Antwerp Maritime Academy

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Use of electronic logbooks: knowledge and interest assessment on Belgian dredging vessels

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Foreword

This subject was chosen because of my combined interest for the dredging sector and innovative technologies. The process of operating a ship has been continuously changing with the arrival of digital technologies and automation on board. To me it seemed evident, that the electronic logbook would one day replace the traditional paper logbook but very little research has been done on the subject. While shedding light on the use of electronic record keeping on board, this research taught me a lot about the dredging sector.

I want to thank everybody who has been involved with the realization of this thesis.
My promotor, Klaas De Hert, for his guidance and patience. For taking the time to help me navigate through the research and writing process.
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The 252 respondents who took the time to answer the survey
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Abstract

Due to extensive regulations and company requirements, officers sailing on dredging vessels spend a significant amount of time on administrative workload. Logbooks such as the deck logbook, the MARPOL record books and cargo record books have traditionally been kept up to date in a paper book. However, with the increase use of digital technologies and automation in the maritime sector, the IMO has recently allowed the use of electronic record keeping for MARPOL logbooks. The electronic logbook software (ELB) has the capability to make the logging process more efficient and less time consuming by centralizing all records into one system and by logging entries automatically. This research will try to assess the relevance of the ELB software implementation on board Belgian dredging vessels by conducting a literature review to understand the benefits and limits of the ELB system for merchant vessels. For the second part, a survey was sent out to seafarers sailing on Belgian vessels in order to assess their knowledge and interest for such a system. The third part focuses on implementation on board Belgian dredging vessels by conducting interviews with maritime professionals. Although, there is little knowledge about the existence of the ELB, both operators and executive staffs appreciate the functionalities the ELB would bring to record keeping and show great interest to work with it on board. It could indeed, reduce the workload of officers if implemented correctly. However, at the moment some challenges still limit its implementation. It is still unclear which port state control inspectors will accept this method of record keeping and the Belgian flag state still has to approve its use under its flag.

Résumé

En raison des nombreuses réglementations et des exigences des compagnies maritime, les officiers naviguant sur les navires de dragage consacrent beaucoup de temps aux tâches administratives. Les journaux de bord tels que le journal de pont, les registres MARPOL et les registres de cargaison sont traditionnellement tenus à jour dans un livre papier. Cependant, avec l'utilisation croissante des technologies numériques et de l'automatisation dans le secteur maritime, l'OMI a récemment autorisé l'utilisation de la tenue électronique des journaux de bord MARPOL. Le logiciel de journal de bord électronique (ELB) a la capacité de rendre le processus d'enregistrement plus efficace et moins long en centralisant tous les enregistrements dans un seul système et en enregistrant les entrées automatiquement. Cette recherche tentera d'évaluer la pertinence de l'implémentation du logiciel ELB à bord des navires de dragage belges en effectuant une revue de littérature pour comprendre les avantages et les limites du système ELB pour les navires marchands. Pour la deuxième partie, une enquête a été envoyée aux marins naviguant sur les navires belges afin d'évaluer leurs connaissances et leur intérêt pour un tel système. La troisième partie se concentre sur la mise en œuvre à bord des navires de dragage belges en menant des entretiens avec des professionnels du milieu. Bien que l'existence de l'ELB soit peu connue, les opérateurs et le personnel exécutif apprécient les fonctionnalités que l'ELB apporterait à la tenue des registres et montrent un grand intérêt à travailler avec ce system à bord. S'il est correctement mis en œuvre, il pourrait en effet réduire la charge de travail des officiers. Cependant, à l'heure actuelle, certains défis limitent encore sa mise en œuvre. On ne sait toujours pas quels inspecteurs des control portuaires accepteront cette méthode de tenue des registres et le pavillon belge doit encore approuver son utilisation pour ses navires.

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Introduction

Logging records has always been part of a ship's daily operation. While in the past most records were related to navigation and were written in the deck logbook in order to have an archive of the ship's whereabouts; nowadays, officers sailing on merchant vessels have numerous recording requirements regarding drills, trainings, tests or inspections; serving as a useful piece of evidence to settle maritime claims in case of accident[1]. While shipping companies impose extensive records of actions related to cargo operation, the extensive international regulation surrounding the shipping sector also brought more recording requirements for officers. For instance, the Safety of life at sea convention (SOLAS) brought requirements for recording events related to navigation and safety. The International Convention for the Prevention of Pollution from Ships (MARPOL) brought record requirement to manage pollution coming from ships. Traditionally, most records are kept in paper format, having a different record book depending on the information recorded. The most common ones being the deck logbook for events related to navigation, the GMDSS (Global maritime distress and safety systems) logbook for events related to communication tools, cargo record book for events related to cargo operation as well as MARPOL logbooks for recording pollution emissions coming from different sources. However, since the beginning of the 21st century, with the arrival of powerful computers on board, the maritime sector as a whole has become increasingly digitized, incorporating digital solutions in lieu of traditional analogue methods. Maritime paper charts have almost entirely been replaced by electronic navigational charts (ENCs), lengthy stability calculations are done through a computer program and GPS positioning replaced celestial reckoning. The introduction of such technologies has a direct effect on the workflow of officers on board by simplifying some processes. Taking the example of the ECDIS (Electronic chart display and information system), while in the past, paper charts required regular manual corrections from officers in order to be kept up to date, nowadays, updates are done in a matter of minutes by importing the corrections directly to the ECDIS database. When looking at record keeping, a change in the MARPOL regulation has recently allowed MAPROL logbooks to be recorded digitally[2]. This new regulation has opened new perspective in terms of improving the efficiency of the record keeping process on board.

[1] Douglas L. Stein, *American maritime documents, 1776-1860, illustrated and described*.
[2] IMO RESOLUTION MEPC.312, « GUIDELINES FOR THE USE OF ELECTRONIC RECORD BOOKS UNDER MARPOL ».

As nowadays much data required to fill record books come from computer screens, the question arises if it makes sense to keep recording it manually. Having a digital record system could have many advantages over paper. Centralizing all record requirements into one system, logging entries automatically and allowing to easily search previously recorded entries could save time for officers and make the ship operation more efficient[3]. Furthermore, while in the past records were mostly kept as a proof of compliance with regulations, electronic record keeping could bring more advance uses of a ship's records by connecting the system to the internet. This allows real time monitoring of all entries so the gathered data could be used to increase ship efficiency through trend analysis. The recent change in regulation, allowing the use of electronic record keeping for records associated with MARPOL is the opportunity to understand if an electronic logbook system (ELB) could viably be implemented on board.

In 2019 the dredging sector represented 18% of the Belgian fleet in Gross Tonnage (GT)[4]. This maritime sector is very competitive in terms of innovation and technologies due to the limited number of companies sharing the market and the level of complexity of the projects. Therefore, dredging companies have to stand out through ship features, design and system integration, meaning that different components form different manufactures are aligned with each other to create a more optimal design, in order to get a competitive edge[5]. Furthermore, unlike conventional merchant ships sailing from point A to B to transport cargo, a dredging vessel will often sail around a same site for months in order to complete a project thus having very different recording requirement. The ELB, being an innovative solution to improve system integration on board, could certainly interest dredging companies that are trying to become more competitive.

Software has already been developed for this specific purpose by well-known maritime software developers but Belgian dredging companies have yet to consider implementing it on board.

The MEPC (Marine environment protection committee) responsible for the MARPOL circular, allowing the use of MARPOL electronic logbooks on board, stipulate that in order to be installed on board, the ELB software must be approved by the flag state or a recognized organization. However, no statement has been issued by the Belgian flag administration concerning ELB yet. Port state authorities who are responsible for inspecting the ship's records also have to accept its use. Furthermore, no research has been conducted to assess its possible

[3] *NAPA logbook (website)*.
[4] Royal Belgian Shipowner's association, *Economic impact study Belgian shipping cluster*.
[5] Murat Tarakci et Jan van de Ende, *The Dutch and Belgian Dredging Industry An Exploration of the Future*.

implementation on board merchant vessels. According to DNV GL, a prominent classification society: "*Electronic logbook (ELB) is supporting a broader goal of more effective ship operation, and DNV GL recommends that shipowners and operators use this option. However, until ELBs have reached full acceptance in the industry, and - in particular - towards the Port States, we recommend doing an individual assessment to ensure, for example, that the relevant Port States accept MARPOL ELBs".* While the ELB system holds promising functionalities in terms of efficiency gains, it is critical to determine if its implementation would result in a positive impact on the ship's operation as a whole. This research aims at determining practicality of the ELB system for companies and assess knowledge and interest of Belgian dredging companies for the ELB system. In order to understand if such system has a relevance on board, the first part of this research will gather information from maritime software developers to determine the components, functionalities and potential uses of the ELB software in order to analyze its potential threats and limitations, strengths and future opportunities. The second part of this research will gather the opinion of seafarers responsible for record keeping, sailing on Belgian flagged vessels. An online survey has been developed to assess their prior knowledge, determine their opinion towards the main functionalities and assess their interest for the implementation of the ELB system on board. The last part will focus on discussing the possible implementation on board dredging vessel of Belgian companies. Interviews have been conducted with maritime professionals, both seafarers and shore personnel to assess which problematic the ELB system could solve, by examining the relationship between administrative workload and record keeping. In order to understand their needs in terms of functionalities, equipment and training, comparisons will be made with similar pre-existing digital systems that are currently being used on board.

Part 1 – Overview of electronic record book usage on board merchant ships

1.1 History of the early logbook.

A ship logbook is a register where events, states or conditions of a system are recorded. The term originates from the word log which was used to describe one of the earliest methods developed around 1600 to determine ship's speed. It consisted of a pie shaped piece of wood fitted with a lead weight on its curved part. The log was tossed overboard and remained more or less stationary while an attached line, marked with equally spaced knots, was let out behind. As the ship sailed forward, the line would unroll. To calculate the speed, of the ship, mariners had to simply divide the length of the unrolled line by the time interval[6]. The speed was measured at regular interval and then recorded in the logbook. With the inventions of different navigation instruments, new information such as time, course and position got recorded in the ship's logbook. The invention of the marine chronometer in 1761[7] made it possible to calculate the longitude, allowing mariners to obtain a precise position that was also recorded in the logbook. Besides the obvious purpose of keeping track of the ship's movement and position, the logbook was the surest way to keep a record of what was happening on and around the ship. Sea state, atmospheric pressure and sky coverage were recorded, which in turn became an interesting source of data for climatologist studying meteorological phenomenon of the open sea. At that time, ship logs were the only source of information providing records on these phenomena[8]. Furthermore, in the early 18th century, as marine insurance started to develop, the logbook became essential evidence to settle maritime claims. Both insurance companies and judicial courts used this document[9]. The logbook was also commonly used by the navy in naval warfare, as it was the only source of reliable information before the invention of other communication means. Nowadays record keeping standards have substantially evolved to cover not only navigation but all departments of a ship's operation.

Around the 18th century, the standardized navigational records of ships where quite similar to the present ones. The book *A Complete Epitome of Practical Navigation* by J.W. Norie[10], includes a sample from the records of the ship Britania on the 25th of June 1835 (Figure 1).

[6] Allen Mordica, « The Speed Log --History, Construction and Use ».
[7] Dava Sobel, *Longitude*.
[8] Teresa Carey, « Ship's logbooks are the first records of climate change data ».
[9] Stein, *American maritime documents, 1776-1860, illustrated and described.*
[10] John WIlliam Norie, *A Complete Epitome of Practical Navigation.*

SHIP BRITANNIA from ENGLAND towards MADEIRA.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks, Thursday, June 25, 1835.
1	7	4	S. W.	S. S. E.		First part a fresh breeze; middle and latter more moderate, and smooth water.
2	7					
3	7					
4	7					
5	6	6				
6	6					
7	6					At 7h. 14m. P. M. the sun set W. 46° 23′ N. by compass, which gives the variation 16° 53′ W. or 1¼ point.
8	5					
9	5		W. S. W.	South.	½	
10	5					
11	5					At 10h. 6m. P.M. the mer. alt. ✱ Antares, or α Scorpii, was 28° 5′ S., making the latitude 35° 57′ N.
12	4	6	S. E. by E.	S. by W.	1	
1	4	6				
2	5					
3	4	4				
4	4					At 9h. A. M. observed as follows:—
5	4					Times by Chron. Obs. alt. Sun's L.L.
6	3		West.	S. S. W.	1¼	21h. 58m. 46s. 48° 10′ 45″
7	3					22 0 8 21 15
8	3					22 1 34 31 50
9	3	6				which give the long. at noon 16° 20′ W.
10	3	2				
11	3					Obs. mer. alt. ☉'s L. L. 77° 28′ 10″ S. gives the lat. at noon 35° 45′ 51″ N.
12	3					

Course.	Dist.	Diff. lat.	Dep.	Latitude N. Acc.	Latitude N. Obs.	Diff. long.	Longitude W. Acc.	Longitude W. Obs.	Bearing and Distance at noon.
S. 29° W.	65′	57′ S.	32′ W.	35° 53′	35° 46′	44′ W.	16° 53′	☽ 16° 12′ Chr. 16 20	Porto Santo S. 2° W. 163m.

Figure 1 Method of keeping a journal at sea

(Source: Norie's book.[11])

Column H represents the time, given in a 12-hour format. The ship's speed expressed in knots is given under the K column. The F column represents the depth in fathoms. The route and wind directions are given in names of direction instead of the modern 360-degree scale. Observation of the meteorological data was noted in the "remarks" column. Position obtained by latitude and longitude was calculated using 2 different methods. The acronym "Obs." refers to the position obtained by observation of celestial bodies. It is compared with the acronym "Accr": position obtained by mathematical calculation derived from dead reckoning. A modern deck log book (Figure 2), has the same core information but has significantly more details. For example, the section dedicated to meteorological data contains: barometric pressure, water and air temperature relative humidity, wind direction and force and sea scale. One should also note that the "remark" section is significantly larger and signature of the officer of the watch is required for each hour. This will be discussed in more detail in the next chapter.

[11] Ibid.

Official Log Book of M/V

Day and Date ……..

1 Time	2 Baro-meter	4 Temperature Air °C	Sea °C	5 Relative humidity%	6 7 Wind Direction Force		8 Sea Scale	9 True Course	10 Gyro compass readings	11 Gyro compass error	12 Magnetic Compass reading	13 Magnetic compass error	14 Log reading N.M	15 Distance made good N.M

NOON REPORT

Noon Position latitude = Longitude λ = Time at Sea d h min + time river/port passage d h min

Day´s run = h min nm Day´s average speed kn Total distance: nm + distance river to berth nm

Clock setting = h min Total time difference h min Distance left nm Voyage Ø speed kn

Fuel - Diesel consumption: t: t: Fuel – Diesel balance: t: t:

Voyage No. from towards

Look Out	17 Nautical remarks and entries according to national- and international rules and regulations; measures taken in the interest of sea-worthiness; safety of life at sea; care of cargo, safety of the vessel and environmental protection	18 Signature Officer Watch	19 Soundings of bilges/empty tanks at _____ Hrs Compt.	Port	Stbd

Check of:

Synchronize/clocks: Fresh water consumption t; Fresh water balance t;

Ballast water t;

Emergency battery :

To be signed and stamp daily

Staff Captain or Chief Mate Master

…… ……

Figure 2 A modern deck log book issued by Cyprus[12]

[12] Council of Ministers of the merchant shipping, « OFFICIAL LOG BOOKS, SHIP' S ARTICLES AND SIX – MONTH LISTS ».

1.3 Legislation on record keeping

The immense growth of maritime trade in the 21st century and the development of new technologies accelerated the elaboration of a common international regulating framework. With the introduction of the 1890 York Antwerp rules[13], setting out the rights and responsibilities of parties involved in general average, (when cargo has to be sacrificed to save lives and/or ship) the logbook became a legally binding document constituting the only archive of the ship in case of peril at sea. In present days, requirements for record keeping on board are not only related to navigation or meteorological event. The international regulation has also introduced compulsory entries for drills and training, test and inspection, port operation and extraordinary events. Furthermore, the development of new technologies and growing environmental laws introduced more data to be recorded. While in the past, records were all made in a single log book, nowadays there are records concerning various areas of operation and management. The following logbooks are commonly found on board:

- Deck log book, for all navigational and meteorological events
- Bell book for recording the ship's movement more precisely when entering or leaving port.
- MARPOL record books
- Global maritime distress and safety systems (GMDSS) record book
- Cargo record book
- Engine record book

All these records are made mandatory onboard merchant ships. In order to understand the extent of record keeping requirement, a small fraction of the related regulation has been collected and listed under.

[13] *York Antwerp Rules 1890.*

Safety Of Life At Sea Convention (SOLAS)

Chapter 5 regulation 28 - Records of navigational activities:

"All ships engaged on international voyages shall keep on board a record of navigational activities and incidents which are of importance to safety of navigation and which must contain sufficient detail to restore a complete record of the voyage, taking into account the recommendations adopted by the Organization. When such information is not maintained in the ship's log book, it shall be maintained in another form approved by the Administration."

Chapter 3 regulation 20 - operational readiness, maintenance and inspection of life saving appliances

20.5 record of weekly inspections and 20.6 record of monthly inspections.

Chapter 4 regulation 17 – Radio records

"A record shall be kept in a radio log book or in the ship's log book, to the satisfaction of the Administration and as required by the Radio Regulations, of all incidents connected with the radiocommunication service which appear to be of importance to safety of life at sea."

MARPOL

Annex I- Regulations for the Prevention of Pollution by Oil

Regulation 17 - Oil Record Book, Part I (Machinery space operations)

"17.1 Every oil tanker of 150 gross tonnage and above and every ship of 400 gross tonnage and above other than an oil tanker shall be provided with an Oil Record Book Part I (Machinery space operations)."

Regulation 36 - Oil Record Book, Part II - Cargo/ballast operations

"36.1 Every oil tanker of 150 gross tonnage and above shall be provided with an Oil Record Book Part II (Cargo/Ballast Operations). The Oil Record Book Part II, whether as a part of the ship's official log-book or otherwise, shall be in the form specified in appendix III to this Annex."

Annex II- Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk

Regulation 15 - Cargo Record book

"15.1 Every ship to which this Annex applies shall be provided with a Cargo Record Book."

Annex V- Regulations for the Prevention of Pollution by Garbage from Ships

Regulation 9 - Placards, garbage management plans and garbage record-keeping

"9.1.3 Every ship of 400 gross tonnage and above and every ship which is certified to carry 15 persons or more engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to the Convention and every fixed and floating platform engaged in exploration and exploitation of the sea-bed shall be provided with a Garbage Record Book. The Garbage Record Book, whether as a part of the ship's official log-book or otherwise, shall be in the form specified in the appendix to this Annex;"

International Labor Organization (ILO)

C001 – Hours of work convention – Article 8c

"In order to facilitate the enforcement of the provisions of this Convention, every employer shall be required to keep a record in the form prescribed by law or regulation in each country of all additional hours worked in pursuance of Articles 3 and 6 of this Convention."

National and company regulations

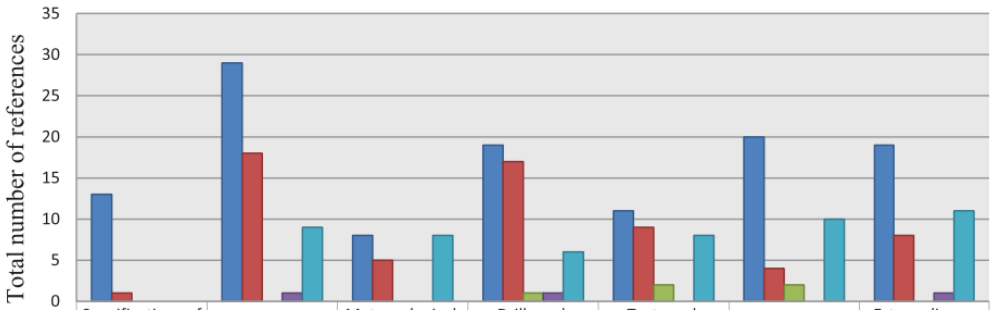
The flag state of a merchant vessel is the jurisdiction under whose laws the vessel is registered. In other words, it is the nationality of the vessel. In accordance with the United Nation's Convention For The Law Of The Sea (UNCLOS), flag states have the duty to enforce ratified international regulations adopted by the International Maritime Organization (IMO). Even though, the IMO has made great efforts to standardize maritime trade, flag states have the right to adopt more stringent rules than the base regulation. In case of the deck logbook, SOLAS mandates to keep record of wind direction, wind force, sea state, sky state and visibility. Major flag states however, also require their ships to record atmospheric pressure, air temperature and relative humidity.[14]. Finally, due to the variety of ships in the maritime sectors, operational record requirements vary greatly depending on ship type and company.

[14] İdris Turna et Orkun Burak Öztürk, « A comparative analysis of deck log records of merchant ships ».

1.4 Limitations of the record keeping system

In their study: *A comparative analysis of deck log records of merchant ships,* I. Turna and O. Burak Öztürk (2020)[15] collected the deck log requirement from SOLAS, MARPOL, ILO, MLC, COLREG, P&I and additional requirements from some major Flag states (Panama, Marshall Island, Liberia, Singapore, Malta, Isle of Man, Bahamas and Turkey). It is important to retain that this study only focuses on deck log requirements and therefore does not take into account other logbooks used on board. Nevertheless, a total of 135 record requirements where found, classified under seven categories as shown in figure 3.

No	Headline	Total number of entries
1	Specifications of the ship (S)	13
2	Navigation (N)	38
3	Meteorological events (M)	8
4	Drills and trainings (D)	25
5	Tests and inspections (T)	11
6	Port operations (*P*)	21
7	Extraordinary events (E)	19



	Specifications of the ship	Navigation	Meteorological events	Drills and trainings	Tests and inspections	Port operations	Extraordinary events
Flag state	13	29	8	19	11	20	19
SOLAS	1	18	5	17	9	4	8
MLC	0	0	0	1	2	2	0
MARPOL	0	1	0	1	0	0	1
Others	0	9	8	6	8	10	11

Figure 3 Distribution of deck recording requirements and their source[16]

Most requirements are supported by different regulations. The record of cargo quantity on board before departure for instance, is required by flag state, SOLAS chapter 5 and P&I clubs. Moreover, the frequency of these recordings varies greatly: magnetic variation must be logged every hour whereas Inspection of survival crafts must be logged weekly. It goes without saying

[15] Ibid.
[16] Ibid.

that some records are only done when a certain event happened, for example: recording the reception of an emergency distress call.

