW, that he should let the fishing boat pass ahead of them. Soon after this the master sat down in his chair and fell asleep. At 22:10 the OOW made a 10-degree course change to starboard with moderate 2-3-degree changes at the time. Lulanyu also made a course change to starboard at 22:13, where after the fishing vessel started to turn to port. At this point the CPA was around 0,7NM. Within less than ten minutes the fishing vessel had turned almost 180 degrees from its original course. *Star Kvarven´s* OOW started to change the ships course to port, again using only small changes. The OOW was trying to keep the fishing vessel to the port side of the ships course line, but by the time the lookout noticed that the fishing vessel was heading to the starboard side – the OOW corrected the ships course to starboard. The master was awakened by the noise of the commands and calls made by the lookout and the OOW and quickly assumed the control of the ship. The ship was changed to manual steering and a hard helm to starboard, while the OOW was trying to lookout for the fishing vessel ahead. As the ships collided at 22:21, there was no registration of the collision onboard *Star Kvarven*. A couple of minutes later, at 22:24 Lulanyu´s AIS signal disappeared from the radar. The fishing vessel sank with all the eight crew members onboard.

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Picture 27. Accident site *Star Kvarven* (AIBN, 2016)

Star Kvarven was flagged to Norway (NIS), so connections to possible FOC-related cannot be ruled out. As we can see from Figure 9 that Norway (NIS) is listed on the accident % per fleet list so the % at a low level (around 1% of the fleet). *Lulanyu 61809* was flagged to P.R. of China, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that P.R. of China is listed on the accident % per fleet list at a low level (under 1% of the fleet). Table 64 below shows the main reasons for why Cargo Ship *Star Kvarven* collided with Fishing Vessel *Lulanyu 61809* in the Yellow Sea.

Main reasons for the accident
➢ *Lulanyu 61809* was the stand-on vessel as a fishing vessel and the ship should have kept a steady course and speed once the risk of collision was established ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ *Star Kvarven* failed to comply with Colregs Rule 15 Crossing situations ➢ *Star Kvarven* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *Lulanyu 61809* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ *Star Kvarven* failed to comply with Colregs Rule 18 Responsibilities between vessels ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 64. Main reasons case *Star Kvarven/ Lulanyu 61809* (AIBN, 2016)

There is no information on what happened onboard the fishing vessel as the whole crew perished as the vessel was lost. So, all analysis has been made from *Star Kvarven´s* point of view. As *Star Kvarven* was the give-away vessel it should have kept a constant minimum safe distance from the fishing vessel regardless of the fishing vessels course changes. This would have avoided the situation. The Filipino OOW should have notified the master who was sleeping in the pilot´s chair on the bridge. Maybe the 3/O did not have the courage to wake up the master regardless of what was written in the master´s night/standing orders.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 65.

DD1- loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD6 - lack of local practices DD7 - lack of teamwork DD8 - lack of capability

Table 65. Causal attributes case *Star Kvarven/ Lulanyu 61809*

To conclude the *Star Kvarven/ Lulanyu 61809* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the OOW of *Star Kvarven* of the movements of the fishing vessel. The safe passing of the two vessels could have been made in a safe manner *if the OOW would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system*. The use of INAV Onboard Advisory system would have alerted the bridge-team of all possible dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a safe passing of the fishing vessel.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the INAV system giving *safe options for collision avoidance pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the two vessels would have been made in a safe manner with INAV system-controlled manoeuvres of OOW´s choice. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention.** The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course.

Table 66. Kongsberg analysis case *Star Kvarven/ Lulanyu 61809*

SANCHI/CF CRYSTAL

ACCIDENT PARTICULARS		
SHIP	Sanchi	CF Crystal
TYPE	Oil tanker	Bulk carrier
FLAG	Panama (FOC)	Hong Kong (P.R.of China)
BRIDGE	Master* - Iranian	3/O - Chinese
CREW	3/O - Iranian	AB - Chinese
	AB - Bangladeshi	
WIND	NE 4-5 Bf	
SEA STATE	Slight	
VISIBILITY	Cloudy, good visibility	
RESULT	Collision. Sanchi - explosion, fire and total loss.	
	3 dead, 29 missing, environmental pollution.	
	CF Crystal - extensive structural damage.	
*Master arrived on bridge only seconds before impact		

Table 67. Accident particulars case *Sanchi*/ *CF Crystal* (MSA, 2018)

The Panama flagged oil tanker *Sanchi* departed the Port of Assaluyeh, Iran on the 16th of December 2017 loaded with condensate oil bound for Daesan, Republic of Korea. On the 6th of January at 19:00 the speed was 10,3 knots when the Iranian 3/O and Bangladesh AB took over the watch. Radars limits for CPA and TCPA were set at 0,9NM and 15min with North up and relative motion display. Only 30 minutes later in the watch, the OOW assessed that all targets in sight would pass astern of the vessel. Soon after he reassessed the situation of *CF Crystal* and said to the AB that the BCR (Bow crossing range) of *CF Crystal* and another ship (possibly *Zhedaiyu*) are minus. At 19:34 *Sanchi´*s COG was 358 and the speed 10,4 knots. The approaching target´s bearing was 022 degrees. The cursor on the X-band radar was shifted to *CF Crystal* but the echo was not acquired, nor was the AIS-target. At this time, the lookout noticed a vessel at the bearing 013, showing red and green. At 19:36, the watchkeeper at *Zhedaiyu* called *Sanchi* on channel 16, where after the cursor was shifted to *Zhedaiyu*. Shortly after the visual AIS-warnings of both *CF Crystal* and *Zhedaiyu* appeared on the radar. The AIS symbols of both targets turned red with "AIS-collision" warning appearing in the right lower corner of the radar. At 19:39 *Zhedaiyu* tried to contact *Sanchi* on the VHF, but *Sanchi´*s OOW was reluctant to answer. *Sanchi´*s OOW was wrongly guiding his AB on why he did not answer the call. He stated that one reason for not answering is that "we don´t understand their language". Still continuing with the same course, the *Sanchi´*s OOW asked the AB to signal *Zhedaiyu* using an ALDIS signal lamp. By then the fishing boat had started to alter its course to port. At 19:45 *Zhedaiyu* was almost abeam *Sanchi´*s starboard. The OOW ordered the AB to signal again, this time towards *CF Crystal*. The OOW understood by now, that he had to act. He realized that the starboard side was "full" which thought he shared with his AB. By 19:46 the fishing vessel was clear of *Sanchi*, but *Sanchi* concentrated only to signal *CF Crystal* by 5 short flashes by the ALDIS lamp not realizing that the CPA was zero. The OOW was reluctant to make any avoidance manoeuvres to starboard even though the CPA was zero. At 19:48 after the OOW and the AB had discussed the size of the closing target, the OOW finally called the master stating that they have a large incoming vessel close by on starboard side and that the CPA is zero. The OOW first orders full port side, then sensing his mistake he changes to full starboard side. Shortly after, the master arrives at the bridge and the OOW keeps telling him that the other ship did not take any action. The master orders hard to starboard which they apparently already did. The actions were too late, as the two ships collided at around 19:50 when *CF Crystal*s bow hit *Sanchi´*s starboard side. The collision breached starboard ballast and cargo tanks, leading to a leakage of condensate oil and consequent fire and explosion. The fire later engulfed the bridge and accommodation areas.

