Automatic opening/closing of watertight frigate doors

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Synopsis

Recent events have demonstrated that ship collisions are still happening today. This is not an exception for naval ships, indeed it is a problem. Cases of collisions are the USS Fitzgerald, USS McCain and Helge Ingstad; as a result the Helge Ingstad finally sank. These events show us that despite following the class rules for design and engineering the human factor remains crucial. So we have to be aware and take in to account that factor. As researchers of the Helge Ingstad's accident concluded: 'Due to the panic reaction of the crew nearly all watertight doors and hatches were left open'.
This paper opens a new view of watertight integrity into naval vessels. The current affairs and author's work experience led to the idea to prevent incidents like the Helge Ingstad's sinking. This paper explains the need of innovation and addresses the challenges to be faced.

Keywords: Doors; Watertight integrity; Automation; Reduced manning; Shock; Emergency response

1 Introduction: Reduced manning and automation

In order to deal with emergency situations on frigates like a fire, a leakage or navigation in shallow waters. The crew size, their location, awareness of the situation and time are essential. However, there are a couple of trends which makes difficult the first one, specifically to have sufficient crew.

Every ship needs a minimum number of crew in order to sail safely form one place to another. It is not a secret that the navy has been putting its best effort on recruiting more technical staff for the last few years. Not having sufficient staff is one of the reasons why the navy has been putting a lot of effort to let as many systems as possible to work automatically. This will reduce the minimum crew size.

Secondly, another reason to make as many systems as possible automatic, is time. In the sense of response time is essential when it comes to external threats. Weapon systems become more and more advanced, for example hyper sonic rockets. The reaction time for these threats shall be reduced significantly. Automatic systems can therefore aid in these situations because they respond and execute faster than humans.

Despite these efforts, due to the lack of technical staff, the navy had no option but to let 2 ships remain in port during this year. This was an unwanted event, that should not happen again.

However, the use of more electrical and automation systems also increases the probability of electric related fires. Recent events showed us that we cannot fully rely on automatic systems. For this the crew shall need extra training in order to sail the ship safely.

The starting of the war in Ukraine directly caused more applications for military vacancies. However with the current economic situation, all sectors are dealing with shortage of personnel. Therefore, it is not likely that the navy will supplement all its vacancies in the coming years. The navy is left with no choice than to sail its ships with less crew, this trend is called reduced manning.

Nowadays, we see that ship classes, which reach their end of lifetime, are being replaced by larger and more complex ships. To sum up, we can oversee that in the near future larger and more complex ships will be sailed with less crew.

2 Emergency situations

Dealing with emergency situations is not something in which automation can always give a direct solution when it comes to reduced manning. The use of more advanced firefighting systems should give more security in case of a fire. But these situations are not predictable, therefore it is vital that the crew keeps a good situational awareness.

Whether there is a fire, a leakage or any other type of emergency the first step is to prevent the situation from spreading out through the ship. That is why the ships are divided in zones and compartments. At the boundary of these zones watertight or gastight closures are placed. When an emergency occurs it is essential that these closures are closed as soon as possible. But with less crew on a larger ship, this becomes a challenge. We tend to explain the starting situation when an emergency occurs with the following figure.

Author's Biography

Robin López Griñón is a naval engineer at DMO in Utrecht, NL. He has a background in both Industrial and Naval Engineering. Furthermore, he has experience being midshipman in the Royal Dutch Navy. He is involved as a specialist in projects for new ships and works on modifications to maintain the existing fleet operational. Working for the naval authority, writing and updating standards forms part of his work.

