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Multifunctional handheld computers on board merchant vessels

- An end user perspective

Diploma thesis in the Marine Engineering Programme

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Abstract

This report will discuss possibilities in how to improve and secure information management on board merchant vessels. With the use of a PDA, it can both assist the end user and reduce the steps of information processing. This might be an interesting solution since the crew manning have been reduced while the information rate has increased in combination with extensive regulations. Therefore, this will require convenient methods to compile gathered data for analysis and presentation.

With the support from a questionnaire that were addressed to active crewmembers in the profession; the intention was to determine if these people were interested in a PDA as a working tool on board ships. Additionally, if they would prefer to use this kind of equipment, the further goal is to establish what features it should contain and what assignments it can be utilised for. Fundamental conditions were features that are available in some of the existing land based PDAs.

When the survey was completed, it was compiled and functions or keywords that were stated a minimum of two times were presented in the results. The results of the survey were then discussed in combination with previously presented facts and findings. Finally, it was concluded that PDAs are interesting as a working tool on board merchant ships, mostly for different types of inspections. This report can be viewed as an introduction to this topic where some features require more studies to become comprehensive.

Keywords: PDA, Personal Digital Assistant, handheld, computer, on board, merchant vessel, secure, simplify, information processing, PMS

Sammanfattning

Rapporten behandlar hur man kan förbättra och säkerställa informationshanteringen ombord på handelsfartyg i kombination med att den administrativa hanteringen minskar för slutanvändaren med hjälp av en PDA. Detta kan vara intressant på grund av att besättningarna har minskat medan informationsflödet har ökat, i kombination med mer omfattande regelverk. Vilket ställer krav på datainsamling; att den kan sammanställas och redovisas, både för kontroll och också analys.

Med hjälp av en enkätundersökning som riktades till yrkesverksamma besättningsmän, var intentionen att ta reda på om det kan vara relevant att införa en PDA som ett verktyg på fartyg. Om besättningsmännen ansåg det, då skulle det ytterligare tas reda på vilka funktioner den skall innehålla och till vilka arbetsuppgifter den främst kan tänkas användas till. Frågorna till enkäten togs fram genom att information söktes i olika databaser tillsammans med studiebesök hos relevanta företag. Utgångspunkten var vilka funktioner som finns i denna typ av utrustning i den nuvarande landbaserade verksamheten.

När enkäten var genomförd, sammanställdes den och presenterades med grunden på de funktioner och arbetsmetoder som nämndes minst två gånger av deltagarna. Detta diskuterades senare för att med hjälp av tidigare sökt fakta och enkätresultat, slutligen kunna dra slutsatsen att PDA: er är intressanta som arbetsverktyg ombord på handelsfartyg, och då främst för olika typer av kontroller. Rapporten kan ses som en introduktion till ämnet där vissa funktioner kräver mer undersökningar för att bli fullständig.

Nyckelord: PDA, handdator, ombord, handelsfartyg, säkerställa, förenkla, information, data, förebyggande underhåll,

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Abbreviation and Definition

ATEX, Appareils destinés à être utilisés en ATmosphères EXplosibles
An EU commission concerning what type of mechanical and electrical equipment should be used in areas where the atmosphere has explosive and gas properties.

Automation System
Refers to a managing procedure where machines and/or processes are controlled by automatic means to reduce the human work. Its system includes among others computer software and sensors, which makes it possible to visualise process information in real time.

CBM, Condition Based Maintenance
It is a method that aims to perform maintenance only when it is needed. This is done by measuring and monitoring components and processes, which subsequently presents information and data regarding damages or the level of deterioration.

Classification Society and **Class Inspection**
When a ship is built, it needs a Certificate of Class to get permission to sail. This is distributed by a Classification society. A Certificate of Class is a guarantee to ensure that the ship is considered safe for operation in all aspects, from the construction of the ship to the technical equipment on board etcetera. The permission to sail is obtained by continuous surveys that confirm its status as a safe vessel. These Class Inspections are performed regularly while every 5th year a comprehensive inspection is performed.

EEBD, Emergency Escape Breathing Device
It is a simple respiratory mask with an air tube that can operate for approximately 10-15 minutes.

IACS, International Association of Class Societies Ltd
This association consist of 13 different Classification societies. They are an interest organisation which involves marine safety and regulations.

IMO, International Maritime Organisation
This is a UN organisation where the membership states' merchant fleet are members. Within the organisation; they initiate conventions and establishes rules and regulations regarding maritime activities.

IP Code, International Protection Marking
A standard published by the International Electro-technical Commission regarding the protection against ingress of water and dust in mechanical and electrical enclosures.

ISM Code, International Safety Management Code
A code regarding ship's safety and is established by regulations that were manifested by the Maritime Safety Committee, MSC.

MLC, Maritime Labour Convention
A system of rules about crewmembers' rights, which entered into force 20th of August 2013.

MSC, Maritime Safety Committee
A primary council within the IMO, which is the most prominent organisation concerning safety. They are the committee that is behind the regulations in the ISM code and in the SOLAS convention.

PDA, Personal Digital Assistant
It is an umbrella term for a small and mobile computer that is used to facilitate working procedures.

PMS, Planned Maintenance System
It is a computerised program for managing and organising the overall maintenance.

Port State Control
These controls are performed by authorised people on the behalf of a nation to verify; that foreign ships meet international regulations regarding equipment and manning requirements.

RCM, Reliability Centered Maintenance.
This is a method that aims to optimise maintenance actions to improve the planning of technical maintenance.

SOLAS, International Convention for the Safety of Life at Sea
This is an IMO convention, which is generated by the MSC, regarding ship safety regulations.

Tank tables,
These are pre-computed list of tables presenting each tank in the ship in relation to different trim values. With the use of the tables, the sounded values in metres can be converted into cubic metres.

TPM, Total Productive Maintenance.
This is a systematic working method with the aim of creating smooth processes. And with the use of each employee's commitment, the aim is to reduce the costs and increase the efficiency in the processes.

1. INTRODUCTION

During the last decade, the number of crewmembers in Swedish and foreign vessels under Swedish management have been reduced (Trafikanalys, 2012), mainly as a result from the technical development considering ship's operational systems and cargo handling procedures (Arbetsförmedlingen, 2013). Before the technical advancement in the shipping industry, it was required to have more manning on board. One example of a contributing factor is that machinery components such as regulatory valves were manually operated. Today, valves that are related to important processes are automatically governed and adjusted by an automation system, which is a control system for operating various types of machineries and processes. An example of a crucial system on board which has developed from manual operation to automatic operation is the boiler system, where temperature and pressure constantly vary depending on the steam consumption on board.

Except from technical development, there are also enforced regulations that require parameters to be recorded and stored (International Maritime Organization, 2010). These regulations are in some cases enforced by International Maritime Organization (IMO) and their treaties. International Convention for the Safety of Life at Sea (SOLAS) is developed by IMO and their state members. It concerns among other things safety in different areas on board, and one outcome is partly a planned maintenance system (PMS), which requires collecting and storing of various data and information regarding the vessel's operation. Some information is handled daily, while other is handled with longer intervals such as, once a week, once a month and so on.

As a result of the technical development, enforced regulations, systematic maintenance, cargo handling and other relevant operations on board, there is now an increasing amount of information that has to be managed and analysed. This is also documented and stored to have a purpose in the long term. Upon future needs it is then possible to look at its history for a follow-up, such as how a parameter has changed over time. However, if information is stored in folders, it can become a quite extensive work to locate the document and then search for one specific or several parameters. In some cases it is interesting to collect the information over a time period to analyse specific parameters and its trend. In such cases, many different documents need to be referred to in order to compile the information into a comprehensible context. This method can be time consuming and there is also a risk of clerical errors.

There are however methods and equipment to simplify information processing and reviews, both ashore and at sea. Several manufacturers of various types of systems and processes develop soft- and hardware equipment to facilitate follow-up and management of the operational parameters and information both in safety and administration aspects.

Most vessels have automation systems which are connected to the operation of the ship and all relevant systems on board. Although the automation system is highly advanced, it is still very difficult to keep track of every process connected to one ship's operation and to monitor

all raw data that are generated each day, since they become more extensive in relation to the complexity of systems. What sets these different automation systems apart is what kind of parameters they store and the potential for compilation. In broad terms, one can generally claim that a newer system increases the ability to log, summarise and present data. On the contrary, there are still features and controls that are not directly connected to the automation system such as low prioritised data. These are on the other hand gathered and analysed manually to support potential troubleshooting by crewmembers in order to identify if the problem is acute or has changed over time. However by identifying these data to collect and log them, for example with a handheld computer called Personal Digital Assistant (PDA) might be a way to ensure information with a less risk of clerical errors.

1.1. Purpose

With the use of existing technical specifications of some land-based handheld computers on the market; it is to identify some current technical solutions that are available today. These will be the basis of suggestions to functions that will be included in similar equipment if used on board merchant vessels. The objective with this report is to determine what kind of features such equipment could have, and also to demonstrate how these functions could simplify procedures and secure the information processing furthermore to reduce the workload for crewmembers on board.

1.2. Questions

As to the objective of this report, following questions will support the subject in matter whereby the purpose will be attained.

1.2.1. Main Question

How can a PDA be used on board merchant vessels to facilitate procedures and information processing, in addition to what purposes may it be used concerning each department?

1.2.2. Sub Questions

i. What is the preferable size of the PDA for the end user, and what other features are required in relation to the environment on board?

ii. Is the PDA required to transfer information to an existing maintenance system, and are there other applications or systems on board that it should be integrated with?

iii. In correlation to existing land-based PDAs, what built-in functions are necessary regarding working conditions on board?

1.3. Delimitations

This report is based on current land-based PDAs and their existing features. Specific functionalities in the software, for example the user interface will not be included, since the report only evaluates if a PDA and its features is pertinent to working conditions on board. As the issue is specifically targeted for the work on board ships, only active crewmembers in the profession will be used in the questionnaire study. However, invitation letters for participating in the survey will foremost be sent to Scandinavian shipping companies.

The potential of future technical developments in specific areas; for example an improved internet access at sea which could implicate a more stable and prompt communication on board will not be considered in this study, since it is only the present circumstances that is concerned. In addition, regarding the report's primary questions, the economic perspective is of course interesting but will hereby not be treated extensively.

Regarding the use of a PDA and its features, comparing the survey's results between different ship types could be interesting since there may be a wide range of varying tasks that could separate them. Therefore, comparing the results between ship's sizes, routes, flag states and the nationalities of the crewmembers are considered to be irrelevant. In addition, statistics will only be based on the results of the questionnaire study.

2. BACKGROUND AND THEORY

Both from a historical aspect and as a tradition, it is typically required to have a great quantity of paper regarding daily information processing. Based on these documents, some of the information is entered into different computer software or in folders depending on what kind of system that is used for gathering information. In order to acquire history records and an overview of data, selecting values between certain time intervals for comparison to display a trend, can thus be inconvenient if folders are used to log gathered data. Either using a PDA and adjusting its software to be able to present history records on site, or applying this function to a stationary computer, an end user may find it easier to collect, store and execute follow-up. The software's layout can then present data which the end user selects, either in a purpose of analysing change in a trend or as a presentation to a 3rd part, for example during inspections concerning the ship's safety that are performed by a Port State (International Maritime Organization, 2014) and Classification Societies (International Association of Classification Societies Ltd., 2014). Their function in the shipping industry will be described in 2.1 maritime regulations and inspections.

Towards industrial productions and processes where automation systems are used in land-based factories, there are developments that have resulted in various types of solutions and methods as an extension to its maintenance system (Svenska Mässan, 2014). These techniques are developed and tested in land-based fields, which could be logistics and warehousing, often with good results (Handheld Group, 2012a). Instead of waiting until equipment to fail or break down, which can result in major repairs with long and expensive delays, directorates have sought after more secure methods to prevent these failures and breakdowns in result to diminish costs and increase availability. Methods developed for this purpose are for example Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM) and Condition-Based Maintenance (CBM). (Holmberg et al. 2010, p.1)

In relation to regulations where guidelines are set for a computerised maintenance on board (International Maritime Organization, 2010; IACS, 2001), there are several different maritime maintenance systems today. Two examples of such are developed by SpecTec and SisMarine, where a PDA could also be a complementary tool to these systems.

2.1. Maritime regulations and inspections

This study is mainly a maritime subject; therefore, to implement and use electronic equipment in relation to the maintenance on board will be affected by shipping regulations and guidelines. For an overall comprehension of how the maritime organisation operates and what regulations are concerned, there will be a brief summary about these matters (Western Economic Diversification Canada, 2012). *Figure 1* shows an informative and distinctive chart about their relations.

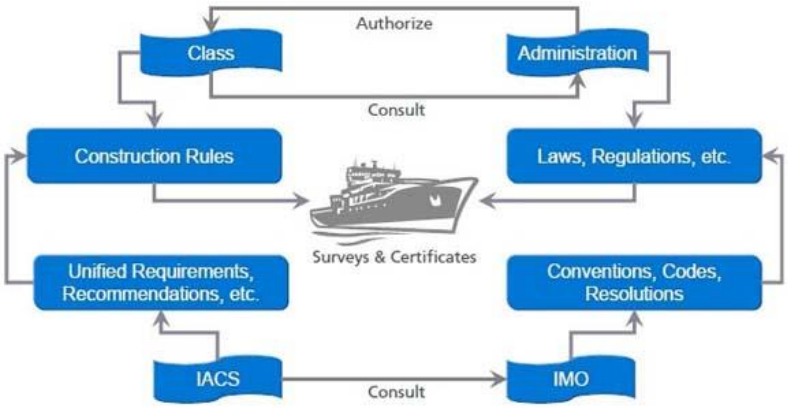

Figure 1 Maritime organisation and relations **(Western Economic Diversification Canada, 2012)**

IMO, which is a UN organisation, is the primary instance that involves all maritime issues. Within the IMO organisation there is a Maritime Safety Committee (MSC), which is responsible of the regulations that are gathered in the SOLAS convention. The latter regulates issues regarding safety in marine efficiencies, which among other things include a ship's operation and its technical equipment. Therefore, it is possible that SOLAS can have a small impact on some areas that are mentioned in relation to a PDA on board.

There are organisations and regulations that have a more direct impact on management and technical matters on board. Although, the most relevant in this subject is the Classification Societies and the Port State, these authorities and their regulations are based on SOLAS, International Safety Management (ISM) and Maritime Labour Convention (MLC). Consequently does the Port State and the Classification Societies construct their inspections on the basis of their own framework, even though their regulations are directly influenced by SOLAS, ISM and MLC.

When crewmembers perform safety and operational checks, it is required to document these since Port State Controls and the Classification Societies may sometimes request to access this paperwork during an inspection. These Port State Controls are performed by governmental authorities in each country that is a member of the IMO.

Beside the Port States, the Classification Societies could also have an effect on some issues regarding implementation of a PDA on board. The Classification Societies are involved when a ship is initially built, where the first inspections are performed at the shipyard during construction of the ship. A Certificate of Class, which is distributed by a Classification Society, is required for the ship to obtain a permission to sail. Furthermore, for the ship to retain this certificate it has to accept regular inspections that are performed by the issued Classification Society. For example, if a PDA is used on board a tanker, it is bound to have an ATEX protection class, which is further described in 2.2.1. This requirement is due to the regulations that determine what electrical equipment should be used on board this type of vessel (ICS, OCIMF and IAPH, 2006). Consequently, the Classification Societies are authorised to inspect the PDA to ensure that it fulfils this specification.

2.2. Available technology

Today, there are PDAs ashore for data processing, where operating parameters are directly entered into a PDA, which wirelessly or by cable can transfer data to a computer program. The basis for this paper is if this technique can also be suitable on board vessels. Current PDAs include following technology; scanner, memory card, camera, USB-port, Bluetooth and wireless connectivity (Handheld Group, 2012b). These features can be means of ensuring information processing and to facilitate analysis since the information is directly transferred to the correct location, where it is possible to collate information with the available features in the software.