The leading events before the accident on board *CF Crystal* were not much brighter. *CF Crystal* was on its way from Kalama, USA to Dongguan, China. At 19:31 *CF Crystal´*s C/O who was the OOW at time, noticed *Sanchi* some 7NM on her port side and because the CPA did not change – he did not pay too much attention to that ship. He believed *Sanchi* was to pass her bow at 0,9NM. Later at 19:42 after a course alteration to port, the OOW found that the CPA of *Sanchi* had reduced to 0,4NM. He could not see the echo of *Sanchi*, only the AIS signal displayed on the radar. This turned his thought into believing that *Sanchi* was only a small vessel and nothing to worry about. At 19:43 the 3/O came to the bridge, relieving the C/O from his watch. After checking the ships position on the paper charts, he turned to the post side radar to check if there were any target around. He found two AIS-targets on the port side. The 3/O believed that *Sanchi* was only a fishing vessel as the echo could not be seen on the radar, only the AIS target. The C/O left the bridge after a call from the master, not taking any time to discuss the current traffic situation with the 3/O. At 19:47 the 3/Officer´s lookout notified the OOW that *Sanchi´*s CPA was only 0,2NM. The OOW now noticed *Sanchi´*s echo on the radar, but still insisted it was a small vessel. Only a minute later, the AB notified the OOW that the CPA was now down to 0,1NM. As the OOW was not responding, the AB again notified the OOW of the close CPA a minute later. The OOW now ordered the AB to change to manual steering and steer starboard rudder without a specific rudder order. The lookout reported when the rudder angle was starboard 20. At 19:50 the two ships collided, resulting in severe damage to *CF Crystal*s bow and deformation of the deck and hatch covers. The subsequent fire caused damage to Crystal´s bulwark and deck facilities.

Figure 28. Accident site case *Sanchi*/ *CF Crystal* (MSA, 2018)

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Picture 29. Accident site case *Sanchi*/ *CF Crystal* (MSA, 2018)

Sanchi was flagged to Panama (FOC), so we cannot rule out any FOC-related issues. As we can see from Figure 9 Panama is listed on the accident % per fleet list at an alarming level (over 3% of the fleet). *CF Crystal* was flagged to Hong Kong (P.R. of China), so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Hong Kong (P.R. of China) is listed on the accident % per fleet list at a low level (under 1% of the fleet) (Pls note that Hong Kong has bigger % than mainland China). Table 68 below shows the main reasons for why Oil Tanker *Sanchi* collided with Bulk Carrier in East China Sea.

Main reasons for the accident
➢ *Sanchi´*s OOW (3/O) had a dangerous attitude towards small ships, as he assumed, they would act even though *Sanchi* was the give-away vessel. He did not act despite of the AB´s warnings of the closing vessel and its CPA ➢ *Sanchi´*s OOW and AB did not concentrate on navigation preceding the accident ➢ The situational awareness on both ships were on very low level ➢ No proper handover of watch between the watchkeeping personnel on *CF Crystal*. ➢ Improper use of AIS as the only navigational aid in identifying the surrounding vessels. ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ *CF Crystal* failed to comply with Colregs Rule 15 Crossing situations ➢ *CF Crystal* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *Sanchi* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 68. Main reasons case *Sanchi*/ *CF Crystal* (MSA, 2018)

This case is a simple yet concerning one. Two modern vessels collide in open waters in good visibility conditions. *Sanchi* as the give-away vessel should have made actions in ample time to the avoid collision, it did not. *Sanchi´*s OOW was not following the rules of the road and eventually ended up in situation where avoidance manoeuvres were limited. This was the main cause of the accident. As the stand-on vessel, *CF Crystal* obligations were making avoidance manoeuvres to avoid the collision once noticing (in ample time) that the give-away vessel was not doing anything, it did not. *CF Crystal´*s OOW thought *Sanchi* was a small fishing vessel by the AIS-symbol as he could not notice any radar echo (badly tuned radar). This was also a causal factor of the collision. *Sanchi* had a mixed bridge crew, *CF Crystal* one nationality present – but both teams failed in this case.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 69.

DD1- loss of situational awareness DD2- lack of alerting DD3 - lack of communication DD4 - complacency DD7 - lack of teamwork DD8 - lack of capability + possible cultural differences/power gap

Table 69. Causal attributes case *Sanchi*/ *CF Crystal*

To conclude the *Sanchi*/ *CF Crystal* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the OOW of *Sanchi* of the movements of *CF Crystal* and other nearby ships. The safe passing of the two vessels could have been made in a safe manner *if the OOW would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system*. The use of INAV Onboard Advisory system would have alerted the bridge team of the dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a safe passing of each other.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for avoiding the crossing ships pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing of the ships would have been made in a safe manner with system-controlled manoeuvres approved by the OOW. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention.** The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ship´s course.

Table 70. Kongsberg analysis case *Sanchi*/ *CF Crystal*

EASTERN PHOENIX/ KEIHIN MARU NO 8

ACCIDENT PARTICULARS		
SHIP	Eastern Phoenix	Keihin Maru No.8
TYPE	Chemical tanker	Oil tanker
FLAG	Panama (FOC)	Japan
BRIDGE	Master - Korean	Master*
CREW	OOW - Filipino	OOW*
	Helmsman/AB - Filipino	*Most likely of Japanese nationality
WIND	NE 3 Bf	
SEASTATE	SE current 0,2 kn	
VISIBILITY	Clear but cloudy, visibility 10-20 km	
RESULT	EP - breach of bow hull plating/damage to bulb and SB plating	
	KM - dents/breaches in bow fenders/bottom	

Table 71. Accident particulars case *Eastern Phoenix*/ *Keihin Maru No.8* (JTSB, 2018)

The Panama registered chemical tanker *Eastern Phoenix*, departed from Keihin Port, Kawasaki Section at 08:55 on the 7th of August 2016. Their destination was Zhangjiagang in China. The departure was under pilotage, with the master and a navigational officer acting as a lookout. One AB acted as a helmsman, who was steering in manual mode. As the ship was departing the port area the pilot instructed the assisting tugboat to confirm the circumstances of the traffic in the area. He also checked the situation himself, both visually and by radar. He did not notice any vessels hazardous to *Eastern Phoenix*, so he informed the master that there is no traffic to worry about. After ordering the course to 140 degrees, the pilot disembarked the vessel at 09:16. After some course changes in the following minutes, *Eastern Phoenix* passed the Position Report Line (KE Line) shown in Picture 30. A report was made accordingly by the navigation officer. After the report, both the master and the navigation officer noticed the Japanese flagged Oil Tanker *Keihin Maru No.8* westbound some 0,5NM of the port bow. The master was confident that *Eastern Phoenix* could pass ahead of *Keihin Maru No.8´*s bow, but the thought was not shared by the navigating officer who felt that *Keihin Maru No.8*was getting to close. The masters view soon changed and he blew the ships vessel to alert *Keihin Maru No.8*. The master sensed that the Tonen Ogishima Sea Berth would be in such a position for *Keihin Maru No.8*, that they would need to keep their speed and course to avoid it. Based on that feeling, the master ordered the rudder set too hard to port, aiming to steer the ship towards *Keihin Maru Mo.8´*s stern. Some seconds later, he noticed that *Keihin Maru No.8* was turning to starboard. He subsequently ordered hard to starboard and the main engine to be stopped. Regardless of the actions made, the ships collided at 09:27 with *Eastern Phoenix* bow hitting *Keihin Maru No.8´*s port bow. As the collision escalated, *Eastern Phoenix* starboard midship collided with Keihin Maru No.8´s port stern.

