The monitoring navigator

Project group 6

Maritime university of Applied Sciences

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Preface

All students at the Maritime University of Applied Sciences have to do research for a project called 'Project 2'. Every year a theme will be chosen by the principals. All second year students are divided into different project groups, and all these project groups are going to do research to a topic that fits with the main theme.

Our project group consists of the following group members:

- Tom Neef
- Chris Remmelzwaal
- Coen Timmermans
- Mitchel Troost

In this report you can read everything about our research during this project, including problem definition, (main) questions, and answers to those questions.

Introduction

Description of the theme and its related topic

This year's theme for the project is Improvements & Innovation. This means almost every single idea complies with the mentioned theme. We chose to approach the theme from the automation side. In the beginning we found it very hard to come up with a subject that has not been done before. Then we decided that every project member writes any possible idea he comes up with on paper, so that we could discuss them separately with our project managers. After the first meeting we had with our project managers there was only one idea that stood out above the rest: Unmanned vessels. Though we found it irresponsible to sail without any engineers on board in case something would break down in the engine room. So we decided to focus our attention to the unmanned bridge. If you want to sail with an unmanned bridge, then the situation has to be monitored from somewhere else. This could be done from the shore, but also from another vessel. The project managers were very enthusiastic and our subject was born: "The monitoring navigator."

Problem definition

Nowadays there are a number of problems in the worldwide shipping industry.
A major problem is formed by the on-going expenses on board. Companies want to compete with each other; therefore they have to ship the cargo more cheaply than the competitors. To still make profits on the transportation the cost should be reduced. With fewer people to work on board the expenses will be lower, this is often already reduced to almost the minimum.

Another problem is the safety on sea. Navigational errors or errors by miscommunication happen all the time. As a result, there are regularly collisions and a lot of near misses. Companies are not always able to sail with well-educated officers due the worldwide shortage of maritime officers.

The idea

Our vision is that it should be possible to sail without any person on the bridge. With the techniques available these days the sky is the limit. During WWII merchant vessels were protected and guided by planes. The only way to do this was to let them sail in convoy. This is the only way to keep control of the vessels and in case something does happen, the vessel in distress can easily get help from the surrounding vessels.

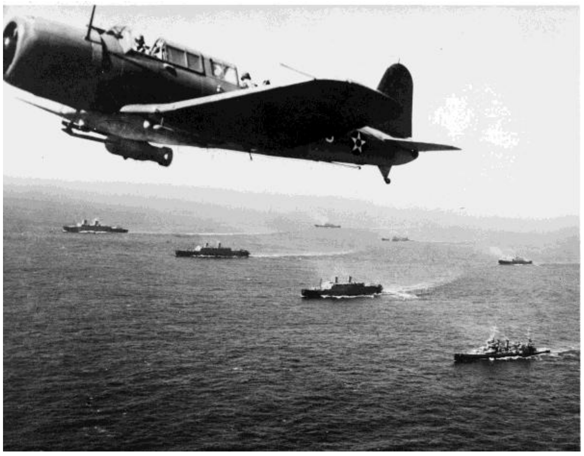


Fig 1: Convoy of vessels protected by military planes during WWII

The idea is to have multiple vessels sailing in the same direction controlled by one mother vessel. For instance container vessels sailing from Rotterdam to New York crossing the Atlantic every day. What if we let these vessels sail in convoy together and have them sailing automatically? If the systems available these days are linked and working together they should easily be able to maintain a safe voyage without having an officer standing by on the bridge.

Goal

We want to find out whether our idea is feasible for merchant shipping. Trying to solve this we came up with the following main question:
"In what way is the monitoring navigator feasible while maintaining the safety of the vessel, crew, cargo and other vessels at sea?"
In order to answer this question we made the following sub questions:

1. How does the monitoring navigator work?
2. What systems need to be added/edited to make the monitoring navigator work?
3. What are the advantages and disadvantages of the monitoring navigator?
4. How is the safety of the vessel guaranteed?
5. What problems will be encountered with a monitoring navigator?
6. What are the solutions to these problems?

Project borders

In this part we will explain the borders of our project to make sure we keep to the point and do not waste our time at minor issues. The most important thing for our entire investigation is that we approach it from the technical side. This is essential to our research because we chose automation as our discipline.

What are we going to research?
We want to find out if it is possible to introduce the monitoring navigator into the maritime industry. We concentrate our research to the unmanned bridge. Finding out what systems need to be applied etc. Basically we are planning our research to answer the main- and sub questions and sticking to it.

What aren't we going to research?
One of the most important things that we won't include in our research is the engine room. For our investigation it is more important to focus our attention to the bridge. Either we take a look at the laws and regulations.

The monitoring navigator

"How does the monitoring navigator work?"