2.2.1. Rugged, IP- and ATEX-class

Due to many land-based industries where the working environment is rough, certain PDAs and measuring instruments have been developed to withstand extreme conditions. Such equipment is often called rugged, which means it has high tolerance of heavy and numerous impacts. Rugged equipment can for example be other cell phones (Handheld Group, 2012c), tablets (Handheld Group, 2012d), PDAs (Handheld Group, 2012e) and measuring instruments such as vibration meters (SPM Instrument AB, 2014). In addition, some of this equipment also has a range of 65 to 67 in IP Code (Handheld Group, 2012b), which could withstand dust ingress and various degrees of water exposure (MPL AG Elektronikunternehmen, 2014).

However, there are directives concerning what equipment should be used in a working environment with explosive atmosphere, also called hazardous areas (European Commission, 1994; ICS, OCIMF and IAPH, 2006). Therefore, this equipment is required to be ATEX-classed and examples of already existing ones are communication radios (Motorola Solutions Inc., 2014a) and vibration meters (SPM Instrument AB, 2014). Although, companies are developing ATEX-classed PDAs[1], there are few existing PDAs that meet these requirements (Atex Equipment Ltd, 2014).

Depending on ship type whether it is a general cargo or a bunker barge, there are different requirements of the equipment that are used on board. For example, on a general cargo it may only be necessary with a rugged and IP-classed PDA while on a bunker barge it is also required for it to be ATEX-classed due to the explosive atmosphere on board (ICS, OCIMF and IAPH, 2006, p.67-73).

Inevitably, the more features an equipment has the more expensive it is. For example, a simple rugged PDA with few software features is less expensive than an advanced ATEX-classed PDA with numerous functions. As a reference cost, a rugged and IP-classed PDA can range from €600 to €1200 in relation to additional features[1]. Regardless, it could also be desirable to use different models for various tasks. On the contrary, it could be important with redundancy where a PDA can be replaced by the same model.

[1] Handheld Scandinavia AB, study visit 11 February 2014

2.2.2. "Offline mode" and redundancy

Since transferring information and among other features are in majority dependent on wireless connectivity, it is common for land-based PDAs to connect by either GSM, 3G or W-LAN (Handheld Group, 2012b; Motorola Solutions Inc., 2014b). Because of easy access to wireless internet ashore, these PDAs can thus be online at all times. If however during some cases where a PDA cannot establish a connection due to poor signal range, one solution may be to store information locally with the use of a memory card or RAM[2]. Subsequently, it can either automatically connect to a network once it has gained enough signal strength, or afterwards synchronising it with a stationary computer where other methods of transferring data are also available, such as Bluetooth or USB-port[2].

A complementary solution may be to install access points where adequate signal range is not available in certain positions[2]. Equipment can thus establish satisfactory connectivity more often. Due to substantial bulkheads and numerous sectioning of a vessel, a poor wireless connectivity is more common on board (Gustafsson, 2013). The latter solution has already been conducted on board for example Stena Nautica (Gustafsson, 2013). The installation cost depends on ship type since it is relatively easier to carry out installations and require less access points on for example a very large car carrier than a cruise ship due to a more open construction. For instance, the cost to install access points on an average ferry is estimated between €30,000 and €40,000[3]. A base station around €500 in addition to installation costs, and there is approximately one base station installed per bulkhead when taking into account around 20 meters distance between each bulkhead.

Beside local storage of data with memory card or RAM, another possible technology of redundancy is to have redundant arrays of independent disks (RAID)[2,] which is a set of disks combined with a body of control software wherein part of the physical storage capacity is used to store redundant information. This enables regeneration of user data in a storage emergency if a disk in the array or an access path fails. (Liu & Özsu, 2009) If a PDA is wirelessly connected to a server on a primary base station computer where a disk crash could occur, it could be suitable for the base station computer to have a RAID installed for the purpose of redundancy.

2.2.3. Scanning techniques

There has been tremendous development within the domain of Information and Communication Technology (ICT), which is a technical foundation for today's information society. It contains methods to process, transmit and present information electronically. ICT in combination with development in computer components and software, provide new solutions to maintenance and have created a field called E-maintenance. It provides diagnostic tools and user friendly interface to collect and present information. Smaller, cheaper and more

[2] Binar Elektronik AB, study visit 17 February 2014
[3] Diwiton AB, phone interview 15 April 2014

effective microprocessors have been developed, this in combination with wireless techniques and internet, the use of handheld computers and PDAs are increasing because of its flexibility during work procedures (Holmberg et al. 2010, p.507-511). Smart Tag which is a more common word for radio frequency identification (RFID) has emerged from barcode technologies and is preliminarily used to collect information electronically from different equipment or objects. As opposed to a barcode, RFID is not required to be visually read by a scanner and will therefore still be readable if they become dirty or covered with paint. There are already many applications that use RFID, and are predicted to increase in use. (Holmberg et al. 2010, p.197-200)

Communication between a Smart Tag and a reader is conducted with radio waves. There are mainly two types of RFID tags, passive and active ones. Most common is the passive type which is powered from the reading device, while the active type has a built in battery that gives a wider detection range. However, the latter one is more expensive and has more features than the passive one. Data is collected from tags with a PDA and it is then wirelessly, by a dock station or by a cable transferred to a host computer. Basically there are three different components in correlation. It is the RFID tag, the RFID reader and the RFID middleware which holds communication between other software. (Holmberg et al. 2010, p.198-200)

In the field of E-maintenance, which is a rather broad area, Smart Tags or barcodes are however the most relevant for this report. This is because these scanning techniques offer a possibility to connect specific items to a computerised system, which may be a more efficient way compared to the procedure that are usually performed today and will be described in the following chapter 2.3, recognised method to process information on board. This method could be a complement to all other important data that are logged from different processes, regarding the ship's operational management that is electronically registered in the vessel's automation system.

In addition to these techniques there are complementary products available to further facilitate management of spare parts and inventory. There are for example stationary and mobile printers that are able to print barcodes and QR labels (Collinder Märksystem, 2014). The stationary printers can be connected to a computer, which in turn has labelling software installed. There are a variety of programs which can be purchased depending on the demand of the end user (PMS Technologies AB, 2013). Moreover, this additional equipment will make it easier to update and replace labels in the storage.

2.3. Recognised method to process information on board

Inspections concerning the ship's safety are performed regularly by a Port State (International Maritime Organization, 2014) and Classification Societies (International Association of Classification Societies Ltd., 2014). They are carried out in relation to SOLAS and more recent regulations such as the Maritime Labour Convention, MLC. When the regulated

external inspections are executed, they will among other things look into history records about these matters. A large number of internal assessments are performed by crewmembers with the use of different checklists to record the procedure. Internal assessments are customarily performed with a pre-printed document where notes are written down and when completed is either transferred to a computer program or filed in a binder. If a PDA could have these pre-printed documents in its software or be downloaded, it could be transferred directly to the computer after the assessment is performed.

Daily information processing on board existing ships is usually handled by the conventional method of utilising paper and pen. For example, during a daily or inspection round, values and observations are written down on either a specific document or a paper/notepad. They are then forwarded to the Third or Second Engineer who in turn shall document the information correctly. Throughout a reporting progress, some information may also be verbally transferred. Consequently there is an unconscious risk of data loss with this kind of chain processing of information, which in hindsight can be difficult to detect. Such examples include; a paper may be lost, handwriting can be misinterpreted and verbal information may be forgotten. There might be a way to improve and secure this procedure of information with a PDA, which could be one possible solution.

There may also be a potential interest of transferring information to a technical department ashore. In some areas, internet access and the data rate on board ships may be limited. Therefore, with existing internet at sea, the wireless transmission has its limitations. One possibility is to use internal W-LAN to locally manage the wireless sharing. In a long term perspective, if the network is developing then the equipment can also be adapted for larger areas.

2.4. Connecting available technology with recognised working method on board

Following subheadings will suggest how an existing PDA with various functions can be useful during different work on board, in comparison to the recognised method performed today in relation to practical experience, as mentioned in previous chapter 2.3.

2.4.1. Barcodes and tags with a scanner function

Following will suggest three examples of how barcodes and tags which are connected to different types of equipment could assist, ensure and reduce the administrative work. Beside below mentioned components and appliances, there are other various kinds of objects that could also be tagged such as machinery components. Inspection and inventory of different equipment may be easier and quicker to perform by using a PDA with a scanner function.

2.4.1.1. Periodic inspections of fire protection appliances

Due to regulations, classifications, and to ensure safety on board vessels, visual inspection of certain fire protection appliances such as fire extinguishers and Emergency Escape Breathing Apparatus (EEBD), have to be performed every month. Meanwhile certain equipment for example portable fire extinguishers are inspected and certified annually, according to Lloyd's Register's requirements which are based on SOLAS regulations. (Lloyd's Register, 2013) It is common to perform these inspections by the use of pad and pen. However, since the equipment and appliances are widely distributed throughout the vessel there is also a potential of an object being unintentionally skipped, whereby it can be of inconvenience to use this method.

With the use of a scanner function in the PDA provided that each component is individually labelled, it could result in a more effective method since it could be integrated with the maintenance system and will automatically make sure all objects are inspected and confirmed by scanning. For example, if each fire extinguisher is individually labelled with a barcode or tag, a PDA could easily scan this and an automatic window could pop-up. Possible functions in this window could be a description of what type of extinguisher it is, what inspection should be performed, field for comments, tick-boxes to confirm an inspection and so on. After confirmation, the information could be transferred to the maintenance system either wirelessly or by connecting the PDA to a computer in a relevant department. This procedure could simplify the administration in comparison to the routines that are performed today, where paper and pen is used during the inspection, and then transferred manually to the computer software.

2.4.1.2. Identifying and sounding of tanks

Different tanks on board, which could range from fuel to bilge and ballast water are sounded daily, weekly or when necessary for example before bunkering. These tanks are regularly sounded by hand to among other ensure the given values of volume in the automation system are equivalent to the manually sounded values. Depending on the vessel type the amount of tanks may differ, but it is however more difficult to remember each tank and its position in relation to the quantity of tanks. In the same way as the method used during safety inspections, sounded values are usually noted with paper and pen. On the contrary, due to potential human errors or unlabelled tanks, the sounded values could be exchanged between tanks. After sounding is done, the noted values are then converted manually into volume by using available folders or documents located in the control room, hence a specific volume is given with possible consideration of an additional correction factor such as ship's trim. Actual weight of the fuel or liquid can be converted manually by using standardised tables where observed temperature is arranged in relation to its density; hence, a volume correction factor is given (ASTM International, 2013). Therefore, it is common on board vessels to perform conversions manually, and logging them afterwards.

In a similar way to which fire protection appliances are described, all tanks on board can also be individually labelled with barcodes or tags. After sounding a tank, scanning the unique tag

will display the correct tank on the PDA where values can be entered. Whereby integrating its software with the vessel's tank tables and additional standardised tables, the sounded value could automatically be converted into actual volume and weight of the current fuel or liquid without using additional folders and documents when converting them manually.

2.4.1.3. Inventory system

Spare part inventory systems on board vessels are usually complex; whether it is connected to the maintenance system or operating as an independent system, the administration remains complicated. In general, new components such as spare parts that have arrived on board have to be logged into the system to confirm that the order is received. This is done by visually determining what type of spare part it is and its quantity while comparing to the receipt. Subsequently through for example the maintenance system's own inventory system, unique labelling stickers are thereby printed. After labelling is done, each spare part has to be distributed to the correct locker and shelf, to easily locate them afterwards when needed. Inspections of spare part inventory are performed regularly to make sure quantities in the inventory system are equivalent to actual quantities in store. Because each component is labelled by conventional stickers with identity numbers without barcodes, performing these regular checks become quite extensive work considering inefficient methods are used. One example of a method is to first print out a relevant inventory list, where such as specific position and quantity of each item is listed. Secondly, this piece of paper as well as a pen is then brought to site, where each item is visually identified, manually counted and checked off accordingly. Later on, with the current result of the inventory check, the spare part system is updated.

At the first stage of identifying new components when confirming that an order is received, conventional labelling with stickers could additionally consist of barcodes. Later, with the use of vessel's spare part system on a PDA and the barcodes, it could thereby simplify the procedure of inventory checks. For example, during an inspection of inventory, a PDA is brought to site where relevant inventory list is shown. While each item is also labelled with a barcode, this could be scanned with a PDA to identify current component. Hereafter, the current quantity of the item could be inserted in the PDA while it is automatically updated in the spare part system. Afterwards, the next item is scanned and its quantity confirmed and so on.

2.4.2. Other hardware technology

Beside above mentioned hardware feature; scanner, existing PDAs may also be rugged and include camera, memory card, USB-port and have different technology of interacting with the equipment.

2.4.2.1. Rugged hardware

An observation from practical experience is that objects could be dropped during work. An example of this could be during daily rounds when the pad with paper or pen may be dropped

due to insensitivity or by accident, whereas during inventory checks there may be less external stress on the equipment of use.

In relation to the above regarding dropping equipment of use, a PDA can thus also be dropped during work. Consequently, a solution to this may be a rugged PDA to withstand external stresses.

2.4.2.2. Slipcase

The work on board vessels, particularly work in the engine department, includes inevitable contact with different oil, concentrate detergents and chemicals. Therefore, it may be likely that the PDA will be exposed to these substances.

Available protective accessories for the PDA are for example slipcases or plastic films that could preserve the screen over time (Handheld Group, 2012f; Motorola Solutions Inc., 2014c)

2.4.2.3. Keyboard/tablet-pen/Touch screen

Reporting work orders in the vessel's PMS is done on a stationary computer in a relevant department. However, it is common to first take notes of the work and then having it transcribed into the report, which may also be done by another crewmember. Describing the work procedure, observations and additional comments may vary in length depending on what work order is performed. From practical experience, some may find it inconvenient to bring paper and pen on site and will instead report from memory. By doing this, there will be a risk of forgetting valuable information.

With the use of a PDA, performing a task and reporting work or taking notes could be done simultaneously by the same person. In that way, it will save time and reduce the risk of forgetting additional information when it can be directly inserted into the PMS. Depending on the length of text to report, the required type of interaction between equipment and human may differ. For example, a PDA with a keyboard may make it easier to type longer texts, while a touch-screen is more suitable for shorter comments. On the other hand, some tasks require the use of gloves which will complicate the interaction with keyboard and touch-screen, and for that reason a display-pen could be useful.

2.4.2.4. Camera

What separates working conditions on board vessels from land-based jobs is that the workplace itself travels between countries at sea, and depending on the ship's trading area the cargo operations may differ regarding regular or irregular stopovers. If machinery breaks down in the middle of the ocean, it is naturally not feasible to visit a wholesaler ashore to obtain an accessory part while still being at sea. To get information and guidelines on how to solve a machinery breakdown, crew officers have to deal with manuals, technical instructions and occasionally make use of temporary solutions. Although if expertise is needed regarding advice and guidelines from example a manufacturer ashore, presenting photographs of the question at issue is a way to clarify the problem and avoid misconception. In that way, a

separate camera is often available and in this case placed in the engine control room. Captured pictures are then transferred to a stationary computer as an attachment to relevant document to then be sent to a person or manufacturer in question.

At the same time, when performing a task or a round, circumstances may occur where it can be of value for the end user to consult with other crewmembers. Describing the situation verbally or in writing is occasionally more comprehensible if pictures are presented as well.

Alternatively, a PDA with a camera could be used for taking pictures, which may be performed instantaneously while holding a PDA, without having to spend time on returning to the engine control room for a separate camera. Additionally, if the PDA is also used to log work orders in the computerised program for the purpose of managing maintenance, PMS, a picture could forthwith be attached in the report to clarify information.

2.4.2.5. USB-port

If a wireless technique is not available on site where tasks are performed, transferring manuals, documents and others onto a PDA could instead be done in advance using a USB cable. Or vice versa, to transfer collected operational parameters to a stationary computer with PMS from a PDA could retroactively be done with a USB port and cable.

Work such as crankshaft alignment or vibration inspections are measured with a separate measuring probe and are generally transcribed onto a pre-set paper with certain template. Afterwards, these data are either logged into the PMS or directly stored in folders.

A potential way of avoiding excessive transcription of information could also be done by connecting an external measuring probe or equipment to a PDA through a USB port, whereafter values may be automatically logged in the PMS or similar.