The leading minutes before the accident onboard *Keihin Maru No.8*; at 09:15 she was proceeding with a speed of 9knots with the master on manual helm and the navigation officer acting as a lookout. Soon the roles reversed and the navigating officer to over the hand steering, while the master started eating while he conned the ship. At 09:21 the master noticed *Eastern Phoenix* on its starboard side, some 1,2 to 1,5NM away. As *Keihin Maru No.8* was the give-away vessel the master ordered the navigating officer to take actions to avoid the approaching ship. As the navigation officer noticed that *Eastern Phoenix* bearing was changing more towards the stern of *Keihin Maru No.8*, he decided to keep the course and speed and see how the situation would escalate. The navigation officer was very confident that he could still steer the ship away of *Eastern Phoenix* even at a closer distance. He was also eager to proceed towards the unloading port as he was destined to leave for holidays. With this mindset, he continued with the steady course. At 09:24 while using a window frame as a reference, the master of *Keihin Maru No.8* noticed that *Eastern Phoenix* was not changing its course. He ordered the navigation officer to steer the ship towards the stern of *Eastern Phoenix*. But as the navigating officer was about to execute, he thought that he could see *Eastern Phoenix* bearing change towards their stern. This outcome made him disobey the master's orders and keep the course and speed. The master shared the same feeling with the navigating officer for a short moment and after some repeated exchanges between the two, the master strongly ordered the navigating officer to act. The rudder was steered hard to starboard. The master and the navigating officer thought that they had made it, but *Eastern Phoenix* continued turning to port. Sensing the upcoming collision, the master took over the helm in the last minutes continuing with the hard-starboard rudder. As the collision was unavoidable, the master ordered the navigation officer to leave the bridge. He disengaged the clutch and left the bridge. Some thirty seconds after taking the wheel from the navigating officer the two ships collided.

The collision ended up with structural damage on both ships and a subsequent oil spill from *Keihin Maru No.8*.

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Picture 30. Accident site of *Eastern Phoenix* (JTSB, 2018)

Eastern Phoenix is a flagged to Panama (FOC) so we cannot rule out any FOC-related issues. As we can see from Figure 9 Panama is listed on the accident % per fleet list at an alarming level (over 3% of the fleet). *Keihin Maru No.8* is flagged to Japan, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Japan is listed on the accident % per fleet list at a low level (under 1% of the fleet). Table 72 below shows the main reasons for why Chemical Tanker

Eastern Phoenix collided with Oil Tanker *Keihin Maru No.8* Southeast of Higashi-Ogishima Island.

Main reasons for the accident
➢ Navigation officer of *Keihin Maru No.8* disobeyed the master's orders when he was making avoidance manoeuvres and subsequently made his own decisions. He knew the master well and had a weak hierarchal relationship with him. ➢ Actions were taken too late on both ships ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ *Keihin Maru No.8* failed to comply with Colregs Rule 15 Crossing situations ➢ *Keihin Maru No.8* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *Eastern Phoenix* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 72. Main reasons *Eastern Phoenix/ Keihin Maru No.8* (JTSB, 2018)

Keihin Maru No.8 was the give-away vessel as she had *Eastern Phoenix* on the starboard side. Both ships failed to keep proper lookout and the ships ended up in a close quarter situation. In the crucial moments, the OOW of *Keihin Maru No.8* decided to disobey the master orders as he thought his own appraisal of the situation was better. *Eastern Phoenix* was of mixed crew, Keihin Maru had unknown setup of bridge crew. We can still assume that as Keihin Maru was a Japanese flagged ship, it would most likely have had a Japanese master. As the master was most likely Japanese and he was childhood friends with the OOW, he was probably Japanese too.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 73.

DD1 - loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD6 - lack of local practices DD7 - lack of teamwork DD9 - pressure + possible cultural differences/power gap

Table 73. Causal attributes case *Eastern Phoenix/ Keihin Maru No.8*

To conclude the *Eastern Phoenix/ Keihin Maru No.8* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the OOW of *Keihin Maru No.8* of the movements of *Eastern Phoenix* (and vice versa). The safe passing of the two vessels could have been made in a safe manner *if the OOW´s would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system*. The use of INAV Onboard Advisory system would have alerted the bridge teams of the dangers ahead. All this integrated data received from the navigational instruments, INAV-sensors and cameras would have led to not losing situational awareness on the bridge. The INAV system would have given the OOW/bridge team more time to assess the risks ahead, evaluate and execute a safe passing of the fishing vessel.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for avoiding the crossing ship pending the OOW´s approval*. *The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing would have been made in a safe manner with system-controlled manoeuvres approved by the OOW. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship would have been INAV system-operated with all the safety parameters of the ship and the operating area in mind, ending up in safe passing of all dangers on the ships course.

Table 74. Kongsberg analysis case *Eastern Phoenix/ Keihin Maru No.8*

USS FITZGERALD/ ACX CRYSTAL

ACCIDENT PARTICULARS		
SHIP	USS Fitzgerald	ACX Crystal
TYPE	Navy Destroyer	Container
FLAG	USA	Philippines
BRIDGE	Officer of the Deck	OOW*
CREW	Junior Officer of the Deck	Helmsman*
	QMOW	All crew were Filipino
	Bosun Mate of the Watch	according to REUTERS (2017)
	Helm	
	Lookout	
	All US citizens	*Most likely bridge manning
WIND	Unknown	
SEASTATE	2-4 feet	
VISIBILITY	Sky was dark, moon relatively bright, unlimited visibility	
RESULT	UF - Berthing compartments breached, 7 US sailors dead	
	Major structural damage and flooding to multiple areas	
	AC - Minor damage to bow structures (REUTERS, 2017)	

Table 75. Accident particulars USS *Fitzgerald*/ *ACX Crystal* (US Navy, 2017)

The Arleigh Burke Class Destroyer, USS *Fitzgerald*, left the homeport of Yokosuka, Japan on the 16th of June 2017 to conduct routine operations. The weather was fine, with unlimited visibility and calm seas. Later that night after series of training sessions, *Fitzgerald* was transiting southwest to sea from their Sagami Wan operating area. At around 23:00, both the commanding officer and the executive officer left the bridge. As the ship passed Oshima Island, the traffic density increased and at about 01:00 *Fitzgerald* approached three merchant vessels from its starboard forward side. These vessels were proceeding eastwards in the Mikono Schima Traffic Separation Scheme. All ships were presenting to have a risk of collision with minimal CPA´s on each ship. In this crossing situation, *Fitzgerald* was the give-away vessel according to the Colregs Rule 15 (crossing situation between two motor-driven vessels). In the last minutes leading to the collision the Officer of the Deck (US Navy rank) and the Junior Officer of the Deck (US Navy rank) onboard *Fitzgerald*, discussed the relative positioning of the vessels, including *CF Crystal*. The Officer of the Deck, who was in charge of the navigation of the Destroyer made a mistake identifying *CF Crystal* and subsequently made a bad decision to not make any avoiding manoeuvres. Even at 01:22 when the Junior Deck Officer recommended to the Officer on the Deck to slow down, the response was that slowing down would only complicate the contact picture. When he later realized that the ship was on a collision course with *CF Crystal*, it was too late. Both USS *Fitzgerald* and *CF Crystal* tried to make avoiding actions in the last minute, but it was too late. The Bosun Mate of the Watch executed the Officer of the Decks last order (full speed, rapid turn to left) at 01:29. A minute later at 01:30, *CF Crystal*s bow struck USS *Fitzgerald*'s starboard side resulting in a damaged outer wall, structural damage and subsequent water ingress. After counting all the sailors after the accident, seven sailors went missing. They were later found in the flooded compartments. In the USS Navy report, there is no information on actions onboard *CF Crystal* leading to the accident.

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Picture 31. Accident site of USS *Fitzgerald*/ *ACX Crystal* (US Navy, 2017)

USS *Fitzgerald* was flagged to the US, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that USA is listed on the accident % per fleet list at a low level (under 1% of the fleet). *ACX Crystal* is flagged to Philippines, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Philippines is listed on the accident % per fleet list at a medium level (between 1 to 2% % of the fleet).

Table 76 below shows the main reasons for why USS Navy Destroyer collided with Container ship *ACX Crystal* in the waters of Sagami Wan.