The fact that all these record requirements do not come from a single written source can cause confusion as to what is mandatory and what isn't, causing some records to be incomplete. Furthermore, the consequent number of records can lead to neglect by the crew. According to the 2019 annual report on Port State progression[17], the port state control of the Paris Memorandum of understanding (MoU) carried out 17908 inspections at the ports of member states with deficiencies found on 9320 of those inspections. Under the deficiency category "certificates & documentations" 641 deficiencies were found for the oil record book, 233 for the garbage record book and 91 for the logbooks/compulsory entries. When considering cargo record book, record of seafarer's hours of work, garbage record book and logbooks/compulsory entries 1305 deficiencies were found resulting in 13 detentions. The consequent number of deficiencies could also be explained by standard discrepancies between flag states. As demonstrated earlier, while flag states comply with the base standards imposed by the IMO, they are free to impose their own specific regulation for their fleet. This lack of standardization does not facilitate port state inspections.

[17] *PORT STATE PROGRESSION: DETENTION RATE DOWN*.

1.4.1 Digitalization on board.

Since the 1980's, digital navigational software and instrument have played an increasing role in daily operations of vessels. In 1996, through the A.817(19) circular, the IMO authorized the use of ECDIS as a bridge equipment on board conventional merchant vessels. Its use has been widely considered as both necessary and useful, substantially reducing the officer's workload by allowing automatic updates[18]. The ECDIS introduced new functionalities providing further navigational assistance as an aid for safe navigation. Its usefulness, was asserted in July 2009 by the IMO's Maritime safety committee (MSC) amending SOLAS regulation V/19, specifying that "All new and existing vessels must install ECDIS on board"[19]. Having digital equipment on board means that data can be automatically recorded and saved digitally. Under SOLAS chapter 5, ships other than passenger ships of 3,000 GT or more, constructed after 1st of July 2002 are required to carry a voyage data recorder (VDR) on board. The VDR performance standards stipulates that ships should continuously maintain a sequential record of their movement. In fact, the utility of the deck logbook can be questioned since items such as position, date and time, or log speed are already recorded by the VDR as seen in table 1. The VDR keeps additional records such as bridge audio and VHF communication audio. Furthermore, records such as air/sea temperature and barometric pressure can easily by recorded through digital means as demonstrated by T. Neuman in his research[20]. Constituting the first milestone of digital record keeping, the primary purpose of the VDR is to identify the causes of a maritime incidents. While already sharing some record requirement with the deck logbook, the VDR goes even further in terms of record keeping at no charge of increased workload for officers.

[18] David Brčić et al., « ECDIS transitional period completion: analyses, observations and findings ».
[19] Acomi Nicoleta, « A REVIEW OF THE USE OF ECDIS FOR THE SAFETY OF NAVIGATION ».
[20] Tomasz Neumann, « The Single-board Computer As a Toll to Measure the Weather Parameters in the Marine Areas ».

Required Items to be recorded	Paper Logbook	VDR
Date and time	X	X
Barometric Pressure	X	
Air and Sea temperature	X	
Wind direction and force	X	X
Sea scale	X	
True course/heading	X	X
Log speed	X	X
Distance made good	X	
Remark from officer in charge and signature	X	
Position	X	X
Bridge audio		X
VHF audio		X
RADAR data		X
Echo sounder		X
Bridge alarms		X
Engine order		X
Rudder order		X
Water tight and fire door status Hull stress		X

Table 1 VDR and deck logbook recording requirement comparison

(Source: Own work)

1.4.3 The efficiency of electronic record keeping

In the context of growing digitalization on board, most sources of information required to fill in the deck logbook such as position, wind direction or true course come from a computer. Taking into account all the additional record requirements, not only mandated by the international regulation but also by the flag administration and those specific to a company, the workload on the officer of navigation can become substantial. Given the fact that some information is already recorded in other systems, there is room for improvement in terms of efficiency. Information on paper has the obvious disadvantage of readability. The disparity in handwritings, especially from crew members of different nationalities can lead to problems of readability which can in turn lead to errors or mistakes. This problem is well documented in the medical sector, where professionals are encouraged to switch to computer-based systems in order to prevent loss of information[21]. Nowadays, due to the intense development of digital communication tools, the operation and management of a ship does not only involve crewmembers. Personnel in shore offices of the company also play a vital role. Frequent information is exchanged through e-mail or telephone. In order to transfer the information to shore, paper records must be scanned and sent by e-mail, generating the double problem of readability and increased workload. Furthermore, even though the records are saved on a computer, the data cannot be exploited in other programs such as Microsoft Excel since it is only a scanned copy. The software to be developed to replace traditional paper recording has therefore the potential to improve efficiency. Pre-existing digital sensors such as those for position or course can be wired to an electronic record book (ELB) allowing for automatic recording. The software would require a simple acknowledgement in the form of a digital signature from the officer in charge. Figure 4 represents the possible data-flow of an integrated ELB system. Data is acquired by the ELB software from sensors such as those concerning navigation or operation. Data is then stored on a dedicated server which automatically dispatches the information to the relevant services without the need for human intervention. While this set-up does not prevent the officers from ensuring the validity of entries made in the logbook it greatly simplifies the data flow.

[21] F Javier Rodríguez-Vera et al., « Illegible Handwriting in Medical Records ».

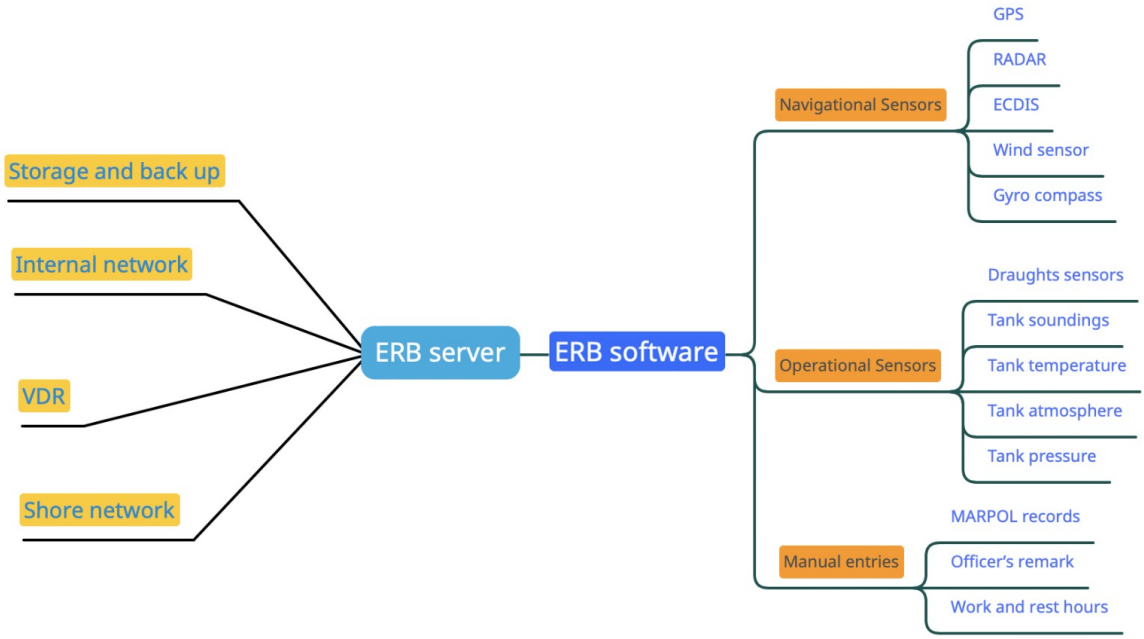


Figure 4 Wire diagram of ELB for the bridge team

(Source: own work)

1.5 Legislation on electronic record keeping

Adopted on 29th November 2001 IMO resolution A.916(22) as shown under, allows the use of electronic records for events related to navigation. This resolution only concerns navigational records.

Resolution A.916(22) Guidelines for the recording of events related to navigation.

2. Method of recording

> "SOLAS regulation V/28 requires that, if the records of navigational activities are not maintained in the ship's log-book, they should be maintained in another form approved by the Administration. Methods of recording should be permanent and may be handwritten, electronic or mechanical."

More recently, entering into force in October 2021, the marine environment protection committee (MEPC) released guidelines concerning the use of ELB for MARPOL logbooks[22]: The amendment enables the electronic recording of all MARPOL record books:

- Oil Record Book, part I (MARPOL Annex I)
- Oil Record Book, part II (MARPOL Annex I)
- Cargo Record Book (MARPOL Annex II)
- Garbage Record Book, part I and II (MARPOL Annex V)
- Ozone-depleting Substances Record Book (MARPOL Annex VI)
- Recording of the tier and on/off status of marine diesel engines (MARPOL Annex VI)
- Record of Fuel Oil Changeover (MARPOL Annex VI)
- Record Book of Engine Parameters (NOx Technical Code).

MEPC 312, stipulates that before replacing a hard copy record, the ELB will be subject to approval by the flag states. A "Declaration of MARPOL electronic record book" must be issued either by the administration or a recognized organization (RO). This is to ensure that MARPOL obligations are met. Shipowners will therefore have to wait for their flag state to approve each software made by the different manufacturers before it can be implemented on board.

In order to analyze the scope of this regulation, major system specifications listed in MEPC 312 were identified and listed below.

[22] IMO RESOLUTION MEPC.312, « GUIDELINES FOR THE USE OF ELECTRONIC RECORD BOOKS UNDER MARPOL ».

4.3 Security and accountability

- 4.3.1 To ensure the security of an electronic record book, it is critical that the system implements Role Based Access Control. At a minimum, all access to the application should use a unique personal login identifier and password for each user. This level of security ensures that the user making entries into the application is accountable for any false entries or omissions.

- 4.3.2 MARPOL requires the signature of the relevant officer entering a record. As such, the electronic record book should implement Audit Logging. Audit Logging records a user code, identifying symbol, such as a graphic character, or an equivalent identifier against each entry to uniquely identify the user and whether the user provided accessed or amended an entry.

- 4.3.4 Records and entries should be protected by measures aimed at preventing and detecting attempts at unauthorized deletion, destruction or amendment. After an entry is saved by the user, the system should secure the information against unauthorized or untraceable changes. Any change(s) to the entry by the same user or a different user should be automatically recorded and made visible both in the system and in any output presentation or printed versions of the electronic record book. The entry should appear in the list of entries in a format that makes it clear that the entry has been amended. To create transparency of changes to saved or verified entries, it is essential that the system is designed to retain both the original entry and the amendment(s).

- 4.3.8 To provide for different stages of the data entry and approval process, the electronic record book should provide a status field for each entry that clearly determines the verification stage of the entry. For example, when an entry has been saved in the system by the user, the entry should reflect a term such as "pending" or "awaiting verification". Once the master has verified an entry, a term such as "verified" should be automatically reflected.

- 4.3.10 To ensure that entries are verified in a timely manner, the system should provide a reminder that verification by the master is required. It is recommended that where possible, verifications occur prior to arrival in port. Entries not verified should be accompanied by comments advising of the reason for non-verification.

4.4 Storage of data

- 4.4.1 To create the same level of confidence as a hard copy record book, any electronic record book should form part of the Information Technology Business Continuity Plan. This includes having an appropriate method for backing up data and data recovery if the system were to fail or not be available from the ships' network. Consideration should also be given to alternate power supplies to ensure consistent access to the system. Both data recovery and power sources are essential to allow ongoing entries to be made and facilitate port State control (PSC) inspections.

- 4.4.2 The electronic record book should have the capability to allow automatic backup of data in the system to offline storage. Backups should ensure the offline record is updated automatically every time changes are made to entries to ensure the backing up process is not forgotten by the user.

- 4.4.3 The recorded data stored in the offline space should be:
  .1 developed using cryptography so that unauthorized access to the information is not possible, and so that once the data has been saved it is in a read-only format with no amendments able to be made to the record (unless done so through the application or by a user with the appropriate level of authorization);
  .2 in a format that can be transferred from the point of record to another storage location. Examples include a local (removable) storage peripheral device, local and remote network storage;
  .3 maintained in a format that ensures the longevity and integrity of the record; and
  .4 In a format that allows output presentation and printing of the record.

6 Inspection and enforcement

- 6.1.1 An electronic record book should have the ability to meet the company verification/audit requirements (such as integration with the ships Safety Management System (International Safety Management Code)). The record book should also have the ability to meet all flag State and survey requirements. In addition, an electronic record book should meet all control provisions as set out in the relevant Annexes of MARPOL. Such a system should also meet any general requirements set out in the *Procedures for port State control, 2017* (resolution A.1119(30)), as amended, as well as support the detection of violations and enforcement of the Convention as outlined in Article 6 of MARPOL.

- 6.3 To accommodate current procedures when investigating illegal discharges under MARPOL, the electronic record book should allow for the specific entry, relevant page, pages or the entirety of the electronic record book to be printed at the time of an investigation and each printed page physically signed by the master to certify it as a "true copy". All printed pages should provide the following details in addition to those required under MARPOL for record books:
  .1 the title and full name of the person that entered the record (in addition to the person's unique username and/or ID in the electronic record book);
  .2 any changes that were made to the entries;
  .3 the date and time of printing;
  .4 the name and version number of the electronic record book from which the true copy was produced; and
  .5 page numbering and number of pages to ensure the report is complete.

Currently, MEPC 312 constitutes the only standards for electronic record keeping on board. Since it is a young system, standards remain limited when compared to other digital integrated systems already present on board;

- For now, ELB performance standards only apply to MARPOL records even though an ELB integrated software could deal with all types of records on board.
- Security features for data remain sparse. There is mention of user ID and password but the regulation does not cover the « online » aspect of an ELB system. Connecting the ELB to an internet network to allow shore access greatly increases the security risk.
- No mention of redundancy measures in case of failure nor maintenance or update standards. In comparison these measures are covered in great details in the ECDIS performance standards (IMO resolution A.817(19))
- Lack of measures against inherent vulnerabilities such as data falsification or failure of the system.
- No training requirements for seafarers

1.6 Presentation and description of an ELB software

As companies and shipowners increasingly focus on ways to operate in an environmentally responsible manner and aim to reduce the heavy burden associated with paperwork through electronic means, the concept of operational logs in an electronic format has become a popular consideration. Many large marine software providers such as Kongsberg, NAPA and RINA each have a dedicated ELB solution proposing the same core functionalities with slight variations. Evidence was found exclusively on the internet where those companies publicly advertise their ELB solution[23]. Having the largest amount of information publicly available, the research focused primarily on the NAPA Logbook system. NAPA is a maritime software company headquartered in Finland who proposes software solutions for ship operators such as loading computer or fleet intelligence. Their logbook system has been approved by more than 20 flag states including, Bahamas, Panama and Malta and is also DNV type certified for MARPOL record keeping[24]. In order to assess the benefit of the NAPA ELB system, it is important to understand that while having inherent limitations, the ELB is not limited to being a digital copy of the traditional paper log book but has the potential to acquire and exploit records in different ways. This part of the study will therefore indicate the base requirement regarding security features, data storage and regulation compliance in a first part, and will then explore the key advantages ELB has in terms of connectivity, automation and data transfer. Through this assessment, a number of limitations concerning implementation, training, cyber-piracy have been identified and will be discussed in the last part.

[23] *NAPA logbook (website)*.
[24] Ibid.

1.6.1 Security

Information contained in the different record books on board should be well maintained and protected. Even if having your log in a paper format makes sharing information more time consuming, it has advantage of being secure in terms of data visibility. The information is only accessible through a physical book which can be stored in a safe location only accessible by permitted personnel. However, tampering of the information is quite simple. Even though records should not be altered after the master's signature, it is easy to add a comment or change a value afterwards. On the other hand, storing information digitally, greatly increases the visibility. Information can be accessed and modified through any computer or electronic device connected to the software. In order to safeguard the information, contained in the ship's record books, the electronic record keeping software should be equipped with strong security features. Both NAPA logbook (NAPA) and K-Fleet Logbook (Kongsberg) go beyond the current regulation in terms of security. User ID and password are required to access the system, access restriction is implemented through role-based access control (RBAC) as shown in figure 5. Crew members each get a role in the system giving them access rights to consult or edit certain records. To prevent tampering, each logbook requires a digital signature from the concerned authority once it is completed. No additional data can be added after that. In terms of traceability, records are kept in an encrypted database where each entry can be directly linked to its creator and modifications are never deleted.

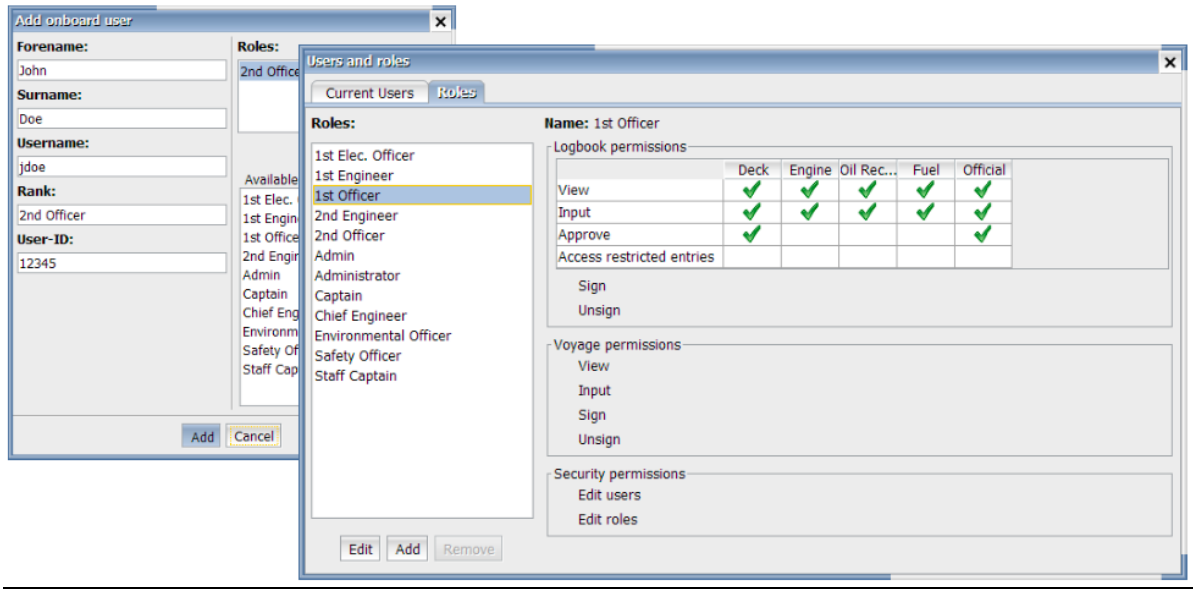


Figure 5 Role based access control of the NAPA Logbook

(Source: NAPA Logbook presentation[25])

[25] Jussi Siltanen, « NAPA logbook ».

1.6.2 Data storage

Data storage is a major advantage of electronic record keeping over the paper format. Whereas physical logbooks can be lost or destroyed, having a digital format allows the data to be duplicated into multiple storage systems where it can easily be accessed. Furthermore, as discussed previously, there is a substantial amount of different logging requirements that must be logged into a lot of different record books. Updating different books is not only time consuming but can lead to confusion as to which logbook a record belongs. According to regulation, an ELB software must have a separate database storage unit where periodical back-ups can be completed in order to protect the integrity of the data. Even if the regulation only concerns MARPOL record keeping, the current ELB software regroups deck, engine, GMDSS, cargo and MARPOL record books into one system resulting in increased visibility and accessibility as seen in figure 6. This translates into having all records in one physical place, accessible on any device connected to the network. The centralization allows easy data exchange between records. An entry that must be recorded into multiple logbooks can be done instantly and automatically. Unlike paper logbooks, the ELB system, having a combined database for all records, lets the user search for a specific entry through a search and filter function. This can be particularly useful during port state control inspections where records are thoroughly examined.

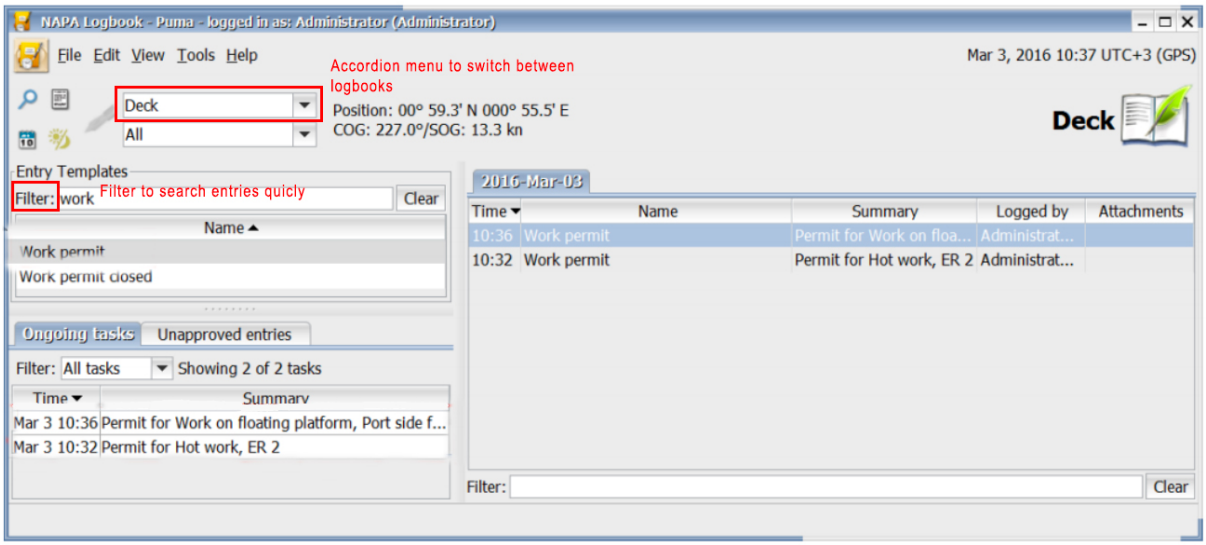


Figure 6 Illustration of the filter function and the centralization of logbooks

(Source NAPA presentation[26])

[26] Ibid.

1.6.3 Regulation compliance

In order to be accepted by a flag state administration, MEPC 312 explicitly requires that the ELB software must be presented in the form as specified in relevant MARPOL Annexes (Annex I, II, III, IV, V, and VI) in order to assist the smooth transition from hard copy record books to electronics ones. According to NAPA's website[27], their company closely follows international regulation on the subject and makes sure that their software is up to date with all regulatory requirement concerning record keeping. In fact, major flag states such as Panama, Cyprus or Malta already have approved the use of the NAPA software. ELB can also facilitate the mandatory reports put into place by the IMO and the European union by automatically logging entries for monitoring, reporting and verification (MRV) and data collection system (DCS) concerning ships of more than 5000 GT[28]. In order to facilitate inspections, attachments can be added to an entry if required. For example, the garbage discharge receipt, if given in paper form, can be scanned and attached to an entry and reports can be printed according to the standard IMO template layout as shown in figure 7.