2.4.2.6. Memory card

Depending on the type of vessel; manuals and drawings relevant to the ship's operation are stored electronically, physically or both. For instructions and to seek guidance, it may be necessary to read relevant manuals or drawings before an overhaul. From practical experience, it is undesirable to have original copies of the manuals on site due to the potential of it being spoiled when it is in contact with oily hands and such. Therefore, it is preferable to take copies or print out relevant pages. It can however be inconvenient to search for the appropriate manual for a specific component if the vessel has not optimally administrated the manuals for the end user.

While scanning an item on site, relevant manuals for the specific component could be available in a PDA. Documents and such can be stored in an external hard drive or server, and through Wi-Fi, W-LAN or Bluetooth a PDA can fetch these documents through hyperlinks. However, if wireless technique is unavailable, it would be in some cases necessary to store gathered information or documents locally in the equipment. An alternative to local storage

would be to insert a memory card in the PDA. Thereafter, with the use of USB-port and cable, the information can for example be transferred to a computer.

2.4.2.7. Speakers and a microphone

Depending on ship type, all or some crewmembers on board have a communication radio. On some ships, it is common for all operational staff in deck and bridge department to have access to a personal radio at all times. This is because communication between personnel is necessary during different operations of the ship such as mooring and cargo handling. Meanwhile, in the engine department it is more ordinary to have a few ones that are shared but used when necessary. During practical experience, communication radios are used while bunkering, this is for example required due to safety and feedback to and from the bunker station and the control room.

Therefore, speakers and a microphone could be incorporated in a PDA as a complement. In a similar way to which a PDA with a camera can attach pictures in an email, a recorded sound could also be presented to an expert who is not on site for the purpose of elucidating a troubleshooting process.

2.4.3. Additional software features

Other than wireless connectivity, GPS and wireless transferring techniques, there may be other useful features in the software which could assist the end user who is carrying a PDA during work on board. Some of those can be history and trend display, text messages and a calculator, which will be described hereafter.

2.4.3.1. History and trend display

When maintenance of certain machinery and other components are carried out; one procedure may be to view an earlier report of the same task or problem. This may be to assist the operator during uncertainty, or it can be needed for possible guidelines in general. An example of this could be during a dismantling procedure. With the use of previous observations and method of solution during a former disassembly they could clarify future plans of actions to crewmembers. Because sharing information and experiences among crewmembers could be valuable for example in safety and troubleshooting aspects. To browse through prior reports and their history records may be done by a stationary computer, which is connected to a potential PMS program if this is used on board. If however during a round there is an occurrence where a machinery component is showing an inconsistency of performance, and in this case it is of interest to immediately browse through its history of work orders to have a better overview of potential problems; then it is inevitable to search for the nearest computer where the vessel's PMS is available.

Though if holding a PDA which is integrated with the vessel's PMS provided that each component is individually labelled, a more timesaving way could be to instantly scan and

identify the specific component with the use of the PDA where after showing its history of work orders could be one of many options in the software.

For example, on a daily round, it may be of interest to have an overview of a specific component's operational parameters. To look at previous operational parameters can be a guideline to make sure it is operating as required or during troubleshooting. From practical experience; collecting and logging of low prioritised data that are not integrated with the vessel's PMS, for example fresh water consumption on board, are usually done with paper and pen during a daily round. Afterwards, the noted values are inserted into a stationary computer where several Excel files are used for presenting a trend display of the data, whereafter each page is then stored in folders. Both the excessive paperwork and the manual managing of obtaining a trend overview make this common method inconvenient.

By using a PDA as an equipment during daily rounds, it could simplify the process of displaying a trend of certain parameters in such cases where troubleshooting is required. Similar to history records, displaying trend of a specific component could be another software option. If trend display is integrated in its software, then by scanning a specific component additional options could be to directly insert values or to easily show its specific trend of an operational parameter. Because of automatic managing of data, this will give the end user an instant and better overview depending on its interface and layout of presenting the information.

2.4.3.2. SMS/text messages

Crewmembers are often exposed to blaring and elevated sounds on deck or during loading and unloading of cargo and likewise in propulsion department when the vessel is in operation. This certainly affects the ability to communicate between different parties. Some work on board requires communication radios to interact with co-workers when each personnel are in different positions. Nonetheless, a communication radio has its limitations due to ambient noise. In addition, interaction over a radio may also be disrupted by other parties' exchange in communication.

To be able to contact a crewmember in distance, a communication radio has to be worn at all times but this is however seldom the case for engineers during for example a daily round. From practical experience, when it is urgent to contact the person in question, it is either done by searching for the person or activating a general alarm that can be heard in the engine room. If a PDA is used during rounds and it was urgent to contact the person who is carrying the PDA or vice versa, this may be done from a text message function instead (Handheld Group, 2012e), and this is of course also applicable for work performed by officers. In that way, communication between parties may be specific without interferences or possible disturbances from ambient noise.

2.4.3.3. Calculator

From time to time, certain calculations need to be performed during a work process. One example of that is when estimating a distance during dismantling of a coupling. The distance of the coupling position on the shaft where it was placed is subsequent important for the assembly procedure to prevent wear and vibrations.

A calculator is usually integrated in the PDA's operating system for example Windows Mobile[4]. Therefore, an easy access to a calculator while carrying a PDA could be desirable when precision is required for a work.

[4] Handheld Scandinavia AB, study visit 11 February 2014

3. METHOD

The method used regarding the research questions for this paper, is a questionnaire study. It was subsequently relevant to choose people that are familiar with the work on board vessels, whereby crewmembers in the profession were invited to participate. (Denscombe, 2009, p.32-39)

In order to answer the questions whether there is a need, and/or what features/areas a handheld computer can be applied on, these were structured with the use of a basic description that was formulated based on features of existing PDAs ashore. To find out existing features and how PDAs are currently used, information was sought out in relevant and existing research, regulations and requirements, technical books/product information as well as occasional study visits. In cases where expertise was required, relevant person/company was contacted for advice and information, which later on will be mentioned in the main text and in the reference list.

3.1. Implementation

For the subject in question, initial information concerning previous research and articles were continuously sought out within different sources, such as in electronic databases. Some of the collected information was used as a basis of compiling pertinent questions for study visits. These study visits were held in relevant companies who develop hardware[5], software[6] or maritime maintenance systems[7]. Notes were written down during each session, and these were later summarised for revision by each company. Revised notes of each study visit which were held in Swedish, are attached as Appendix A, A1 and A2 in this report. Based on the gathered information, a basic description and relevant questions for the questionnaire study were hereby being formulated.

Furthermore, the questionnaire study was held online on surveyplanet.com (2014.03.10-2014.03.30). Before initiation of the study, a pilot test was performed by a former crew member who in turn gave feedback on the estimated time spent on the survey. The estimated time along with a basic description was later used as an introduction for the participants. Invitation letters were sent out to individuals, publicly posted on landgången.se (2014.03.14) a seafarer's community, and in addition sent out to several Swedish, Norwegian and Danish shipping companies, with inquiry if the invitation letter could be further passed on to their ships. The survey was open for approximately three weeks, afterwards the results were summarised and are presented in the following chapter.

Throughout the procedure, discussions were held with different parties among other the tutor, other teachers, students and people in the surroundings, which subsequently lead to a visit at a

[5] Handheld Scandinavia AB, study visit 11 February 2014
[6] Binar Elektronik AB, study visit 17 February 2014
[7] SpecTec AB, study visit 18 February 2014

maintenance exhibition and additional inquiries to different companies. Some of these experiences did not contribute to the purpose of this report, although it provided a broader insight to the subject in matter.

4. RESULTS

As mentioned in the method chapter, a questionnaire study was carried out online for approximately three weeks. Some questions had predetermined answers while others were of purpose to freely express opinions and personal thoughts. These questions were in relation to personal opinions about how a PDA should be designed and used on board, and those regarding design features were set up as hardware and software functions, which had predefined options to answer. Meanwhile, more open questions such as how a PDA can be used on board different departments had unlimited words for the participant to express ideas.

However, to further analyse and collate answers of the survey, personal data of the participants would be necessary. These questions were the first in the survey and are hereby introduced as the first subheading. Thereafter, predefined and indefinite answers are presented. It should be noted that only the most interesting information is compiled; however, all answers are attached as Appendix B.

4.1. Personal data of the attendee, Question 1 to 5

To begin with, the survey had questions concerning the responders' personal situation. These were formulated to accomplish comparison between the responders' answers. Furthermore, it will facilitate compilation of the gathered information, which will in turn give a possibility to analyse the material from different perspectives. For example, observable differences or similarities between the participants' answers in relation to the ship type or rank.

The amount of participated crewmembers was a total of 24 people and is hereby presented in various categories. When it came to Ship type *Figure 4*, Container/RoRo/RoPax was the most represented among the different ship types. In addition, this ship type had the most balanced distribution between different departments. Meanwhile, work experiences were evenly spread from 1 to 40 years' experience as a crewmember, which *Figure 3* shows. The number of each gender and the variety of nationalities are presented in *Figure 5*. And finally, as *Figure 2* presents, there were more participants from the engine department than other departments.

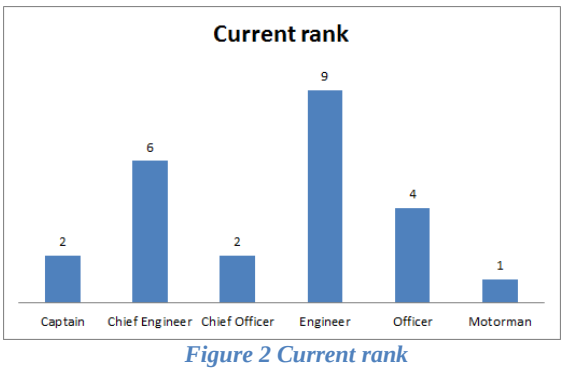

Figure 2 Current rank

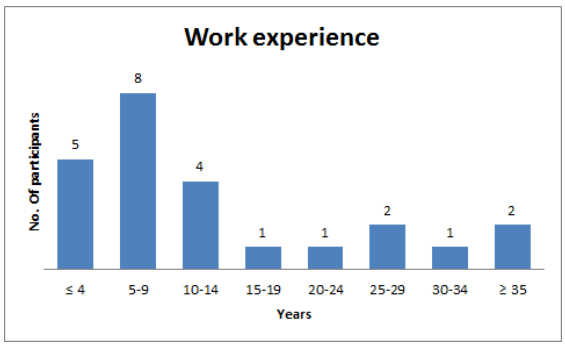

Figure 3 Work experience

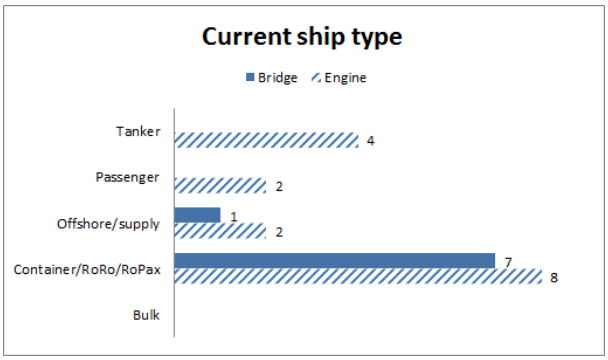

Figure 4 Current ship type

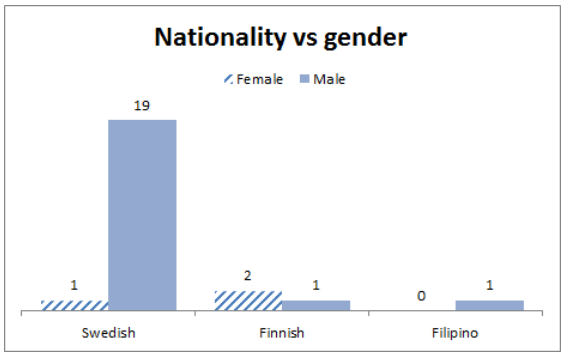

Figure 5 Nationality vs. gender

4.2. Predefined answers, Question 6 to 18

The second part of the questionnaire concerns what functions the PDA should have in relation to the working conditions on board, referring to 1.2.2 sub question iii. These questions were formulated with fixed options for the responders to choose from, such as specific multi-choice alternatives or yes/no options. Some of the responders' answers are compiled into different diagrams, which will provide a comprehensible overview of what features that the responders thought were preferable to include in the PDA.

4.2.1. [Q6&Q7] Should the PDA have a scanner function?

The first question regarding if the PDA should have a scanner function was formed as a fixed question, with either yes or no as alternatives. All attendees thought that there should be a scanner function in the PDA.

The following question was then in relation to what kind of scanning method the participants thought were appropriate for the work on board. There were three different kinds of techniques that were suggested in the survey; conventional barcode, QR and RFID. It was possible to give multiple answers, thus 24 candidates gave a total of 32 answers. *Figure 6* shows how many times each label was mentioned by each department, whereas *Table 1* presents a more detailed overview of each answer by different ranks.

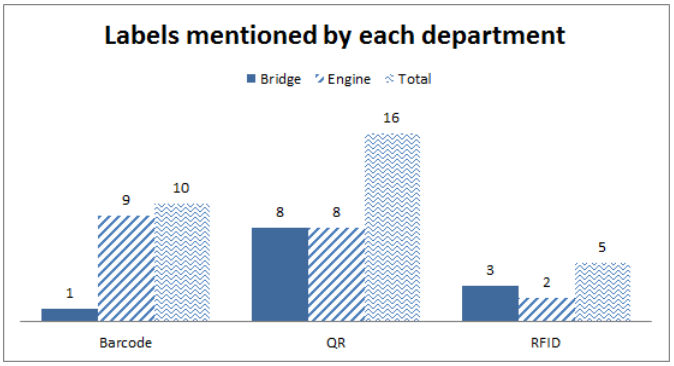

Figure 6 Labels mentioned by each department

	Barcode	QR	RFID	Barcode, QR	QR, RFID	Barcode, QR, RFID
Captain		2				
Chief Engineer	4	1		1		
Chief Officer		2				
Officer		2			1	1
Engineer	3	3			2	1
Motorman			1			
Sum	7	10	1	1	3	2

Table 1 Labels mentioned by each rank

4.2.2. [Q8] Keyboard/touch-screen and/or display-pen?

The question that was referred to various techniques regarding human interaction with the equipment allowed multi-choice options. 24 people gave a total of 30 answers which are shown in *Figure 7*, where it also differentiates each department.

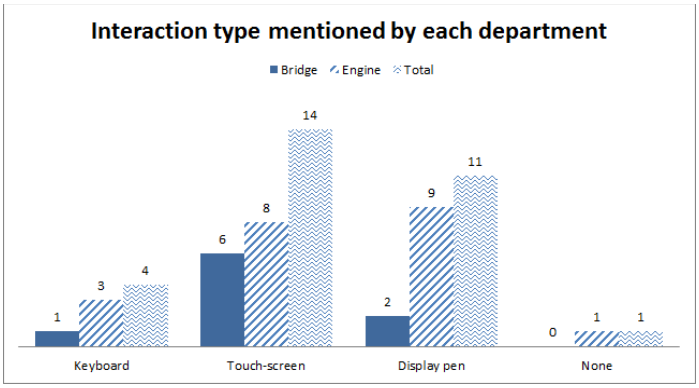

Figure 7 Interaction type mentioned by each department

4.2.3. [Q9] Speakers and/or microphone?

Out of 24 responders; 12 people expressed an opinion if there should be speakers or microphones in the PDA. While *Figure 8* shows differences between the engine and bridge department, 12 people did not reply and all of them are from the engine department.

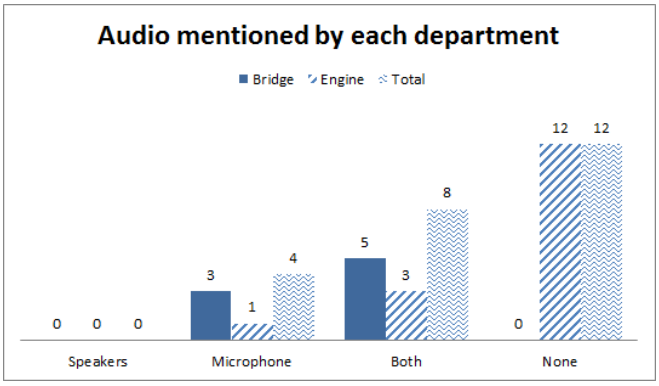

Figure 8 Audio mentioned by each department

4.2.4. [Q10] USB-port?