Main reasons for the accident
➢ A compilation of failures by leadership and OOW´s (or OOD´s) to plan for safety, appropriately adhere to sound navigation practices, execute basic watch standing principles, properly use navigation tools, and deliberately and effectively respond when in extremis ➢ The Officer of deck of USS Fitzgerald possessed unsatisfactory level of knowledge the Colregs ➢ The OOD did not calculate the CPA of *ACX Crystal* and other nearby ships using all available means ➢ Watch standers on USS *Fitzgerald* were inattentive, disengaged and party unaware of several nearby ships ➢ USS *Fitzgerald*'s approved navigation track did not follow the Vessel Traffic Separation Scheme in the area ➢ Lack of proper communication on the bridge of USS *Fitzgerald* ➢ No communication was established between the ships in the minutes leading to the collision ➢ When actions were taken onboard USS *Fitzgerald*, the OOD first decided to go to SB, but soon evaluated there was insufficient sea room. He ordered orders: full ahead, flank speed ahead, full left rudder and finally hard left rudder. The Conning Officer "froze" in the moment and soon the OOD and the Conning Officer both begun shout orders to the helm. Eventually the Boatswain of the Watch put the rudder over hard left and pushed the ship´s throttles forward. These actions were only 30s before impact. The ship briefly started to come to left and increasing speed before hitting *ACX Crystal*. ➢ The Officer of the Deck on USS *Fitzgerald* did not report to the Commanding Officer of the increased traffic in the area as it was written in the standing orders. ➢ The events leading to the accident onboard *ACX Crystal* are unknown due to lack of information available, thus causal attributes contributed by *ACX Crystal* cannot be evaluated in full. ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ USS *Fitzgerald* failed to comply with Colregs Rule 15 Crossing situations ➢ USS *Fitzgerald* failed to comply with Colregs Rule 16 Actions by give-away vessel ➢ *CF Crystal* failed to comply with Colregs Rule 17 Actions by stand-on vessel ➢ Both vessels failed to comply with Rule 34 Manoeuvring and warning signals

Table 76. Main reasons case USS *Fitzgerald*/ *ACX Crystal* (US Navy, 2017)

While USS *Fitzgerald* was patrolling on routine operations close to Oshima Island, the traffic was increasing. The navy ship was navigating with a 20kn speed outside the Traffic Separation Scheme when three merchant vessels were approaching from starboard side with a risk of collision. Even though, there is a somewhat known and followed unwritten rule that `if it is gray, stay away´ in the trade, USS *Fitzgerald* was the give-away vessel in terms of the Rules of the Nautical Road - the Colregs. As the stand-by vessel *ACX Crystal* was also obliged to make avoiding manoeuvre, if USS

Fitzgerald did not comply with her part. Neither ship did anything until the last minute, when it was already too late. The Officer of Deck of USS *Fitzgerald* lost his situational awareness completely and subsequently failed to assess risk of collision, make avoiding manoeuvre in ample time and sound any warning signals whatsoever. The rest of the watch standing team onboard a modern warship did not do a better job assisting the Officer of the Deck. The US flagged Navy ship USS *Fitzgerald* had only US nationals onboard with multiple officers and ratings to secure a safe passage of the warship. Still the navy ship succeeded to collide with a merchant ship in a pretty normal crossing situation, in calm seas and unrestricted visibility. The Filipino flagged *ACX Crystal*´s crew were all Filipino and the bridge crew kept the speed and course as expected by the Colregs. But they should have reacted to USS *Fitzgerald*s lack of actions and made their own to avoid the collision. As Rule 2 says in the Colregs, you can also deviate from the Rules if that is the only solution left. Do not keep the course until the bitter end would have been every sensible seaman's advice to *ACX Crystal*s bridge team. Due to this and some similar incidents in the past, The US Navy later (completed 23 Oct 2017) conducted a Comprehensive Review of Surface Fleet Incidents, to address the larger problems and their causes leading up to these incidents. In this review, the US Navy found out that there was poor seamanship present and failures to follow safe navigational practices. In each of the cases this Navy Review scrutinized, the bridge and CIC watch standers did not maintain situational awareness and recognize that a significant error chain was in motion. Additionally, when confronted with an extreme situation, watch standers actions failed to comply with given procedures and practices. In the scope of this accident, use of Kongsbergs INAV system´s would have saved lives of US Navy marines.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 77.

DD1 - loss of situational awareness DD2 - lack of alerting DD3 - lack of communication DD4 - complacency DD5 - culture DD6 - lack of local practices DD7 - lack of teamwork DD8 - lack of capability DD9 - pressure DD10 - distractions

Table 77. Causal attributes case USS *Fitzgerald*/ *ACX Crystal*

To conclude the USS *Fitzgerald*/ *ACX Crystal* case, modern ships with multiple officers on the bridges can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the OOD/OOW of the movements of nearby ships. The safe passing of the two vessels could have been made in a safe manner *if the OOD/OOW would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system(s)*. The use of INAV Onboard Advisory system would have alerted of all the dangers ahead. The INAV system would have given the bridge teams more time to assess the risks ahead, evaluate and execute a safe passing of each other.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for avoiding the all vessels ahead pending the OOD/OOW approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOD/OOW had failed to activate his choice in ample time.* The passing would have been made in a safe manner with system-controlled manoeuvres approved by the OOD/OOW. The bridge team could have been on monitoring mode for possible human intervention at any time of their choice.
INAV Onboard Zero	**Accident prevention**. The ship(s) would have been INAV system-operated with all the safety parameters of the ship(s) and the operating area in mind, ending up in safe passing of all dangers on the ship(s) course(s).

Table 78. Kongsberg analysis case USS *Fitzgerald*/ *ACX Crystal*

8.2.3 Fishing vessel or ship case/s

NOCC OCEANIC/ YUJIN MARU

ACCIDENT PARTICULARS		
SHIP	NOCC Oceanic	Yujin Maru No.7
TYPE	Car carrier	Fishing vessel
FLAG	Marshall Islands (FOC)	Japan
BRIDGE	3/O -Filippino	Deckhand
CREW	AB - Filippino	
WIND	NE 4-5 kn	
SEASTATE	1-1,5 m	
VISIBILITY	Cloudy with heavy rain, very low visibility	
RESULT	NO - scratches on bow plates	
	YM - total loss of ship and master	

Table 79. Accident particulars case *NOCC Oceanic*/ *Yujin Maru No.7* (JTSB, 2015)

The Car Carrier, *NOCC Oceanic* left the Keihin Port in Kawasaki (Republic of Panama) at around 17:00 on June 22, 2013. Onboard was the master with a crew of 21 seamen. The master´s watch keeping orders were made so that the second officer had the 00-04 watch, the C/O 04-08 and the 3/O from 08-12. A deck hand was also assigned to each rotation. However, in order to facilitate holidays to some seamen, sole lookout duties could be performed to the officers if they complied with the Bridge Procedure Manual prepared by the Management Company (Wilhelmsen Ship Management). On Sunday the 23rd, the 3/O arrived at the bridge at 07:50 and was told by the chief officer that there were no ships in the vicinity. As the weather was good the master had deemed the conditions good just 20 minutes earlier – stating to the chief officer that the 3/O could act as sole lookout. This would also give the deck crew some time off as it was a Sunday. The 3/O proceeded with the autopilot at a speed of 15,8kn and with both radars set on 6NM and 12NM range respectively. Shortly after 09:15 it started raining, with thick rain clouds approaching from forward port side. The 3/O contacted the master, but only suggesting that off-duty crew members shut the doors to the living quarters. At 09:30 the visibility was so bad that even the bow 30m away could hardly be seen. The 3/O switched to navigation by radar, but the influence of the rainfall he could not recognise any ships in the vicinity. As there were no AIS information from other ships displayed on the radar, the 3/O thought that there were no ships present in the area. The 3/O did not report the weather change to the master and continued sailing ahead with the same course and speed. Nor did he sound any audio signals due to the restricted visibility as he should have according to the COLREGs. At 11:00 the rain had stopped completely, and the good visibility again was regained. At any point did the 3/O notice any other sounds, except for the normal sounds of the raining. At 16:30 the vessel was contacted by a patrolling Japanese Coast Guard aircraft telling that the ship had a scratch on the hull. After crew inspection, no defects were really found by the crew. At 19:10 the master was contacted by their agency that they should stop the VDR recording and return to Japan. *NOCC Oceanic* had collided with the fishing vessel *Yujin Maru No.7* and not even noticing it. At the time of the collision, there was only a deckhand on the bridge of the fishing vessel. At the point of the impact, the deckhand lookout was sitting on the floor of the bridge, resulting in a blind area from approximately 45 degrees starboard to behind due to the rear wall. As a result of the collision, the deckhand fell in the water and later saved himself by swimming to the inflated raft. All crew members onboard the fishing vessel were unharmed, except for the master who went down with his ship.