The basic principle of the monitoring navigator is really simple and the name explains it all. The monitoring navigator is someone who monitors multiple vessels via screens and other tools, required to maintain a safe voyage. The monitored vessel will no longer need an officer on the bridge. It can be done from an office at the shore, or from the mother vessel. We think that it is too soon to just control vessels from the shore. If something does happen, immediate action can be taken since the mother vessel is always around.

Our idea is that the monitoring navigator controls the mother vessel, and that the other vessels in the convoy follow it automatically at a selected relative distance. All necessary data will be transmitted to and from the mother vessel using advanced integrated systems. In which pattern the vessels sail, is depending on the chosen convoy type.

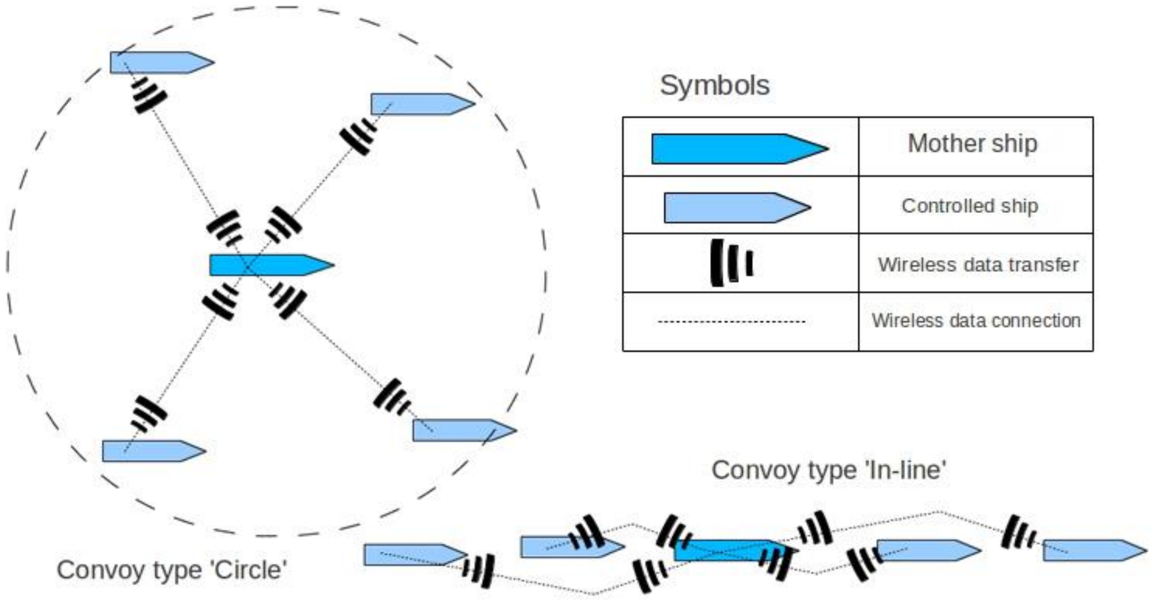
Convoy types

The monitoring navigator is able to use two convoy types called 'circle' and 'in-line'.

The 'circle' method is the most common method of sailing vessels in convoy. When the convoy uses the circle-type, the mother vessel is always in the center of the 'circle'. This means, the other vessels are surrounding it at a fixed relative distance. The convoy type 'circle' is a safe method, since the vessels sail alongside each other. The risk of collision with vessels in the convoy is very small, and in case of an emergency, altering course to prevent collisions is easily possible. However, during voyages in crowded areas, sailing in a relative big circle is not practically.

Another possible type is the 'in-line' method. Sailing in front of each other makes it possible to cross heavy traffic zones. Possible collisions can also be avoided with altering the course of the vessels. Furthermore, the mother vessel is always close enough to her followers in case of an emergency.

Since even the largest 'in-line' convoys would be in range of the wireless communication system, the 'inline' type looks like the best option when sailing in convoy with a monitoring navigator.



Full diagram; See appendix I.

Types of vessels

A lot of different types of vessels could sail in convoy using a monitoring navigator. The most usable type will be the container vessel. Since there are a lot of big container terminals with a lot of capacity, hundreds of containers could be processed within a couple of minutes. Normally, all container vessels arrive at those terminals at different dates and times. Using a monitoring navigator, all container vessels will arrive at the same time, and all containers can be processed at the big terminal. The only difference is that all containers now have to be processed at the same time, instead of during the whole day.

Applicable areas

Since sailing with vessels in convoy is not very practically near the coast due to heavy traffic, the best application of the monitoring navigator is at the ocean. For example, the North Atlantic or the Pacific are very appropriate areas for convoys of monitoring navigators. Because of the huge area and the relatively small traffic, there is enough space to minimize the risk of collision with other vessels.

Why not sail with no crew at all?