The question was formed with either yes or no alternatives. The result shows that all attendees thought there should be a USB-port in the PDA.

4.2.5. [Q11] Memory card?

This was formed as the previous question; 22 people preferred a memory card while two persons who were from different departments, did not.

4.2.6. [Q12] Camera?

The options in this question were either yes or no. 21 attendees thought that the PDA should include a camera whereas 3 people representing the engine department thought not.

4.2.7. [Q13] Calculator?

As above, the choices were either yes or no. 20 out of 24 participants thought that the equipment should be incorporated with a calculator. On the contrary, three persons from the engine department and one person from the bridge department gave no as an answer.

4.2.8. [Q14&15] Bluetooth and/or Wi-Fi?

In the questionnaire; Bluetooth and Wi-Fi were two different questions, however, they are presented together since both are a wireless transferring technique. A total of 20 people; 14 from engine department and 6 from bridge department, thought that there should be a Bluetooth feature. Meanwhile, 22 people voted in favour of Wi-Fi and among those were 14 representatives from the engine department and 8 from the bridge department. An overview of this is shown in *Figure 9*.

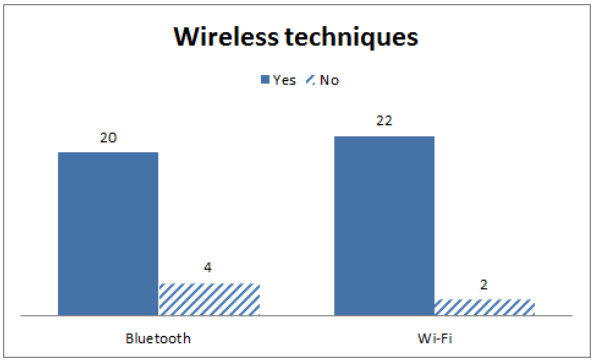

Figure 9 Wireless techniques

4.2.9. [Q16] Texting and/or Email function?

The question about whether written communication should be available in the PDA was formed with the possibility of multiple answers; texting, email or none. Texting and email was mentioned 12 times each, meanwhile 9 people thought that these features of communication should not be included in the PDA.

4.2.10. [Q17] GPS?

Attendees were able to answer yes or no, furthermore they could leave a comment for additional elaboration of the chosen option. Only one person out of 24 thought that a GPS should be incorporated in the PDA.

4.2.11. [Q18] Additional software functions?

There were two fixed options available, and these were history and trend display. However, a third option was available for adding other functions, whereby two added the option of having planned maintenance system integrated in the PDA, *Figure 11*.

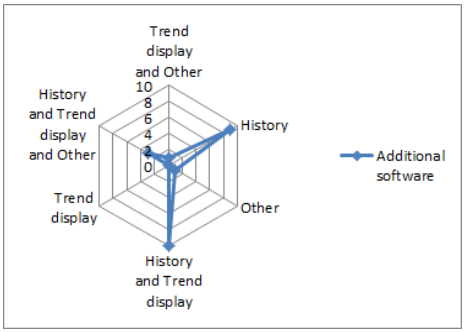

Figure 10 Additional software functions (a)

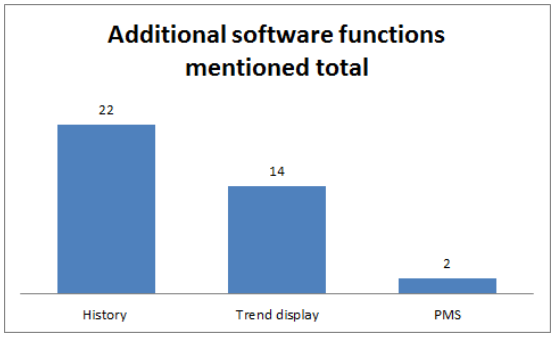

Figure 11 Additional software functions (b)

4.2.12. Summary

A summary and an overview of above questions are shown in the following *Figure 12*.

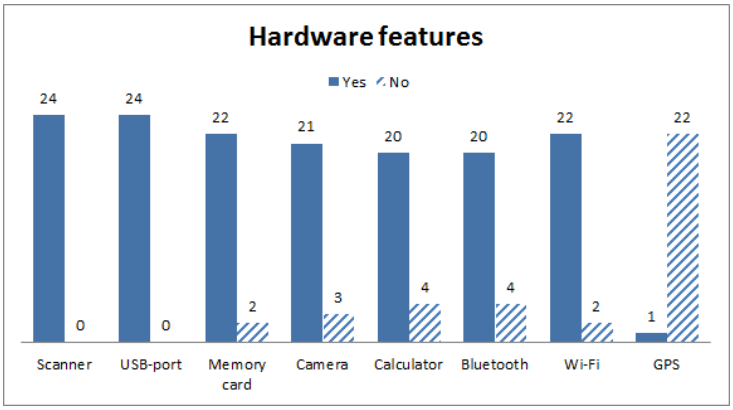

Figure 12 Summary of hardware features

4.3. Indefinite answers, Question 19 to 26

The last part of the survey is specifically concerning 1.2.1 main question, 1.2.2 sub question i and ii. These questions were formulated in such a way to make it possible for the responders to freely express opinions and ideas. As a result of the open questions, the indefinite answers would have to be compiled by the use of a word processing program to be able to define and count common keywords that were mentioned by the participants. Furthermore, when different words were used to describe an equivalent function for example; “PMS” and “maintenance system”, they were added to the same summation. Finally, words and/or functions that were mentioned two times or more are compiled into comprehensible diagrams to get an analysable overview.

4.3.1. [Q19-Q21] How can a PDA be used in each department?

These questions were directed to each individual department on board; bridge, deck and engine. Consequently, the results will provide similarities and differences between these departments, which can furthermore be analysed.

Out of a total 8 people who are associated to the bridge department, there were 5 people who answered. While 6 out of 16 in the engine department provided possibilities for how a PDA can be used in a bridge department. *Figure 13* is only based on keywords that are mentioned by two individuals or more.

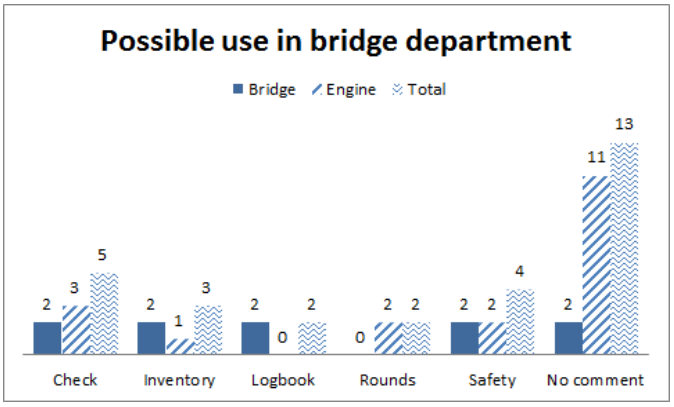

Figure 13 Possible uses in bridge department

In relation to how a PDA can be used in a deck department, common keywords that are mentioned by two participants or more are shown in *Figure 14*. 5 out of 8 crewmembers from the bridge department as well as 7 out of 16 from the engine department responded.

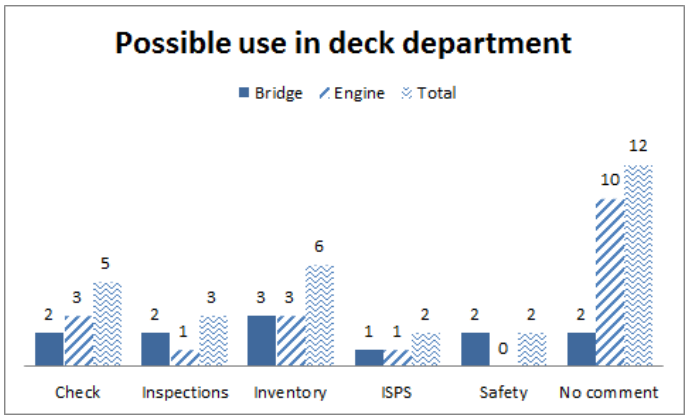

Figure 14 Possible uses in deck department

15 of 24 people that are shown in *Figure 15* provided various possibilities for how a PDA can be used in an engine department, whereby 14 out of 16 persons in the engine department answered and 1 out of 8 persons from the bridge department.

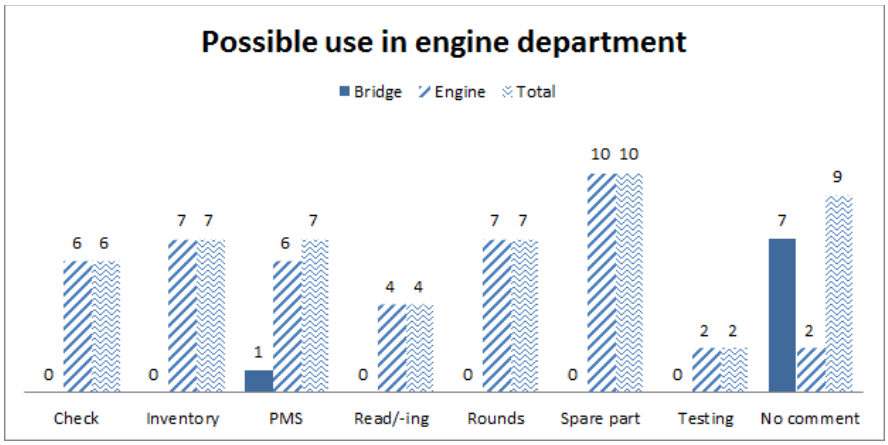

Figure 15 Possible uses in engine department

4.3.2. [Q22] How should the number of PDAs be distributed on board?

The question was composed as an open question, and among 24 crewmembers there were 20 people who responded, as *Figure 16* shows.

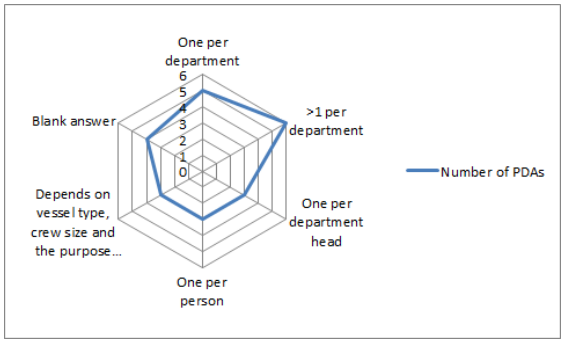

Figure 16 Number of PDAs on board

4.3.3. [Q23] Can a PDA be applicable on board a ship?

Out of the total 24 participators, there were 23 people who thought that a PDA could be incorporated on board a merchant vessel.

4.3.4. [Q24] What physical features of the PDA do you think is important?

The question had no predefined measurements for the attendees to consider; hence, they wrote down their own expressions. A simple matrix of their answers is compiled in *Table 2.*

Keywords	No. Times mentioned	Existing sizes as reference				
		IPhone	Galaxy	Half IPad	Fluke	IPad
Smartphone		-	-	-	-	-
Large smartphone	1	-	1	-	-	-
> Smartphone	1	-	-	1	1	1
Handy size	4	4	4	4	4	-
Half size of IPad	1	-	-	1	-	-
Pocket size	5	5	5	5	5	-
Fluke size	1	-	-	-	1	-
Tablet size	1	-	-	-	-	1
Not too small	2	-	2	2	2	2
Not too big	3	3	3	3	3	-
Depends	2	2	2	2	2	2
	TOTAL	14	17	18	18	6

Table 2 Preferred dimensions

4.3.5. [Q25] To what systems should the PDA be connected to?

There were three options for the participant to choose from and these were; none, maintenance system and other. The latter gives the attendee an opportunity to add desirable systems other than the maintenance system, which are presented in *Figure 17*. However, only the keywords that are mentioned more than two times are presented in the diagram.

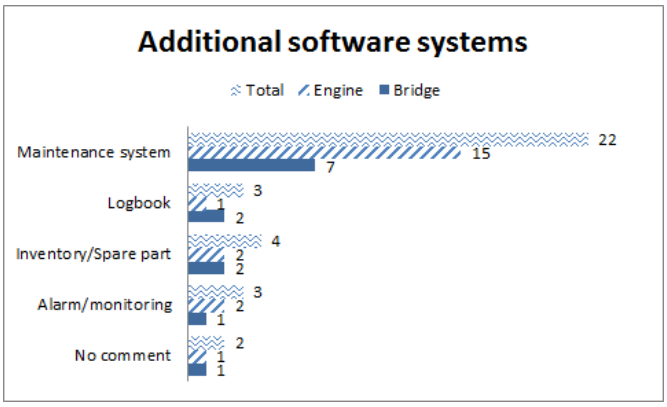

Figure 17 Additional software systems

4.3.6. [Q26] Additional comments

For this optional question with no predetermined alternatives, there were 11 respondents. Some of the information they gave were profound; therefore, each responder's answers are given in full text.

"A PDA should first be implemented in one usage as otherwise one would have to run around and look for as everyone is using it for Everything." – **no.1**

"If the maintenance system in a PDA should be useful then it has to be integrated with the system in an adequate way. If I am sitting by a computer in the control room while looking for spare parts/compiling a list of work orders or anything else in the maintenance system then I do not want to have to open a new session in the PDA to look for the same things all over again. Then I would just end up writing down the information onto a piece of paper instead. I want to quickly and easily transfer information to the PDA so that I can 'pick up where I left off' to later take it all down to the engine room, just as easy as printing out a paper. In the same way, I want to smoothly transfer information from the PDA to the stationary computer in the control room when confirming a work order. Circumstantial syncs with third-party programs ruins it entirely, it should be integrated with the maintenance system itself in a convenient way. Ideally when I log in again then I will end up where I left off in the last session.
However, to bring the alarm and monitoring system out to the engine room then it does not have to be as smoothly configured and integrated with the rest, since the pros of having 'the control room' with you in the engine room weigh over the cons."
- no.2 (freely translated from Swedish)

"Good idea perhaps to minimise paper amount on board." – **no.3**

"The risk with this type of tool is always that common sense will suffer if it goes too far. If a computer always tells you what you should do and what to inspect, then you will not need to think for yourself. In that case, you do not need to have an expensive crew since anyone who can read is suitable. Safety will suffer but the ship is ascertained, and you can always get a

hold of new crew who can read." – **no.4 (freely translated from Swedish)**

"I believe that simplicity is important. Not too many bugs in its software, otherwise it will be forgotten in a locker somewhere." – **no.5**

"It should be investigated which RF frequencies are best to use on board so that they won't affect other systems, or that other ship borne systems like UHF doesn't affect RFID. Wi-fi is easy and inexpensive to set up on board. PDA will be easy to connect to servers and systems via Wi-fi. Cloud should be used via Wi-Fi instead of internal memory of the device. Telecommunications transmit/receive bandwidth shouldn't be a problem as the cloud server would be on board. Keyboard should be available for cases that longer reports should be written on scene. Otherwise display pen is sufficient." – **no.6**

"(Vessel A) once had a barcode reader in the engine department, and it was used to log running hours. The barcode reader identified the specific component where after the running hours were submitted by hand in the device. I do not know how long they were doing this but what I understood it worked so-so.
If the PDA is of suitable size then maybe it can also be connected to the alarm and monitoring system so that you can see and acknowledge engine alarms in the device, though this would mean a PDA for each Engineer. (Vessel B) has a system which is convenient when it is possible to read and acknowledge alarms on a portable device, however most of the Chief Engineers in Swedish shipping would be surprised if the Engineers could acknowledge alarms elsewhere than in the control room."
- no.7 (freely translated from Swedish)

"RFID would be less useful than QR, it could however complement it. Without an ID scanner it's so much less useful that it probably won't be used at all." – **no.8**

"It's a very interesting topic. I think the future will prove your idea and these devices will come in use on board ships in a near future, but as usual all the special regulations in shipping will slow things down." – **no.9**

"I see this PDA as contribution to already existing systems on board, but it should be constructed in the software so it will save time and effort regarding paper work.
In my job it would benefit really good regarding digital logbook, PMS on deck. Also you can bring risk assessment with you." – **no.10**

"I think this is a very good idea, if this could be implemented then a lot of time could be saved, when you have all parts/components stored." – **no.11**

5. DISCUSSION

Initially, credible and trustworthy sources and references such as legal framework and scientific information were deliberately used for this study. During certain circumstances it was necessary to use companies and technical specifications of equipment for descriptive information that is relevant for this report. These were accordingly used as references. Nevertheless, technical specifications are considered to be reliable even though they can be of a promotional purpose.