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Picture 32. Unconventional Bridge Design of *NOCC Oceanic* (JTSB, 2015)

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Picture 33. Accident site of *NOCC Oceanic* (JTSB, 2015)

NOCC Oceanic is flagged to Marshall Islands (FOC), so we cannot rule out any FOC-related issues in this case. As we can see from Figure 9 Marshall Islands is listed on the accident % per fleet list at a low level (under 1% of the fleet). *Yujin Maru No.7* is flagged to Japan, so connections to possible FOC-related matters were not analysed for the ship. As we can see from Figure 9 that Japan is listed on the accident % per fleet list at a low level (under 1% of the fleet).

Table 80 below shows the main reasons for why Car Carrier *NOCC Oceanic* with Fishing Vessel *Yujin Maru No.7* Southeast of Kinkazan, Ishinomaki City.

Main reasons for the accident
➢ The 3/O did not spot the fishing vessel on the radar(s), possibly due to bad tuning of the radars and/or not cross-checking S-band to X-band radar echoes ➢ *Yujin Maru No.7* did not have AIS ➢ The 3/O onboard *NOCC Oceanic* did not report the rapid change in weather to the master as per company rules ➢ No extra lookout duties were added on either ship ➢ Both ships continued with the same speed as in good weather ➢ No audio signals were given in restricted visibility ➢ Both ships failed to comply with Colregs Rule 2 Responsibility ➢ Both ships failed to comply with Colregs Rule 5 Look-out ➢ Both ships failed to comply with Colregs Rule 6 Safe speed ➢ Both ships failed to comply with Colregs Rule 7 Risk of collision ➢ Both ships failed to comply with Colregs Rule 8 Action to avoid collision ➢ Both ships failed to comply with Colregs Rule 19 Restricted weather ➢ Both ships failed to comply with Colregs Rule 35 Sound signals to be used in restricted visibility

Table 80. Main reasons case *NOCC Oceanic*/ *Yujin Maru No.7* (JTSB, 2015)

The 3/O of *NOCC Oceanic* falsely though that because they were in the middle of the ocean, there would be no other ships. The fishing-vessel *Yujin Maru No.7´*s radar echo on *NOCC Oceanic´*s radar was not seen because of the heavy rain. Obviously the 3/O was too inexperienced in tuning the radar(s) correctly. He should also have compared the S-band radar to the X-band radar images together to be sure that no ships were in the proximity or inside of the heavy rain area. Neither ship posted extra lookouts regardless of the sudden deterioration of weather, nor did neither ship sound the correct sound signals for restricted weather. The deckhand on the fishing vessel that acted as a lookout was sitting on the floor and leaning against the rear wall, resulting in a blind area from approximately 45 degrees port and starboard of the bow. He was instructed to contact the master if he noticed other ships around. As he had the blind area astern, he could not notice *NOCC Oceanic* approaching. He was also not permitted to do any radar adjustments or touch any navigational instruments. So possibly NOCC´s radar image was not seen on the fishing vessel´s radar or the deckhand did not follow the radar image. As he was not allowed to touch any instruments, he did not have the possibility to sound any audio-signals to warn any approaching ships. *NOCC Oceanic* bridge team was all Filipino nationals so they should have been fine communication and cultural wise, as Filipino´s are usually quite closely bonded according to my own experiences. The nationality of the deckhand onboard the fishing vessel is unknown but as he was alone, the only communication issue was/should have been informing the master of the deteriorating weather. Maybe he was reluctant to inform the change of the weather as he was only told to contact the master if he noticed other ships around.

The causal factors in terms of the dirty dozen (Figure 11) by MCA (2016) are analysed based on the facts available in the accident report. As the Dirty Dozen factors were not analysed in full in the original accident report, the below causal factors are a product of the overall picture perceived by the writer. The causal factors thought to be involved in terms of the dirty dozen (Figure 11) by MCA (2016) are shown in the below causal attributes table 81.

DD1 - loss of situational awareness DD2 - lack of alerting DD4 - complacency DD6 - lack of local practices DD7 - lack of teamwork DD8 - lack of capability DD9 - pressure DD10- distractions

Table 81. Causal attributes case *NOCC Oceanic/ Yujin Maru No.7* (JTSB, 2015)

To conclude the *NOCC Oceanic/ Yujin Maru No.7* case, modern ships can collide if the situational awareness is lost. The use of different Kongsberg INAV system products could have avoided this accident as analysed below, hence the use of technology or other means to secure the safe passage of ships is advisable.

Kongsberg product	Analysis
INAV Onboard Advisory	**Most likely accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system reminding the OOW of *NOCC Oceanic* of the movements of *Yujin Maru No.7*. The safe passing of the two vessels could have been made in a safe manner *if the OOW´s would have followed the guidance (visual track given as per set safety parameters) provided by the INAV system(s)*. The use of INAV Onboard Advisory system would have alerted the bridge team of the dangers ahead. The INAV system would have given the bridge team more time to assess the risks ahead, evaluate and execute a safe passing of the fishing vessel.
INAV Onboard Control	**Accident prevention** with all the integrated data presented on the Kongsberg GUI for safe navigation. This would have led to the system giving *safe options for avoiding the fishing vessel ahead pending the OOW´s approval. The system would also have automatically chosen the safest option to navigate past all targets in case the OOW had failed to activate his choice in ample time.* The passing would have been made in a safe manner with system-controlled manoeuvres approved by the OOW. The use of INAV Onboard Control system would have given the bridge team the possibility to go to monitoring mode while passing the ship ahead, subsequently reinforcing and restoring the situational awareness to high level.
INAV Onboard Zero	**Accident prevention**. The ship(s) would have been INAV system-operated with all the safety parameters of the ship(s) and the operating area in mind, ending up in safe passing of all dangers on the ship(s) course(s).

Table 82. Kongsberg analysis case *NOCC Oceanic/ Yujin Maru No.7*

We can assume that only *NOCC Oceanic* would have been the only ship in this scenario to have the Kongsberg products onboard.

8.2.4 Summary of Asian Accidents

In this chapter the Asian cases are summoned together to find common grounds or reasons behind the accidents. Out of these nine cases, which involved 14 ships only 4 had mixed crew. Out of these 4 mixed crew ships 2 were FOC-flagged to Panama. The majority of the 14 ships were of one nationality with 9 ships and with only 2 crew compositions that were unknown (*Yujin Maru No.7* and *Keihin Maru No.8* could also be one nationality/of Japanese origin but this cannot be verified either way). We can clearly see that crew of only one nationality were favoured in the Asian waters. *Beetle´*s, *Maersk Kendal´*s and *Sewol´*s crew contributed to the own fate by making mistakes they should have not. *Sewol* was also wrongly loaded, and the cargo was not secured correctly. An unexperienced 3/O was allowed to navigate alone through the Maenggol Channel with the heavily overloaded unstable ship, showing grocer lack of safety from the master and the company itself. The *Estelle Maersk´*s pilot was Chinese so he could speak fluently with *JJ Sky´*s bridge crew. The only problem was that *Estelle Maersk* Danish master had no possibility to follow that conversation, leading to misunderstandings in the port entry priority order that ended in the collision. In all the Asian accidents there were crew of different nationalities, so some cultural causes for the accidents cannot be ruled out. This also shows that a certain level of maritime English is needed to avoid misunderstandings in communication between ships.

Three of the Asian accident cases involved FOC-flagged ships so we cannot rule out that FOC-related safety issues had a partial impact on these accidents.