In our eyes it is not responsible to sail without any person on board. To maintain a safe and economical voyage, engineers will still be required because there is always work in the engine room and there are no robots yet that can replace these tasks. For example, what if the temperature in one of the cylinders is too high? It **could** be that the valve-timing is off. If you would proceed without adjusting it would harm the cylinder itself, the valves, the efficiency and so on. If you have an engineer on board then this would just be one of the easy routine jobs that can be fixed very quickly. There are dozens of other examples that may seem like a small problem in the beginning, but could end really bad if no action is taken.

A team of engineers can stay on the mother vessel, in case of deficiencies this team can be shipped to the monitored vessel with a tender. But in the past mistakes have been made, people were biting off more than one can chew. So the monitoring engineer should be of later concern, let’s say phase 2.

Systems

"What systems need to be added/edited to make the monitoring navigator work?"

To make the monitoring navigator work on board of vessels, a lot of systems have to be added or edited. In this chapter you can find such systems, including a description and the application in our project. You can also find out how we are going to connect all those individual systems with each other.

The BATS Communication system

Since our project needs a solution for transmitting data from vessel to vessel, we need to find a proper and usable system. These signals need to travel a relatively small distance, but we need to be sure that the mother vessel receives all required information from the other vessels.

The BATS AMATS-300 system from manufacturer Broadband Antenna Tracking Systems, Inc. (BATS) could be a possible solution. 'AMATS' stands for Automatic Mobile Antenna Tracking Systems, and provides real-time data and video transfers via wireless broadband. The AMATS-300 unit consists of an integrated radio, GPS, auto-aiming device and the BATS power control unit.

Using this system, uninterrupted high-bandwidth wireless connections can be made between moving vessels. The speed of these connections can be up to 100 MB/sec at 40 kilometers. The AMATS-300 can even make connection with vessels at a distance over 60 kilometers, although those connections are much slower.

The system also utilizes a GPS-Assisted Gyro Stabilizer System to compensate vessel movements and to maximize the connection stability during turns and vertical movements of the vessels. The extensive built-in remote management capabilities of the BATS AMATS-300 make it possible to fully integrate it into our systems.

The camera infrared system

To keep 'watch' on the vessels without a crew on the bridge, a camera infrared system will be used. This system can detect suspect objects or situations during the voyage. In order to get a full 360 degrees view, a lot of infrared camera will be placed on different spots of the vessel. Because of this, the system monitors the electromagnetic radiation around the whole vessel. Using an advanced computer system, the image of the monitoring cameras will be analyzed. If any suspect object or situation is detected, the computer will generate an alarm, with a related priority. This alarm and the retrieved information will be sent to the Master vessel, so action can be taken, if needed.

It is a big advantage to use the infrared system while sailing in areas with a lot of piracy. Since the system can detect the suspect objects much faster than the human eye, action can be taken very quickly to protect all vessels.

Unmanned sea navigation system from Samsung Heavy Industries

Back in 2000, Samsung Heavy Industries introduced its unmanned sea navigation system. This system communicates with the vessel through the Internet. The integrated bridge system contains the navigation system NARU 2000 and the vessel control system SSAS 21. Using these systems, unmanned navigation is feasible.

The NARU 2000 system is designed to maximize safety and economic efficiency of the sea navigation of vessels. The system includes an electronic chart system. The SSAS 21 monitors all major systems of the vessel. The system transmits all important information via satellite to the head office.

Wärtsilä's fully integrated vessel control system

Wärtsilä designed a communication and control center (the Wärtsilä 3C). These systems connect several separated systems on board to one single interface. Through this interface, you get full command and control of each system on board of the vessel.
The retrieved data from all systems can be sent the owner's head office. All data from the systems in the engine room can also be monitored on the Wärtsilä 3C. The system includes an advanced safety system, to provide full reliability and comprehensive awareness of the conditions of all systems on board. Wärtsilä's control center will be used on each vessel in the convoy, so all systems on board of the individual vessels can be controlled through this console. The mother vessel will be equipped with additional consoles to be able to control every other vessel.

A picture of Wärtsilä's fully integrated vessel control system

Preventing collisions using the radar with ARPA, AIS and ECDIS

To ensure all vessels in the convoy stay at a safe distance of each other, we will use the radar with the ARPA-system (Automatic radar plotting aid). This system automatically plots the track of vessels within its current radar range. On the radar screen, all important information will be shown, such as the vessel's course and speed.
To identify all vessels on the radar, the radar will have to communicate with the AIS-system on board. Using the AIS-system, specific information about the vessel's current voyage can be retrieved, such as destination, ETA. Information about the vessel itself, its length, breadth and draft, can also be found via AIS.