The following discussion of methodology will describe the event of choosing the specific method of this report, and due to certain circumstances why this was chosen in comparison to the other methods. However, during the progress there were different factors that were found concerning reliability and validity of the chosen method, which will further be reasoned in this heading.

Moreover will the result discussion deliberate and emphasise common answers among the survey attendees regarding features, the size of the PDA, possible use of such equipment in each department and so on. Therefore, it should be noted that even though this study is focused on what a PDA can be used for, the discussion of the results will only deliberate results that are of most interest and are in uniformity mentioned by the participants.

5.1. Discussion of methodology

Among the first actions during thesis initiation, a method should be determined. Usually it is the question formulation and its purpose that postulate this decision. (Denscombe, 2009, p.183-184) In this study, the question is of such nature that people's opinions are important. Consequently, a literature study could not be used more than to search for facts. People under consideration for participation are geographically spread out; therefore, interviews would have to be conducted by phone and be recorded. Both implementation and compilations of these interviews were considered excessively time consuming within the timeframe (Denscombe, 2009, p.255-262). A questionnaire would be a more swift procedure, though open questions were considered onerous and ambiguous to compile; hence, focus groups were evaluated to be the best method (Denscombe, 2009, p.237). This is because answers can be promoted to be elaborated during a discussion between participants. Throughout the process it was noted that the method of using focus groups was difficult to execute in practise, instead a questionnaire was prepared and finally executed.

Crewmembers live on board a vessel during their whole working period and this can differ from one week up to more than ten weeks. When off-duty, they are not bound to a specific workplace and could live wherever they prefer. The body of opinion is geographically spread out and during working periods they are stationed on one ship. Therefore, the required administration to gather these people to one specific place during a common timeframe was not seen as achievable. (Denscombe, 2009, p.241-243) Other alternatives had to be considered

and interviewing by phone was one option. Though, in combination with focus groups, discussants would have to talk in a specific order and it was evaluated to be difficult for a moderator to structure and organise the discussion. (Denscombe, 2009, p.239-240) Consequently, the use of online discussion groups, where all participants could express opinions simultaneously during the whole session, was evaluated as the most preferable method in this case.

Regarding the first intention to use focus groups, different open-source internet platforms were tested. Eventually Adobe Connect was chosen to be the most satisfying for this purpose because of a user-friendly layout and useful features. This platform was however used by the license of Chalmers University of Technology and was not an open-source.

When the choice of an online discussion forum was decided, it was discussed if groups would be conducted with participants' real names or with a concealed identity. From experience, the environment on board is quite conservative by tradition and the group dynamics are often hierarchically structured. Therefore, concerning group dynamics, the use of anonymity within the discussion groups was selected (Denscombe, 2009, p.243-244). In this way, it was easier to integrate individuals without the consideration if the participants were known to each other or not. Even though strangers could find it difficult to discuss with each other, it was considered more preferable with anonymity than having the risk of the debate being influenced by a potential group dynamic.

Invitation letters with a general description were sent out to individuals, publicly posted on landgången.se (2014.02.23) a Swedish seafarer's community. The letters were also sent out to different shipping companies, with inquiry if the invitation letter could be further passed on to their ships. (Denscombe, 2009, p.40-41) The individual responders then received more detailed information about the actual conditions for participation, with the basis of discussion as an attachment. They were divided into different groups based on current position and department, either engine or bridge area. They were also assigned pre-set usernames for the purpose of anonymity and a link to an online scheduler; doodle.com, where they could book certain times for participation. The intention was then to match groups according to the results from the online scheduler.

Former crewmembers with on board experience were invited to participate in a pilot group. The purpose was to evaluate the concept and procedure before the actual focus groups would be executed. When the basis of discussion were finalised, invitations were sent out together with a doodle scheme where they could register to several available times. Due to poor responses from these invitations, the use of pilot groups could not be performed.

Nor could the actual focus groups be carried out due to same reasons as above. Additional reasons could be that too many meeting slots were offered, which caused problems to constellate groups since the scheduled time opportunities were too many in relation to the number of participants. Other reasons could be a too complicated process for the participant,

and that the chosen method is relatively modern and in general not yet established.

While the process continued and the planned focus groups did not appear to be fully accomplished according to expectations, discussions about alternative methods were commenced simultaneously. The target group was the most important in this context and because they were geographically spread, an alternative was to use a questionnaire instead. Earlier to support the moderator during the performance of the focus groups, a foundation with questions had been established. It was decided that this material would be adapted into a questionnaire study. Preparations were done beforehand in case focus groups would not eventuate.

Meanwhile, there were different types of online platforms where a questionnaire could be initiated. Different platform had various functions regarding how such answering alternatives could be designed. For example, settings can be selected to be just one or several choices when it came to answering a question, furthermore comment boxes could be added in addition to a question either separately or in combination with other response options. Some different online platforms were tested and the choice fell on surveyplanet.com.

When it was certain that the focus groups could not be performed, it was decided to use the survey instead. Those who already agreed to participate in the focus groups were approached again to take part in the online questionnaire instead. Shipping companies that were contacted earlier were once again emailed with a new petition to send a new invitation to their employees with a link to the survey. As before, it was additionally publicly posted on landgången.se (2014.03.14) once more.

By using an online survey means less control of who will participate, which means this method may be biased (Denscombe, 2009, p.27-28, 41-42). For example, there may be a possibility that some of the participators did not comply with the requirements of being an active crewmember. During a discussion whether the survey should be posted in additional seafarer's groups on facebook.com, it was determined that the risk of increasing biases were too high since anyone could participate due to partly anonymous participation. Therefore, the choice was to not post in these community groups even though it may have resulted in a higher response rate in relation to the short timeframe.

During the process it was noted that there were some issues for some participants to open the survey in their browsers. This may have been one disadvantage of using an advanced online survey, since its additional features of settings require certain system requirements for the browser in use. Therefore, some who wanted to participate may have been left out due to their browser did not comply with the survey's requirements.

Also, during the three weeks there should have been a few more reminders such as once a week. This reasoning is taken into account due to the fact that there was only one reminder that was sent out, and this occurred when there was approximately one week that remained of

the survey until it was closed. An observation is that some people who were interested in participating in the focus groups did however not participate in the survey. Reasons for this may have been due to previous mentioned issues such as incompatible browsers and/or that not enough reminders were sent out.

At the end of the three weeks, it was also concluded that some of the questions should not have been with two options; yes or no. But more convenient would have been to propose options such as must have, good to have and not necessary. In that way, it may have been easier to differentiate and analyse the results more profoundly. Instead, "yes or no" options may consequently only indicate functions to be "good to have", which makes it difficult to differentiate what is necessary and what is not, regarding 1.2.2 sub question iii.

Additionally, there were indications that more crewmembers were interested to participate in a survey rather than focus groups. With this in mind, the response rate would likely be greater if questionnaire study was chosen from the beginning and not focus groups.

5.2. Result discussion

The most comprised data from the questionnaire is presented in the following sections. Though there is a comprehensive amount of information, the results of the survey will be available in Appendix B. Subjects that were mentioned more than one time obtained more attention than those that were stated exclusively. Nonetheless, individually stated answers are intriguing as a whole, though it is not realistic to discuss all pieces of information.

5.2.1. Survey attendees

The amount of participated crewmembers, which was a total of 24 people in the study, was relatively low in relation to the number of crewmembers that were in attempt reached out to. The result still gives a reasonable representation of various crewmembers regarding current situation that exists in the branch of merchant fleet (Trafikanalys, 2012).
Container/RoRo/RoPax had the most representatives when it came to different ship types. In addition, these ship types also had the most balanced distribution between different departments. Work experiences were evenly spread from 1 to 40 years, which is another factor where the results of the survey are well represented concerning different generation mind-sets. Based on practical experiences, the gender distribution in the survey is considered to be moderately accurate. In addition, based on yearly shipping prognosis made by Swedish employment agency (Arbetsförmedlingen, 2013), the number of women in the survey which is 12.5%, are within predicted percentage 5-20% depending on ship type.

However, the variety of nationalities is not well represented. The reasons for this is probably that most participators were notified through shipping companies from the Sjöfartens Utbildnings Institut SUI, which is a governmental institute in Sweden that distributes trainee posts for Swedish students at different maritime programs. Several inquiries for participation

were also sent to acquaintances that are crewmembers while it was finally posted online in a Swedish community for seafarers. In the survey, there were more participants from the engine department. A hypothesis is that it is basically a technical issue and it could attract engineers more than officers. In order to analyse the material in a situation where the objective is to find out specific differences between different ship types, different positions or any other relation, this questionnaire study is as a whole not sufficient.

Further analyse of the results 4.3.3, can a PDA be applicable on board a ship, also indicated that there was only one out of 24 who disagreed with this matter. Taking this into account, the indirect selection of survey attendees may have been biased based on the degree of interest among these participants. Basically, due to an introductory text in the invitation letters, these letters may have unknowingly appeared to be mostly directed towards those who found this subject interesting. Therefore it is possible that people who did not find the survey interesting enough or did not believe that such equipment could work on board, chose not to participate in the questionnaire study. The estimated number of crewmembers who this concerns is unknown; furthermore, this conclusion is also of significance to the whole survey.

5.2.2. Scanner and labelling type

Though the techniques are closely associated to each other, one item does not function without the other. Therefore, in this section they are compiled as one topic. There was no separate question about the scanning modus operandi itself, due to the fact that it is the labelling technique which decides what kind of scanning method should be used, or vice versa. At the beginning, the RFID tag was considered to be of greater interest because it would not be affected if it becomes dirty or covered with dust, which it will be at some areas on board a vessel. Also, unlike barcode or QR tag, radio wave transferring from an RFID tag will not be influenced if it becomes covered with paint during restoration and maintenance.

On the other hand, discussions were held at Collinders AB's booth at Underhållsmässan, a maintenance fair in Gothenburg (Svenska Mässan, 2014). Various labelling printers were presented and certain problems with RFID were explained. One example is that it is easy to block the radio waves by unwanted materials in the way, which disturbs the connection between the RFID and its reader. Another example is the cost differences in comparison to the traditional barcodes or QR labels. According to Collinders AB, it is more expensive with RFID. With these issues in mind, barcodes and QR labelling may have a slight advantage regarding working conditions on board, since they are also cheaper to replace than RFID. As stated in 2.2.3 scanning techniques, a new label can be printed and replace a damaged one by using a stationary or mobile barcode/QR printer. This can be purchased as a complement and additionally be connected to a planned maintenance system and its inventory of spare parts. In the survey, RFID had the fewest votes. This may be due to similar disadvantages of the RFID as mentioned above, or that this technique may be relatively modern and unknown among some of the attendees.

5.2.3. Wireless techniques

The possibility to use a PDA to its full extent as presented initially, requires either Wi-Fi or internet access. As opposed to ashore, the internet connection on board is not reliable in the same extent. They often have a limited bandwidth that is also shared between different users on board. The latter in combination with areas below the water surface and metal hull that decreases signal range; provides internet that is not fully reliable when it comes to data transferring in relation to utilising a PDA on board a ship. Although, there is of course a possibility to install Wi-Fi access points to cover the entire vessel as mentioned in 2.2.2, but the limitation is solely about cost and how much the ship owners are willing to invest in this matter. Because if it is not a passenger ship, installing additional access points for wireless internet would merely be of purpose for the crewmembers. Ships built during the last five years, have more or less Wi-Fi installed[8], but it could still be necessary to do additional installations if a PDA is used on board.

While Bluetooth is not required as a wireless transmission on site during a specific assignment, it is more about transferring data locally and wirelessly to a stationary computer or additional equipment such as a printer. The result of the survey indicates more or less that wireless techniques of transferring information are preferable.

5.2.4. Features and preferable size

Evidently, a PDA needs different functions to fulfil its purpose. Scanner and labels are considered to be the most interesting part in this equipment since this function will modify and develop working procedures on board ships more directly, which is further described in previous chapter 2.4.1.

As mentioned in 2.4.2.3, another essential feature is the possibility to enter alphabetic characters and numbers. Depending on the length of the text that is written, a suitable interaction with the PDA may differ. Some tasks that are performed on ships require use of gloves, which means a keyboard might not be considered since gloves do not improve the ability to interact with key buttons. However, if a keyboard is used then it should at least have sizable buttons. Moreover to make the device easier to clean, there should be no gaps around the buttons where dust and grease could be accumulated. On the market there are solutions like rubber-moulded sections for this purpose. In the survey, touch-screen is preferred. Crewmembers from engine department desired a display pen in a greater extent than those from bridge department. A reason for this could be that the engine room environment consists of more dirt and grease, which encourages a more frequent use of gloves. Additionally, if it is used by an ISPS (International Ship & Port facility Security code) guard to register people who is boarding and leaving the ship during port operations, a display pen could be used for signing on and off in this context.

When it comes to if a USB-port should be built in or not, there is not much to add. It is utterly

[8] Diwiton AB, phone interview 15 April 2014

a feature that a PDA should have, which the questionnaire also confirms. What is worth discussing in relation to measuring probes mentioned in 2.4.2.5, is the fact that it may not be sufficient with only a USB-cable between the measuring probe and the device for it to function, without the need of using additional connectors. This is because existing instruments for measuring purposes such as a vibration meter has different transducers and connectors (SPM Instrument AB, 2014). As a whole, these various types of transducers have different purposes to measure specific parameters. Subsequently with this in mind, if in the future a PDA will be used for this purpose, it will undoubtedly require a developing process where manufacturers of the individual measuring devices are involved. Therefore, it is not foreseeable that a PDA will be used in this area, at least not within a prompt future and especially when it comes to rarely performed measurements. Moreover, taking current situation into account, it is more probable that the purpose of a USB-port will be to transfer data locally if wireless transferring is not available or preferred.

Similar to a USB-port, a memory card is nowadays cheap and is a common component in most electronic equipment such as computers, mobile phones and cameras. If a PDA becomes a reality whereas a ship does not have a Wi-Fi installed or if it is exposed to a temporary shut-down, a built-in storage like a memory card will thus be useful. Consequently, a PDA should absolutely have a memory card, which the survey also confirms.

The starting point was to investigate if some common features in existing PDAs that are used ashore could also be used for working purposes on board a merchant vessel. Therefore, some of these features may have appeared to be unnecessary at first, and one of them is microphones and speakers. As explained in 2.4.2.7, communication radio is used daily on board. Although, this may not be the case for all ship types, but an observation made from internship experience is that staff on deck and at bridge use it more regularly than those who work in the engine department. This could be a reason to why 75% of the responders from the engine department did not answer this question. Among those who responded to this question, everybody except one thought that there should be both microphone and speakers. If a PDA will be used as an alternative to audio communication, both components should be incorporated by necessity. If this equipment becomes a reality on ships in the future, it might replace the communication radio since carrying both a PDA and a communication radio could be inconvenient.

Another not so obvious feature at first is a camera. Nonetheless, 21 of 24 participants thought that a PDA should have a camera. As described in 2.4.2.4, there are several situations where a camera could be suitable; therefore, most of the participants find it convenient to include this function in the PDA. First and foremost, some tasks are performed at positions that are difficult to reach since there may be potential obstacles along the route of the assignment. In general, these could be ladders, cargo and watertight doors. Therefore, the proceedings between these obstacles to reach a location where a task will be performed can be time consuming. If there is a possibility to take pictures with the PDA on site to be able to retroactively present the problem, then it could probably save time in comparison to how it is generally performed today, which usually consists of moving back to the engine control room

to find a co-worker whose whereabouts can be difficult to find. If Wi-Fi and a text message function are also available then the picture can furthermore be sent with an inquiry to a colleague. If not, the picture can instead be brought back to the engine control room where a discussion can possibly clarify the situation before turning back to the site. Consequently, without a camera, the simplified and timesaving procedure does not exist today. Instead, there is a possibility that another crewmember is accompanied with to the actual site, which may also interrupt their work. This is an additional dimension of the aspect that is described in 2.4.2.4, where the focus is more about troubleshooting and using it during communication with companies or persons ashore. However, to be able to use a PDA in this context to its full extent, it is required that each crewmember has a PDA that includes a camera. Consequently, it will result in a personalised and standardised tool for everyday use.