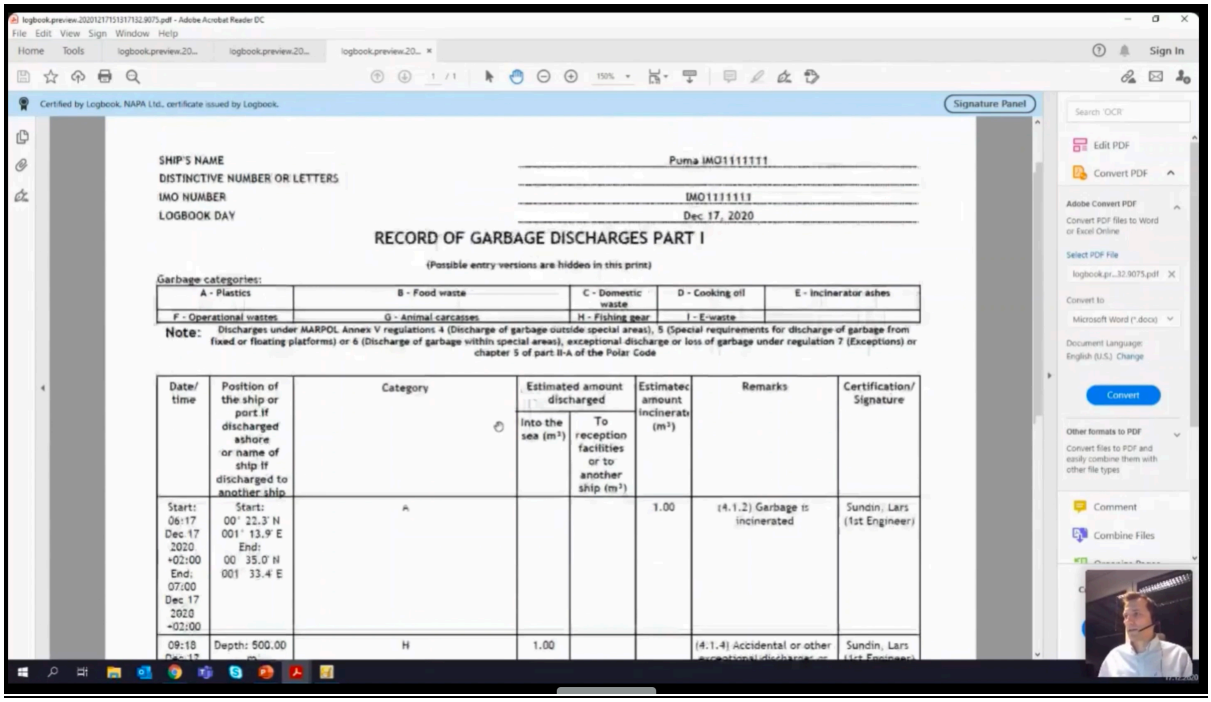


Figure 7 automatic creation of IMO garbage discharge template in pdf format

(Source NAPA Webinar[29])

[27] *NAPA logbook (website)*.
[28] DNV, « MRV and DCS ».
[29] Tommi Vihavainen et Jussi Siltanen, *MARPOL record keeping and NAPA Logbook Webinar*.

1.6.4 Connectivity

One of the major differences between paper and digital recording is that data can be shared easily. With the rise of highly efficient digital communication systems on board, such as network connection through satellite, information can be shared across users and platforms instantly. Ship to shore e-mail has become a common form of communication for most ships nowadays. As explained in this research, in an environment of effortless communication, the ELB system can be directly wired to the ships' network, to allow easy access for shore personnel. This can significantly reduce the officer's workload when information has to be transferred to shore. In order to send information coming from a paper logbook, an officer has to first, collect the information (probably from a computer screen), then manually record the entry into the logbook before typing everything back on a computer in order to send it by email. Having the logbook database connected to the NAPA office network, as illustrated in figure 8, would allow the shore team to directly look up the necessary information. The same goes for intraship sharing of data: no need to call up the engine control room (ECR) to ask for engine records required on the bridge. All the data can be reviewed immediately from any computer using the software if the user has the rights to access the requested information. Economic and environmental efficiency are major focus points for shipping companies. In order to stay competitive, it is crucial to have reliable data regarding your ship's performance. Having a connected ELB database allows the export of entries to third party software which is especially useful for performance analysis.

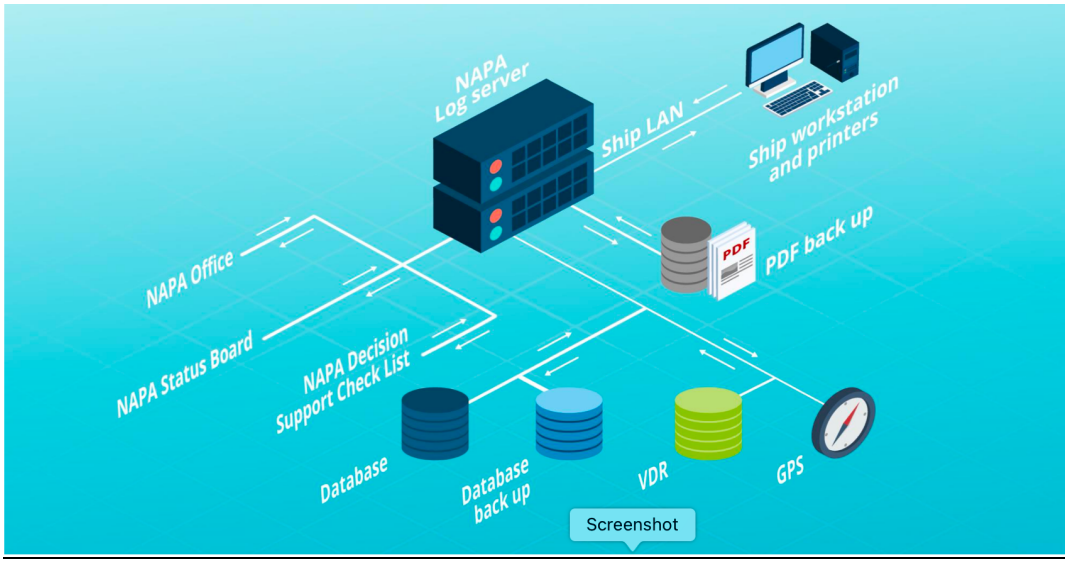


Figure 8 NAPA Logbook connection platform

(Source: NAPA Logbook presentation[30])

[30] Siltanen, « NAPA logbook ».

1.6.5 Automation

While the MARPOL regulations have played a significant role in the reduction of marine pollution, the new regulations have created an additional bureaucratic burden for officers since eight additional record books have been introduced. Nowadays a captain's day is mostly spent sitting at a computer, filling in administrative paperwork. While some records are only kept in order to comply with regulations, it would make sense to implement a system to log entries automatically. If connected to the relevant pre-existing sensors an ELB system can record entries directly into the relevant log book requiring a simple acknowledgment from the officer in charge. For example, the software can be wired to the GPS on a time-based recording. Every hour the position will be logged in the system and checked by an officer. Automation can also be implemented for operational records where checklists are used for every specific operation. The position of a remotely operated valve can easily be logged automatically into an electronic checklist thus avoiding mistakes and eliminating the manual task of logging the position of the valve every time it changes. By introducing automation in record keeping, the ELB system supports a broader goal of more effective ship operation which could lead in the long term to global automatization of the shipping activity.

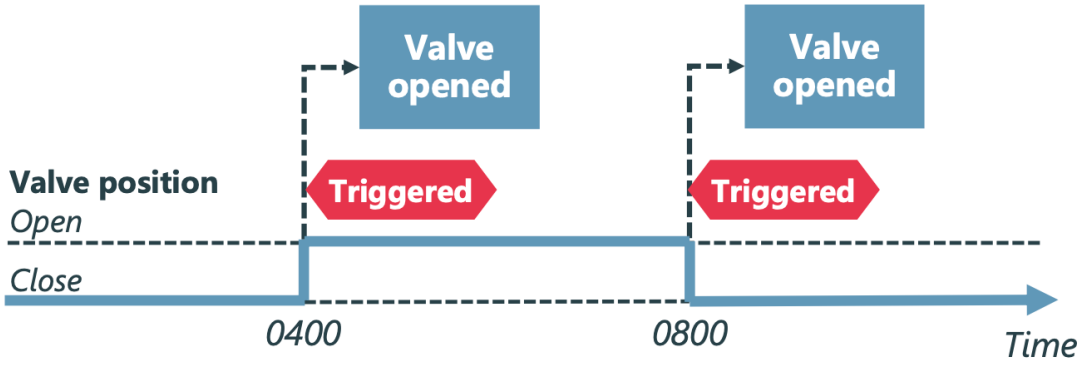


Figure 9 Automatic triggering of Logbook entry

(Source: NAPA Logbook presentation[31])

[31] Ibid.

1.6.6 IoT and Big Data

While ELB development is still at an early stage in 2022, digital data acquisition of logbook entries sets the foundation for more advanced uses of digital data records. It has been established that by increasing connectivity and automatization the ELB can reduce the officer's workload. The system also generates exploitable data on the ship's performance which can have possible uses when looking at concepts such as the Internet of Thing (IoT) where physical objects are embedded with sensors and exchanging data with other systems. This technology, while being prominent in many industrial sectors, lags behind in the maritime world[32]. Having real time remote monitoring of your ship's essential parameters is already a reality in the private yacht sector, where solutions such as Yacht Sentinel exist to do so.[33] Additionally, the opportunity to condensate a large amount of digital data coming from many different fields of a ship's operation allows shipping companies to start exploiting the field of big data. According to Sinay[34], a maritime data solution provider, big data analysis is a way to find hidden patterns in a very large data set by using specialized algorithms to make real-time predictions. This technology already has maritime applications in estimated time of arrival (ETA) predictions, improved ship design and automated analysis. By summarizing the added functionalities in figure 10, It can be concluded that just like installing dual fuel engines on board a ship to forecast the more stringent emission regulations to come, installing ELB on board is a way to future-proof a ship.

[32] Pedro-Luis Sanchez-Gonzalez et al., « Toward Digitalization of Maritime Transport? »
[33] Rupert Holmes, « Monitoring apps: How the Internet of Things can turn your boat into a smart boat ».
[34] Sinay, « Big Data in the Maritime Industry: The Next Big Revolution ».

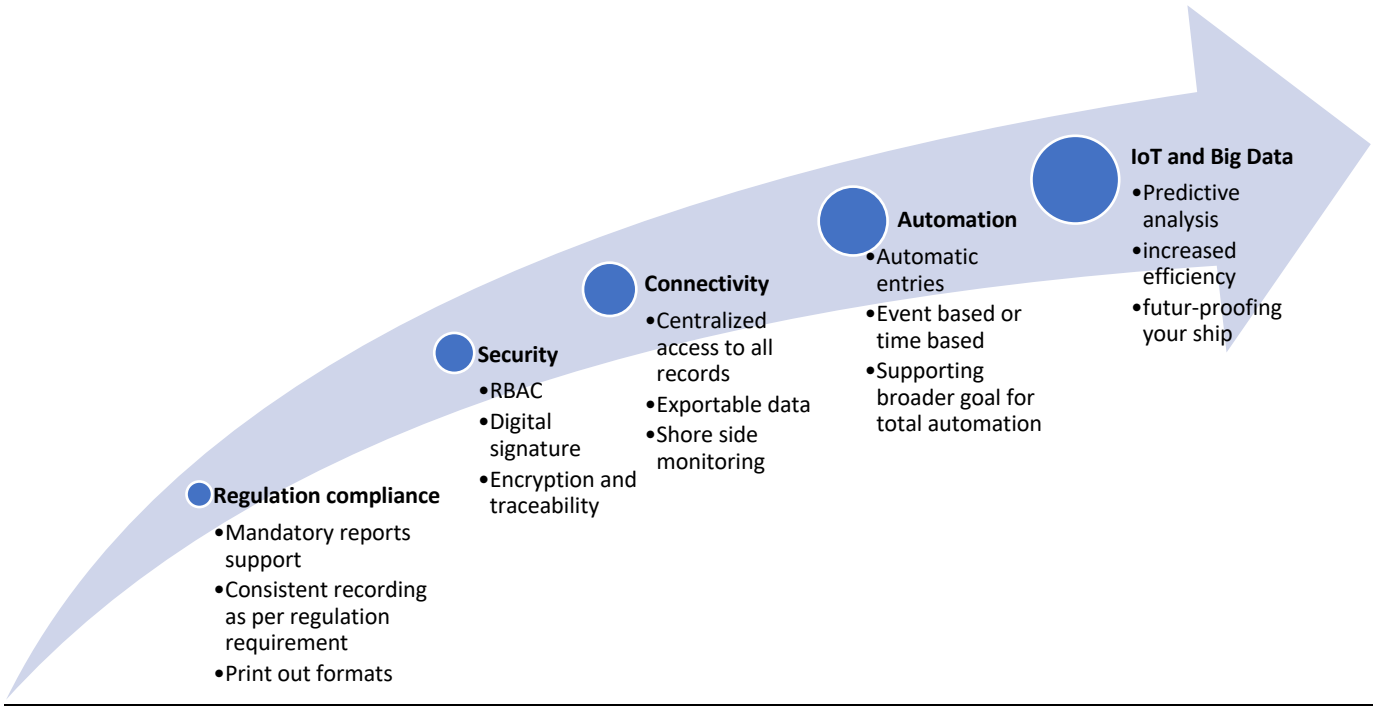


Figure 10: Summary of the development of functionalities of an ELB system.

(Source: own work)

1.7 Limitations of the ELB software.

The ELB system, holds multiple developments opportunities not only for ship operators but for the maritime sector as a whole. Reducing the workload for officers and allowing for more advanced data analysis for optimizing operations. While holding promising perspectives, it is also important to think about the possible drawbacks resulting from such system. After having looked at the added functionalities of the ELB system the study will analyze the resulting limitations in order to give in figure 12 the full picture of outcomes resulting in the development of the ELB system.

1.7.1 Implementation and training

Due to the high level of integration with other systems and the diversity of record keeping requirements on board merchant vessels, the ELB installation has to be tailored for each ship. Whether developed internally or purchased at a third-party manufacturer, the ELB software will therefore require a lengthy period of configuration and testing during which the ship's operation could be impacted. Modern ships use computers in their daily operations but the fact that that these computers were not specifically designed to operate an ELB software should not be overlooked as this could potentially cause reliability issues, increasing the officer's workload. Additionally, despite the growing role of computer software in the ship's daily operation, the STCW convention does not provide any ICT training requirement resulting in a great variety of IT proficiency between seafarers. Even if a shipping company sets-up training for a specific computer program, each software works differently, thus requiring additional training when a new program is implemented.

One could also argue that it is not necessarily in a seaman's best interest to accept a digital system that requires additional training, potentially increasing their workload during a prolonged trial and error period, while paving the way to increased automation of operations. This hypothesis will later be verified in this study. If automation offers good perspective in terms of reduced work load, efficiency and productivity; it will surely transform the way people work on board. Beneficial consequences in the long run for the seaman's profession are therefore still uncertain.

1.7.2 Cyber-piracy

As it is the case with ELB, shipping is relying increasingly on digital solutions for the completion of everyday tasks. The rapid development in information technology presents shipowners with increased possibilities for operational optimization. However, these developments rely on connectivity which increases the potential risk of cyber vulnerability. Between 2010 and 2020, 46 maritime cyber security incidents were recorded through a retrospective analysis[35]. Although the number of incidents is not overwhelming, considering the number of incidents per year as shown in figure 11, we can see that that this number has been multiplied by seven from 2010 to 2020. According to Israeli cybersecurity specialist Naval Dome, attempted cyberattacks on the maritime industry increased by 400% between February and June 2020[36]. BIMCO's guidelines on cyber security onboard ships[37] explain that the maritime industry has a range of characteristics that affect its vulnerability to cyber incidents:

- the use of operational technology systems that cannot be patched or run anti-virus due to type approval issues
- the availability and use of computer controlled critical systems, which may not have the latest patches installed or be properly secured, for the ship's safety and for environmental protection use of legacy information technology systems that are no longer supported and/or that rely on obsolete operating systems.

Since digital communications are already widely used on board merchant ships, installing an ELB system will not necessarily trigger risks linked with cyber piracy. Nevertheless, it still constitutes an additional data channel transiting over the internet, thus increasing vulnerability to cyber theft.

[35] Per HÁkon Meland et al., « A Retrospective Analysis of Maritime Cyber Security Incidents ».
[36] Security Magazine, « Maritime Industry Sees 400% Increase in Attempted Cyberattacks Since February 2020 ».
[37] BIMCO, *The guidlines on cyber security on board ships*.

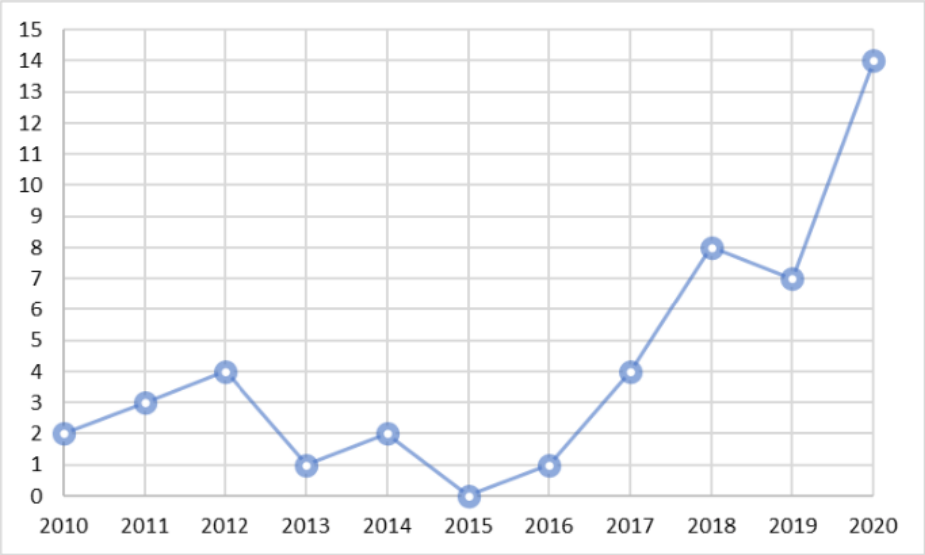


Figure 11 Number of maritime security incidents over 10 years[38]

1.7.3 Regulation

As of February 2022, the only international regulation for the use of ELB on board are the ones of MEPC 312. As demonstrated in this research, while establishing the baseline for operational use, the ELB performance standards introduced by the MEPC 312 remain limited. According to MEPC 312, the ELB system needs to have the same functionalities as a traditional record book and nothing more. No mention is made of connectivity or automation which are established to be the key improvement factors over traditional paper recording. Furthermore, basic requirements such as crew training or redundancy measures are omitted. This regulation void pushes flag state administrations to set up their own rules, leading to a disparity in standards across flags, impeding the work of inspectors and port state control officials. While major flag state such as Panama (MMC-193), Cyprus (Circular No. 19/2017) or Luxemburg (CAM 009/2019) have already accepted the regulation described under MEPC 312, the Belgian administration has yet to issue an approval statement. Although MEPC 312 constitutes an effort to modernize maritime trade, it is safe to admit that the scarcity of regulation and of a common performance standard for ELB could discourage shipowners for transition to digital record keeping.

[38] Meland et al., « A Retrospective Analysis of Maritime Cyber Security Incidents ».

1.7.4 Economic factors

While no information is publicly available on the price of installation, operation and maintenance of an ELB system, replacing paper logbooks by a digital solution would incur additional costs for shipowners. ELB is still a young technology, no research has been done to assess its gains in terms of productivity or efficiency. While it could potentially improve the work for operators, this might not be a sufficient argument for shipowners who would have to allocate further resources in record keeping when the current system works well, being inexpensive and requiring no maintenance. The ELB system has yet to prove that it can be a worthwhile investment. This could be achieved through scientific research or by interviewing companies that have already installed ELB in order to assess what the outcome is. Furthermore, although there is a great number of maritime software companies proposing an electronic logbook service, they do not provide any scientific data supporting their claim of reduced workload and greater efficiency.

1.8 Conclusion

As demonstrated earlier, the ELB system has the potential to reduce the workload associated with administrative records through automation while greatly simplifying the logging process. While the paper logbook records had no other purposes but to be archived in order to comply with regulation, the ELB system brings additional functionalities for a minimum amount of effort: versatility in terms of data exploitation, integration with other digital systems such as VDR, easy access of archives with a search function and integration of all logging requirements into one system. More importantly, through digital technologies such as big data and increased automation, the ELB system paves the road to the maritime digital transformation which is currently taking an increasing role in the sector. It is therefore clear that even though there is s no predictions regarding the economic or efficiency gains of an ELB system, investing in a technology that grants shipowners enhanced fleet connectivity holds value in the long term as the trend of digitalization will continue to increase in every actor of the maritime supply chain. It is however important to acknowledge the existence of limitations. In terms of potential capability of the ELB system the regulation still has to come up with standards for data sharing, automation and connectivity. This legal void could lead to some laxism in terms of cyber-piracy protection which have recently soared in the maritime trade resulting in costly incidents. Furthermore, it is likely that such an innovative system, involving a high degree of integration will require a long implementation period during which it could bump into refractory seafarers who could be reluctant to use the system. In order to assess the likelihood of a successful implementation on board, it is essential to determine the opinion of seafarers who will be the one working with such system. The second part of this study will therefore try to assess the knowledge and interest of seafarers for the electronic logbook software.