Finally, we will connect the AIS system to the electronic chart system called ECDIS. With the AIS system connected to ECDIS, all vessels in range can be viewed inside the electronic chart.

Kongsberg's DP and DARPS systems

As a backup or even a replacement for the ARPA, AIS and ECDIS systems, a DP system can be used. 'DP' stands for dynamic positioning, and is mainly being used in the

offshore. The purpose of DP is to keep a vessel at a given position. Drilling vessels and dredgers use the DP system to stabilize the vessel in order to work below the sea surface at the right position. Shuttle tankers and supply vessels do also use DP systems.
These systems are very accurate to prevent dangers.

Besides keeping a vessel at a given position, a DP system is also able to keep a relative distance between another vessel or structure. This feature of the system is really useful while sailing in a convoy. All vessels in the convoy will be equipped with a DP system, and all those systems will be controlled by the monitoring navigator on the mother vessel. A safe relative distance can be set up depending the sea state and the weather. The DP system also requires an alarm system to generate alarms in case of a failure of one of the DP systems in the convoy. If a system fails, the monitoring navigator will be able to manually control the vessel to prevent a possible collision. Then the monitoring navigator will need to find a solution for the problem.

Manufacturer Kongsberg Maritime produces DP systems that can be fully integrated on vessels sailing in convoy. Furthermore, Kongsberg developed the Differential Absolute and Relative Positioning Sensor (DARPS). This system is used to get reliable and accurate absolute and relative positioning of two vessels. If the vessels would sail with a relative distance within one mile, DARPS could also be used in our convoys. The vessels could obtain the position and heading of each other using a laser. All data will be transmitted and received by an integrated UHF system (ultra high frequency).

The connection between the systems

To enable sailing in convoy with a monitoring navigator, all systems described above have to be connected with each other. This connection will be realized by LAN networks: a LAN network will be created on board of each vessel. All required data from the vessel will be obtained from all the systems and sensors on board via the LAN network. This data will be stored on a computer, which is also in direct connection with the BATS system. The computer will send all important data via the BATS system to the mother vessel.

All important data from the vessels in the convoy will be received by the mother vessel. The mother vessel is also equipped with a LAN network and a computer. The data received by the BATS system on board of the mother vessel will be send to the computer through a LAN connection. This computer stores all the data, and sends it to the control consoles on the bridge.

The connection between all vessels will always be alive using test signals. If a connection fails, an alarm will be activated to indicate a vessel may encounter technical problems. In that case, action has to be taken by the monitoring navigator. A satellite connection can be established to realize a backup connection with the concerning vessel.

The mother vessel will of course also send data to other vessels in the convoy. If the course and speed of one of the vessels need to be changed, the required data will go all way back via the computer on the mother vessel, through the BATS system and through the computer of the concerning vessel. The data will be sent to the control console on the bridge, where the course and speed will be altered.

As for the bridge control consoles, both Samsung Heavy Industries' and Wärtsilä's systems could be used on board of the vessels in convoy. However, Wärtsilä's 3C system would probably the best solution, since this console is much newer than Samsung Heavy Industries' almost twelve year old system.

Advantages & disadvantages

"What are the advantages and disadvantages of the monitoring navigator?"

With every new idea advantages and disadvantages occur. The monitoring navigator is no exception. We think that the advantages weigh heavier than the disadvantages and these can be solved as well or will solve itself in the long term. We can divide the pros and cons into three divisions (pros and cons of convoy sailing included):

1) Financial
2) Technical
3) Safety

The pros and cons will be mentioned, and will be explained after each division.

Financial

Advantages:

1. Lower costs of personnel
2. Larger quantities can be transported at once.
3. No need for building new vessels
4. More vessels can be manned with the current amount of crew available.

Disadvantages:

1. Installing the systems will cost money
2. Vessels needs to be in dock
3. The systems required are expensive

Not only will there be fewer officers that need to be paid, but what about all the other costs that companies need to make for their employees. For instance: food, insurances, training courses etc. This also can be a great addition to solving the worldwide shortage of officers.

When sailing in convoy larger quantities can be transported to the same port in one voyage. Because this system can be implanted into existing vessels, no new vessels have to be built in order to use this system.

Because the number of navigating officers is reduced to the ones on the mother vessel, companies can use the remaining officers to man other or newly built vessels instead of hiring new employees; another money saver.

Installing the systems won't be cheap. When calculating in short term figures, the profit won't be as high as you would have normally, but this obviously pays out later on.
If companies choose to let their vessels use the monitoring navigator, the vessels concerned won't be making any money when lying in dock. The purchase of these systems will not be cheap either; most of the systems required are state of the art and brand new.

Technical

Advantages

1. The monitoring navigator requires a lot of developing and will lead to more improvements and innovations in the maritime industry.