There is an essential difference between the participators' answers when it comes to the amount of PDAs on board a ship. It varies from one PDA per department to one PDA per person. One reason could be that there are no determined or predefined functions in relation to one or several designated assignments. Therefore, participators did not have a specific situation in mind when they responded to this question. If the number of PDAs should be determined in a more substantial way, a specific vision about its features in combination with a distinct purpose for its utilisation would be necessary. This could be one reason to why answers were diffused. As mentioned above, using a PDA in certain aspects could require one per crewmember. Meanwhile, if it is solely used to perform checks as in, 2.4.1.1 and inventories as described in 2.4.1.3, one PDA per department could be sufficient. Consequently, the question asked in relation to this problem was too broad; therefore, this matter cannot be determined.

Apart from features in the PDA, its actual size should also be of importance. The whole concept is built on mobility and thus it should be simple and manageable to carry while climbing ladders and performing tasks when both hands are occupied. Therefore it should be possible to keep it in a pocket or suspended in a hook on work wears. For the purpose of analysing and to provide a better overview, the following *Figure 18* demonstrates various dimensions from existing hardware. Starting from the left is an iPhone, Galaxy, half-size iPad, Fluke multimeter and iPad. These sizes are proportionally shown with comparison to an average female and male hand. The result from the survey in 4.3.4 indicates that sizes from Galaxy to Fluke multimeter are more preferable than an iPhone or an iPad. Moreover, depending on what the PDA is used for, its screen resolution and brightness may also be of importance due to convenience for the end user.

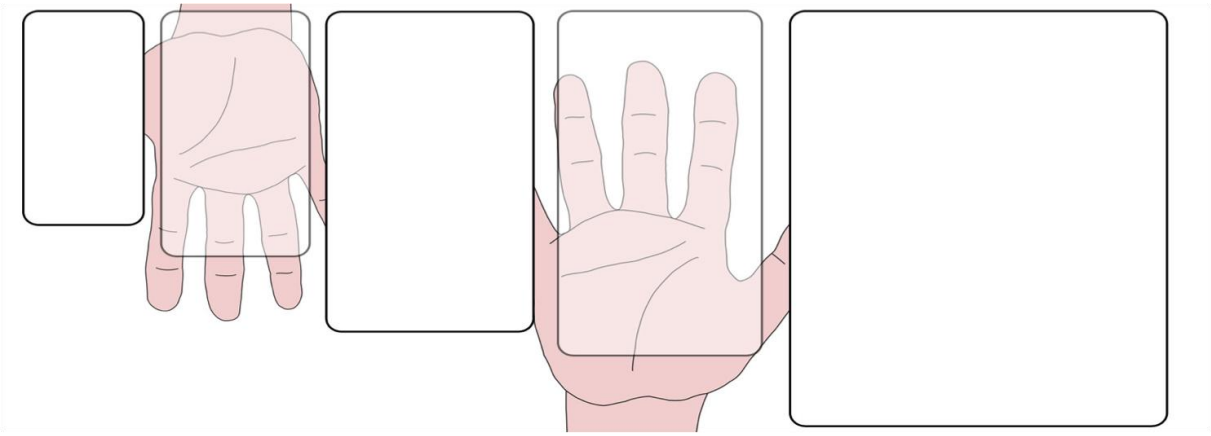

Figure 18 Overview of preferred dimensions of a PDA

Among its physical attributes, keyboards and buttons have already been mentioned. Furthermore, its possibility to withstand impacts is significant and it should therefore primarily be constructed to endure such conditions. It should also be manufactured in materials that can tolerate corrosive chemicals and solvent lubricants. Finally, IP and ATEX classifications regarding dust, water conditions and explosive atmosphere should be taken into consideration.

5.2.5. Possible use of a PDA at different departments

Even though this report investigates what possible use a PDA can have on vessels, the focus is still on features that are in total mentioned two times or more. This is because it is more interesting as a whole to look into aspects that are encountered by several people rather than features that are solitarily mentioned. While the questions regarding various departments were asked separately, the presentation of the results is collaborated as they have much in common. The results show that many participants did not contribute answers in each department, and an adequate assumption is that crewmembers predominantly responded in relation to their own department. As participators accounted for their current positions, this is also indicated by the questionnaire.

History and trend display was particularly asked in the questionnaire and is closely associated with how such functions can be used, as described in 2.4.3.1 and presented in 4.2.11, where the result indicates clear interest in these features. Due to different circumstances on board, it is important to be able to troubleshoot and perform analysis. Therefore, if it is possible to show data in a comprehensible overview for analysis on site, it could in some aspects be convenient and timesaving during assignments. To entirely benefit from this procedure as a whole, it will require wireless transferring from where the position of the task is performed to the host computer, where operational parameters are gathered in the maintenance system. Consequently, if it is possible to check specific machinery's recent overhauls in combination with its running hours, it can immediately clarify a situation.

When open questions were transcribed, these were analysed by looking for repeated words, although they were not always mentioned in the same context. On the other hand, they had a line of argument and uniformity in the way that they were mentioned. For example, the word "checks" reoccurred in different aspects and is obviously a substantial subject for the participators. While analysing results from questions about possible use at different departments, features that were repeated and mentioned in all departments were foremost; check, round and inventory. As already stated in the title of this report; a multifunctional handheld computer which means it should be suited to several functions and adjusted to the entire ship. Where PMS is used on ships, the program used on board is the same for the entire ship and is shared between each department. Even though each department may perform different tasks, they still have PMS, ordering merchandise and keeping track of stocks in common. This may explain why there is a unity of answers in the open questions disregarding different departments.

"Inventory" is mentioned in all three departments, summarised to a total of 15 times. In land-based efficacies, inventory checks are common tasks. Most branches have records of their stock items to keep regular track of their momentary items. This provides a possibility to analyse consumption historically and furthermore an opportunity to plan stowing items in relation to a presumed use in the future. As discussed in 5.2.2 there are printers on the market which could be connected both to stocks and PMS. Combining these with a PDA for logging inventory and items that are used on site while performing duties could improve working procedure tremendously. While engine staff abundantly mentioned "spare part", it was the most common feature mentioned in this department. It is closely related to inventory and for that reason it is mentioned in this context. If a PDA is connected to the PMS and used in combination with work orders, then used spare part could directly be noted in the report on site and later transferred to the host program when finished. Thereby, stocks will automatically be updated.

On the market there are several different manufacturers of different equipment which can be used as a PDA. The range is not only about the various features found in them, but also about what kind of environment it is suitable for. Depending on where in the ship a PDA is to be used, there are different requirements on what the equipment will have to withstand. Should it only be used to perform inventory of stocked goods or to perform work orders on site in the engine compartment? Inevitably, differences in these demands will affect the price since higher demands equal higher expenses. If redundancy is considered to be important, it could be essential to ensure exchangeability between devices if several PDAs are used on board one ship, subsequently all items can thus be interchangeable.

When it comes to additional comments in the questionnaire, they are presented in its entirety since they provide information that is impossible to compile into diagrams. Many important aspects are pinpointed in these comments. For example it is stated by participator no.8 that without a scanner it would probably not be used. In a way this confirms the statement made in 5.2.4 that different labels in combination with their scanning technique are the most interesting part in this device. However, what will prevent implementations of a PDA as a

working tool on board is mentioned in comment no.6 and no.9. While no.6 points out investigations concerning what frequency to be used for RFID tags (if utilised), no.9 discusses the time to process, adapt and implement regulations regarding shipping industry.

Among other things no.2 mentioned; is the ability to bring the monitoring system out to the engine room. In this aspect it may be in the future that there could be a possibility to start and stop pumps wirelessly with a PDA while standing next to the pump, instead of communicating with a colleague who manoeuvres it from a distance. Actions like this have to be managed in a safe way and should not interfere with other equipment. For example, it could be of tremendous consequences if the lubricating pump that is in operation is unintentionally stopped. This could cause a major shutdown that will affect the vessel's course, which in the worst case scenario could lead to a grounding or collision.

In conjunction with safety; no.10 mentioned that a PDA could give a possibility for the personnel to bring risk assessments to the site. This is another interesting feature in the PDA, which an end user can benefit from. Risk assessments are performed regularly and are kept as a record, since there is a possibility that a Port State Control will examine this during an inspection. With a predesigned template in a PDA it is possible to insert information directly into the document and then it is transferred when it is completed. From practical experience, these procedures are often executed with paper and pen. Afterwards, the information is either typed into a document in a computer or filed in a folder.

5.3. Sustainability, economic aspects and development

A general statement is that IT-technology has the ability to decrease the consumption of paper. Although the IT era is often referred to as; "the paperless society", it may not always be the truth. On the contrary, this could be accurate if PDAs are adapted on vessels since a lot of papers are stored in different folders, which may be of purpose to evaluate and present data history. Considering the descriptions mentioned in 2.3 and 2.4 about working procedures where data and information is gathered with a PDA instead, there will certainly be a reduction of the paper consumption on board provided that they are easy to use. As no.5 expresses; "...simplicity is important….otherwise it will be forgotten in a locker somewhere" in addition to what no.2 says; "...Then I would just end up writing down the information on a piece of paper instead…". Taking these statements into account, it indicates that it is important with a manageable interface where the functions' reliability is considered to be priorities in the PDA. Therefore, these factors should be in consideration when developing a PDA for this purpose.

Inevitably, if a smaller amount of paper is utilised it will benefit the environment. On the other hand, one or several PDAs and labelling material have to be manufactured which will affect the environment negatively. A PDA's lifetime, which is approximately 5 years[9], have to be evaluated in relation to the estimated amount of sheets that could be reserved during this time. In addition, the amount of labels that will be used during this time will also contribute to

[9] Handheld Scandinavia AB, study visit 11 February 2014

the conclusions if a PDA is sustainable. Consequently, these circumstances are too comprehensive to investigate in the context of this report.

Primarily, using a PDA might not foremost be of economic benefits. Although, the advantage in that aspect is more or less about savings on the reserved amount of paper, which altogether could be expected to become a rather small sum in total. Advantages are more likely regarding work management, which could reduce the time spent on typing collected data into different computer programs and a more secure and manageable working procedure.

As mentioned in 1.3, this study does not treat the economic perspective to an extent. However, an inevitable factor is the cost versus the profit that will affect both interests and the potential of such equipment on board. These costs may concern investment, technical development, additional installations and to adjust related systems. The costs should be evaluated in relation to the amount of time saved on paperwork with a PDA, instead of continuing with the conventional procedures that are usually performed today. As discussed in 5.2.4; if the PDA is used once in a while or as everyday standard equipment then this will directly affect the investment costs, since the latter require one unit per crewmember whereas if it is occasionally used then it might be sufficient with one PDA in each department.

Merchant vessels are generally more or less bound to have an approved PMS. This is endorsed by Classification Societies and moreover adjusted to regulations regarding ship operations, as mentioned in chapter 2.1. It could be expected that several parties need to cooperate if a PDA will be implemented on ships. PMS developers have superior knowledge about their individual programs as well as being adequately informed about all regulations throughout shipping industry and ship's operational requirements, and may therefore have the most beneficial foundation to initiate a similar project. If a PMS developer or another party decides to generate a PDA in this context, cooperation could be a benefit throughout a developing process. This is because additional observations that are made during the progression of this study are that companies would benefit from each other's area of expertise to fully improve such equipment.

6. CONCLUSIONS

The goal was to perceive if a PDA would serve as a tool on merchant vessels. As a whole, the survey is not a comprehensive foundation. On the other hand, it indicates interest among participants to use a PDA as a working tool on ships and it gives a fair idea about how it can be used.

A fundamental starting point of this study was how inspections that are performed regularly are executed, and how this procedure could be improved in combination with how information processing could be simplified and be more secured. Answers from the questionnaire give a strong indication that inspections, rounds, checks and inventories should be incorporated in a tool like this. Consequently, the possibility to connect it to existing systems installed on board, foremost concerning the PMS program is preferred. A factor that was emphasised by the responders was, it should be simple to manage or otherwise it will not be used.

When it concerns a PDA's actual size and physical aspects, specified measurements for its specific dimensions are not determined. Despite that, it is clear that it should be of a manageable size, easy to grip and carry with one hand during work or when relocating. It should be rugged and adapted to the specific environment directed towards different ship types. Hence, it should be classified to the actual regulations regarding the vessel's category of operation. There are several hardware manufacturers on the market who already have models that could fit these conditions. Therefore, these models that are already standardised are reckoned to be sufficient to fulfil the need in this aspect.

Furthermore regarding what built-in functions are necessary for working conditions on board, a conclusion is that this study is not sufficient in order to make a certain statement of each function. It only gives an indication that most of the mentioned functions in the study, beside GPS, are preferred. However, features that is strongly desirable and may be stated as a necessary function in a PDA is a scanner and USB-port. To acquire a substantial and reliable foundation in this context, it should be accomplished in a large-scale. Also, to differentiate necessary and "good to have" functions should accordingly be done by rating options in the survey.

There are several aspects to look at when it comes to introducing a PDA as a working tool on ships. If it becomes a reality, this report gives a wide picture about its use and its abilities. The following list will suggest additional subjects that can be interesting to investigate more thoroughly.

- If a study is carried out in a large scale, this will further give a possibility to analyse results between different ship types and departments more extensively, for example differences or similarities in how a PDA can be used?
- Since the SOLAS convention regulates a large amount of operational procedures, it could be interesting to investigate what features in the PDA could be affected by the SOLAS regulations. Furthermore, do the Classification Societies have any framework

in relation to implementing a PDA on board?
- What are the benefits of implementing a PDA on board a ship when it comes to the economic aspects?

Finally, valuable insights during the progress of this report are; required technical knowledge to incorporate a PDA on vessels is available today, but the essential topic is to consolidate people with knowledge and companies who believe in this project.

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APPENDIX A

Studiebesök: Binar Elektronik AB

Företaget

Binar Elektronik ingår i industrikoncernen Binar AB som förutom affärsområdet Automation även har verksamhet inom Varningsljus och ljud (First Alert), samt verkstäder för kontraktstillverkning. Inom Binar Elektronik utvecklas bland annat industriella produkter baserade på elektronik och mjukvara för automation-, styr- och positioneringssystem. Företaget är bland de ledande i landet på utveckling och leverans av stödsystem för industriella tillverkningsprocesser Systemen är ofta baserade på Japanska produktions principer. Leveranser sker till bl.a. Volvo Personvagnar, Scania och Volvo AB samt dess underleverantörer.

Svar på frågor

1. **Om man tar fram en mjukvara kan den kopplas till annan mjukvara?**

Databaskoppling är en lösning till samarbete och kommunikation emellan mjukvaror. Då definierar man ett interface där de olika systemen hämtar och lämnar information. Ett annat sätt är att skicka filer, t.ex. html eller textsträngar. Annan lösning kan vara att använda en hjälpmjukvara som fungerar som en brygga mellan olika system, t.ex. OPC-server.

2. **Om det går att göra det, måste det ske under ett samarbete med den andra mjukvarans tillverkar/distrubitör?**

Ja, någon typ av samarbete måste ske. Det är dock möjligt att en leverantör skapar ett mycket väldefinierat gränssnitt där andra utvecklare kan ansluta sig. Generellt är det dock mycket gynnsamt för ett projekt där flera leverantörer samarbetar, att de har en god och tät kontakt.

3. **Hur lång tid tar det att ta fram en mjukvara?**

Mycket svårt att säga, detta är beroende på komplexitet, men uppskattningsvis, ca 3-6 månader.

4. **Vilka kostnader för att ta fram mjukvara?**

Svårt att säga specifikt, men för att få en uppfattning så kostade ett helt kundspecifikt system för kvalitetsuppföljning drygt 1 miljon kr. Andra mjukvaror som är mer som standard har en licenskostnad på t.ex. 500-1500 € En lösning kan dock vara att betala licens och utvecklings kostnad per år, istället för engångskostnad

5. **Samarbetar ni med tillverkare av tex underhållssystem? Om nej, hur ser ni på framtida samarbete med dessa?**

Hjälper gärna till med mjukvaru-utveckling. Ser inga problem med att utveckla, men det krävs specifika applikationskunskaper om underhållssystem ombord fartyg som de inte har.