Looking at the Dirty Dozen reasons (Figure 11), the Asian cases are much alike each other. All accidents analysed had some sort of loss of situational awareness and complacency. Most accidents had lack of alerting, lack of communication, lack of local practices, lack of teamwork and lack of capability. Half of the accidents had lack of safety culture and pressure. One third accident had distractions as causal attribute.

Fatigue and Fit for duty were not reported as causal attributes in the Asian accidents, but these cannot be fully excluded in real life.

Generally speaking, the use of different Kongsberg systems would have supported the OOW through its Automation Awareness in all cases and eventually avoided the accidents. Kongsberg systems do not recognize “restricted weather” conditions, so ships need a human presence and decision to reduce speed and sound the appropriate sound signals as per Colregs whenever conditions so require (case *NOCC Oceanic*/*Yujin Maru No.7*).

CASE	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	CD	FOC
Beetle	■		■	■	■	■			■					
Sewol	■	■	■	■	■	■	■	■	■					
Estelle Maersk/ JJ sky	■	■	■	■		■	■							
Maersk Kendal	■	■	■	■			■	■		■			■	
Star Kvarven/ Lulanyu 61809	■	■	■	■		■	■	■						
Sanchi/ CF Crystal	■	■	■	■			■	■					■	■
Eastern Phoenix/ Keihin Maru No.8	■	■	■	■		■	■		■				■	■
NOCC Oceanic/ Yujin Maru No.7	■	■		■	■	■	■	■	■	■				■
USS Fitzgerald/ ACX Crystal	■	■	■	■	■	■	■	■	■	■				

Table 83. Causal attributes Asia cases

8.3 Differences between Europe and Asia accidents

We can clearly see that where mixed crew were favoured (table 7) in the European waters maybe partly because of the economics, the Asian ships were manned profoundly by crew of one nationality. At least in the cases covered by this thesis.

The three FOC-flagged ships in the European cases, compared to the four in the Asian cases represented no significant difference between them. But we can clearly notice that FOC-flagged ships represent a high percentage of the accidents in this thesis. The causal attributes of both the European and Asian attributes can clearly be compared using the below table 84. The Human factors and cultural errors involved are more reviewed in sections 8.3.1 and 8.3.2 respectively.

CASE	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	CD	FOC
HAMBURG	■	■	■	■	■	■	■						■	■
COSTA CONCORDIA	■	■	■	■	■	■	■			■			■	
VICTORIA	■		■	■		■	■		■				■	■
SOLA TS/HELGE INGSTAD	■	■	■	■	■	■	■	■	■	■	■		■	■
PETUNIA SEAWAYS/PEGGOTTY	■	■	■	■		■	■	■	■					
PRIMULA SEAWAYS/CITY OF ROTTERDAM	■	■	■	■	■	■	■						■	■
EXPRESS SAMINA	■	■		■	■	■		■		■				
RED FALCON/PHOENIX	■		■	■		■	■	■		■				
BIRKA TRANSPORTER/WILLEMPJE HOEKSTRA	■			■	■	■				■	■			
CASE	DD1	DD2	DD3	DD4	DD5	DD6	DD7	DD8	DD9	DD10	DD11	DD12	CD	FOC
Beetle	■		■	■	■	■			■					
Sewol	■	■	■	■	■	■	■	■	■					
Estelle Maersk/ JJ sky	■	■	■	■		■	■							
Maersk Kendal	■	■	■	■			■	■		■			■	
Star Kvarven/ Lulanyu 61809	■	■	■	■		■	■	■						
Sanchi/ CF Crystal	■	■	■	■			■	■					■	■
Eastern Phoenix/ Keihin Maru No.8	■	■	■	■		■	■		■				■	■
NOCC Oceanic/ Yujin Maru No.7	■	■		■	■	■	■	■	■	■				■
USS Fitzgerald/ ACX Crystal	■	■	■	■	■	■	■	■	■	■				

Table 84. Causal attributes all cases

8.3.1 Human factors and errors

Most, if not all the accidents in this research have some sort of human error element as the main cause of the accident. Looking at the Dirty Dozen (MCA, 2016) reasons (Figure 11), the European and the Asian cases are much alike each other. All accidents analysed had loss of situational awareness and complacency as causal attributes to the accident. Fatigue was reported in two European cases and in no Asian cases, but the reality is probably the same. Fit for duty were not reported as causal attribute in both the European and Asian accidents, but these cannot be fully excluded in real life. All other attributes were more or less the same. To go more into detail of each Dirty Dozen attribute you may summarize all (European and Asian) as below:

1. Situational awareness was lost in all cases, either partly or totally
2. Alerting was almost non-existent; no challenges were raised in any of the ship accidents
3. Communication was on a low level. Mostly if there were communication, it was not concerning navigation.
4. Complacency. Day in day out, seems to be a rule which is easily followed. Routine becomes a safety risk. Lack of useful checklists seen or at least no proof of their use.
5. Culture. No strong cultures seen in the accident cases, more towards the weak one or non-existent one
6. Local practises. There was no evidence of working practices in any of the cases.

7. Teamwork. Lack of strong teamwork seen in many cases. Needs to be more supportive.
8. Capability. A mixed crew can be an asset as there are many nationalities onboard. But the lack of basic skills, that is normal to some part of the world can surprise the other. There is a risk here.
9. Pressure. This is the trend now, as time is money. Many times, the schedules to keep are more important than proceeding with safe speed. Many cases in this thesis can relate to this. Other shortcuts can also affect safety of the ship
10. Distractions. This can be extra persons on the bridge (*Costa Concordia*), heavy radio traffic by VTS or other ships (for example *Maersk Kendal*)
11. Fatigue. No case was found to be caused by fatigue alone or OOW´s falling asleep. But this can still be a causal part as watch keepers are not so vigilant when they do not get enough sleep. Out of own experience different stages of fatigue can be felt every day. This also changes many times during a contract and increases towards the end of the contract.
12. Fit for duty. All seafarers were declared fit for duty, but this can be deceptive. In all the ships sailing the oceans, there are crews with different types of seaman. All from fitness fanatics to heavily obese individuals who hardly does anything to keep fit. Alcohol is still part of the industry and the combination of alcohol/lack of sleep is a killer. So regardless of the lack of ”fit for duty” attributes in the European cases, I am confident (out of own experience) that this was one of the causal factors with fatigue that was involved in more accidents than reported.

8.3.2 Cultural differences

As mentioned earlier, mixed crew were favoured in the European waters whereas the Asian ships were mostly crewed by one nationality. The competitiveness and possible profits gained using foreign crew could have a downside in the decrease of safety. There have been multiple studies on the risks of multicultural crews with most of them recognising the risks involved, mainly in terms of cultural differences and communication problems (Knudsen, 2004). The problem lies in that there are no requirements or criteria by SOLAS, IMO or flag states to test the crew of their language proficiency, so this falls solely in the hands of the shipping companies and their standards. The seamen operating the ships are of different cultural and training backgrounds, without a common language. Many things can go wrong and in the crucial moments of developing accidents we need a platform that makes us understand the situation in a similar way to make the correct avoiding manoeuvres.

9 Conclusions

The fragmented environment of the bridge designs is usually complex with the individual instruments scattered around and thus not always ideally located (an example case *City of Rotterdam* (MAIB, 2017), where the location of VHF not reaching centreline caused the optical illusion effect that mislead the pilot). This results in difficulties to follow the presented data for correct interpretation. Subsequently the situational awareness is in the OOW´s own hands and limited to his/her capabilities on how it is interpreted. The situation on the bridge can get complicated when factors onboard or in the vicinity of the ship change. The visibility can change, wind and currents can change, alarms or other distractions on the bridge can affect the OOW´s concentration. The difficulty is to anticipate the overall situation and developing risks correctly (Wallin, 2016). Kongsberg´s Intelligent sensor fusion reduces this cognitive load, thus enhancing (and restoring if momentarily lost) the situational awareness of the OOW.