Disadvantages:

1. The required systems are very complicated; special engineers are needed
2. Transferring all data requires too much bandwidth
3. The lack of an experienced nautical officer in heavy weather

The monitoring navigator consists of a variety of systems. All these systems need to work together, transfer data to each other and can also break down. To make this work improvements and innovations are needed. Especially for the automation discipline in the maritime industry, the Monitoring Navigator can take the technologies onto the next level.

Nowadays companies already are able to deliver state of the art bridge-systems to vessels all around the world. However, these systems are so advanced that the engineers from the companies are flown in to give courses to the crew regarding the system. This is good thing because it is important to know your vessel. But what if the system breaks down? Fixing the installation is something else than using it. When this happens on one of the vessels, and especially on the mother vessel, the crew **must** be capable to repair anything in order to avoid collision(s).

An exchange in data is required to control the other vessels from the mother vessel. This means if you would want to watch all gauges and other data live from the mother vessel, **all data** needs to be streamed constantly to the mother vessel. This is not possible because it would use a lot more bandwidth than available. This means that the data needs to be separated; vital data and data that is important when borders are exceeded. Instead of a live stream of all data, only the vital data should be streamed constantly. Other data, for instance the rolling and pitching of a vessel, is only important they become too severe.
It would be a waste of bandwidth to send these kinds of data on calm seas for example.

In calm seas the autopilot can easily calculate the right course and speed with all the instruments and information available nowadays. Even an experienced officer cannot estimate a better optimum than the autopilot can calculate. There is a lack of an experienced officer as soon as the weather gets heavier; wind directions and the state of the sea vary constantly. This is the time when that experienced officer has its advantage compared to the autopilot. He is the one that is able to move the vessel quickly to calmer seas. This is better for the durability of the hull (deformations) and the installation (load changes on the crankshaft).

Safety

Advantages

1. The influence of the human factor in marine accidents can be lowered.
2. If something **does** happen, help is nearby

Disadvantages

1. If the mother vessel is not under command, the remaining vessels could become unguided projectiles.

An international research has shown that 9 out of 10 accidents that happen at sea are caused by human error or the crew’s negligence. The monitoring navigator is still operated by humans, but assisted by many instruments. For instance, what about infrared camera’s? These cameras are able to see a lot further than the human eye, especially in the dark. So the safety on sea really benefits from the monitoring navigator. The crew’s safety aboard one of the vessels is also increased. Crew can be evacuated easily with help from the other vessels and fires can be extinguished faster and better when more people are able to assist.

If, for any reason the mother vessel would become not under command, then the other vessels could end up being unguided projectiles. Therefore all precautions should be made to avoid any problems with the mother vessel.

Safety

"How is the safety of the vessel guaranteed?"

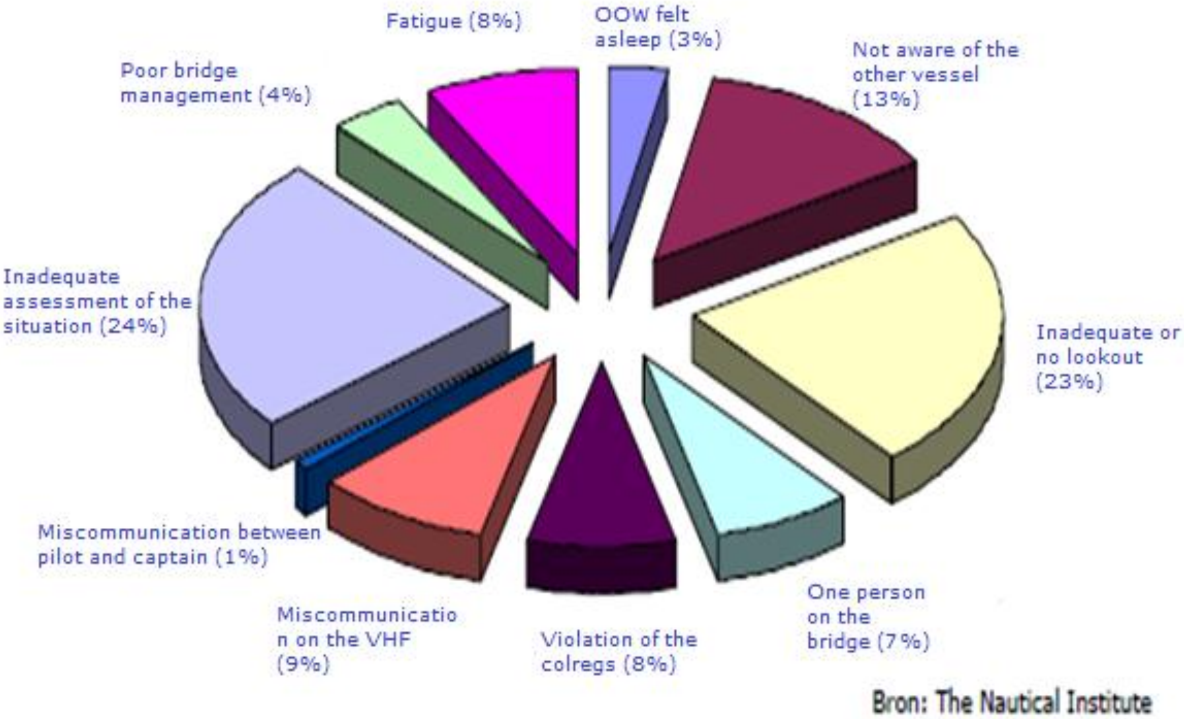
Since the beginning of the shipping industry, safety has always been an important factor. Especially in recent decades safety has been considered as an important factor. Several systems have been developed to insure the safety for crew and cargo. This development is not over yet. This sub question contains the safety aspect and in what way it is guaranteed.