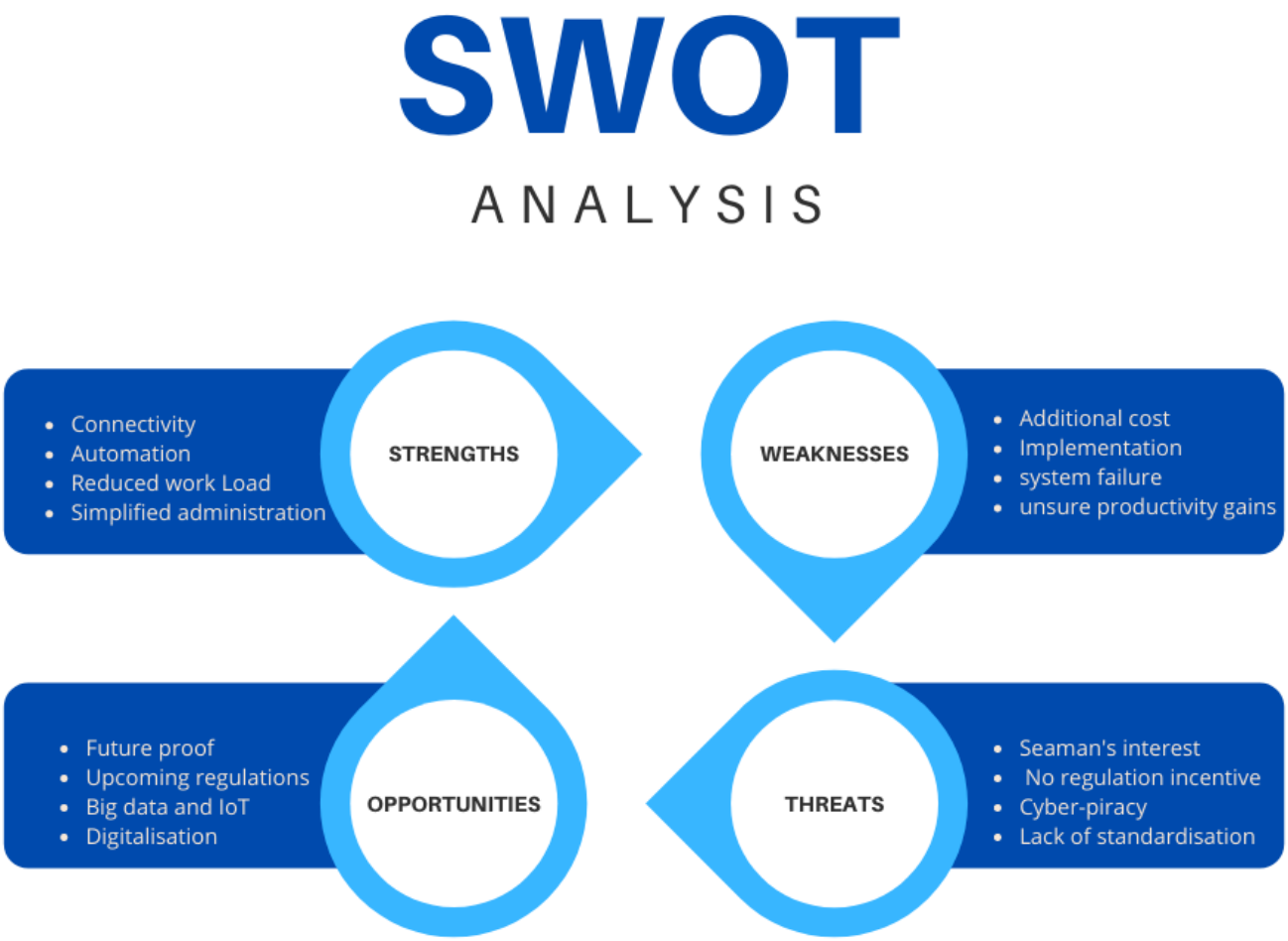


Figure 12 SWOT analysis of the ELB system

(Source: own work)

Part 2 – Knowledge and interest of seafarers for an ELB software

2.1 Introduction

The ELB system has useful features that could enhance the efficiency of the maritime sector as a whole in the long term. While in theory it seems that ELB could reduce the workload of officers sailing on seagoing vessels there are some possible downsides. As with any new technology, the ELB system faces some challenges in terms of implementation. However, before determining how it should be implemented, one should assess its relevance for seagoing vessels. It could be that even though installing ELB seems like a good idea in theory, the maritime sector has no interest for it. In order to determine the interest of the maritime sector for the ELB system, this research will focus on assessing the opinion of ship operators, being the ones who will be interacting with the software. Ship officers are confronted with record keeping on a daily basis and already work with a lot of digital technologies such as the ECDIS for navigation or operational software for cargo. Having their opinion on the relevance of ELB is essential to determine its applicability for the maritime sector as a whole. In the second part of this research, a survey was designed in order to assess the knowledge and interest of seafarers working on Belgian operated vessels for an ELB system on board. Questions will first focus on establishing how much is known on ELB by officers and secondly assess the relevance of major features of the ELB. Officers will also be encouraged to give their point of view in terms of implementation on board. The survey will be sent to 4 major Belgian maritime companies: Jan De Nul, Deme, Exmar and Bocimar operating dredging vessels, gas carriers and bulk carriers. In order to determine its relevance and limitations from an operator's perspective, this survey will assess interest of officers and provide insights on their point of view towards implementation.

2.2 Methodology

2.2.1 Establishing target population.

Target submissions was set to 200 in order to maintain a good confidence level and a small margin of error by keeping the target population relatively small. The survey is therefore targeted at seafarers occupying an officer or engineer position and sailing on Belgian owned ships. According the 2017 economic impact study of the Belgian shipping cluster by The Royal Belgian Shipowner's association[39], in 2016, the number of employed seafarers on Belgian owned ships counted 2,629 in the maritime dredging sector (translated from the word "waterbouw" in Dutch), 442 in the towage sector and 2,379 in the merchant marine sector. Since the towing activity does not involve open sea activity it is not subject to the same record keeping requirements and will therefore be omitted from this study. Since the ratio of management position to other seafaring jobs on board merchant ships and dredgers is usually 1:1 we can assume that about half of the seafaring population occupies an officer or engineer job on board[40]. The target population can therefore be approximated using equation 1, totaling 2,504 seafarers.

$$Target\ population\ size \sim \frac{Dredging\ seafarers\ n° + Merchant\ marine\ seafarer\ n°}{2}$$

Equation 1 Population size approximate calculation

(Source: own work based on data from RBSA[41])

[39] Royal Belgian Shipowner's association, *Economic impact study Belgian shipping cluster*.
[40] IMO resolution A.1047(27), *Principles of safe manning*.
[41] Royal Belgian Shipowner's association, *Economic impact study Belgian shipping cluster*.

2.2.2 Sharing medium

In order to reach the target population, Belgian owned maritime companies were approached by contacting shore management staff so they could distribute the survey to the entire fleet through email. Staff contact was obtained through university professors of the Antwerp Maritime Academy who had previous professional ties with Belgian maritime companies. Because the ultimate scope of this thesis is to assess the possible implementation of the electronic logbook on board Belgian dredging vessels, the survey was sent out in priority to DEME and Jan De Nul (JDN). The two major Belgian dredging companies accounting for 77 trailing suction hopper dredgers (TSHD) and cutter suction dredgers (CSD)[42] [43]. These two are the only kind of dredging vessels where navigating officers are required. Contact was also established with EXMAR, a Belgian gas carrier company, operating 38 LPG vessels and Anglo-Eastern, a Hong Kong based ship management company operating Belgian flag vessels for the account of Bocimar, the dry bulk branch of the Compagnie Maritime Belge (CMB). Email exchange was done through the promotor of this thesis and tacit agreements were made with all those companies to share the survey with their fleet once completed. To increase its reach, the survey was also shared on the professional social network LinkedIn, but only very few responses were collected through this mean.

[42] Royal Belgian Shipowner's association, *Economic impact study Belgian shipping cluster*.
[43] DEME, *Activity report*.

2.2.3 Survey medium

Before compiling the survey questions, interrogation arose as to what medium was best suited to send it out to seafarers that would mostly fill it out from their work location. As nowadays most maritime companies have implemented internet on board their fleet, it was decided to create a cloud survey using Google docs survey program instead of sending hard copies. Besides the costs related reasons, an online survey is much more flexible and easily adaptable, allowing to easily create dynamic questions where users will be redirected to certain questions based on their previous answers. Furthermore, Google survey, unlike other digital survey options, can be filled in directly over the internet. Google survey can automatically arrange the submission into an exportable format which can be imported into most spreadsheet software preventing tedious manual copying of the data. Having a cloud also makes the data available in real time for effortless collaboration which was important in order to get feedback and input from professors.

2.2.4 Survey Structure

In order to properly express the goal of the survey to the participants and to receive as many replies as possible it was decided to keep completion time to a minimum of 4 minutes. To obtain an optimal fill rate, the survey was divided into 6 sections displayed independently as shown in figure 13. Exposing all questions at once could make the survey appear longer which could potentially reduce the fill rate. This method allowed to display a progression bar at the bottom that would tell the submitter how far they were in the submitting process. Keeping the introduction message short and to the point also felt necessary in order to encourage responses.

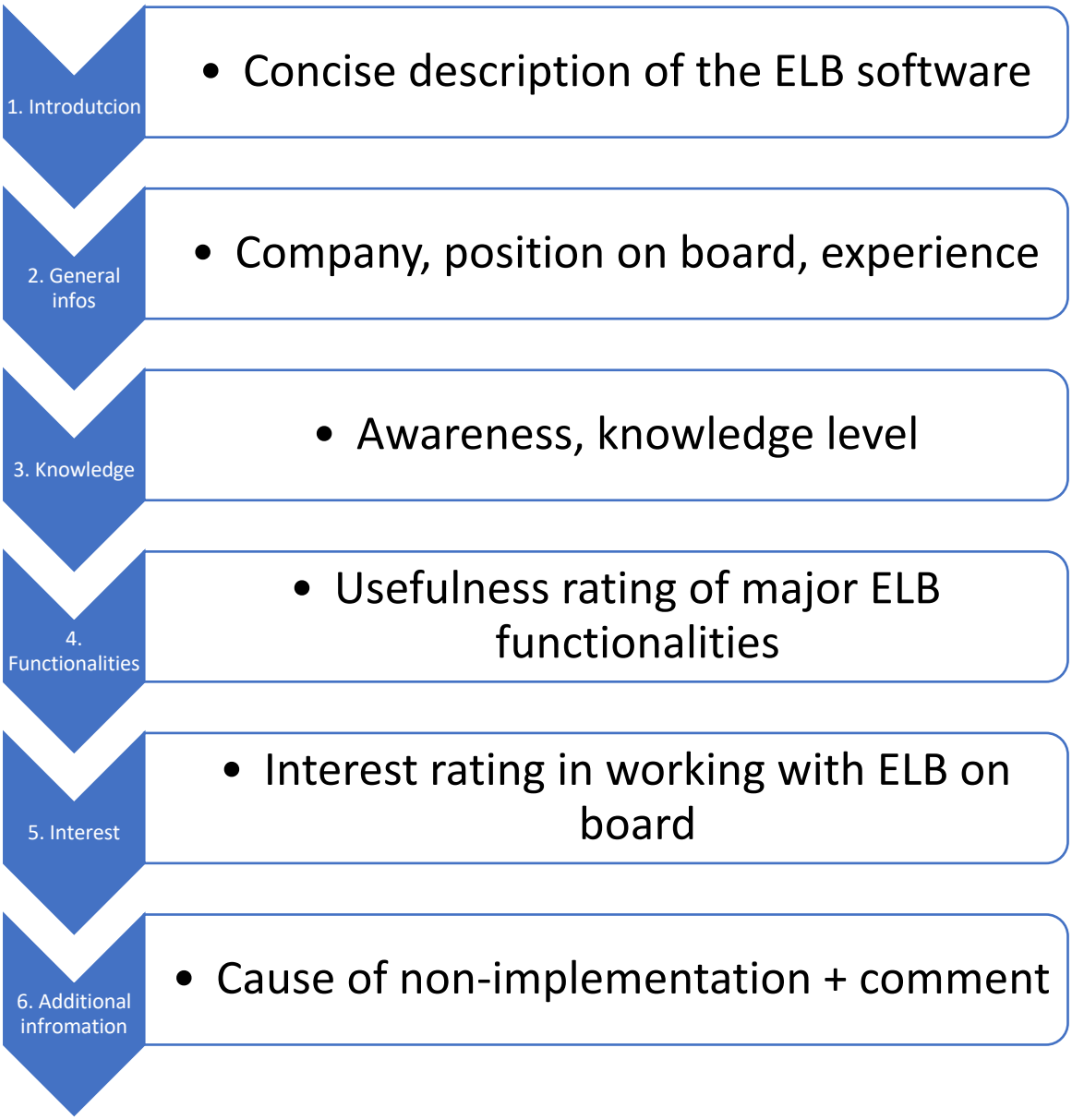


Figure 13 ELB survey structure

(Source: own work)

2.2.5 Question design

Open questions

Open questions were kept to a minimum primarily because they become an additional burden for the respondent, making the survey appear too time consuming which could potentially lead to drop out. Open questions are also much more time consuming to organize and analyze. Open questions were nonetheless used for the questions “current company”, “Current position in the sector” which retrospectively could have been avoided since the target population was only seafarers and the survey was only sent out to specific companies.

Drop-down menu

This option was only used for the question “years of experience” in the general info section since it was the only applicable question.

Single choice rating questions.

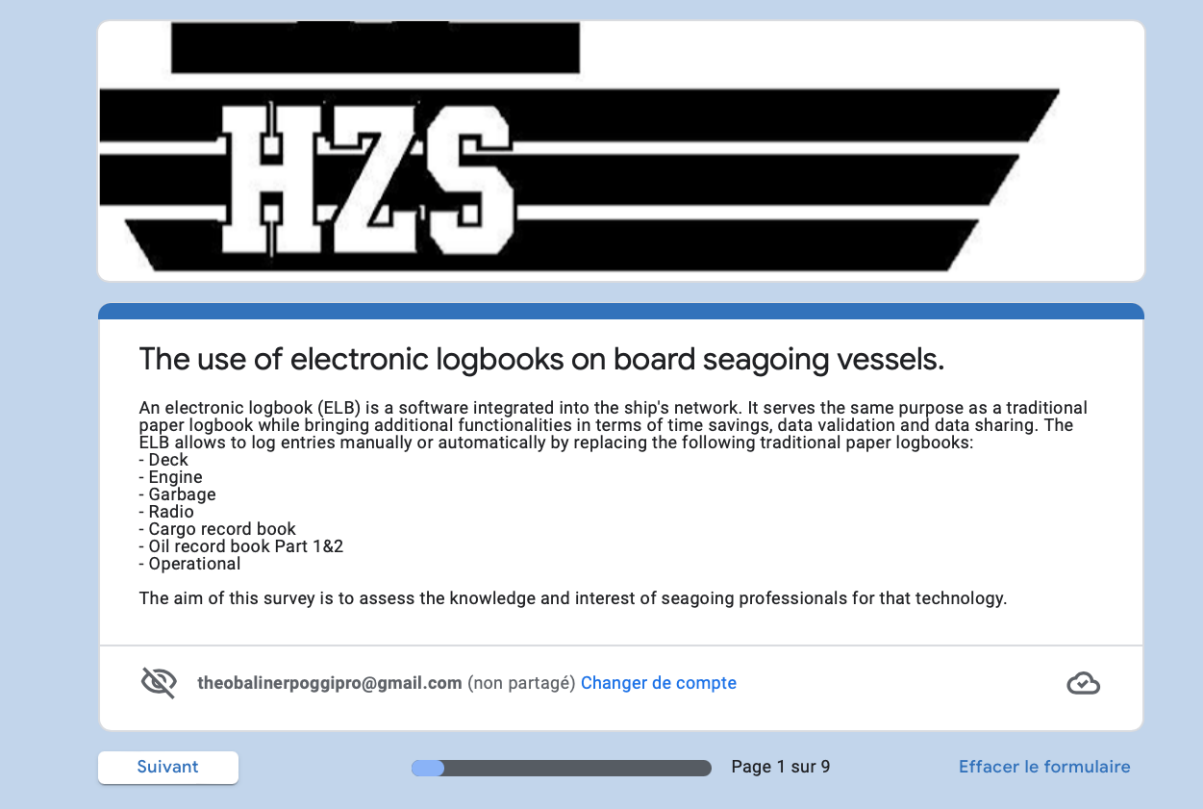
This option was commonly used for the knowledge, functionalities and interest section. This proved to be beneficial to remain impartial as they provide the respondent with a scale of agreeability on 1 to 5 for each statement, with 1 being strongly disagree, 5 strongly agree and 3 no opinion. Giving the submitter an option to have no opinion felt important to correctly reflect their judgement on the statement. Careful attention was also given to the phrasing used to compose statements to remain as impartial as possible to not influence results. This question design is also particularly useful to compile descriptive statistics charts as the answers can be organized in tables much more easily than open questions.

Additional information Section

This facultative section contained an open question “Additional comment” where submitters were encouraged to add comments or opinions that were not reflected in the previous sections. Even though most submitters left this section blank, the comments received became a channel to further express the reason why they felt the way they did. This section became a useful source of information for opinions that could not be expressed in the rest of the survey.

Introduction message:

In order to give submitters some context as to what an electronic logbook is, it was necessary to give a brief description of the system; explaining how it works and what kind of records it can take care of, while stating the goal of the survey. Keeping the description short and to the point was essential to reduce submission time.



2.2.6 Review by professors

Frequent meetings were held with the promotor of this thesis, where the survey was discussed in details. A draft version was first elaborated and tested to make sure everything worked appropriately before sending it to the selected maritime companies. In order to get an outside point of view, the final version was sent to a statistics professor of the Antwerp Maritime Academy to check for any additional mistakes.

2.2.7 Chronology

After defining a research statement in October 2021, a timeline was established. This section of the research gives an overview of the planning that was put in place in October and the tasks achieved during the course of the 2021-2022 academic year. Over the course of 3 months (December- February) 252 survey responses were received in total.

	Planned Tasks	Achieved
October	• Validate structure with promotor • Start preliminary research on the ELB (Part 1).	• 26/10 Discussion of survey design with promotor. • Preliminary research for part 1. • Designing the survey on google forms.
November	• Designing the survey. • Start receiving survey application from December. • Continue research for part 1.	• 03/11 finalizing survey details with promotor. • 08/11 Sending the survey to companies for pre-check. • Additional part 1 research.
December	• Exam break. • Reception of survey submissions.	• 02/12 Survey sent to EXMAR, JDN and DEME. • 16/12 Survey sent to Anglo-Eastern
January	• Exams. • Receive survey submissions. • Start contacting Dredging. companies for interviews.	• 10/01 166 responses received so far. • Contact established with JDN and DEME for interviews.
February	• Contact interview participants. and design interview. • Conduct interviews. • Close the survey submission. • Finish writing part 1.	• Multiple meetings set up with JDN and DEME for interviews. • Writing Part 1. • 252 survey responses received in total.
March	• Conduct interviews with DEME and JDN. • Start analyzing survey Data.	• 09/03 First interview with a DEME captain • 10/03 Second interview with DEME captain • 04/03 Part 1 finished and pending for review.
April	• Write Part 2 and 3	• Internship on board dredging vessel
May	• **23/05 Deadline for thesis.** • 30/05 Thesis must be submitted to the administration.	
June	• Prepare for defense.	

2.3 Limitations

2.3.1 Technical problem leading to data loss

On the 14 of December 2021, after email exchanges, Anglo-eastern agreed to relay the survey to their fleet on the condition that it must not be completed in an online format. As this information was relayed during the exam period, a pdf version was hastily created using the Adobe acrobat pdf program to answer their request. Due to the restricted timeline, little time was given to testing the PDF survey version which resulted in input issues. This is something the writer was aware of at the time but did not have time to fix due to the upcoming exams. On the 21st of December Anglo-Eastern did notify that some submission issues were reported by the crew of certain vessels. A second, version was therefore created and sent out again. Upon reception of the results on the 8th of January 2022, it was noticed that submission answers of sections 4 and 5 made on the first survey version were extremely unreliable and could not be trusted. Out of 86 total submissions from Anlgo-Eastern, 50 of them were made on the first version of the pdf survey. Section 4 and 5 of these submissions were therefore discarded from the analysis.

2.3.2 Little causality questions

The aim of the survey was to assess interest and knowledge of ELB from seafarers working on Belgian owned vessels. Questions on Knowledge and functionalities of the ELB system were therefore priorities. Retrospectively, additional questions directed at explaining the reason for their opinions would have been a valuable source of data for determining the relevance of ELB on board. For instance, asking why did the functionality of having real time shore-monitoring was useful or not could have given more insights on the reason for their choice. The only question of this sort asked why the submitter thought that ELB was not implemented on board. However, those types of questions would have been difficult to process, each submitter would have their own individual opinion. Fortunately, the open question “additional information” at the end of the survey proved to be valuable for that purpose as submitters spontaneously expressed the causality behind their opinion.

2.3 Results of the survey

2.3.1 Company

In total, 4 companies were contacted over the course of 3 months. (December to February). Out of 252 responses, 63 were received from DEME, 54 from JDN, 37 from EXMAR and 86 from Bocimar. Since the survey was also shared on LinkedIn, 11 responses were collected from other companies. It is important to note that having defined a population of 2054 seafarers, the 252 received responses represent 12,3% of the total population. However, since only a few selected companies were contacted, the sample has not been selected randomly. The relative share of responses shown in table 2 displays that 46.6% of respondents work for either JDN or DEME. Both companies are heavily involved in the dredging sector which was important for the third part of this study where focus will be directed at implementation on board dredging vessels.

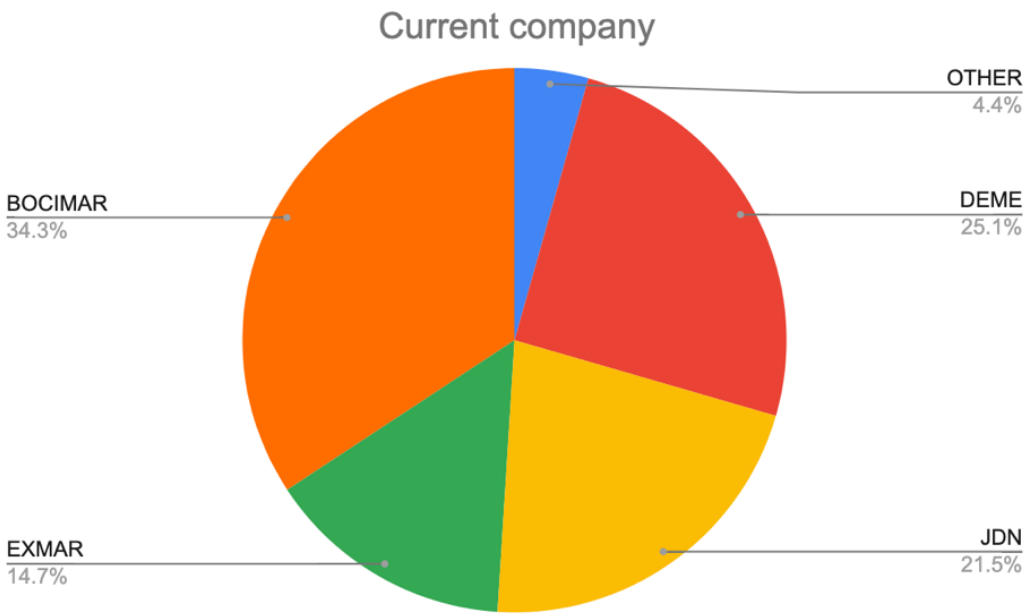


Table 2 Relative frequency of companies

(Source: own survey)

2.3.2 Vessel type

It is however important to note that although submitters sailing on dredging vessels are the most represented as shown in table 3, they only represent 40.8% of the results as JDN and DEME are also involved in the offshore sector. Therefore, 18 submissions were recorded for seafarers working on offshore ships. Bocimar and EXMAR only operate on one vessel type, respectively ulk carrier and gas carriers. In order to be as precise as possible the gas carrier category was divided in two sub-groups (LNP and LPG). However, having received more submissions from Bocimar, the second most represented vessel type remains bulk carrier. Looking at table 3 it is clear that the vessel type is very concentrated between dredger and bulk carrier accounting for 75,2% of submissions when combined.