The crew that operate the ships comes with various backgrounds in terms of training and experience. This alone increases the possibilities of an accident. Adding to that, the crews have different cultural backgrounds that makes it even more complex (Knudsen, 2004). The increasing amount of electronics onboard creates an ever-increasing pressure on familiarization on newcomers. New OOW´s have a minimal time to familiarize themselves with the equipment onboard, before taking over a solo watch. Companies have different approaches (or in worst case scenario no approach at all) to secure and confirm everyone's readiness to take over the watch. A newcomer could pose a serious threat to the ship´s and possible passengers' safety. Having Kongsberg INAV systems onboard could easily correct this risk by having a back-up system to watch out for human mistakes bound to happen.

There has been studies and wide-range research on fatigue and the consequences and dangers on lack of sleep. Despite of that and how experienced the officers are, fatigue continues to be a leading cause of accidents in the maritime industry. We know from research that fatigue has an impact on human judgement, decision making ability, response-time and productivity (Martha Report, 2017). This eventually puts the mariners and ships in danger. Vessel owners should try to minimize the effects of fatigue onboard, either by policies or other means.

On many of the accidents in this report, the failure of bridge collaboration was evident. Even though many of the officers involved in the accidents, were properly trained in terms of Bridge Resource Management – the cooperation of the bridge team failed. One valuable input of the Kongsberg INAV systems in these situations, is that it collects all necessary information on one display. So, if one person of the manned bridge is vigilant, he/she will see the whole navigational overview on that screen. This does not relieve the inputs and feedback from all watch standers, but this would ensure that the situational awareness would be greater and give more time for discussions and subsequent actions needed.

The growing use of technology and greater use of different sensors have a potential to improve navigation and to avoid incidents (Allianz, 2019) but at the same time accidents do happen due to over-reliance on technology. The new generation of seafarers could be tempted to trust more on technology than good old basic navigation skills. Even though the new technology such as the Kongsberg INAV systems can be very useful as an integrated tool for increasing situational awareness and system-controlled collision avoidance, it is crucial that new (and old) seafarers keep getting appropriate training in the fundamentals of navigation. This is to develop a solid understanding of navigation principles and the rules of good seamanship.

Use of Kongsberg INAV products could have avoided most of the accidents in this research if not all, regardless of what system would have been in use during the accident. As Kongsberg systems do not yet recognize the restricted weather conditions, there must be some human interaction to monitor the weather conditions and act accordingly. This is to adjust speed (safe speed/ subsequent min CPA according to circumstances), sound the correct signals and increase possible lookouts. The system alarms would work best if there is a possibility to custom operate them through multiple gadgets and apparatus that are commonly found onboard.

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Figure 15. Predicted increases in World Seaborne Trade (ICS, 2019)

As we can see from figure 14, the prediction is that the World Seaborne Trade is only increasing in the coming years. This will lead to more possible accidents if there is no breakthrough in safety measurements. In the past new legislation has been reactive where new laws have been put in place only after a disaster. In Figure 15 shows this timeline for shipping accidents and how they affected the maritime safety legislation. As we can see from the Marine Traffic density map (Picture 23), the most used traffic lanes are already crowded. The European and Asian accidents analysed in this thesis happened in the hotspots of today. Should the maritime industry for once be proactive and legislate new laws concerning back-up systems for navigation to support the human decision-making process. The ISM (International Safety Code) is a good start with its promotion of ´safety culture´ through the ships Safety Management Systems. But it is not enough as companies and ships treat the laws and regulations as they seem fit. IMO has also introduced Formal Safety Assessment (FSA) and Human Reliability Analysis (HRA) which is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property by using risk and cost/benefit assessments" (IMO, 2000). What IMO should do is to implement these methodologies into a world-wide data base for maritime accidents such as the IATA Ground Damage Data Base (GDDB) made for ISAGO and IGOM in the aviation world. This would lead us to understand the marine accidents of the past, today and avoid best the future ones.

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Picture 34. Traffic density map (Marinetraffic, 2019)

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Figure 16. Timeline for shipping accidents occurred and how they affected the maritime safety legislation (Butt N. et al. 2014)

The researchers roll in this work has been significant. Own experience, opinions and ideas are the basis of what is not written in the accident reports. What is the reliability of the research? At least the primary data can be supported by literature. There is also a detailed plan on how the thesis is done. What can be criticized is that there is restricted amount of cases that have been researched. There is also restricted amount of data available in the accident reports. As the cases are a variety of European and Asian cases, the accident reports originate from different countries. My final statement on the results of this thesis would be that any system that can minimise the risks and misunderstandings involved in shipping, is worth looking at. The intelligent Kongsberg systems should be seen as a new life, environment and cost saving insurance that works proactively.

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Annex I. Breakdown of all accidents in this thesis

Source: All accident reports in this research

Accident Type	Accident year	Ship group	Ship type	IMO number	Name	Flag	Year built	Age	Ship group	Ship type	IMO number	Name	Flag	Year built	Age
Grounding	2015	Passenger	Cruise ship	9138329	Hamburg	Bahama	1997	18							
Grounding	2012		Cruise ship	9320544	Costa Concordia	Italy	2006	6							
Grounding	2017	Cargo ship	Container	9290165	Victoria	Portugal	2004	13							
Collision	2018		Oil tanker	9724350	Sola TS	Malta	2017	1	Government	Navy fregate	N/A	KNM Helge Ingstad	Norway	2007	11
Collision	2016		Ro-ro	9259501	Petunia Seaways	Denmark	2003	13	Historic vessel	Motor launch	N/A	Peggotty	UK	1944	72
Collision	2015		Ro-ro	9259513	Primula Seaways	Denmark	2004	11	Cargo ship	Car carrier	9473468	City of Rotterdam	Panama	2011	4
Grounding	2000		Ro-ro	6613548	Express Samina	Greece	1966	34							
Collision	2018		Ro-ro	9064047	Red Falcon	UK	1994	24	Pleasure boat	Motor cruiser	N/A	Phoenix	N/A	2005	13
Collision	2011		Ro-ro	8820858	Birka Transporter	Finland	1991	20	Fishing vessel	Trawler	8705826	Willempje Hoekstra	Netherlands	1986	25
						Total age of 9 ships		140					Total age of 5 ships		125
						Average age EUROPE ships		18,9							

Accident Type	Accident year	Ship group	Ship type	IMO number	Name	Flag	Year built	Age	Ship group	Ship type	IMO number	Name	Flag	Year built	Age
Collision	2016	Passenger	Catamaran	8922137	Beetle	Japan	1990	26			Collision with a marine mammal				
Foundering	2014	Cargo	Ro-ro	9105205	Sewol	South Korea	1994	20							
Collision	2016	Cargo	Container	9321495	Estelle Maersk	Denmark	2006	10	Cargo	Container	9347968	JJ Sky	Hong Kong	2004	12
Grounding	2009	Cargo	Container	9332999	Maersk Kendal	UK	2007	2							
Collision	2014	Cargo	Bulk/Container	9396153	Star Kvarven	Norway	2010	4	Fishing ship	Trawler	N/A	Lulanyu 61809	China	2007	7
Collision	2018	Cargo	Oil tanker	9356608	Sanchi	Panama	2008	10	Cargo	Bulk carrier	9497050	CF Crystal	Hong Kong	2011	7
Collision	2016	Cargo	Chemical tanker	9552692	Eastern Phoenix	Panama	2010	6	Cargo	Oil tanker		Keihin Maru No.8	Japan	1990	26
Collision	2013	Cargo	Car carrier	9624029	NOCC Oceanic	Marshall Islands	2012	1	Fishing ship	Tuna long-liner	N/A	Yujin Maru No.7	Japan	2011	2
Collision	2017	Government	Navy destroyer	N/A	USS Fitzgerald	USA	1995	22	Cargo	Container	9360611	ACX Crystal	Phillipines	2008	9
						Total age of 9 ships		101,0					Total age of 6 ships		63
						Average age ASIA ships		10,9							

Annex II. Beaufort wind force scale (UK MetOffice, 2019)

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Annex III. Colregs in short (IMO, 2019)

Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs) Adoption: 20 October 1972; Entry into force: 15 July 1977

The 1972 Convention was designed to update and replace the Collision Regulations of 1960 which were adopted at the same time as the 1960 SOLAS Convention.