The sub question is divided into parts. The first part will consists of the safety before introducing the unmanned bridge. The second part consists the safety after introducing the unmanned bridge.

Today

"Safety before introducing the unmanned bridge."

The Nautical Institute
A rapport of the International Union of Marine Insurance (IUMI) shows that the amount of vessels that has lost decreased during the last 2 decades. Expressed in % of the total world fleet there is a reduction of 0,45% in 1994 to 0,15% in 2007.
The Nautical Institute has studied the causes of collisions and running a ground of the past 10 years. The main cause is human factors, which is 60 percent. The remaining 40 percent are mechanical shortcomings. 24 percent of the human factors were related to inadequate assessments of the situation. 23 percent to inadequate lookout. The most important cause is in 13 percent of the cases, that the officers of the watch are not aware of the other vessel up to (or just before) the moment of collision. Other causes were confusion in the VHF communication, violations of the Colregs, fatigue of the OOW, poor bridge management and miscommunication between pilot and the captain.



Currently used systems
Systems to guarantee safety on board of vessels nowadays are:
- Global Maritime Distress and Safety System (GMDSS)
- Emergency Position-Indicating Radio Beacon (EPIRB)
- NAVTEX
- Inmarsat
- High Frequency (HF) radiotelephone and radiotelex (narrow-band direct printing) Equipment, with calls initiated by digital selective calling (DSC).
- Search and Rescue Radar Transponders (SART)
- VHF

Future

"The safety after introducing the unmanned bridge."

Intermediate stages
Before there can be sailed unmanned there should be taken intermediate stages.
Like sailing in convoy or from the shore.

Rules and regulations
We have not looked at the rules and regulations, because a lot must be added/edited to sail unmanned. The Royal Navy has less strict regulations as commercial vessels. Therefore there will be experimented with them.

Distance between vessels
In order to guarantee safety for vessels there must be at a respectable distance between them. When an accident occurs, action must be taken to prevent damage. Increasing the distance between the vessels should reduce the chance of collision. The place on earth is crucial for the distance. When the convoy is sailing at the Atlantic Ocean distance can be increased. A distance of 2 nautical miles should be enough. When the convoy is sailing at the North Sea distance should be decreased to 0,5 nautical miles. In the future this can be done closer.

New traffic lane
Also an own vessel traffic lane can be added. This new traffic lane can be positioned alongside the existing, so vessels sailing in convoy do not disturb other vessels.

Ports
Just before entering port the convoy sailing in 'in-line', then a team of pilots come on board of the vessels and do their job. It is also possible to use DP, speed and course can be measured very accurate.

Piracy
An additional advantage for safety is less piracy. There will be less crew on board of the vessels. In the future this will be completely unmanned so lives are saved.

Systems
The most important factor of sailing unmanned are the systems that need to added/edited. Sub question 2 has explained all those systems. Below a list of these systems.

- The BATS Communication system
A system to transmit data from vessel to vessel.

- The camera infrared system
The watching eye of the vessel, it suspects objects.

- Unmanned sea navigation system from Samsung Heavy Industries
This system is for a date communication through internet.

- Wärtsilä's fully integrated vessel control system
Several separate systems in one system for command and control.

- Preventing collisions using the radar with ARPA, AIS and ECDIS
For the plotting, identification and electronic chart.

- Kongsberg's DP and DARPS systems
Dynamic positioning to hold the vessel on a given position. DARPS is a system that is used to get reliable and accurate absolute and relative positioning.

- The connection between the systems
To connect al systems above there must be a communication network, we use the LAN network.

Problems

"What problems will be encountered with a monitoring navigator and what are they possible solutions?"

Some of the problems have been partly explained in other chapters. This chapter therefore provides a good overview of the problems and their solutions as it gives an idea where we stand with the development.