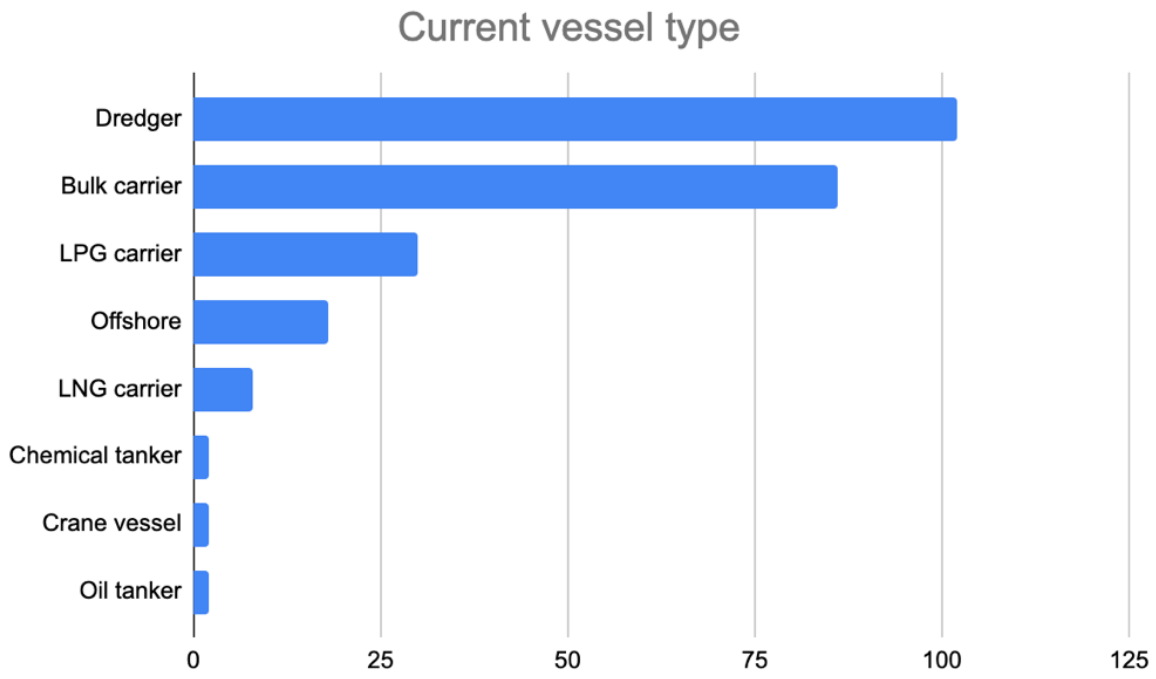


Table 3 Absolute frequency of vessel type for each respondent

(Source: own survey)

2.3.3 Years of experience as a seafarer

One of the hypotheses deducted from part 1 of this research was that, seafarers who have been sailing for a long time, would be less inclined to transition to a digital record solution. In order to understand if experience was a determining factor for the validation of the implementation of the ELB on board, it is important to get point of views from both experienced and inexperienced seafarers. Submissions displayed in table 4, show that 159 respondents had more than 10 years of experience, representing 63,9 % of results. Looking at this result indicates that additional brackets should have been created for tiers above 10 years in order to get a more accurate description of submitter's experience. Furthermore, the bracket design should have been clearer since multiple tiers could potentially be checked for a submitter finding himself between two brackets. For example, somebody having 3 years of experience can both check the bracket 1-3 years and 3-5 years, constituting a significant question design flaw.

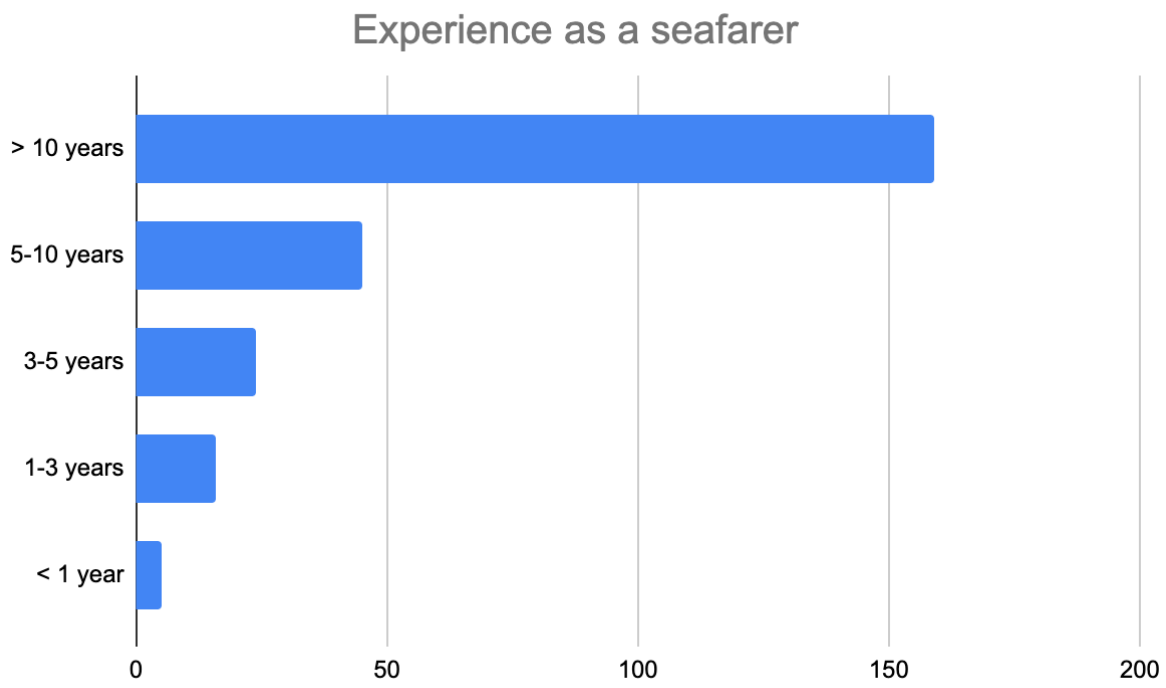


Table 4 Absolute cumulative frequency of years of experience

(Source: own survey)

2.3.4 Position on board

The survey focused on seafarers having a position on the bridge or engine department. They are directly responsible for record keeping on board. Table 5 shows that 50 submitters are masters and 46 are 2nd officers. 13 submitters responded with something else than a deck or engine position on board as a current position, and were therefore not taken into consideration in further data descriptions. When representing sector proportion for each position in table 6, we can see that Masters, 2nd officers, Chief engineers and Chief officers are all representative of the 3 major sectors; namely dredging, bulk and gas transport, with a larger proportion of masters in the dredging sector. However other positions such as 3rd officer and other engineering position are not so homogenous.

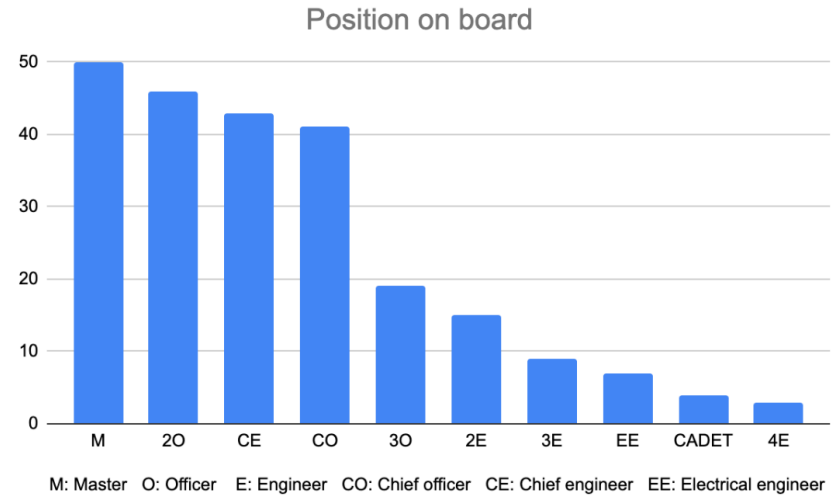


Table 5 Absolute cumulative frequency of position on board

(Source: own work)

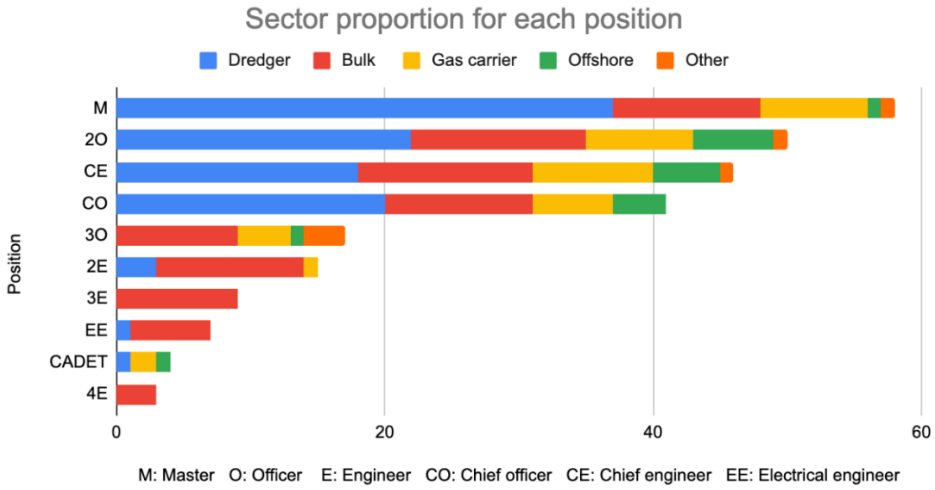


Table 6 Proportion of each maritime sectors according to position on board.

(Source: own survey)

2.3.5 Knowledge on the ELB

After the recent regulation concerning electronic MARPOL record keeping, it is interesting to see how aware seafarers are of that solution. It must be noted that although the regulation has been out for a year, most seafarers are not aware of the existence of the ELB on board merchant ships as shown in table 7. Furthermore, out of the 252 submitters only 15 had experience with some form of electronic logbook system on board as shown in table 8. Out of the 70 submitters who did hear of ELB before this survey, the most common form of channel was by far, speaking with other professionals constituting 49,2% of the entries as shown in table 9. For this question, multiple entries could be submitted and it is worthy to mention that most submitters heard of ELB through multiple channels.

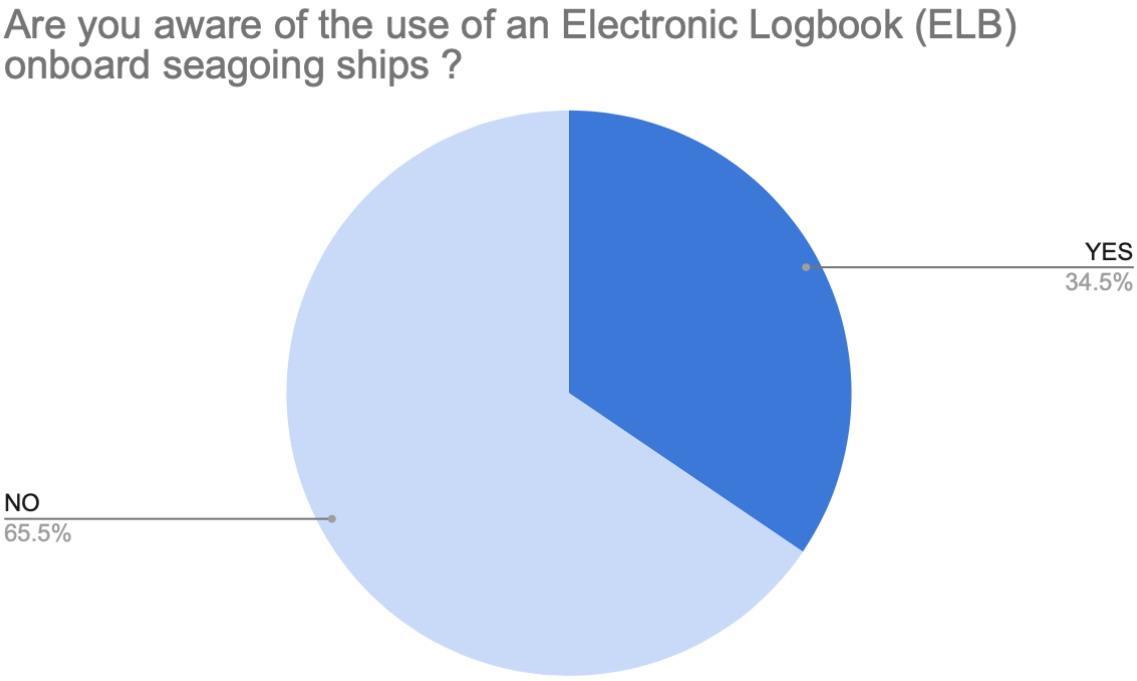


Table 7 Awareness on the use of ELB on board

(Source: Own survey)

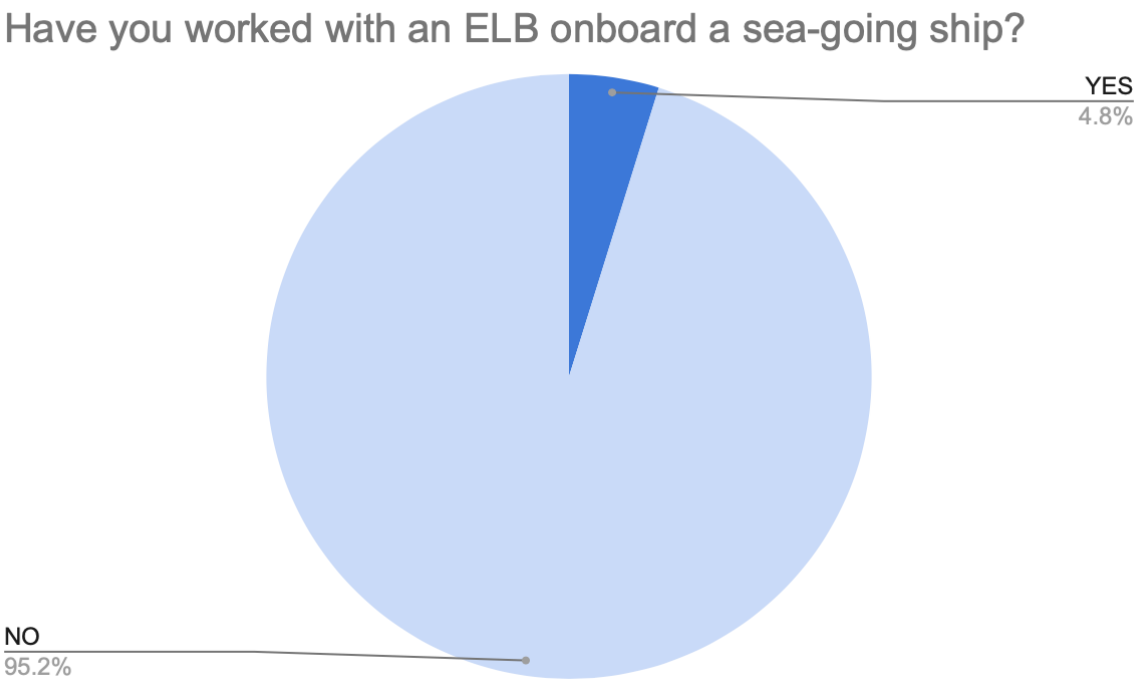


Table 8 Relative submission frequencies regarding ELB knowledge and use on board

(Source: own survey)

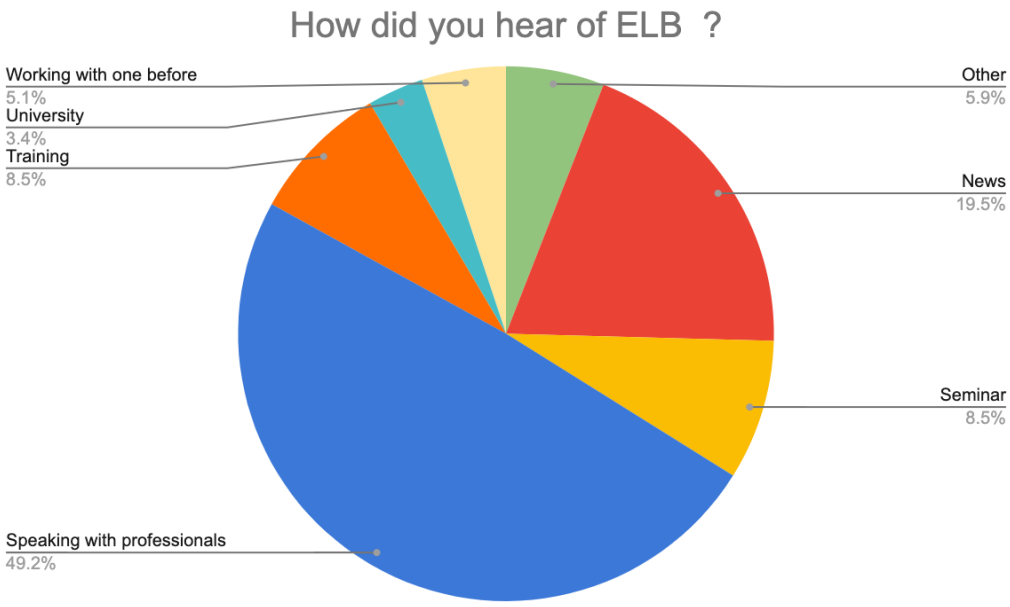


Table 7 Relative frequencies of ELB channel information

(Source own survey)

2.3.6 Functionalities

This section of the survey focused on giving the submitter a brief description of the ELB functionalities that were discussed in the introduction of this research. In order to maintain an impartial approach, 8 questions about functionality are presented in a neutral statement as shown in figure 14. The purpose of this was to assess the relevance of the ELB system from an operator's point of view before measuring their interest for such system on board. Even though the option was left to not answer the functionality questions, the average submission rate for all 8 question is 98,9% with the lowest, being question 4, at 98%.

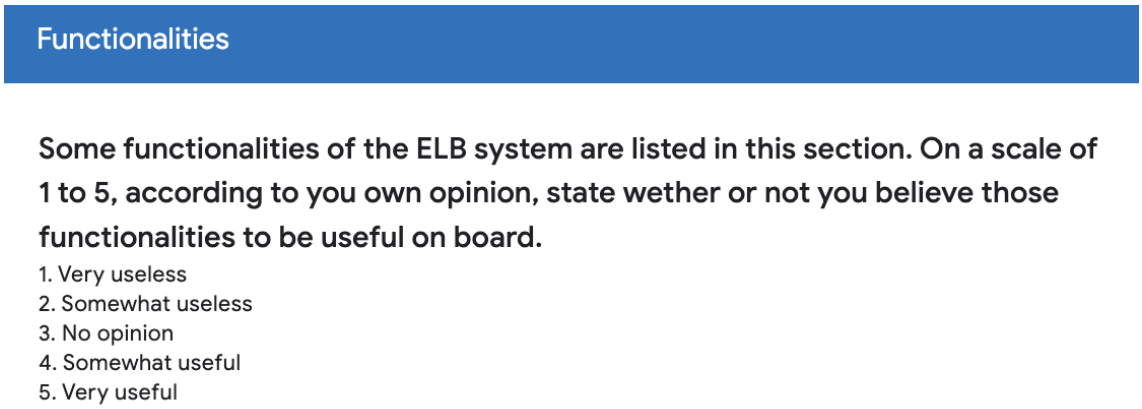


Figure 14 Header statement preceding the functionality questions

(Source: own survey)

Questions presented to submitters are displayed on the next pages, key words have been highlighted in blue to give the reader a concise view of the examined functionalities. Considering Table 8 and 9, it is clear that the vast majority of seafarers find the presented functionalities either useful or very useful. For question 1 to 4 the results are very homogenous. On average, 85,1% of submissions are either "Very useful" or "Somewhat useful". Moreover, the share of "no opinion" is, for every question, always greater than the "Somewhat useless" or "Very useless" portion.

Looking at table 10 however, we can clearly see a similar pattern as for question 1 to 4, however, the average drops to 75,7% for questions 5 to 8. Question 6: "The ELB data can be automatically relayed ashore in real time allowing for trouble-free monitoring" displays much less unanimity.

The submitted answers clearly show that for this population sample there is little debate concerning the usefulness of the discussed functionalities. Results show a significant consensus for question 1 to 4: logbook centralization, automatic logging, search function and automatic data report are found to be useful functionalities. Furthermore, functionalities of question 5, 7, and 8: automatic back up, electronic signature and the ability to link other programs are also considered to be useful. Looking at these results, it is safe to conclude that according to seafarers, the ELB system as a whole, brings useful functionalities on board. However, looking at question 6, seafarers find that the fact that ELB data can be relayed ashore in real time not a useful functionality. This could be explained since real time shore side monitoring would allow the shore team to expand their influence in the ship's daily operations. Operators might feel like it gives shore staff too much control resulting in a "Big brother" type of scenario, where the company would be constantly monitoring the ship's parameters thus restricting the role of officers on board. In order to confirm this theory, this issue will be examined in part 3 of this research where interviews will be conducted with maritime professionals of the dredging sector.

- **Question 1** The ELB allows the centralization of all logbook records into one system. Meaning all logs from the engine and deck department are accessible on any computer running the software.

- **Question 2** If connected to other systems such as GPS, Navigational software, ER monitoring system or cargo software, the ELB software can log entries automatically while still requiring acknowledgement thus avoiding mistakes.

- **Question 3** A search function is integrated into the ELB software allowing to look up any entries from all logbooks

- **Question 4** The software creates automatic data reports and daily reports which can be exported into other programs.