Technical provisions
The COLREGs include 41 rules divided into six sections: Part A - General; Part B - Steering and Sailing; Part C - Lights and Shapes; Part D - Sound and Light signals; Part E - Exemptions; and Part F - Verification of compliance with the provisions of the Convention. There are also four Annexes containing technical requirements concerning lights and shapes and their positioning; sound signalling appliances; additional signals for fishing vessels when operating in close proximity, and international distress signals.

Part A - General (Rules 1-3)
Rule 1 states that the rules apply to all vessels upon the high seas and all waters connected to the high seas and navigable by seagoing vessels.

Rule 2 covers the responsibility of the master, owner and crew to comply with the rules.

Rule 3 includes definitions.

Part B- Steering and Sailing (Rules 4-19)
Section 1 - Conduct of vessels in any condition of visibility (Rules 4-10)

Rule 4 says the section applies in any condition of visibility.

Rule 5 requires that "every vessel shall at all times maintain a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision.

Rule 6 deals with safe speed. It requires that: "Every vessel shall at all times proceed at a safe speed...". The Rule describes the factors which should be taken into account in determining safe speed. Several of these refer specifically to vessels equipped with radar. The importance of using "all available means" is further stressed in

Rule 7 covering risk of collision, which warns that "assumptions shall not be made on the basis of scanty information, especially scanty radar information"

Rule 8 covers action to be taken to avoid collision.

In Rule 9 a vessel proceeding along the course of a narrow channel or fairway is obliged to keep "as near to the outer limit of the channel or fairway which lies on her starboard side as is safe and practicable." The same Rule obliges a vessel of less than 20 metres in length or a sailing vessel not to impede the passage of a vessel "which can safely navigate only within a narrow channel or fairway."

The Rule also forbids ships to cross a narrow channel or fairway "if such crossing impedes the passage of a vessel which can safely navigate only within such channel or fairway." The meaning "not to impede" was classified by an amendment to Rule 8 in 1987. A new paragraph (f) was added, stressing that a vessel which was required not to impede the passage of another vessel should take early action to allow sufficient sea room for the safe passage of the other vessel. Such vessel was obliged to fulfil this obligation also when taking avoiding action in accordance with the steering and sailing rules when risk of collision exists.

Rule 10 of the Collision Regulations deals with the behaviour of vessels in or near traffic separation schemes adopted by the Organization. By regulation 8 of Chapter V (Safety of Navigation) of SOLAS, IMO is recognized as being the only organization competent to deal with international measures concerning the routeing of ships.

The effectiveness of traffic separation schemes can be judged from a study made by the International Association of Institutes of Navigation (IAIN) in 1981. This showed that between 1956 and 1960 there were 60 collisions in the Strait of Dover; twenty years later, following the introduction of traffic separation schemes, this total was cut to only 16.

In other areas where such schemes did not exist the number of collisions rose sharply. New traffic separation schemes are introduced regularly and existing ones are amended when necessary to respond to changed traffic conditions. To enable this to be done as quickly as possible the MSC has been authorized to adopt and amend traffic separation schemes on behalf of the Organization.

Rule 10 states that ships crossing traffic lanes are required to do so "as nearly as practicable at right angles to the general direction of traffic flow." This reduces confusion to other ships as to the crossing vessel's intentions and course and at the same time enables that vessel to cross the lane as quickly as possible.

Fishing vessels "shall not impede the passage of any vessel following a traffic lane" but are not banned from fishing. This is in line with Rule 9 which states that "a vessel engaged in fishing shall not impede the passage of any other vessel navigating within a narrow channel or fairway. "In 1981 the regulations were amended. Two new paragraphs were added to Rule 10 to exempt vessels which are restricted in their ability to manoeuvre "when engaged in an operation for the safety of navigation in a traffic separation scheme" or when engaged in cable laying.

In 1987 the regulations were again amended. It was stressed that Rule 10 applies to traffic separation schemes adopted by the Organization (IMO) and does not relieve any vessel of her obligation under any other rule. It was also to clarify that if a vessel is obliged to cross traffic lanes it should do so as nearly as practicable at right angles to the general direction of the traffic flow. In 1989 Regulation 10 was further amended to clarify the vessels which may use the "inshore traffic zone."

Section II - Conduct of vessels in sight of one another (Rules 11-18)

Rule 11 says the section applies to vessels in sight of one another.

Rule 12 states action to be taken when two sailing vessels are approaching one another.

Rule 13 covers overtaking - the overtaking vessel should keep out of the way of the vessel being overtaken.

Rule 14 deals with head-on situations. Crossing situations are covered by Rule 15 and action to be taken by the give-way vessel is laid down in Rule 16.

Rule 17 deals with the action of the stand-on vessel, including the provision that the stand-on vessel may "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.

Rule 18 deals with responsibilities between vessels and includes requirements for vessels which shall keep out of the way of others.

Section III - conduct of vessels in restricted visibility (Rule 19)

Rule 19 states every vessel should proceed at a safe speed adapted to prevailing circumstances and restricted visibility. A vessel detecting by radar another vessel should determine if there is risk of collision and if so take avoiding action. A vessel hearing fog signal of another vessel should reduce speed to a minimum.

Part C Lights and Shapes (Rules 20-31)

Rule 20 states rules concerning lights apply from sunset to sunrise.

Rule 21 gives definitions.

Rule 22 covers visibility of lights - indicating that lights should be visible at minimum ranges (in nautical miles) determined according to the type of vessel.

Rule 23 covers lights to be carried by power-driven vessels underway.

Rule 24 covers lights for vessels towing and pushing.

Rule 25 covers light requirements for sailing vessels underway and vessels under oars.

Rule 26 covers light requirements for fishing vessels.

Rule 27 covers light requirements for vessels not under command or restricted in their ability to manoeuvre.

Rule 28 covers light requirements for vessels constrained by their draught.

Rule 29 covers light requirements for pilot vessels.

Rule 30 covers light requirements for vessels anchored and aground.

Rule 31 covers light requirements for seaplanes

Part D - Sound and Light Signals (Rules 32-37)

Rule 32 gives definitions of whistle, short blast, and prolonged blast.

Rule 33 says vessels 12 metres or more in length should carry a whistle and a bell and vessels 100 metres or more in length should carry in addition a gong.

Rule 34 covers manoeuvring and warning signals, using whistle or lights.

Rule 35 covers sound signals to be used in restricted visibility.

Rule 36 covers signals to be used to attract attention.

Rule 37 covers distress signals.

Part E - Exemptions (Rule 38)

Rule 38 says ships which comply with the 1960 Collision Regulations and were built or already under construction when the 1972 Collision Regulations entered into force may be exempted from some requirements for light and sound signals for specified periods.

Part F - Verification of compliance with the provisions of the Convention

The Rules, adopted in 2013, bring in the requirements for compulsory audit of Parties to the Convention.

Rule 39 provides definitions.

Rule 40 says that Contracting Parties shall use the provisions of the Code for Implementation in the execution of their obligations and responsibilities contained in the present Convention.

Rule 41 on Verification of compliance says that every Contracting Party is subject to periodic audits by IMO.

Annexes

The COLREGs include four annexes:

Annex I - Positioning and technical details of lights and shapes

Annex II - Additional signals for fishing vessels fishing in close proximity

Annex III - Technical details of sounds signal appliances

Annex IV - Distress signals, which lists the signals indicating distress and need of assistance.