As ship operators are searching for reducing cost by reducing the number of people on board they have to deal with a number of problems. As with all new developments there are also a number of problems with 'The Navigator monitoring'. During this study, we have not looked at the role of engineers aboard the vessels. Only problems related to the navigation of a convoy mentioned as 'The Navigator monitoring' are listed in this chapter.

Problems of the past

Japan

In the mid-90's the Japanese tried to build an unmanned vessel. The 10,000-dwt merchant vessel was navigating without any problems through a 20-miles wide street between southwestern Japan and South Korea. The voyage was planned and fully executed by onboard computers. The marine technologist executing this project wanted to see whether it was possible to sail unmanned.

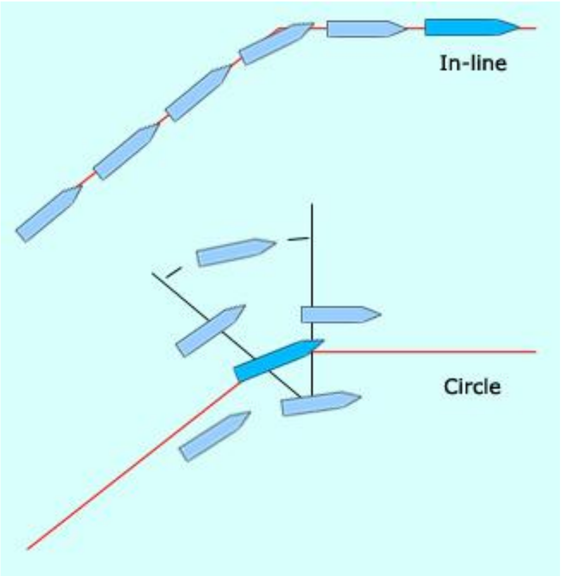
They failed this research because they could not find solutions on the problems they had to encounter with. These days the technology a step further and we have more advanced systems available.

Problems

The monitoring navigator will sail with state of the art technology. Most of these technologies are already in use in the offshore sector. The systems are tested and approved by the classification societies. They have not been used in combination of each other; together they will form the basic of 'The Monitoring Navigator'.

Ensuring the safety between the monitored vessels

Where vessels sail close to each other is a risk of danger. In chapter 1 have explained that we have come with two types of convoys, a convoy of vessels in a line and a circular convoy. Both types have their advantages and disadvantages. Looking at the safety, the convoy of vessels in a line is preferred. If the vessels follow each other in line, they will turn in the same position. In a circular convoy vessels will turn on different points increasing the risk of collisions, as the turning radius is greater for vessels on the outer borders of the circle.



The addition of a relative positioning system makes it possible for vessels to sail close together. Considering the fact that vessels sail close together the risks are still very small, the vessels will be lined up and follow the vessel ahead. The possible problem herby is the distance between the mother vessel and the last vessel.

Distance between vessels
As mentioned before we sail with a number of vessels close together. But the exact distance of close is not given yet. A good distance depends of a number of factors.
With the relative positioning systems it is possible to sail with a few meters distance. This system will be redundant. In case of a lost connection the onboard computers can be programmed to automatically alter course to starboard. A possible collision will be prevented. The distance needed for this change will be in the order of several hundred meters. For altering course 20º to starboard we will only need 174 meters in accordance to the theory of turning.

Entering ports
Entering ports can be a risky situation, small waterways with risky turns. On this moment a vessel entering a port need to embark a pilot to sail into port. When there is no one on the bridge the pilot has to do this by his own or a team of pilots have to embark to fulfill all the tasks on the bridge.

The vessels in our convoy are equipped with DP so there position can be very will kept.
In theory a pilot is not needed because the vessel can keep course and speed very well using DP. This route can be made in advance, so each vessel can be led to his berth.
But as port authorities make money and ensure safety in their port on pilot services it is not expected to disappear.

System failures
System failures will lead into unwanted situations; systems have to react on things happening and give alarms when needed. So when a system fails another system should take over. Most imported systems will be redundant, such as the relative positioning system and the data connecting systems. If the relative positioning system fails, an automatic course alteration will be made, to avoid collisions with the vessel ahead.
The mother vessel can then decides what to do. We are using the BATS-system as our main data communications system, satellite connections will be our redundant system.

Costs
The purchase costs in the will be higher than sailing with a manned bridge, especially after the introduction of the monitoring navigator. We use state of the art technologies, with are not widely used. However running cost will be lower so it will save money in the lower term. It is simply investments that need to be made to save money on the longer term.

Conclusions

"In what way is the monitoring navigator feasible while maintaining the safety of the vessel, crew, cargo and other vessels at sea?"