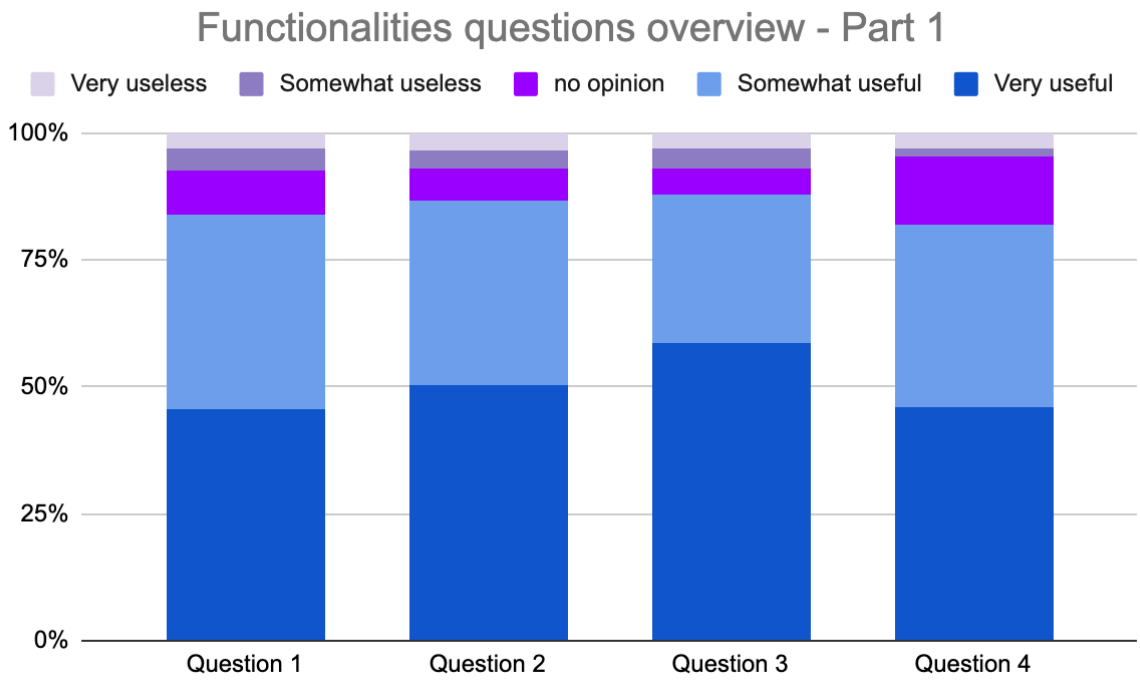


Table 8 Relative frequency of answers for questions 1-4 on functionalities

(Source: own survey)

- **Question 5** The ELB software can be linked with other operational programs such as the maintenance log allowing for a centralized access to information.

- **Question 6** The ELB data can be automatically relayed ashore in real time allowing for trouble-free monitoring.

- **Question 7** ELB data can be automatically backed up and archives can be accessed by as search tool.

- **Question 8** The ELB allows the master to electronically approve and sign all daily entries.

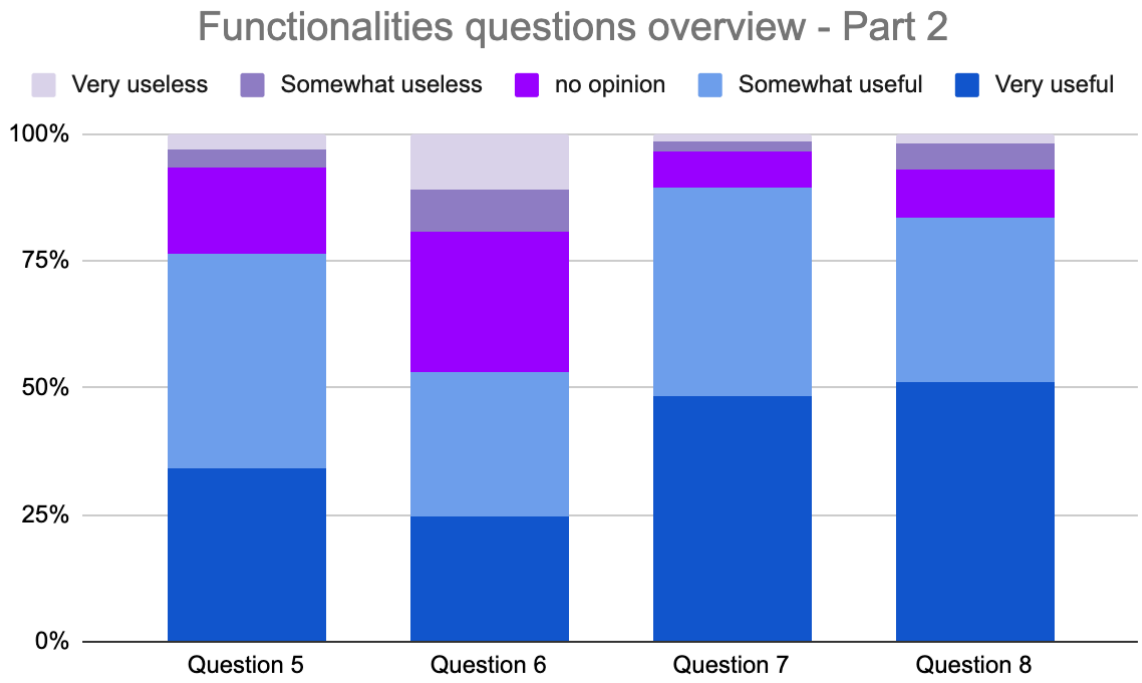


Table 9 Relative frequency of answers for questions 5-8 on functionalities

(Source: own survey)

2.3.7 Interest

The survey was designed to assess the knowledge and interest of seafarers for the implementation of ELB on board. The "Functionalities" section constituted a base in order to give context to seafarers regarding the ELB system. Besides rating the functionalities, it was also necessary to establish whether or not seafarers considered the ELB as a plausible efficiency gain and whether or not it could bring positive outcomes for their jobs. This section contains 4 statements that must be answered using a scale of aggregability from 1 to 5. Fill rate and question design remain the same as for the "Functionalities" section (>98%).

The first statement: "Errors while filling the logbook are common on board" as shown in table 10, indicates that a majority of the sample agrees with the statement (57,3%). This question was asked to verify that having a paper logbook could indeed cause filling errors.

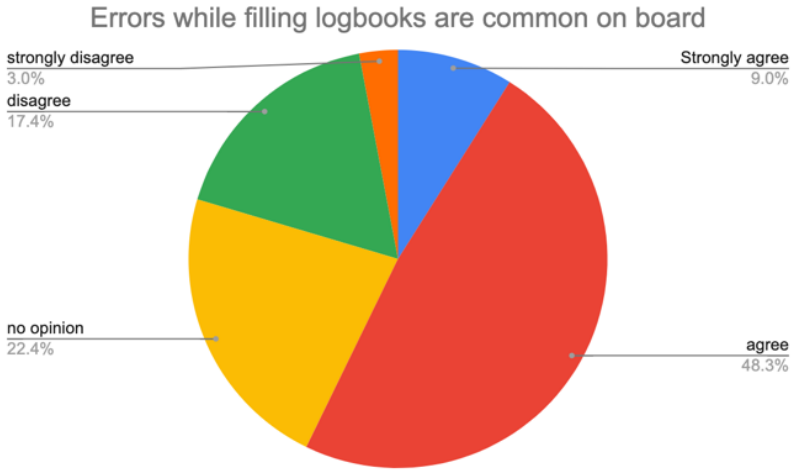


Table 10 Errors while filling the logbook are common on board, cumulative frequency

(Source: own survey)

The 3 remaining statements as shown in table 11, 12, and 13 all show that installation of an ELB software would be positively received by seafarers on board. 59,7% of submitters agree or strongly agree that an ELB system will have a positive impact on the operation of the vessel and 61,7% agree or strongly agree that ELB will make life easier for officers. It is worthy to note that the disagree and strongly disagree submissions represent a very small fraction of the submissions since the no opinion answer represents a consequent portion of the answers. 30,8% for table 11 and 26,9% for table 12. The most important statement of this survey "I would like to work with ELB on board" received a strong majority of positive answers. 71% of submitters agree or strongly agree with this statement.

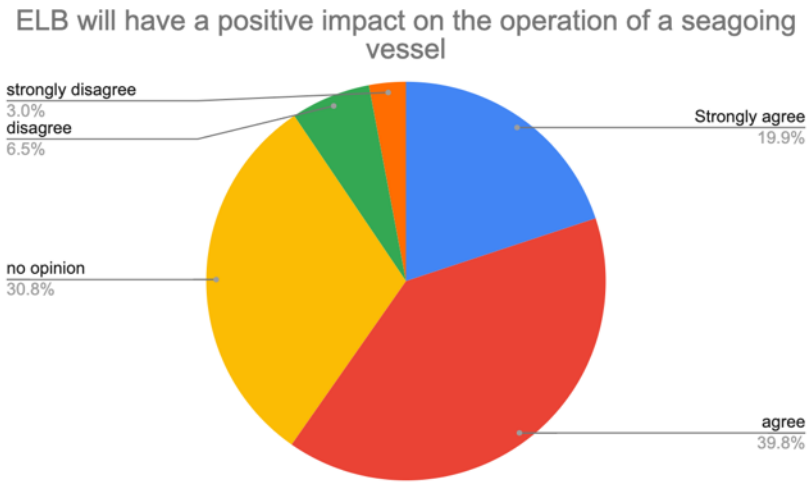


Table 11 ELB will have a positive impact on the operation of a seagoing vessel cumulative frequency

(Source: own survey)

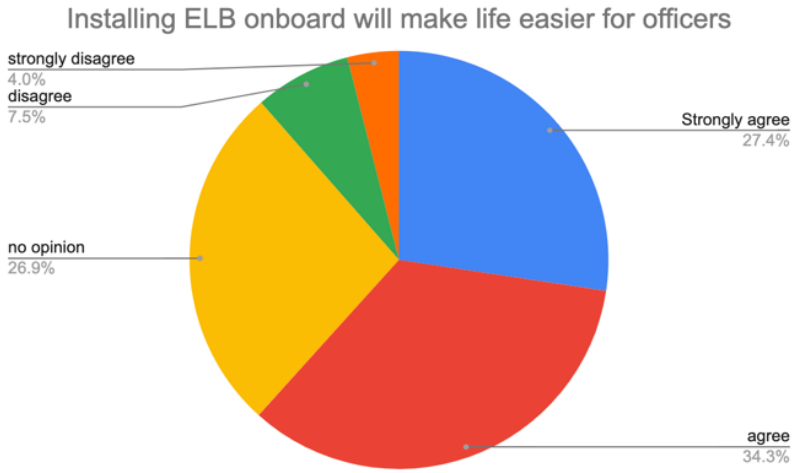


Table 12 Installing ELB on board will make life easier for officers, cumulative frequency

(Source: own survey)

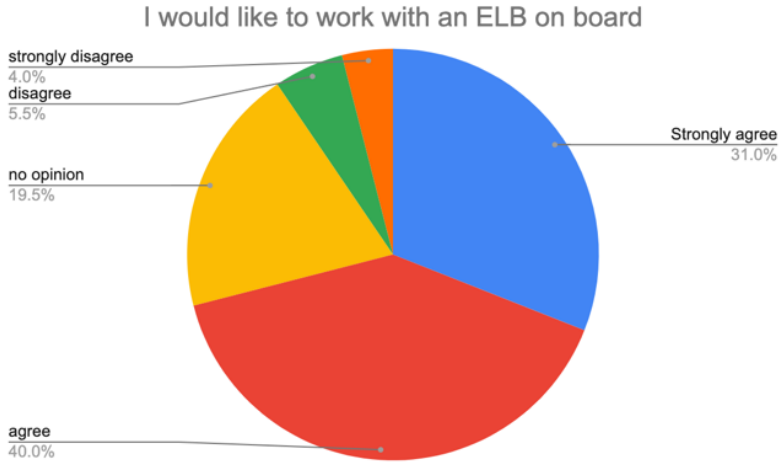


Table 13 I would like to work with an ELB on board, cumulative frequency

(Source: own survey)

2.3.8 Implementation

The question of table 14: "Reason why ELB is not yet implemented on board" gives us an outlook at the point of view of submitters on this matter. This question was designed as a multiple-choice answer where submitters could choose from a list of answers. This was done in order to facilitate the manipulation of the data afterwards, since an open question would have generated a lot of different answers. Most submitters checked multiple answers therefore, a total of 517 entries were received. When looking at table 14, we can clearly see that there is no unanimous answer. Lack of implementation is not due to a single factor but a lot of different ones.

Some insightful answers were given in the "other" answer, which was left blank for participants to add an information they felt was missing from the list. Here are a few of these comments:

- *"Port states worldwide is an enormous challenge."*
- *"Biggest issue will be to convince Class to use these ELBs"*
- *"It's an additional thing that runs electronical & most likely via internet and as long as poor internet is on board vessels it will not work"*

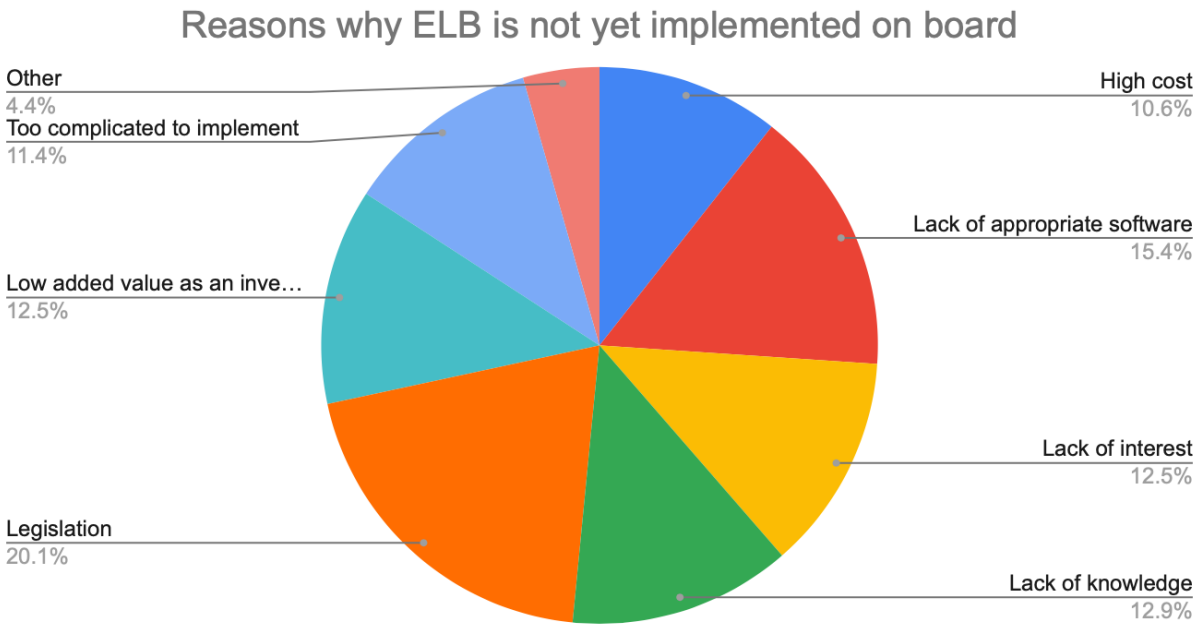


Table 14 Reasons why ELB is not yet implemented on board, cumulative frequency

(Source: own survey)

2.3.9 Additional comment section

The last section contains an open question for submitters to add any comment they felt was necessary. The instructions were left intentionally blank in order to give submitters the option to express themselves freely. Although, most submitters left this section blank, a total of 38 comments were received. Out of the total comments, 13 gave a positive feeling about the ELB implementations:

- *"One centralized system for all logbooks would be a great improvement"*
- *"Everything will become digital. That's just the way the world is headed. Since I've started working here, crew evaluations and QHSE have been digitalized. Both were an improvement"*
- *"Administration work will become easier and officer/engineers can focus on practical things and they'll have more situational awareness."*

10 comments had a more negative feeling towards ELB. The most common reason was the difficulty of implementation. Indeed, a lot of submitters feel that the digital tools on board are not adapted to work for such a system. A lot of comments mention that instead of reducing the workload, the ELB will instead increase it because of a long implementation period where both paper and electronic logbook will have to be kept simultaneously:

- *"Everything must be filled in manually in the very slow computer, and it takes hours. Therefore, it makes it really easy to take the old-fashioned paper log book and to write inside with a pen."*
- *"ELB should reduce workload not just add additional burden by creating huge reporting (keep it simple). Nowadays all new systems have very poor human interfaces and require numerous unnecessary information".*
- *"Main Issue: due to slow computers on board, the simple job of a written log book entry will turn into an additional burden."*
- *"With a multitude of manufacturers (bridge systems, DCS, engine control systems etc, a real implementation and joint use is still far away. The initial steps will be a big pain... Hence my low enthusiasm in implementation."*

A number of statements also revealed some important factors to take into consideration for ELB implementation: ICT infrastructure and training, user interface and cyber-security threats, and system integration were also mentioned.

2.4 Result analysis

2.4.1 Lack of unanimity between sectors

Out of the entire surveyed population, only a small margin of submitters disagree or strongly disagree with the interest statements. As shown in table 15, 11,3% disagree or strongly disagree with statement 1. “Installing ELB on board will make life easier for officers”. It is also important to note that most submitters who disagree with this first statement usually disagree with the rest.

	1. Installing ELB onboard will make life easier for officers	2. ELB will have a positive impact on the operation of a vessel	3. It is useful to install ELB on board	4. I would like to work with an ELB on board
Disagree and strongly disagree	**23**	**19**	**20**	**19**
Relative percentage	**11.3**	**9.4**	**9.9**	**9.4**

Table 15 Seafarers disagreeing with the interest statements

(Source: own survey)

When looking at the kind of ship, those seafarers work on in table 16, we can see that the offshore sector holds an important share compared to the relative frequency of the entire sample of table 18. While the offshore sector only represents only 7,2% of total submissions, 26,1% of seafarers who disagreed with statement 1. come from the offshore sector.

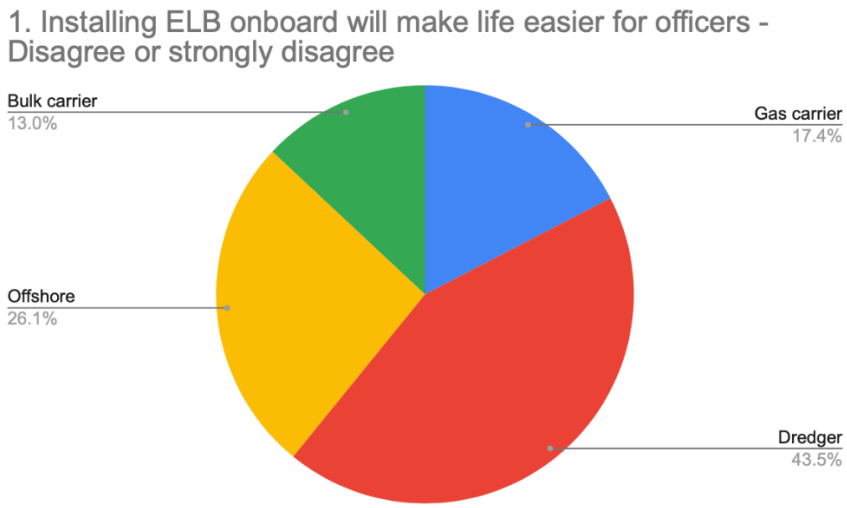


Table 16 Current vessel type for seafarers disagreeing with statement one, cumulative frequency

(Source: own survey)

It is even more noticeable for the statement 4. "I would like to work with ELB on board", Table 17, displaying the vessel type of submitters who disagree with statement 4. shows that the offshore vessels represent 42,1% off all submitters while the bulk carrier sector only represents 10,5%.

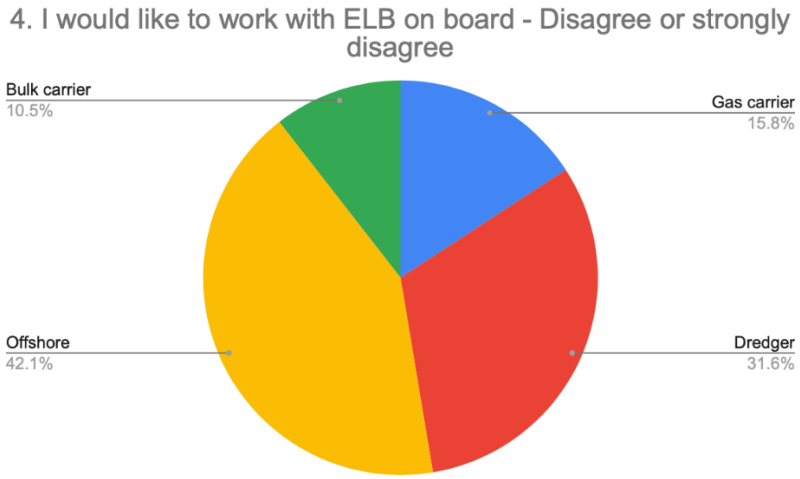


Table 17 Current vessel type for seafarers disagreeing with statement 4

(Source: own survey)

When compared with the current vessel type of the entire sample in table 18, we can see clearly that despite representing only 8%, the offshore vessels are largely represented by disagreement with statement 1. and 4. The opposite is true for the bulk carrier sector. Representing 34,4% of the entire sample, their share of disagreement for 4. Is only 10,5%. This shows that although a majority of submission want to work with ELB, some maritime sectors like the offshore might be less inclined to do so.

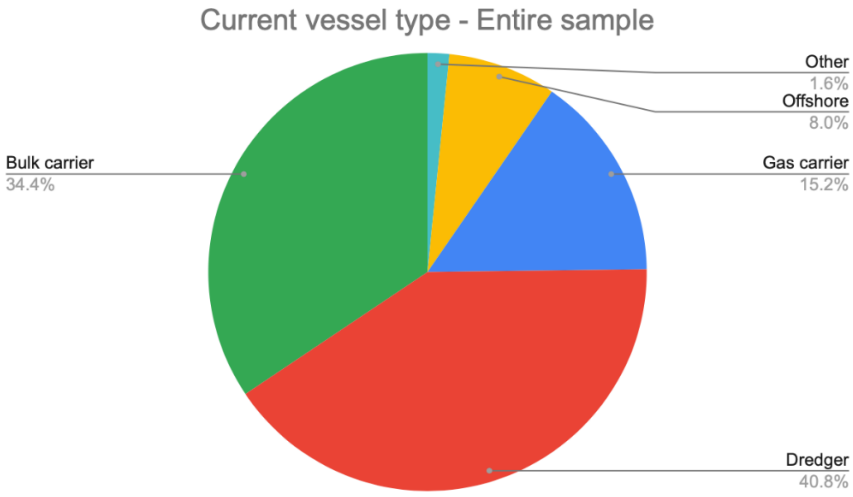


Table 18 Current vessel type - Entire sample, cumulative frequency

(Source: own survey)

2.4.2 Lack of knowledge

As discussed earlier, ELB experience is almost non-existent amongst seafarers operating on Belgian vessels. Out of 252 submissions, only 12 persons had previously worked with an ELB software on board vessels although the technology has been available for many years. The majority of submitters (65,5%) are not even aware of the existence of an ELB software on board seagoing vessels. It is also surprising to see that the main source of information seems to be the word of mouth between colleagues, representing 49,2%, while news and training represent only 19,5% and 8,5% of the information source. Moreover, when looking at the knowledge level of submitters who did hear of ELB in table 19, we can see that only 15,7% of them report being very familiar or fully familiar with the concept. This shows that despite showing great interest for this technology as demonstrated with the "interest" section of this survey, there is a lack of awareness from officers.