6. **Kan man sammanföra information med "externa" program t.ex. systematiskt underhållsprogram? Om ja, vilka?**

Det går att utväxla data mellan olika system och givare till ett underhållsprogram.

APPENDIX A

Givarsignaler som finns i systemet kan t.ex. vara anslutna till en PLC via något bus system t.ex. CAN eller Profibus. Data från flera PLC-er kan hämtas in via OPC till en dator som sedan via databas eller filöverföring kommunicerar med underhållsprogrammet.

7. **Kan man plocka ut parametrar/mätvärden under ett tidsintervall och med programvarans hjälp göra sammanställningar? Finns det olika layout typer?**

Trendvisning är möjligt att programmera in. Exempel för PLC finns också. OPC kommunicerar med alla tillgängliga PLC och hämtar värden från dessa. Statistik skapas genom databas. Fördelen är att de endast frågar efter information varvid själva funktionen inte påverkas.

8. **Finns funktion för text meddelanden? Hur fungerar det?**

Ja, SMS/mejl via t.ex. GSM eller W-LAN. Andra sätt kan vara exempel, MiniCall.

9. **Kan någon av era nuvarande mjukvaror fungera för förutsättningarna ombord? Om inte har ni intresse av att utveckla en modell som passar ändamålet?**

Även om det inte finns något som direkt kan appliceras så finns det flera mjukvaror som man skulle kunna utgå från, ett exempel är ”Signal-Server”. Ofta upptäcker man att en industriell kunskap kan användas i många branscher bara man har tillgång till någon som har den aktuella applikationskunskapen.

10. **Internet är oftast dåligt ombord, kan ett intranät skapas som ger en trådlös funktion med överföring textmeddelanden osv.?**

Enheten i sig behöver inte läggas i nätet konstant, utan kan ha lokal minneskort eller RAM. Sedan med installerade W-LAN accesspunkter kan enheten koppla upp sig direkt om tillräcklig signal, eller så synkar man med datorn i efterhand.

11. **Finns det miniräknare?**

Miniräknare, eller andra beräkningar kan läggas in i systemet, normalt finns en enkel räknare med i de olika operativsystemen. Man kan även låta utförda mätningar ta stöd av “Expert system”, d.v.s. ge en bedömning av värdena utifrån tidigare erfarenhet

12. **Om tagg-identifiering till individuella komponenter används, kan man hyperlänka till dess manual?**

Man kan identifiera givare och komponenter via RFID eller streckkod. Systemet kan sedan hämta upp manualer, filer etc. filarea genom hyperlänkning. se fråga 6.

13. **Vilka frekvenser används, störningar till andra system t.ex. nödsystem vilket inte får påverkas?**

Vet inte gällande frekvens störningar. Men antar att det finns standard utfärdad gällande frekvensområden på fartyg.

APPENDIX A

14. Redundant system?

Förutom lokal lagring finns exempel, RAID. Data går på minst två diskar, vid en disk krasch "på rätt sätt" blir det då redundant. Eller också att två datorer går parallellt.

Utmaningar

- Vilja till att, och möjligheten för samarbete gällande kommunikation mellan enhet och underhållssystem.

Övrigt

- Möjligheten till direkt överföring av data till PDA, istället för att gå via fartygets automationssystem, kan lösas genom OPC server i PDA.
- ASTM-beräkning i mjukvara anses inte vara något problem.
- Med hjälp av W-LAN och accesspunkter kan ett eget GPS system byggas upp.
- Minneskapacitet, inga problem om endast text filer/värden.
- Binar löser problem på distans genom fjärrhjälp-/åtkomst till mjukvaran.
- Ringlistor finns också.

APPENDIX A1

Studiebesök: Handheld Scandinavia AB

Företaget

Består av 9 dotterbolag, varav alla är privatägda. I dessa företag äger Handheld mellan 55-90%. Företaget grundades 1977, blev inte ett eget märke förrän 2003. Internationellt har företaget totalt 50-60 posterade.

Design och utvecklingen av produkter sker i samarbete med kunder i Sverige. produktionen sker i Asien. I deras nuvarande produkt-utbud ingår det smartphone, handdatorer, surfplattor och PC, där alla innehar en livscykel på minst 5 år och har en IP-klassning mellan IP65-IP67. Handheld är endast tillverkare av handenheter, de säljer inte sina produkter direkt till kunder, det sker via återförsäljare.

Svar på frågor

1. **Kräver handdatorn ett eget program eller kan man föra över informationen till redan existerande program, typ systematiskt underhållsprogram?**

En PDA bör kunna kopplas till det befintliga systemet, som t.ex. underhållssystemet. De anser att underhållssystemet kan kommunicera med de flesta andra parter, då deras nuvarande produkter redan kan göra det genom W-LAN, 3G eller GSM. Hänvisar oss till utveckling av mjukvaran.

2. **Kan man sammanföra information med "externa" program t.ex. systematiskt underhållsprogram? Om ja, vilka? (krävs det då samarbete med dessa programs företag?)**

Samarbete med andra, inga problem.

3. **Hur ser ni på möjligheten att använda utrustningen inom sjöfarten?**

Det närmsta som företaget har kommit i kontakt med gällande sjöfarten är havsdykare och sponsring av Puma Race. De har dock fått förfrågningar från hamnarbetare, och är för övrigt positiv gällande utveckling av produkter i denna bransch.

4. **Om denna utrustning skulle bli ett verktyg ombord, hur står den då emot olika oljor/kemikalier?** Det är inte frågan om den utsätts för olja, utan när den blir det!

Det finns ingen nuvarande Handheld produkt som är olje- eller kemikaliebeständig. Enligt företaget anser de att skärmen är den känsligaste delen och därmed rekommenderar de att använda skärmskydd. Det finns också fickor som kan användas i utsatta miljöer, men fickorna rekommenderas inte för konstant förvaring på grund av kondens som kan orsaka fuktskador. För övrigt kan man skölja av utrustningen med vatten.

5. **Kan man plocka ut parametrar/mätvärden under ett tidsintervall och med programvarans hjälp göra sammanställningar.**

Historik finns, men den hanteras i mjukvaran och justeras utifrån användarens behov/önskemål.

APPENDIX A1

6. **Kan någon av er nuvarande modell fungera för förutsättningarna ombord? Om inte har ni intresse av att utveckla en modell som passar ändamålet?**

Baserat på deras produkt-utbud idag, rekommenderar de Nautiz X7.

7. **Kan andra programvaror laddas ned?**

Alla deras produkter har Windows plattformar, d.v.s. funktioner kan läggas till och tas bort genom applikationer.

8. **Finns funktion för text meddelanden?**

Där deras handdatorer har 3G, finns också SMS funktioner.

9. **Internet är oftast dåligt ombord, kan ett intranät skapas som ger en trådlös funktion med överföring textmeddelanden osv.?**

Deras lösning till dålig täckning är att informationen även kan finnas lokalt i utrustningen, d.v.s. en lokal lagring. Därefter genom installerade accesspunkter så kan informationen överföras genom roaming. "Off-line mode" finns också.

10. **Finns det miniräknare i handdatorerna?**

Ja, miniräknare finns.

11. **Om tagg-identifiering till individuella komponenter används, kan man hyperlänka till dess manual?**

I "Offline mode" måste manualerna redan finnas lagrade i handdatorn som PDF: er eller liknande för att hyperlänkning skall fungera. För övrigt är detta möjligt.

12. **Kostnader?**

Deras olika produkter kostar mellan 6000 och 12 000 kr per enhet.

13. **Vilka frekvenser används, störningar till andra system t.ex. nödsystem vilket inte får påverkas?**

Frågeställningen gjordes aldrig direkt, men detta styrs oftast genom standard.

14. **Vilken information byggs era fallstudier på? Finns det några vetenskapliga artiklar eller liknande om fallstudierna?**

Kunderna får ett av formulär som är framtaget av Handheld, vilket användaren fyller i. Fallstudierna används sedan som ett informationsmaterial och/eller som en grund för en intressent att hitta användbara funktioner utöver den problemställning de själva har.

APPENDIX A1

Utmaningar

- Anpassning för direkt överföring till PDA istället för att gå via fartygets automationssystem.
- Explosionsrisk ombord, kräver speciell EX/ATEX-klassning.
- Satellit uppkoppling.

Övrigt

- RFID, Radio Frequency Identification kan vara bättre alternativ till streckkod eftersom miljön ofta gör att streckkoder blir oläsliga för en scanner efter viss tid.
- Extern mätutrustning via USB, kan vara möjligt. Samma gäller automatisk beräkning gällande ASTM-tabeller.
- Användning av PDA:er förekommer inom flottan
- Utveckling av mjukvaran bestämmer möjligheterna att använda PDA:s inbyggda funktioner så som scanner. processor, kamera mm

APPENDIX A2

Studiebesök: SpecTec

Företaget

Global verksamhet, huvudkontoret för mjukvaruutveckling på Cypern. Består av mindre kontor i många länder, där en person kan vara knuten till mjukvaruutveckling. I Göteborg finns försäljning, support och kundanpassning.

AMOS Mobile

Den finns på marknaden men inte i någon större utsträckning. Kunder har uttalat önskemål om denna typ av utrustning, däremot har de inte specificerat till vad och hur den skall användas. Kunder vill ha en färdig lösning och det alternativ som tagits fram verkar inte fylla deras behov. SpecTec distribuerar endast mjukvaran, har viss rekommendation till hårdvara med operativsystemet Windows mobile. Det finns även explosionklassade, men blir dyrare (EX/ATEX).

Svar på frågor

1. **Ni har en PDA som ni kallar Amos Mobile, används den ombord på fartyg**?

Handdator har efterfrågats. Dock har konceptet inte blivit framgångsrikt. Finns inte på svenskflaggade fartyg, men används ombord på utländska fartyg idag som t.ex. passagerarfartyg under vaktrundor.

2. **Hur tåliga är PDA enheterna som ni har, t.ex. IP-klass, vibrationer, värme mm?**

Säljer endast mjukvaran. Viss rekommendation kan förekomma gällande utrustning med Windows Mobile. Viss hårdvara finns även som explosionsklassad (EX/ATEX), t.ex. Motorola.

3. **Kan vilken enhet som helst användas om er mjukvara laddas in?**

Se ovan

4. **Är er mjukvara enbart kopplat till UH systemet och reservdelar? Vad för funktioner i mjukvaran har ni idag? Eventuella funktioner ni vill utveckla?**

Idag är AMOS Mobile kopplad till UH-systemets funktioner: Arbetsorder, in/ut lager och gångtider. Funktioner som kamera och miniräknare finns i operativsystemet.

5. **Hur ser ni på samarbete med företag som utvecklar ruggade hårdvara?**

Kan ej svara på rak arm eftersom produktutveckling inte sker i Sverige. Finns det ett uttalat behov och en kund som vill köpa ett större antal enheter kan det presenteras för ledningen. Det krävs ett ekonomiskt vinst perspektiv.

6. **Satellit uppkoppling, EX-klassning, anpassning till mätgivare ombord?**

Handenheten har inte separat satellituppkoppling, bara W-LAN. Däremot har AMOS på den stationära datorn satellituppkoppling, via omvandlare.

APPENDIX A2

7. **Vad är er lösning när det gäller dålig täckning ombord? Kan ett intranät skapas som ger en trådlös funktion med överföring textmeddelanden osv.?**

I så fall måste W-LAN byggas ut. Eventuellt kan utökning av komradio systemet förbättras istället, för att få en bättre verbal kommunikationsmiljö. En lösning är att det finns databas i handenheten så att den fungerar även utan täckning och att synkning sker när den får täckning.

8. **Kan man sammankoppla externa mätutrustningar med t.ex. USB-kontakt? Om ja, vad finns det idag?**

Samarbete finns med bl.a. Mimic för vibrationsmätning detta är dock ett interface mellan Mimic och AMOS på en stationärdator, och då används Mimics handenhet till vibrationsmätning.

9. **Kan man plocka ut parametrar/mätvärden under ett tidsintervall och med programvarans hjälp göra sammanställningar?**

Ja, det finns historik. UH-systemet anses inte ha behov av momentana värden. Värdet loggas en ggr per dygn/vecka/månad beroende på utrustning.

10. **Kan andra programvaror laddas ned?**

Programvaror kan laddas ned till operativsystemet Windows Mobile.

11. **Finns funktion för text meddelanden?**

Funktionen för text meddelanden finns i operativsystemet, men svårt att använda pga. överföringsmöjligheter. Medan i själva AMOS Mobile mjukvaran finns inte funktionen.

12. **Finns det miniräknare?**

Ja, miniräknare finns i operativsystemet.

13. **Om tagg-identifiering till individuella komponenter används, kan man hyperlänka till dess manual?**

Hyperlänkning fungerar till PDF filer och liknande som ligger lokalt i datorn. För trådlös funktion krävs utbyggt W-LAN och separat dataserver.

14. **Vilka kostnader för att ta fram mjukvara?**

Kostnad för att köpa dagens hårdvaruutrustning ligger på ca 3000 - 10 000 kr beroende på tillvalsfunktioner och till vilken kund. Mjukvaran har ett 5-siffrigt grundpris i Svenska kronor Utöver grundavgift tillkommer 20 % i licenskostnad per år. En EX-klassad hårdvara på ca 10 000 kr per enhet.

APPENDIX A2

15. **Vilka frekvenser används, störningar till andra system t.ex. nödsystem vilket inte får påverkas?**

Radiostyrd frekvens är reglerat av standardiserade band, ca 90 % av frekvenserna är militära. Enstaka frekvenser är fria, som 2.4 GHz och 5.0 GHz.

Utmaningar

Kunderna kan inte säga specifikt vad dem vill ha, utan vill ha en perfekt utrustning.

Övrigt

- Passiv RFID-tagg tros vara tillräckligt för de flesta behov. Både tekniskt och prismässig, då man själv kan skriva ut dessa.
- Om streckkod används rekommenderas QR då den har en felhanteringsfunktion.
- Tankpejling finns inte eftersom det ej är kopplat till underhållet. Elektronisk maskinlogg krävs för att funktionen skall fungera.
- Bilder kan bifogas i arbetsordern AMOS Mobile, men beror på hårdvaran.
- Hyperlänkning till sidor fungerar dock inte i AMOS Mobile.
- Windows Mobile utvecklas inte längre, kommer att ersättas med Android/IOS.
- Användning av dubbla touchtekniker i utrustning, kan jobba med handskar.

APPENDIX A3

Sammanställning av telefonintervju: Diwiton AB

Installations kostnader

1. Beroende på fartyg, men en normalstor färja ca € 30000 - 40000.
2. Ungefär en basstation per skott (var 20 meter) en basstation ca € 500 + installationskostnad.
3. Nyare fartyg sedan ungefär fem år tillbaka har Wi-Fi nät installerat. Kan kräva viss utbyggnad för fulltäckning i kombination med en PDA.

Installation mm

1. Lättare utföra installationer på handel fartyg kontra passagerarfartyg, då det är öppnare konstruktioner.
2. Tillkommer kopplingar till varje funktion, en till larm, en till lager och så vidare. En fysisk koppling till en server och en mjukvara för protokollet.
3. Olika Wi-Fi system har olika protokoll, användningsområdet bestämmer protokollet.
4. Finns olika tillverkare.
5. Slavarna inom systemet finns som EX-klassade, går även installera i EX-klassade kopplings boxar.
6. Annan möjlighet är radio, kostnad blir ungefär den samma men täcker större områden.