During our research we already concluded that the monitoring navigator is feasible technically. The systems are ready for it and the offshore industry proved that these state of the art systems are able to work together; loading and discharging of gas with the accuracy of just a few cm with dynamic positioning. For our idea, sailing with a mother vessel that monitors and controls the surrounding vessels, the main problem lies in costs of the systems. Up to now these systems are mainly used in the offshore because they can afford to make this kind of investments. But, with our application of sailing in convoy, where there are significantly higher amounts transported at the same time with less personnel it should be very profitable.

We see the monitoring navigator as a first step to unmanned shipping. When we are able to transmit more data over larger distances and the worldwide acceptance of unmanned shipping is there, then it is easily feasible to control the vessels from the shore.

Looking at the safety part, we conclude that the safety is increased when sailing in convoy. Help is nearby and when sailing in line there is not much that can go wrong. Only in crowded areas, when other vessels would interfere with the convoy, major problems could arise.

You have to keep in mind that we have not looked to laws and regulations. A lot needs to be added/edited here to make this legal. However, as earlier told it is safe and if rules are edited so that convoys have the highest priority, just like in traffic, then even busy shipping lanes are no problem.

Recommendations

In order to make this all work, both companies and seafarers need to work together. Acceptance inside the shipping community is mandatory, but also the companies need to put in a lot of money for these systems. To breach the taboo of these delicate topics we believe that it should be done, just once to proof that it works, just like the Japanese did 20 years ago. If people do choose to sail in convoy, we highly recommend sailing in line, as described earlier.

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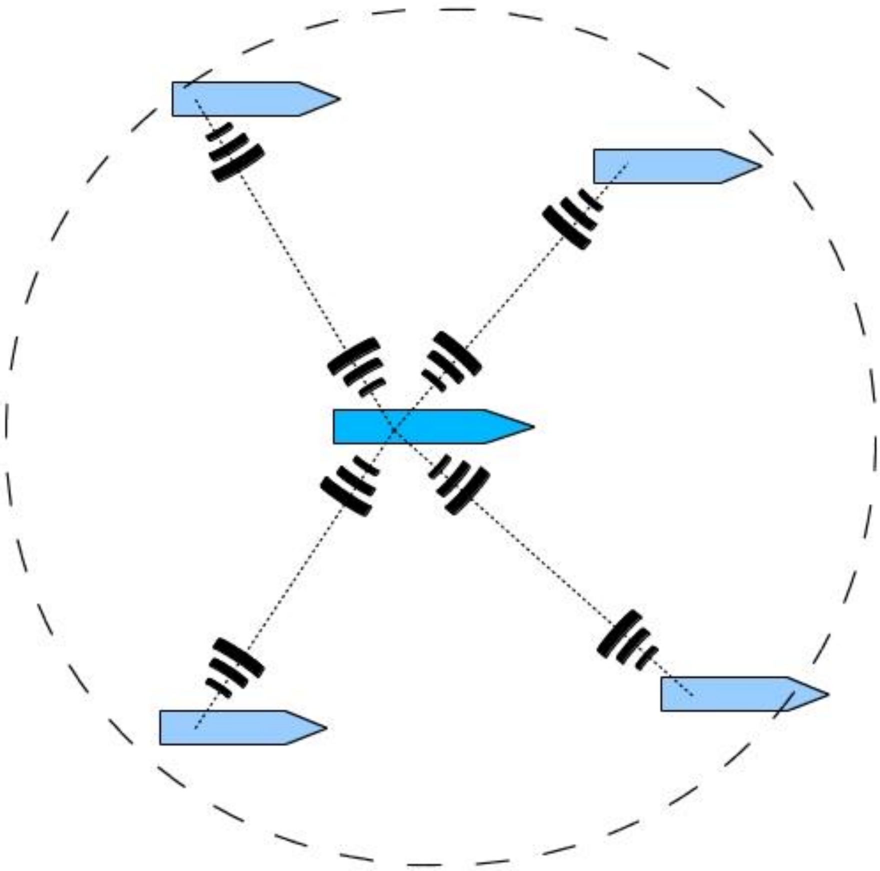
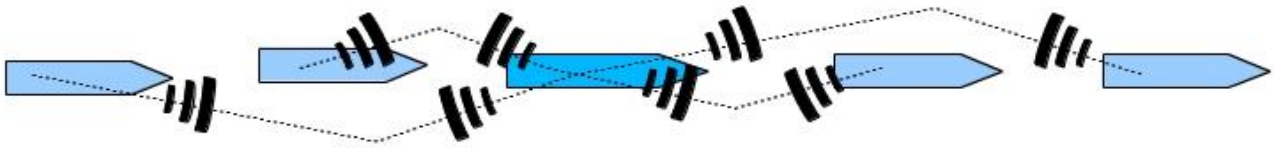
Appendix I – Convoy types

Convoy type 'Circle'



Convoy type 'In-line'



Symbols