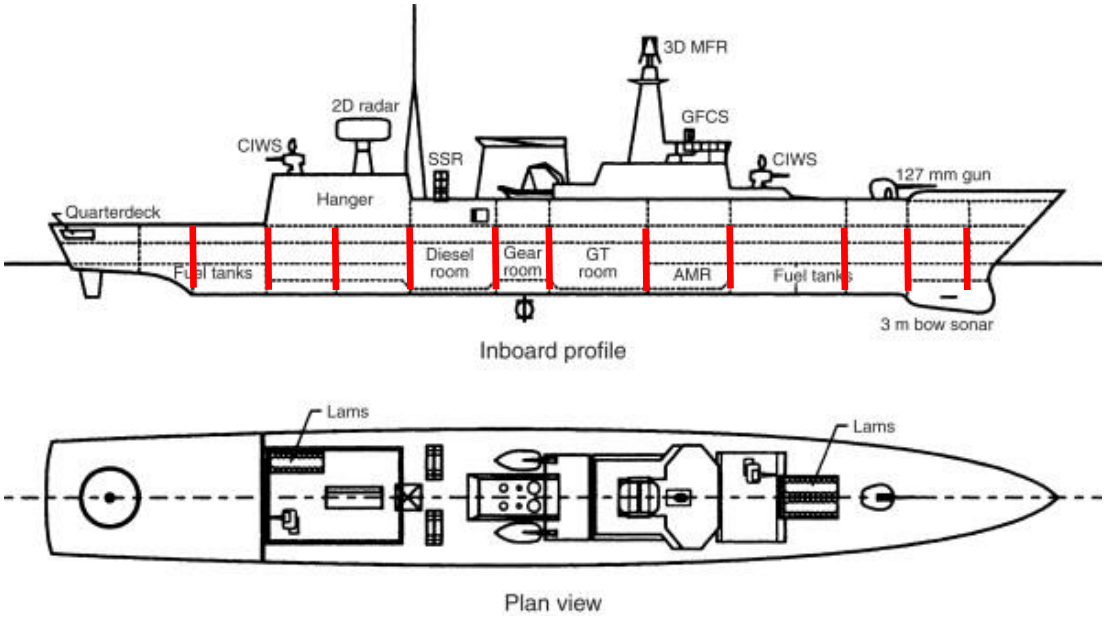

Figure 1 Schematic overview of a frigate.

The deck below the Quarterdeck is considered to be the damage control deck. This means that from this deck it is possible to pass through watertight bulkheads (the red lines) by doors. All lower decks are only reachable by hatches within the watertight section. Considering this, we can conclude that there are about 10 to 11 watertight bulkheads, and for each section at least 2 hatches to reach the lower decks. A rough estimation gives us at least 30 closures. These closures need to be closed manually by the crew in case of an emergency.

The closing time is depending on the distribution and the number of crew. Taking in account that closing each section takes 2 minutes if the distribution of crew is spread out through the ship in time of an emergency. This will mean that 11 crew members are not available to respond to an emergency for 2 to 5 minutes. But if the distribution of the crew is not spread out but concentrated or if there is not enough crew available due to the operation or night-time, this will obviously take longer.

3 Why has this not been invented before?

Watertight doors on board frigates are based on the same design principles for more than 30 years. The basic designs of gas tight, water tight or blast doors are the same. It is based on a door with a rubber inlet to provide a seal which closes completely the door. The door frame has a coming in which the rubber inlet will be pressured. The design has a heavy closing mechanism to reach an equal pressure around the whole coming.

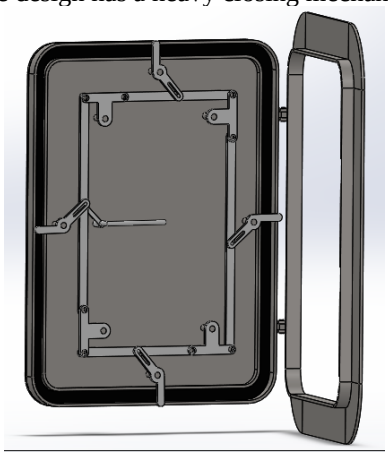

Figure 2: 3D model of a watertight door

The reason because this design has not changed is mostly due to the underwater shock requirements. Doors and hatches need to remain in place during an underwater shock event. Preferably after the event they can still be

opened and closed. Doors and hatches which are used on civil vessel cannot be used on board frigates. During a shock event, these doors will not remain in place and can cause leakage between watertight bulkheads.

Doors, which are placed on lower decks, experience a higher requirement of water pressure and they have also to endure a heavier shock load. The heavier the door is, the heavier the closing mechanism has to be. The consequence is that doors are heavier on frigates than the doors on civil vessels, even though both doors have the same purpose.

If the defence department does not express their needs, the industry cannot develop new equipment. In the international shipbuilding industry, the market of naval vessels is considered small. Therefore, development and research for new equipment have to be financially supported by the ministry of defence. In other words, the industry will not be easily triggered to develop new equipment for naval vessels without cooperation of the defence department.