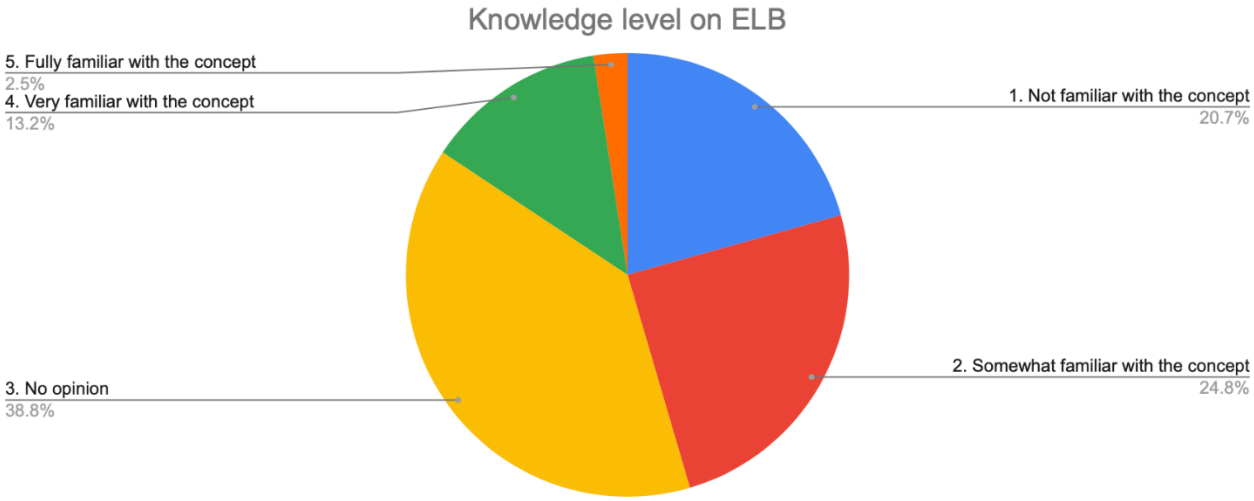


Table 19 Knowledge level of submitters who heard of ELB, cumulative frequency

(Source: own work)

2.4.3 Useful added functionalities

ELB brings a lot of useful functionalities on board according to operators. Out of the 8 assessed functionalities 7 of them were found unanimously to be somewhat useful or very useful. The most appreciated functionality is the search function with 58,8% of submitters finding it to be very useful and 29,1% finding it somewhat useful which clearly shows the enthusiasm for such a feature. The ability to log entries automatically is also found to be 86,5% somewhat useful or very useful and the ability to digitally sign the logbook for the master 83,5% somewhat useful or very useful. However, question 6 "The ELB data can be automatically relayed ashore in real time allowing for trouble-free monitoring." did not receive such unanimous responses. There is a fear that allowing data to be relayed ashore would give too much control to the company since the shore offices will gain even more access to the on-board operations of the ship, reducing the autonomy of officers. This fear of a big brother scenario was also confirmed in the comment section where many comment went in that direction:

- *"An ELB would make things way more difficult. VDR is already collecting all necessary data. Giving more remote control and vision is already killing our job."*
- *"With all data becoming directly available, I have a fear of micro 'management' from side who is 'monitoring' / receiving the data."*
- *"It's only a tool to monitor the crew"*

These comments point out the divergence of interest that can exist between the on-board crew and the shore offices of the maritime companies. Having shore connectivity is a key advertising point for NAPA logbook on their website, we can assume that this is a feature wanted by shipowners. Although this survey only assesses the point of view of ship operators, those comments show that even if ELB could be beneficial as a whole in terms of functionalities, some submitters believe that it could potentially go against the officers' interests when used to remotely manage the ship.

2.4.4 Strong interest and seafarers' insight

The survey results also show that a majority of submitters would like to have an ELB system on board. 51% agree or strongly agree with the statement "I would like to work with an ELB on board" and only 9,5% disagree or strongly disagree with it. We can therefore conclude that despite the challenges ELB installation can face, seafarers will welcome it positively. The 38 individual comments received from the "additional comment" section also show a strong engagement from seafarers. While some purely negative comments where received, most comments explained that they agreed with the concept but gave reasons why they think it will not work. This amount of feedback also shows that seafarers feel directly concerned by this technology since it is something that will directly impact their job. Most comments, positive or negative, gave some insight as to what kind of challenges ELB could face when implemented on board. Many submitters believe that the ELB system could potentially increase the workload of officers on board depending on different factors not only related to the ELB software itself. This is why 26,9% of submitters expressed no opinion for the statement "ELB will make life easier for officers" because, a successful ELB implementation does not only depend on the quality and the ease of use of the software but on a lot of other factors. Quality and reliability of computers on board, quality of integration with other system or acceptance by port state control also have to be taken into consideration when looking at the bigger picture. If maritime companies do not take all factors into consideration, this could increase the workload for officers.

2.5 Conclusion

The ELB system is an automated software, integrated with existing digital sensors, designed to increase the efficiency of the labor associated with the numerous record-keeping requirements on board sea going vessels. The aim of this survey was to get an operator's perspective on the ELB system by assessing the knowledge level and interest of officers sailing on Belgian vessels. 252 responses were obtained from seafarers working for 4 major Belgian companies operating in the gas, bulk and dredging sector. The survey results show that there is a lack of knowledge for this system. Almost no seafarers had previous experience with an ELB software on board and only 34,5% of them heard about its usage for sea going vessels. Out of the 70 officers who did know about its existence, the most common way they heard about it was speaking with other professionals. The ELB has therefore not yet received much attention from officers of the surveyed companies. When questioned about the main functionalities, the majority of submitters found them to be very useful or somewhat useful which shows the relevance of such device on board. The fact that 71% of submitters would like to work with ELB on board also shows the strong interest for this system. However, when looking at individual sectors, it seems that the Offshore sector is not as keen for implementation. While only representing 8% of the total surveyed population, the sector represented 42% of the total disagreement when asked if submitters would like to work with ELB on board. The survey results also showed that despite a majority of submitters, willing to work with ELB on board 26,9% of submitters have no opinion on the statement: "ELB will make life easier for officers". A number of comments also pointed out the difficulty of proper implementation. The possible lack of proper ICT installation, the lack of integration with other systems due to the multitude of systems from different manufacturers or the lack of acceptance from port state control could all result in an increased workload for the officers. There is also a fear that, through increased shore connectivity, the ELB will allow micro-management from shore offices. While this survey shows that the majority of seafarers are eager to install ELB on board, the challenges should not be overlooked and companies will have to address those issues for a successful ELB implementation.

Part 3 Application on board dredging vessels

3.1 Introduction

The ELB system has been proven to have a potential application on board merchant vessels. As demonstrated in part one, it does not only substitute the traditional paper logbook but also brings additional features, allowing for the automation of record keeping, simplifying the administrative burden for officers and reducing their workload. Nevertheless, this software would incur an additional purchase cost for ship owners, when productivity gains are still unsure. Part 2 of this study clearly demonstrated, through a survey, that officers working on Belgian vessels are eager to work with such a system on board. A lot of questions about its implementation still remain, but officers approve of the additional features the ELB system would bring to record keeping. After determining interest of seafarers, this study will attempt to determine if the features described in part 2 could be implemented in the dredging sector. In order to achieve this goal, a number of interviews were conducted with maritime professionals working both at sea and ashore in order to obtain their opinion on the advantages and disadvantages the ELB can have for the sector. The interviews will focus on what impact the ELB system could have on the administrative overload by assessing its functionalities and looking at similar digital systems that are currently being used on board. Interviews will also determine the possible limitations the ELB system could face regarding implementation and approval by port state control and flag state administrations.

3.2 Methodology

3.2.1 A focus on the dredging sector

Dredging is the process of removing material from, rivers, sea or oceans in order to deepen waterways or to reclama land. A lot of different dredging installations exist, the most common one being cutter suction dredgers (CSD) and trailing suction hopper dredgers (TSHD). Those two types of installations, equipped to sail on oceans are therefore classified as SOLAS vessels meaning that they have to abide by the same IMO regulations as merchant vessels. The dredging sector represented in 2019, 18% of the Belgian fleet in Gross Tonnage (GT)[44]. This maritime sector is very competitive in terms of innovation and technologies due to the limited number of companies sharing the market and the level of complexity of the projects. Dredging companies have to stand out through ship features, design and system integration, meaning that different components form different manufactures are aligned with each other to create a more optimal design, in order to get a competitive edge[45]. The ELB, being an innovative solution to improve system integration on board, would certainly interest dredging companies that are trying to become more competitive. Furthermore, unlike conventional merchant ships sailing from point A to B to transport cargo, a dredging vessel will often sail around a same site for months in order to complete a project thus having a very different use of the logbook. Despite having a work of very different nature, dredging vessel must comply with the same rules as traditional merchant vessels. If we take the example of a standard trailing suction hopper dredger, the dredging cycle is to sail empty to the dredge area, start dredging, sail full to the dump area and sail empty again, continuing until the end of the project, only stopping for bunker operations and major repairs. Due to the nature of the dredging work, even though the deck logbook has to be filled according to SOLAS requirements, the information recorded does not have the same relevance because precise data is already being recorded for the dredging operations. Dredging vessels would therefore be more inclined to increase automation of the logging process, by switching to a paperless solution.

[44] Royal Belgian Shipowner's association, *Economic impact study Belgian shipping cluster*.
[45] Murat Tarakci et Jan van de Ende, *The Dutch and Belgian Dredging Industry An Exploration of the Future*.

3.2.2 Interview Design

DEME and Jan De Nul, the 2 Belgian dredging companies, were contacted in the end of February 2022 to establish appointments over the course of March 2022. Contact was established by e-mail thanks to the promotor of this thesis who had previously worked as a deck officer for Jan De Nul. Requests were sent to both companies, to interview officers sailing on dredgers as well as staff members working ashore in the maritime department. The goal was to get an operator's perspective as well as a managing perspective. For the interview style, it was decided to keep an informal approach, asking open ended questions where the interviewee could elaborate on his own experience or opinion. A main axis as well as some specific questions were thought through in advance, depending on the profession and rank of the interviewee. Questions were also reviewed by maritime professionals in order to assure their quality. All of the prepared questions were designed using the research of part 1 and 2.

3.2.3 Data analysis tools

The unstructured interview format was preferred for the flexibility it offered in terms of questions. This format also has the advantage to make respondent more at ease, giving them the opportunity to give more details and nuance to their answers. However, this method can make it difficult to compare responses between participants, making the analysis more challenging. In order to accurately compare and analyze responses, every interview was recorded and transcribed using a web based automatic transcription software called Otter.ai. Transcriptions were sorted using a qualitative data analysis program called ATLAS.ti, which allows the user to annotate responses with code words, to quickly make links between data and find the relationship between them.

3.2.4 Interview responses and Anonymity

A total of 5 interviews were held over the internet, using a video conference tool (Microsoft Zoom) during the month of march 2022. 4 of them were held with maritime officers working on board dredgers and 1 of them was done with a staff member working in shore offices. In order to preserve the anonymity of the participants, no information will be given regarding their personal information or their company.

3.3 Interview outcome

3.3.1 Record requirements and administrative workload

As any SOLAS ship, a dredging vessel has a lot of recording requirements: MAPROL record books, deck log book, GMDSS record book but also hours of work and hours of rest, safety checklists related to life saving appliances and firefighting equipment. Furthermore, as per company requirements, dredgers have extensive cargo records to keep up to date. The loading operations of a TSHD, time sailing empty, time to load, time to sail full and time to discharge are traditionally recorded in a paper logbook. This can become quite time consuming since a TSHD can do more than 10 cycles in a 24h period.

"Every loading operation has to be entered in the logbook, and we do a number of 14 to 15 trips per shift of 12 hours. So that is 14/15 times loading, dumping etc... This should all be entered in our logbook, so it's rather full by the end of the day." (Captain, 21/03)

Because of all these record requirements, crew members need to dedicate a consequent amount of time to the administrative workload. This is particularly true for the captain who must spend most of his time on administration.

"*Before, a captain's job was 40% paperwork and 60% productivity on deck; nowadays 80% is paperwork." (Captain, 24/03)*

Because of the numerous regulations and company requirements, officers have the feeling that too much of their time is spent filling up paperwork instead of concentrating on improving things on deck. This is particularly concerning because the time they spend on administration does not directly add value to the dredging production,

"We need to lower the [administrative] burden or no joke, start getting an administrator on board. It would get the mates to sail. Before, when you were second mate, you really could train a lot. Now it's a lot less because there is this burden. And then when they become first mate, they don't have this burden of the administration. But they have to sail for 12 hours and be confronted with a lot of other things. Now the office always says, you're their captain so you can sit behind the wheel and show them, but then they forget they also send 12 hours of administration to our desk." (Captain, 10/03)

Although the amount of administrative work is unlikely to decrease in the future, companies should focus on finding ways to make it more efficient. Every interviewed seafarer mentioned that although more and more systems are being digitalized and ships have access to the internet for sharing data with the shore, there has not been a reduction in workload for officers. Some attest that complying with company policy requires unrealistic jobs to be performed.

"If we really want to do the thickness measurements, according to the company rules, I need one guy, 10 hours a day, 360 days per year, because they want the data." (Captain, 10/03)

Furthermore, with the arrival of internet on board, emails seem to be the main channel of shore-ship information exchange. Recuring documents such as, crew change documents, contracts, certificates, timesheets or operational records add up to a consequent number of emails. An interviewed captain reported getting around 70 emails a day. The inability to cope with the flow of emails or email overload can have serious consequences for employees. Studies have demonstrated adverse effects such as anxiety, loss of control, task fragmentation or even e-mail addiction[46]. In order to reduce the email flow, a solution proposed by a captain would be to have recuring documents on a cloud-based system that way the necessary staff members could have direct access to it.

"In my age we used to write letters that were mailed by post. And now imagine if the office would do the same, right? They wouldn't write 70 emails a day to everybody. We had this mindset before and I want to go back to that mindset, focus and get things done and give access to everybody who needs the info. Once it's in the cloud, everybody can read it, even for port state control, you have a pre-audit from the head office, okay, they have access to the system." (Captain, 10/03)

[46] Kim McMurtry, « Managing Email Overload in the Workplace ».

According to the 2nd officer, logbook records such as the deck logbook or the GMDSS logbook could also benefit from being digitalized. Since most records occur at regular intervals, and require similar information to be logged every time, they could easily become automated.

"For example, some record documents, you have to fill in every time again name of port, time, name of vessel, callsign of the vessel. These cells could be prefixed. Some documents you have to fill it again and again the same parameters every time. If you look at the GMDSS logbook: it's one page, but every day you write the same information. If you could have a way of doing it digitally it would be beneficial. Actually, I would be in favor of having it in a digital way" (2nd Officer, 14/03)

3.3.2 Limitations of the deck logbook

During dredging operations, deck logbook records such as latitude, longitude, course and speed are not recorded because the ship is constantly maneuvering. Instead, the officer in charge of record keeping must write down a sentence such as: “Engaged in dredging operations as per dredging plan” for the entire dredging period. However, information such as meteorological observations, safety drills, bunkering are still being recorded. But unlike information contained in the cargo record book, the deck logbook has no practical use for operators. It is not used to improve the dredging operation nor the productivity. However, the ship is still required to keep the deck records for a minimum of 5 years on board. In case of an accident or during a port state control inspection, records can be used as evidence to prove that the ship complied with international regulations.

“Most of my logbooks are gathering dust in my office, in the cabinet, but yeah, it's a requirement. So, we have to do it. Also, when all goes well, we don't need the logbook but in a matter of emergency then all of a sudden it becomes very important. Also nowadays, we have the VDR, everything is being reported. So, the importance of the logbook becomes less and less because now first thing they're going to ask in an incident is to pull VDR data and let us see what has been going on for the last hour. This is becoming an overlap.” (Captain, 21/03)

One argument that has been made multiple times concerning record keeping in general is that the disparities in handwriting can make the logbook difficult to read. Especially since dredging vessels in general operate under a multi-national crew. This is particularly problematic when data has to be retrieved for inspections or internal audits.

“My biggest issue sometimes is that not everybody has the nicest handwriting. Sometimes I spent more time figure out what is written in the logbook, since everybody has a different way of keeping records or setting dates differently. That's one of my pet peeves, I want the data to be written correctly. I see this not only in log books but also in our safety meetings and our tool boxes and stuff. It should be in uniformity and I think that a digital book can help with this, to keep uniformity around the whole system. In that way can be a big improvement for me.” (Captain, 21/03)

3.3.3 Automation of the cargo records

Dredging vessels have extensive operational record requirements as explained earlier. Dredge cycle records (dump time, dredge time etc.) and production values must be recorded frequently. This information is usually taken from the user interface supervisory control and data acquisition system (SCADA), a system composed of computers, sensors, a user interface and

commands which monitors the entire dredging installation. The SCADA is used by the dredging operator on the bridge to monitor and control every step of the dredging process. Production values relative to the performance of the ship such as density, pump revolutions per minute, or fluid velocity are also calculated by this system and displayed to the dredging operator. Although production values are automatically logged by the SCADA, the dredge cycle values, still have to be manually recorded by officers. This process is rather inefficient because it requires the 2nd mate to go to the bridge at every stage of the dredging process. During an interview with a captain, he used the analogy of a car factory to describe this logging process:

"I think if you check General Motors, or Ford, they produce cars. There is nobody writing down: five minutes to install door, 10 minutes to install mirror. And that's how we did it before in dredging, when the conveyor belt moves forward it means that this process is done. So, it's the same with the sequence of dredging." (Captain, 10/03)

Some dredging companies have very recently set up an automatic electronic dredging cycle record book (CRB) which acquires data directly from the SCADA system thus reducing the workload for officers who previously had to record everything manually. The data can then be exported to an excel file in order to be sent to the relevant personnel.

"Before the CRB system, everything related to the dredging cycle was manually inserted by the second mate into an Excel file. And now the CRB system is getting most information directly through the SCADA system, which is the dredging, operating console system and it helps a lot. We actually don't have to do so much work as we used to do before. A lot of it is now automated and at the end of the dredge day, we can actually generate the Excel file that we used to insert manually, we can extract it through the program, so it's actually creating the Excel file for us and then we send it to the different people that need it to get the dredge times and quantities." (2nd Officer, 14/03)

The CRB, which constitutes one of the cargo record requirements, was very recently implemented on board. At first, it was not well perceived by the crew who feared a form micro management from the shore team since they would have a daily access to the cycle values. However, after implementation on board, the feeling seems to be quite positive: 3 interviewees mentioned their approval of the system due to the reduced workload.

"It's still helping us a lot because we can focus more on our job and less on inserting values manually. Because I think a lot of people were a bit skeptical at first. People had the idea that it's like a big brother system, they will look for every minute at everything, they will ask questions like why is that trip longer? And that was what people were afraid of. But now that we are using it. I think the general opinion for sure is that people are actually very positive about the system and they actually say it's very useful." (2nd Officer, 14/03)

The successful implementation of CRB on board dredging vessels, therefore shows how digitalization and automation can increase the efficiency of the administrative workload of dredging operations. However, there are some limitations to this program when it comes to user interface. The officer reports that even though the logging process has been automated, some human intervention is still required in order to export the data to shore staff members. The CRB program generates an excel file than must be manually uploaded to the different servers and this action has to be performed twice during a 24h period.

"The program [CRB] takes much more clicks to upload one document. You do maybe three- or four-times the number of clicks compared to sending them by mail. So, in that perspective, you spend more time uploading one document into this system and that's something to take into account when developing a software." (2nd Officer, 14/03)

Moreover, the officer explained that during some projects, a paper record copy of the operational record has to be completed in parallel of the CRB in order to satisfy customer requirements. This partially defeats the purpose of having a digital software and doubles the workload for officers in charge of record keeping.

"For this project, we are actually doing a manual backup. So still, we must spend some time on a daily basis to fill it manually, to write down things in terms of dredging, dumping etc... So again, you're doing double things now." (2nd Officer, 14/03)

The CRB program currently used on board is still very recent. It has been adopted for less than a year, therefore it is still in its implementation phase but some lessons can be learned from it. It shows that any new technology implemented on board will require an adaptation time during which some kind of software support is essential. Since the CRB is an internally developed software, officers are in regular contact with software developers.

"People in the office that are working on the CRB, are still doing a lot of efforts to improve the system continuously. When I came on board, I saw that the system had a completely different new layout, more user friendly. In that perspective, it's actually a continuous process of improvement, they are working quite a lot on it to continuously improve the system which is nice." (2nd Officer, 14/03)

3.3.4 Automation of the maintenance software

Dredging vessels are equipped with an advance maintenance software to manage assets, monitor work orders and plan maintenance. This tool is essential on a dredger because it allows to foresee required maintenance and allows to reduce downtime of the dredging equipment.

"If you're planning to do a repair in a year. For example, you changed the suction wire. So next year I know I'm going to do it again, you can make the work orders if you scheduled one and then you can forget about it and the systems will say okay, I need 200 days to order and deliver on board. So, it will it will keep this requisition until 200 days before you want to do the repair then it will buy the wire. So, you don't need to sail all the time with the full stock on board. It's a good system. If it is being checked." (Captain, 10/03)

Recently, a new maintenance software has been introduced on some dredging vessels, allowing more flexibility in terms of functionalities. The software has multiple functionalities providing some degree of automation such as a spare parts directory, a consumable part agenda or a maintenance planning program. The vessel management system (VMS) containing jobs related to safety as per ISM code requirement (International safety management code) has also been added to allow officers to directly log their safety jobs on the system.

The company tries to diminish the workload because we switched over to […] as our management program in fact. And all our work orders and ISM work orders are now connected in this software" (Captain, 21/03)

As demonstrated, this program has many applications on board and is used daily by crew members. Due to its high versatility in terms of functionality, and its relative complexity, companies require special training for officers before they could start using it.. This is also something to take into consideration when installing a new program on board.

"I would say, if a new program comes on board, it's nice to let us officers get to know the program and find things ourselves but then maybe, shortly after, getting a course where you can ask questions. Because for the maintenance program, we got the course before ever seeing or using the program. It's not very efficient because you are so overloaded by what you see, and you're not used to it" (2nd officer, 14/03)

3.3.5 Functionalities

VDR data acquisition

Interviewees argued that some information recorded in the deck log book was already being recorded in the VDR. Since the digital platform is already there, data coming from the VDR such as course, position or heading could already be exploited to be automatically recorded in an electronic format, without having to install new sensors. Moreover, the most recent IMO VDR performance standards, resolution MSC.333(90), increases the scope for VDR proactive use. Instead of only being an evidence tool in case of incidents, by increasing the data retention period, the VDR data can be reviewed on board or ashore to analyze trends[47]. The fact that some data is already present, would greatly simplify the implementation process for shipowners.