4 What does this innovation intends to do?

This innovation intends to open and close doors fully automatic. We experience this when entering stores or shops. There is no local push or control button, everything works automatically. Doors like these can even detect if a person is approaching the door, but it will not open for a cat or dog. However these systems are only purposed to work with one door, there is no central box that connects all doors to one button or system. The idea of this innovation is to integrate an automatic closing and opening system to a frigate door, and to integrate the controls with the ships platform management system. The following schematic overview will help to explain the purpose.

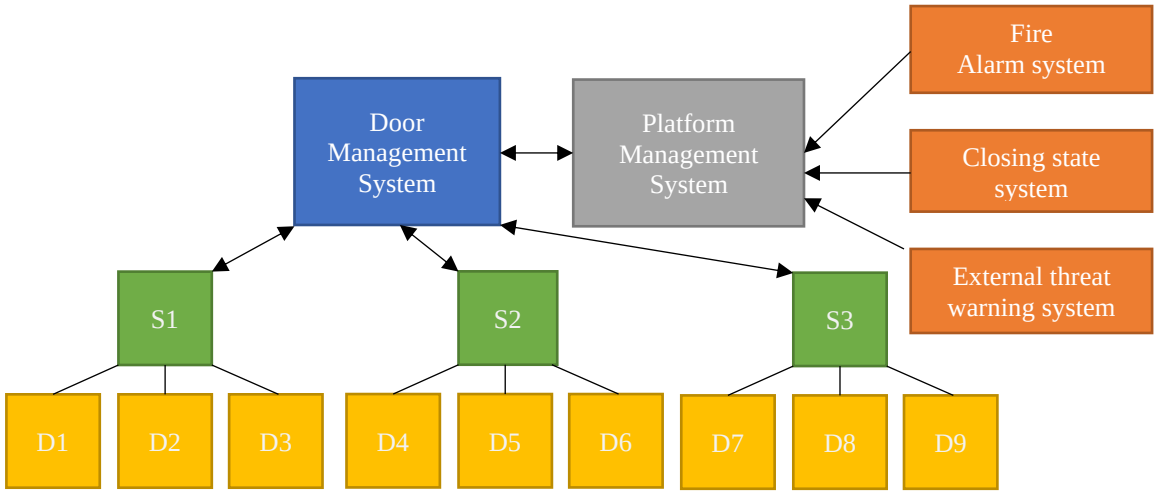

Figure 3: schematic overview of the integration

The gray box represent the Platform Management System(PMS) and the orange boxes systems which give input to the PMS. Nowadays these are existing systems used on frigates. The green boxes represent different watertight sections, S1, S2 and S3 with their own control box. Each section has a number of doors and hatches connected to the control box(the yellow boxes).

For example when the fire alarm system send a warning to the PMS, the PMS can give an order to the door management system to close all doors in the relevant section. When the doors are closed, the PMS receives a confirmation. This process can take place within half a minute. To compare the time and effort to perform this action by the crew, this system will aid the crew significantly when it comes to damage control actions.

Another action which can be integrated is the use of the X,Y and Z closing states. The officer of the watch can order a specific closing state due to the conditions where the ship is sailing in. For example in narrow or shallow waters. The closing state can be directly executed because of the connection with the PMS. There will be no check necessary by the crew. Also the system can maintain the closing state, for example after passage of crew the door will be closed again, This can sometimes be forgotten without the system.

5 Benefits and additional flexibility of automatic doors

Taking in account the previous paragraphs, this innovation intends to resolve two major issues. The first is time, it will be possible to close directly all doors and hatches with a push on the button. This pushing movement will achieve a separation of watertight and fire zones immediately.

The second is human availability, the crew will be directly available for participating in the emergency response. In the old situation, the crew was needed to close and check all the necessary doors and hatches. This

would mean that during several minutes a couple of crew members shall be appointed with this task. Thanks to the automatic closing of the doors, these crew members will be directly available for emergency response.

5.1 AI possibilities in emergency response

The EIB (electronic Incident Board) is a digital representation of the paper version. In future frigates, it will be possible that the EIB could give an advice based on all the data that is coming from different systems. For example, the smart rooms, the fire control panel and cameras. Based on all this data, the EIB will be able to give an advice for emergency response like a smoke extraction plan, or to recommend the doors closing to keep the watertight integrity. Having the possibility to close doors and hatches automatically, the operator of the EIB could accept and directly execute the advice given by the EIB. This can make the emergency response less independent of crew training or human interpretation.

5.2 Easier transport trough the ship

For transporting goods, one hand needs to remain free in order to open and close the doors. When automatic doors are installed, the crew can pass through these doors basically hands-free. This will make easier to transport goods through the ship, especially for light objects with large dimensions.

5.3 Predictive maintenance

Data stored by the door management system can be used to predict maintenance. For example, the force, which is required to close the door, can give an indication whether maintenance or lubrication is necessary. Or for instance, the number of openings and closings could be an indicator for maintenance.

5.4 Less injuries

Watertight doors have a bad reputation when it comes to causing injuries. Closing and opening of the doors sometimes do not go smooth and it requires an extra effort. They can cause also bruises when limbs get stuck between the closing mechanism or the levers.

If the doors can open and close automatically, the crew could pass handsfree and that shall prevent injuries.

6 Overcoming the challenges

This innovation has a lot of benefits to offer, but there are challenges to overcome. Before a system can be placed on board a naval vessel. First the system needs to be certificated.

Integration with IT systems is a challenge. The system needs to be used on a frigate, and therefore be durable and resilient.

6.1 Modes of operation

Shell hatches, container hatches or hangar doors are able to close and open fully automatic. This is due to their size and they are locally controlled by hydraulics or electric motors. However, the use of hydraulics would be too powerful for normal doors. Where normal ship doors have a higher frequency of closing and opening, hydraulics would operate too slow for this application. Pneumatics or spring based applications would be more suitable for this innovation.

Adding pneumatic cylinders to the doors and to the opening mechanism should not be a challenge. The challenge lies on the connection between several door sensors and programming the desired door's behaviour.

There have to be programmed different modes of operation. It is also vital that the door can still function manually when there is no electrical power or if the sensors or mechanism have been damaged. Based on the applicable closing state, external threats and damage control situation, a certain behaviour can be desired of the systems, this should be programmed partly in the door management system. However, these situations cannot always be predictable, the use of AI can give a handout in quick decision making.

6.2 User experience

The experience of the user is very important in this innovation, even it is critical for the success of the innovation itself. Doors and hatches are constantly opened and closed on board a frigate, which means that the user should be satisfied. The innovation has to give a better experience to the user, in comparison with the old process. Otherwise, the innovation does not have sense.

For example, if it takes more time to pass through a door or hatch than without the automatic opening systems, it is likely the crew would prefer the old situation than the innovation. The best way to achieve feedback of the

user is to set up 2 doors next to each other, one original and one with the automatic system. Then, the user could choose which is the best option.

6.3 Manual override

All these systems are based on the availability of electric current. However, it is likely that a frigate sometimes experiences a failure of power. Then, the doors need to be operated manually. To maintain the original function of the door, as a backup, will make the system more resilient.

6.4 Integration in ships management systems

As it has been mentioned earlier, the door behaviour needs to be integrated into the ships management system. There are some examples like the EIB or the PMS (Platform management System). It is preferable that the automatic doors are integrated in the ships systems rather than making a stand-alone system.

6.5 Universal refit system

Unfortunately for this innovation watertight or gastight doors cannot be produced in standard measurements. Each costumer and ship have its own requirements when it comes to width, height and clear passing space of a door. It is expected that navies would like to install this innovation on vessels in service. Therefore it would be wise to develop this system in a way that its suitable for each type of door. In that way it can be placed on existing and new ships.

6.6 Commercial production

Once this innovation has been already tested, it is important that a commercial party is able to produce the product. The navy could be the launching customer of the product. It would be wise to involve a commercial party in the process, even better from the starting point. This will help to develop a product which can be produced and is affordable for navies worldwide.

7 Conclusions

Despite all the benefits, automatic watertight doors for frigates have not been developed. Looking at the trends, it is rather a matter of time before navies express their need for this innovation. Preferably the developing of this innovation must start now, rather than after another major accident, like the sinking of the Helge Ingstad. All the secondary benefits should be enough to get available funds for further research.

Although there are still some challenges to take in the development of this innovation, these challenges are possible to overcome.

To conclude, this innovation will take place sooner or later. However, it is preferably to be done by the department of defence in collaboration with commercial companies.

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