"I think that there is already quite a lot of parameters logged into the current VDR software compared to the old VDRs. Now there is a lot of data logged actually, so the platform is already there for logging certain parameters" (Maritime department, 15/03)

Centralization

The software for the CRB is developed internally. Therefore, it could also be programmed to have a deck logbook module, allowing to centralize both deck log records and operational records in one program. This would mean that officers would only need to master one program instead of 2 different ones, and sharing information would be much easier.

*"**Theo Baliner Poggi -** Do you think it could be useful to centralize all records, like deck logbook, operational and GMDSS into one software, that way you have one user interface.*

***2OS –** Yes definitely, because, the CRB system, I think there's a lot of opportunities there to include different pages for different needs. I think it will be really not difficult to actually implement a digital logbook into this CRB system, for sure" (2nd Officer, 14/03)*

This claim is also supported by a captain. Because of the multitude of different logbooks on board, having all records centralized into one system would reduce the time it takes to physically find all the logbooks and give a better overview of what needs to be recorded.

[47] *OCIMF report: Recommendations on the Proactive Use of Voyage Data Recorder Information*.

"If it is centralized and it all can be accessed by the appropriate people, I see an advantage in that. Now, we have a bit of a wild load of logbooks. So, if we can keep an overview on that, it would be nice." (Captain, 21/03)

Engine room records

Some of the paper logbooks such as the MARPOL or bunker record book are maintained by the engineers and kept in the engine control room. Those records have to be regularly signed by the master who remains responsible for their content. When analyzing the survey responses for this thesis it was found that centralizing all records from the deck and the engine department could be a useful functionality. Although not having a significant impact on workload reduction, this functionality can also be applied to dredgers since it would allow to centralize all record on the ship's server. The master would therefore have direct access to the record from his personal computer.

"I have to sign it [Bunker record book] and have to trust the engineers, which is a difficult exercise, but yeah the oil logbook as well is kept up to date by the engineers. And every time when a page is full or two pages are filled, they come up and then I randomly pick some things out and check. That, I can do it on a daily basis." (Captain, 21/03)

Search function

The search function functionality is also quite sought after. When information from the logbook is requested by the company or during an inspection, it can be very tedious to manually search for information. For example, if the officer needs to find the date of all the safety drills during the month of march, he will have to go through each page of the month individually, then write an email, or scan the logbook pages before sending the data. A search function would allow to instantaneously look up the results and copy paste them in an email.

"What we would be very useful is that if you want to see what time you arrived in port because of dues you have to pay, then you really have to go to the archives find this logbook with the dates, and I'm sure that with Ctrl F in a database it's easier. You don't need to scan and so on." (Captain, 10/03)

Shore connectivity

Dredging vessels already share a lot of information in real time with shore personnel. The production values from the SCADA system for example, are automatically uploaded to the ship's server where they are sent to the shore without the need for the operators' intervention. This is because the production department needs to have regular access to the production values in order to analyze trends and performances.

"They can perfectly follow the vessels, where they are sailing. They have access to do whatever we're doing production wise" (Captain, 10/03)

This system however, could also be applied to other record requirements even if they require some form of human intervention. For example, rest hours, which have to be filled weekly by the captain for each crew member. The excel file that must be sent by email could be replaced by a cloud-based document available on board and ashore and updated weekly.

"It would be very handy [Shore connectivity] for a lot of people. And I think if the head office would follow up, it would be much handier for them to see: okay, where is the vessel now? What are we doing? Instead of all this... It will it will decrease the mail. And that's what is, I think, the main goal with the administration on board" (Captain, 10/03)

3.3.6 Limitations of electronic record keeping

It was confirmed during the interviews that it would be useless for the deck logbook to become electronic if it is merely a digital copy of the existing paper version. In order to be an attractive solution, the logbook will need to bring useful additional functionalities.

"If things like positions, noon positions, discharging and all this can be done automatically, then yes, I see an improvement. If it just the same thing that we have to fill but becoming digital and we just have to type it in, then I don't see really an advantage for it." (Captain, 23/03)

There is already a high level of digitalization on dredging vessels. The entire fleet is equipped with maintenance programs for ordering spare parts and placing work orders, the dredging operations are operated through the SCADA system and the vessel management system is also accessed through a computer software. A number of interviewees argued that because of the lack of uniformity between software manufacturers, and the plurality of computer programs on board, data exchange between program is always a simple process. Information and documents must be recorded in multiple systems requiring operators to manually save it multiple times in different folders.

"*The evolution that I've seen, in terms of administration, with small little digital systems is that they actually give us an array of more work. Let's say, for documents and things you have to upload. Before we had to upload it in one system just on our server. But now we also have a digital system for our documents. So now we are doing a double job. So, it's actually increasing our work time on the computer. I hope that at some stage it will be more efficient." (2nd Officer, 14/03)*

This friction between different system in turns creates an additional workload for officers that could easily be avoided.

"Most of the time, it's digital and writing at the same time, the same thing done twice. For example, weekly check lists of the VMS [vessel management system]: We manually fill in the paper version according to company procedure then we scan and save it in a computer to save it in our own file but also on the common server so they can be viewed by the office and everybody else" (2nd Officer 14/03)

This points out that switching to a digital system does not necessarily make the work more efficient for officers. Indeed, independent software like the CRB and the vessel management system must be designed so that the data can go from person A to person B without requiring

too many steps. This is something that must be taken into consideration before developing new digital tools.

While digital record keeping can alleviate the workload of officers through automatic acquisition off the data, there is a concern amongst interviewees that having too much automatization could potentially lead to a disconnection from the outside world. If for example, heading, wind or humidity data would be acquired automatically for the deck logbook, although requiring a digital acknowledgement, officers could potentially acknowledge the values without even looking outside.

"Maybe it is also not bad that after a period of time, he [the officer] looks to the wind and to the position and to the certain parameters of the ship so that he is aware of the actual conditions. Also, something to take into account is that it's not so bad that he is now and again, writing something down. That is pushing him to have a look." (Maritime department, 15/03)

This phenomenon has been observed with officers who over rely on the digital tools available for dredging operations. Since all the necessary production data is displayed on the SCADA system and navigational data is displayed on the ECDIS and RADARs, some officers have the tendency to focus too much on computer screens instead of looking outside.

"Old guys used to call it the PlayStation generation. We learned how to sail using our eyes and the radar so we were looking a lot more outside than the current generation. I sometimes film them [the officers] and then afterwards, I show them: Look you haven't been looking outside for more than five minutes. You've seen the data, but you haven't seen it for real. How close the ships came? How much space you still have? Yeah, that's also a drawback of these multi screens." (Captain, 10/03)

3.3.7 Challenges for the ELB implementation

Despite all the limitations explained above, all the interviewed professionals have shown great interest for electronic record keeping and trust the ELB to improve administrative workload efficiency. Many statements backup the implementation of a digital solution for record keeping on board.

"To have it [the logbook] all integrated in one, to have the data immediately accessible. We don't have to wait for this anymore, this is this the future, this is why we are having this meeting." (Maritime department, 15/03)

"I think it will be better because you don't need to keep everything on a hardcopy." (Captain, 09/03)

"If the maintenance program levels out and we would have the electronic logbook, I only see improvements for the crew. As long as they don't start to reduce crew because of it" (Captain, 10/03)

However, in its current state, ELB faces many challenges preventing its implementation.
The lack of a cost assessment, the non-conformity with port state control and the lack of flag approval have been identified as major threats to ELB implementation. These were discussed in details during the interviews and will be analyzed in this next part.

Lack of cost assessment

It was established that the ELB system would bring useful functionalities to the dredging sector. Delivering more efficiency to the administrative workload and contributing to a more streamlined flow of data if implemented correctly. However, being a relatively young technology, there is still no research available on its economic gain. Although, ELB has been approved by the IMO, it seems to remain a rather niche product. Therefore, there is no incentive for ship owners to incur additional costs for this technology. For maritime companies to start implementing ELB, they would need to have tangible evidence either from software manufacturers or from research papers that it would bring a return on investment.

"We need to have a return here. what is the win? What is the profit which you can make? What is the advantage here? Why should we do this? It would be easy for me to go to my boss and say, okay, we can for example, save 28% of the administrative time. This will cost money but you will have an easy return here." (Marine department, 15/03)

Port state control

Port state control (PSC) is the inspections of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. When inspectors come on board, they have a close look at the ship's records in order to make sure that crewmembers follow the appropriate regulations. DNV GL recommends that shipping companies do an individual assessment of PSC, to ensure that the port states relevant to the ship's area off trade accept ELBs[48].

"When we have a port state inspection, we must be able to show an original logbook so we need to know if the ELB is internationally recognized by everybody. If we have to do it double and keep a manual and an electronic logbook then it's just more job." (Captain, 21/03)

Because of the current lack of recognition from port state authorities, it wouldn't make sense to implement the ELB if a paper version also has to be kept up to date for port state inspections. Having looked at websites of the Paris MoU, there is no public information available about the acceptance of ELB. Companies would have to contact authorities themselves. Furthermore, the interviewees mentioned that in certain situations, alterations have to be made to the logbook after it has been signed. Having an electronic format would prevent any form of alterations when it is required.

"Sometimes we forget to fill in something in the logbook and maybe a day later, we noticed that we forgot to enter a safety drill or something. So that's easy to write when it was done on the day before of course, and that might be not so easy in a digital logbook. I don't know if every entry will be timestamped but I suppose that will be the case. Then this option is gone of course." (Captain, 21/03)

This is useful when logging mistakes happen, however preventing alterations to the log book would also bring more transparency by discouraging fraud.

[48] DNV GL, « MARPOL ELECTRONIC RECORD BOOKS – OPTION AVAILABLE FROM 1 OCTOBER 2020 ».

Flag approval

MARPOL MPEC 312, clearly stipulates that the ELB software installed on board must be provided with a written declaration of approval by the Administration or a recognized organization[49]. This means that every ELB software manufacturer will have to be assessed by flag states in order to make sure that their system complies with MEPC 312. As explained in Part 2, there is already a multitude of software manufacturers therefore, accepting each individual software would be a long process that flag states are not necessarily willing to undertake. Moreover, due to the area of operation or legal aspects, Belgian dredging companies do not operate their dredging fleet under one single flag state. Although Luxemburg and Belgium flag state are the most common ones, Cyprus, Mauritius and Netherlands flags are also used. This would off course be an obstacle for companies wanting to implement an ELB system across their entire fleet, not only because the software will have to be individually accepted by the different flags but also because each flag has their own specific requirements for record keeping. As of today, some of the mentioned flag states have already approved the use of MARPOL electronic record keeping. Luxemburg and Cyprus have recently issued circulars allowing the MARPOL ELBs[50] [51] but the Belgian is yet to issue any statements.

"I think ELB implementation is theoretically perfectly doable, but the flag states at this moment are the one who do not have that much confidence in the system. Because ELB for Belgium flag is still not allowed." (Maritime department, 10/03)

Many interviewees also mentioned that in order to facilitate flag approval, it would help to form a cluster of maritime companies in order to make a case to the flag state, showing that there is interest for such a technology.

"If you're going to address this to the flag state, if you do this with one company it will not be so easy, but if we have a cluster of different companies working on the same flag, you can have a bigger case to negotiate." (Maritime department, 15/03)

3.4 Discussion

Administrative work has been taking an increasing role in the officer's daily work on board dredgers. Besides the standard logging requirements of SOLAS vessels, officers also have

[49] IMO RESOLUTION MEPC.312, « GUIDELINES FOR THE USE OF ELECTRONIC RECORD BOOKS UNDER MARPOL ».
[50] *Use of Electronic Record Books for MARPOL Related Record Keeping.Use of Electronic Oil Record Books (EORB) on board Cyprus flagged vessels*.
[51] *Use of Electronic Record Books for MARPOL Related Record Keeping*.

extensive operational records associated with dredging operations as well as general maintenance of the vessel. A captain stated that while in the past only 40% of his daily job was administrative work, nowadays it takes around 80% of his day. However, many solutions have already been put into place to reduce the officer's workload.

A software allowing automatic digital record of the production cycle has been introduced. While in the past, production cycle values were recorded manually for every trip by the 2nd officer, the new system acquires data automatically from the SCADA system and creates a digital log of the production cycle that can be exported to Microsoft Excel. While it is still in an early stage of development, most seafarers see it as a significant improvement in terms of administrative workload, allowing them to focus more on improving things on deck.

All of the interviewees also agreed that implementing an electronic deck logbook would have an improvement on the workload. Besides having advantages in terms of automatic recording, having shore connectivity, centralizing all records into one software and implementing a search function are appreciated functionalities. Furthermore, those functionalities should not only concern the deck log book but could also be implemented for other record books such as MARPOL, bunker or engine record books.

However, some digital systems recently introduced on board still require to keep a manual copy either through printing or manuscript. Some user interfaces still need optimization because they require an unreasonable amount of "clicks" to complete a task. Therefore, instead of decreasing the workload for officers it doubles the job. There is also a fear that having the data already recorded without the need for human intervention would discourage officers to double check the information, disconnecting them from the outside world.

However, despite those existing limitations, interviewees recognize the potential efficiency gain of the ELB. In order to reach a proper implementation, greater awareness of port state authorities and flag states is required. Both companies, DEME and Jan De Nul are both eager to implement ELB on board their fleet but even though the Luxemburg flag state has approved its use, the Belgian flag state is still lagging behind.

Conclusion

The concept of keeping logs in an electronic format has been proven to have many useful functionalities over the standard paper version. The ability to centralize all record book into one system can greatly facilitate the logging process for officers. Indeed, the ELB software does not only apply to the traditional deck logbook but can incorporate all the other mandatory record requirement such as the GMDSS logbook, the MARPOL logbooks, the bunker book and the cargo record book as well as non-regulation records associated with cargo operations. Digital acquisition of the data could help reduce the administrative burden associated with record keeping by logging entries automatically. This should be particularly easy for the deck logbook where some of the entries are already recorded by the VDR. Furthermore, the ELB software has the ability to connect directly to the ship's server in order to transmit data to the shore office in real time allowing for a greater transparency. Digitalization and connectivity are taking an increasing role in the daily operation of a ship and the ELB system is supporting this broader goal of more effective ship operation.

The survey results clearly show that seafarers sailing on Belgian vessels know little about the ELB since only 34,5% off them reported having heard of it. Despite this, the functionalities brought by the ELB system are positively received by seafarers. 7 out of 8 of the exposed functionalities were agreed to be either useful or very useful by more than 75% of submitters. However, several concerns were raised towards the implementation as many believe that, due to the poor ICT infrastructure present on ships, the ELB will add an additional burden for officers during the implementation period. However, after reviewing the functionalities and exposing their concerns, 71% of submitters agreed that they would like to work with an ELB system on board.

After speaking with dredging professionals working for Belgian companies, it was found the administrative workload has taken an increasing impact on the job of officers on board up to the point that there is a need to either reduce the load or make the work more efficient. While digitalization and connectivity is already present on board, there is a lack of integration between each individual software. The technology is there but at the moment, every program works in its own ecosystem having little integration with other digital systems.

Recently some dredging vessels have replaced their traditional production cycle logbook with an automated digital software. Despite being in early stages of development, the software has been successful at reducing the daily administrative work and thus was met very positively by officers in charge of record keeping. Dredging companies could therefore further reduce the

administrative load by integrating an “all inclusive” record system which would also take all the other logbooks into account.

Dredging professionals have all agreed that ELB implementation would be beneficial from an operator’s perspective. However, many dredging vessels sail under the Belgian flag and the Belgian flag state has not yet approved the use of ELB on board. There is also a lack of standardization from port state control authorities since no statements have been issued on their part regarding approval of the ELB system instead of the traditional paper logbook for their inspections. Furthermore, as no research has been done on the maritime applications of the ELB, there is no scientific claims supporting an increase in efficiency or a cost reduction for maritime companies. This lack of incentive could therefore limit the supplementation of ELB on board. If software developers want to convince maritime companies to purchase their technology further research has to be done, either by making an economical assessment of the ELB system or by interviewing companies who have already switched to an all-digital format.

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Annexes list

1. Pdf version of survey.
2. MARPOL MEPC 312
3. Interview question

Annexes

The use of electronic logbooks on board seagoing vessels.

An electronic logbook (ELB) is a software integrated into the ship's network. It serves the same purpose as a traditional paper logbook while bringing additional functionalities in terms of time savings, data validation and data sharing. The ELB allows to log entries manually or automatically by replacing the following traditional paper logbooks:
- Deck
- Engine
- Garbage
- Radio
- Cargo record book
- Oil record book Part 1&2
- Operational

The aim of this survey is to assess the knowledge and interest of seagoing professionals for that technology.

*Required

General information

1. Current company (if none please state: other) *

2. Current position, or position held in the sector *

3. Type of vessel sailed on

Tick all that apply.

- [ ] Dredger
- [ ] LNG carrier
- [ ] LPG carrier
- [ ] Oil tanker
- [ ] Chemical tanker
- [ ] Container ship
- [ ] Passenger ship
- [ ] Other: _____

4. Experience as a seafarer *

Mark only one oval.

- ◯ < 1 year
- ◯ 1- 3 years
- ◯ 3-5 years
- ◯ 5-10 years
- ◯ > 10 years

Knowledge

5. Have you worked with an Electronic Logbook (ELB) onboard a sea-going ship?

Mark only one oval.

- ◯ YES *Skip to question 9*
- ◯ NO *Skip to question 6*

Knowledge

6. Are you aware of the use of ELB onboard seagoing ships ?

Mark only one oval.

- ◯ YES *Skip to question 7*
- ◯ NO *Skip to question 9*

Knowledge

7. How did you hear of ELB?

Tick all that apply.

- ☐ Seminar
- ☐ University
- ☐ Training
- ☐ Speaking with other professionals
- ☐ News
- ☐ Working with one before
- ☐ Other: _____

8. On a scale of 1 to 5, how would you rate your knowledge level

Mark only one oval.

	1	2	3	4	5	
Not Familiar with the concept	◯	◯	◯	◯	◯	Fully familiar with the concept

1. Not familiar with the concept
2. Somewhat familiar with the concept
3. No opinion
4. Very familiar with the concept
5. Fully familiar with the concept

Functionalities

Some functionalities of the ELB system are listed in this section. On a scale of 1 to 5, according to you own opinion, state wether or not you believe those functionalities to be useful on board.

1. Very useless
2. Somewhat useless
3. No opinion
4. Somewhat useful
5. Very useful

9. The ELB allows the centralisation of all logbook records into one system. Meaning all logs from the engine and deck department are accessible on any computer running the softwa

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

10. If connected to other systems such as GPS, Navigational software, ER monitoring system cargo software, the ELB software can log entries automatically while still requiring acknowledgement thus avoiding mistakes.

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

11. A search function is integrated into the ELB software allowing to look up any entries from logbooks

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

12. The software creates automatic data reports and daily reports which can be exported int other programs.

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

13. The ELB software can be linked with other operational programs such as the maintenance log allowing for a centralised access to information.

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

14. The ELB data can be automatically relayed ashore in real time allowing for trouble-free monitoring.

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

15. ELB data can be automatically backed up and archives can be accessed by as search tool

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

16. The ELB allows the master to electronically approve and sign all daily entries.

Mark only one oval.

	1	2	3	4	5	
Very useless	◯	◯	◯	◯	◯	Very useful

Interest

Based on the information discussed above, on a scale of 1 to 5, state wether or not you agre with these statements ?

1. Strongly disagree
2. Disagree
3. No opinion
4. Agree
5. Strongly Agree

17. Errors while filling logbooks are common on board

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

18. Installing ELB onboard will make life easier for officers

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

19. ELB will have a positive impact on the operation of a seagoing vessel

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

20. It is useful to install ELB on board

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

21. I would like to work with an ELB on board

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Additional information

22. ELB has not yet been implemented onboard Belgian owned vessels. Why do you think tha is?

Tick all that apply.

- [ ] Legislation
- [ ] High cost
- [ ] Low added value as an investment
- [ ] Lack of interest
- [ ] Lack of knowledge
- [ ] Lack of appropriate software
- [ ] Too complicated to implement
- [ ] Other: _____

23. Additional comments

_____

_____

_____

_____

_____

All done !

Thank you for taking part in this survey.
You can contact the author for additional information or if you wish to receive a copy of the research paper once it is finished.

Théo Baliner, student researching for Klaas De Hert

Contact: klaas.de.hert@hzs.be

APPENDIX

EXAMPLE DECLARATION

DECLARATION OF MARPOL ELECTRONIC RECORD BOOK

Issued under the authority of the Government of:
……
(full designation of the country)

In reference to the requirements set out in the
International Convention for the Prevention of Pollution from Ships (MARPOL)

Name of ship……

IMO number ……

Flag State of ship……..

Gross tonnage……..

This is to declare that the electronic system designed to record entries in accordance with MARPOL Annex(es) …….. installed on board the ship listed above has been assessed by this Administration to meet the relevant requirements as set out in MARPOL and is consistent with the Guidelines developed by the International Maritime Organization (IMO).

Electronic Record Book Manufacturer	.....
Electronic Record Book Supplier	.....
Electronic Record Book Installer	.....
Electronic Record Book Software Name/Version	.....
Electronic Record Book is in accordance with MEPC Resolution/s	.....
Date of installation (dd/mm/yy)	_____

A copy of this declaration should be carried on board a ship fitted with this Electronic Record Book at all times.

……..	……	……
NAME	SIGNATURE	DATE (dd/mm/yy)

Seal or stamp of the Authority, as appropriate

***

Interview questions:

Presentation + CONFIDENTIALITY

1. Data used for research purposes only
2. Recording for transcribing purposes
3. Information not linked with your name

Presentation on ELB

1. Paper administrative load on board
2. Who is in charge of the logbook ? and operational logbook ? MARPOL logbooks ?
3. Manual things that could become digitised ?
4. Do you think ELB could be useful on board ? Why ?
5. Engine/deck separation: is there a lot of information shared between departments ?

Are dredgers **more technologically advanced** than merchant ships ?

1. Have things changed a lot in terms of technology on board ?
2. Examples ?
3. Any advantages ?
4. Disadvantages ?
5. How ?
6. General feeling of seafarers ?
7. Is Cybersecurity training useful ?

Operational records

1. Already automated ? How good is the software ?
2. Any information taken from the source or everything comes from sensors ?
3. How frequently do you record information ?
4. Shared information with shore ? any other information shared with shore ?

Tell me more about **Maintenance software**

1. Implementation
2. Ease of use ?
3. Reduced workload ?
4. connected to shore ?
5. automation