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			Percentage	Total
[Q1] Nationality				
Swedish			83%	20
Finnish			13%	3
Filipino			4%	1
Other			0%	0
Total answered		*24*		
Total left blank		*0*		
[Q2] Gender				
Male			88%	21
Female			13%	3
Total answered		*24*		
Total left blank		*0*		
[Q3] Current position				
Captain			8%	2
Chief Engineer			25%	6
Chief Officer			8%	2
Engineer			38%	9
Officer			17%	4
Motorman			4%	1
AB			0%	0
Total answered		*24*		
Total left blank		*0*		
[Q4] Work experience as a crew member				
Lowest	1			
Highest	40			
Average	12,71			
Total answered		*24*		
Total left blank		*0*		

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			Percentage	Total
[Q5] Current ship type				
Tanker			13%	3
Container/RoRo/RoPax			63%	15
Bulk			0%	0
Passenger			8%	2
Offshore/supply			13%	3
Other			4%	1
Total answered		*24*		
Total left blank		*0*		
[Q6] Should the PDA have a scanner function?				
Yes			100%	24
No			0%	0
Total answered		*24*		
Total left blank		*0*		
[Q7] If yes, should it be by conventional barcode, QR or RFID?				
Conventional barcode			42%	10
QR			67%	16
RFID			25%	6
Total answered		*24*		
Total left blank		*0*		
[Q8] Keyboard/touch-screen and/or display-pen?				
Keyboard			17%	4
Touch-screen			58%	14
Display-pen			46%	11
None			4%	1
Total answered		*24*		
Total left blank		*0*		
[Q9] Speakers and/or microphone?				
Speakers			33%	8
Microphone			50%	12
None			50%	12
Total answered		*24*		
Total left blank		*0*		

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			Percentage	Total
[Q10] USB-port?				
Yes			100%	24
No			0%	0
Total answered		*24*		
Total left blank		*0*		
[Q11] Memory card?				
Yes			92%	22
No			8%	2
Total answered		*24*		
Total left blank		*0*		
[Q12] Camera?				
Yes			88%	21
No			13%	3
Total answered		*24*		
Total left blank		*0*		
[Q13] Calculator?				
Yes			83%	20
No			17%	4
Total answered		*24*		
Total left blank		*0*		
[Q14] Bluetooth?				
Yes			83%	20
No			17%	4
Total answered		*24*		
Total left blank		*0*		
[Q15] WiFi?				
Yes			92%	22
No			8%	2
Total answered		*24*		
Total left blank		*0*		

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			Percentage	Total
[Q16] Texting and/or Email function?				
Texting			50%	12
Email			50%	12
None			38%	9
Total answered		*24*		
Total left blank		*0*		
[Q17] GPS?				
Yes			4%	1
No			92%	22
Comments			33%	8
Total answered		*24*		
Total left blank		*0*		
Comments	#8	"Know your ship, beware of hazards without trusting technic too much"		
	#9	"Why? There is plenty gps's on a boat"		
	#12	"Not working except on open deck"		
	#14	"Hopefully the PDA will stay onboard..."		
	#16	"GPS could be necessary to record position of cargo or other damage for the insurance company. However, GPS performance is poor under deck"		
	#17	"GPS won't work in the engine room"		
	#20	"If GPS is found necessary it should be possible to connect wireless to one of the ship's GPS"		
	#22	"Not necessary in first versions, can be a future asset for MOB-Boat Crew to use GPS"		
[Q18] Additional software functions?				
History			92%	22
Trend display			58%	14
Other			21%	5
Total answered		*24*		
Total left blank		*0*		
Other	#7	"Access to spare parts system/maintenance system"		
	#16	"Flashlight, connection to ship's network printers, voice recorder. Access to product data sheets should be available e.g. noxious or harmful substance"		
	#19	"Easy to use inventory function"		
	#20	"There are so many functions that should be possible to add. Communication via Wi-Fi. CCTV watch, Start and stop of equipment such as fans, ballast etc"		

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	#22	"Can be good if you can link it to a onboard computer instead to save memory and processor, then you can use it together with PMS system onboard as well"		
[Q19] How can a PDA be used in a bridge department?				
Total answered		*11*		
Total left blank		*13*		
	#4	"In my opinion if ever it could be incorporated on every individual onboard, it may be used as a communicating device. For example if the officer needs assistance of the Captain and he could not be located on his cabin. It is more convenient and swift to call his attention. Also the other way around, if a crew member is in need of help and no one else is in sight it is very much advised that each one is holding this portable unit and immediately call for help to the officer on watch that in return the officer could alarm for search and rescue on that individual that needs assistance"		
	#8	"For safety officer: safety check lists (weekly, monthly)"		
	#9	"Checking off equipment that has been subject to inspection rounds. Stores and supply inventory"		
	#12	"In an emergency they might help with scanning evacuated cabins or public areas to continuously report to the bridge"		
	#14	"For the safety officer when checking fire equipment"		
	#15	"Yes, for doing safety inspection or inventory. It could also be used for identifying antennas etc"		
	#16	"PDA could be used for keeping inventory, quality of inventory items, amounts of inventory items and state of inventory items (new, broken, checked, to be checked. to be renewed/ordered etc.) and placing of the inventory items on board. Inventory items are items in groups of Life Saving Appliances, ship's medicines and medical equipment and various publications on board. LSA: EEBD, life buoys, life vests, rafts"		
	#17	"Safety rounds in the vessel"		
	#18	"Checklists"		
	#20	"If integrated with the bridge system it could be used as an electronic log book"		
	#22	"You can use it as OOW, if you get relieved by capt this can be logged directly that he/she has the conn/watch. link it together with digital ships logbook. there is no limit to what it can be as long the PDA can change programs like APPS in todays in telephones"		

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[Q20] How can a PDA be used in a deck department?				
Total answered		*12*		
Total left blank		*12*		
	#2	"Inventory and chemical logging"		
	#4	"I think it can be used as a safety equipment inventory and condition checker. Where in you may input the detailed inspection conducted and state items that would be needed to replace which is to expire or deteriorated. Also to the deck department items it may be used as well in relation to safety equipment stated usage"		
	#8	"Reefer check rounds, fire rounds"		
	#9	"Checking off equipment that has been subject to inspection rounds. Stores and supply inventory"		
	#10	"Vid genomsökning av fartyget, tex vid misstanke om fripassagerare ombord, eller bombsök. ISPS-kvittenser, har besökaren lämnat fartyget?"		
	#12	"Similar as in the engine room regarding maintenance and stock keeping"		
	#15	"For inspection, manuals and inventory, for example paint"		
	#16	"Similarly like on Bridge the inventory items could be recorded. Washing liquids, SOPEP absorbing material, ropes, hydraulic oil for winches, ramps"		
	#17	"Collecting readings from reefer and heater containers"		
	#18	"To scan cargo, containers, lorries etc. and then transfer automaically to loading program"		
	#20	"Documentation, start and stop of cargo fans and Hydraulic units, Ballast control, ISPS control. communication via WiFi"		
	#22	"Safety Observations, Near miss, PMS, MOB-Boat crew, there is no limit to what it can be as long the PDA can change programs like APPS today in telephones. Water tight."		
[Q21] How can a PDA be used in an engine department?				
Total answered		*16*		
Total left blank		*8*		
	#1	"For spare parts inventory and storing purposes"		
	#2	"For rounds and routines with soundings, spare inventory"		
	#5	"Check spare parts, Register spare parts, read manuals during overhaul and manage the PMS system"		
	#6	"Jag ser många potentiella användningsområden för en handdator i maskin, både kopplat till larm/övervakningssystemet och till underhållsystemet. Det kan tillhandahålla en möjlighet att titta på skärmen i kontrollrummet samtidigt som jag gör något ute i maskin (test/felsökning av olika givare är bara ett av otaliga exempel). Många grejer som i dagsläget får göras med två personer, en med radio i kontrollrummet och en med radio ute på plats, hade kunnat göras av en person. Det hade också varit smidigt att ha en PDA kopplad till underhållssystemet, för att kunna ta med sig arbetsbeskrivningar, leta		

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		efter reservdelar och dylikt."
	#7	"A good way to register transactions in the spare parts store with a barcode"
	#9	"Reporting work. Spare parts inventory. Receiving goods etc."
	#10	"Dagliga, vecko- och månadsrutiner. Reservdelshantering, inventeringar. Ett sätt att snabbt plocka fram trender på tex drifttemperaturer på en specifik komponent, om den läses av dagligen"
	#12	"Daily round. Daily/weekly sounding round. Greasing round. Stock keeping. Monthly inventory chemical store and lubricants store. Various PMS checks, leak and vibration check of pumps can be one example"
	#14	"For daily rounds. When receiving goods it would be nice to just scan and the information will be transferred to AMOS"
	#17	"Collecting readings from your run time meters, stock taking of spare parts or when you are testing your boiler and cooling water, you can write down your values direct in the PDA and then transfer it to your computer. Read and acknowledge engine alarm"
	#18	"For checklists, daily rounds and spare part handling"
	#19	"For inventory updates. For signing off work. Checking required spares for a job"
	#20	"I leave this to the engineers"
	#22	"Safety observations ex. PMS"
	#23	"To read off locally placed running hour counters and transfer the readings to the maintenance program onboard. Include the daily checklist motorman/engineer performs. Useful when you make inventory of the spare parts you have onboard. Example you have a barcode or the number of a spare part that you can scan/identify with the PDA and update the stock. Later when you are done with the inventory you can update the stock in the maintenance system. When you scan a component in the engine room you will get all the data of the specific component. For example all spare parts connected to the component so that you easily can order new parts rather than search in the instruction book"
	#24	"Tar mig friheten att svara på svenska. Jag är en vän av att förenkla tråkiga arbetsmoment, och i princip allt som innebär att traska omkring med ett papper och skriva av siffror räknar jag som tråkigt. Man skulle exempelvis kunna använda den till just det ni föreslår, att inhämta gångtider och liknande vid ronder och liknande. Den stora vinningen jag ser är nog framförallt att det skulle vara ett välfungerande interface för att inhämta data från diverse utrustning, i kombination med loggande givare. Jag tänker mig det främst för retrofitting på båtar där inte allt redan är uppkopplat från början, samt på mindre grejer, som helt enkelt inte är rimliga att koppla upp mot fartygets övervakningssystem. Man skulle exempelvis kunna tänka sig att man loggar temperatur/vibrationer i lager till större pumpar och liknande, och på så sätt kan gå från det där med preventivt underhåll på gångtimmar, och istället åtgärda i ett tidigt skede när tecken på slitage börjar märkas. En stor fördel här är att man 1) kan se tecken på slitage som är tämligen abstrakta för de mänskliga sinnena (för att falla tillbaka på pumpar, hur känner man att ett lager vibrerar mer eller går varmare än det brukar, i tid,

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		innan det nått kritiska nivåer, utan att det blir en ren gissningslek?), 2) att man kan hantera oändligt mycket mer data, och 3) att det finns en verifikation på att det faktiskt görs på ett riktigt sätt"		
[Q22] How should the number of PDAs be distributed on board?				
Total answered		*20*		
Total left blank		*4*		
	#1	"1 for each department"		
	#2	"2, 1 deck dept (ABs) and 1 in engine"		
	#4	"As i initially stated it is advisable to have each crew on board"		
	#5	"In engine department I think there should be two pieces. One for the Cheng and one for the 1steng"		
	#6	"En per person är förmodligen överflödigt, en eller två i maskin hade räckt bra i mitt fall"		
	#7	"One per department. This will reduce the number of crew members operating it as it is quite easy to get faulty information when too many persons handle one system"		
	#8	"Department heads (ch. eng, 1st engineer, ch.off. OOW) One for rating on duty during rounds"		
	#9	"Everyone who has access to the PMS and used such in a daily basis"		
	#10	"En per avdelning borde räcka till att börja med för att se om systemet faktiskt funkar att använda som det var tänkt. Skall den användas för tex ISPS-sök krävs det fler"		
	#12	"Depending of crew size, two per department and one spare on bigger vessels?"		
	#14	"Depends what the use is"		
	#15	"Two on deck, one for chief officer and one for safety officer"		
	#16	"Depends on the ship type. On large cruise ships there could be more than one/department. On smaller crew vessels one per department is enough"		
	#17	"More than one per department"		
	#18	"One or more per department"		
	#19	"1 for deck (only one person/group doing work involving digitally stored data/information.)? 1 or 2 in engine depending on how work is organized"		
	#20	"I think it would be enough with 3 per department to begin with"		
	#22	"One for each person that it will benefit"		
	#23	"One per department should be sufficient"		
	#24	"Ja, det beror väl helt på vad man kan övertyga en snål redare om. Men optimalt vore det väl med en mer eller mindre personlig enhet, säg en per tjänst eller så"		

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[Q23] Can a PDA be applicable on board a ship?				
Yes			96%	23
No			4%	1
Comments			8%	2
Total answered		*24*		
Total left blank		*0*		
Comments	#1	"Mainly used for inventory and spares, to use it on rounds then it has to be indestructible"		
	#6	"Har själv tänkt tanken många gånger och hade planer på att titta närmre på det som examensarbete. Ser fram emot ert resultat"		
[Q24] What physical features of the PDA do you think is important?				
Total answered		*19*		
Total left blank		*5*		
	#1	"Larger than a cell phone"		
	#2	"Half size of iPad"		
	#4	"Portable, handy and durable in which a water proof device is a necessity"		
	#5	"Holding it with one hand should be enough and fit in your pocket. It should also have a cover that could withstand falls, dust, oil and water. It should also be EX-class"		
	#6	"Tror att en dator i smartphone-storlek blir för liten för att kunna visa det jag vill visa (mimikbilder från larmsystemet, bruksanvisningar, inventeringslistor och liknande). Därför tänker jag mig något i tablet-storlek (åtminstone 10")"		
	#7	"Regarding size and shape I would say that something in the line of a regular Fluke multimeter is a way to go. Not too small and not too big"		
	#8	"A bigger cell phone size. Max weight 300g. Very durable, waterproof"		
	#9	"Should be of considerable size. Big display and big push-buttons. Engineers hate touch-screens"		
	#10	"Stryktålig, oljebeständig. Batteriet ska tåla att PDA:n står i sin laddare när den inte används. Lösenordsskyddad/krypterad överföring av information för att undvika att informationen används av obehöriga"		
	#12	"Not too small. Rugged. One day use without recharging. the display must be visible by older people as well, brightness and size are important"		
	#14	"Not too big. Of course high IP-class. Rubber protection"		
	#16	"Waterproof, dustproof and doesn't break easily if dropped. Easy to carry in pocket (pocket size tablet)"		
	#17	"Size, shape, weight, the unit should be easy to hold with one hand. Easy to clean. Resolution"		
	#18	"Handy size and rugged so it can be dropped or get Dirty by oil and similar"		
	#19	"Maximum size around 10x15x4-5 cm"		
	#20	"It must be sturdy and water resistant/proof. Big enough to show details		

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		on the screen and small enough to not be in the way when working"		
	#22	"It should be easy to carry with you, that has to be tested by a survey group"		
	#23	"Not too big, optimal would be that it could fit in your breast pocket in a boiler suit"		
	#24	"Stryktålighet är förstås A och O i ett maskinrum. Den måste klara mekaniska påkänningar, lösningsmedel, värme, kyla, och också vara mer eller mindre vätsketät, alternativt vara tillräckligt billig och enkel att ersätta (i meningen att det inte ska vara för mycket krångel med att programmera den för den specifika utrustning man har ombord) för att det inte ska vara någon "big deal" om en PDA går åt skogen. Vad det gäller storleken, så blir det ju givetvis en kompromiss mellan skärmens storlek med användbarhet i förlängningen, och hurpass smidig den blir att ha med sig. Hade man tänkt sig den som något man tar med sig på en daglig runda kan den ju förstås vara större än om den är tänkt som en "kompanjon" man alltid har i fickan"		
[Q25] To what systems should the PDA be connected to?				
None			4%	1
Maintenance system			96%	22
Other			39%	9
Total answered		*23*		
Total left blank		*1*		
Other	#1	"Spare part module"		
	#6	"Larm/övervakningssystem"		
	#7	"As mentioned above, it should also be connected to the spare parts software(in case there is two separate systems)"		
	#12	"To vessel's engine log book and possibly also bridge log if electronic"		
	#15	"Purchase system"		
	#16	"Inventory and ordering systems. Email. Cloud access"		
	#17	"Engine alarm system"		
	#20	"There are many systems that could be controlled/watched via a PDA. see above"		
	#22	"Bridge Digital ships logbook, ex watch conditions. safety observation tool not direct linked if there is fault in observations"		

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[Q26] Additional comments				
Total answered		*11*		
Total left blank		*13*		
	#1	"A PDA should first be implemented in one usage as otherwise one would have to run around and look for as everyone are using it for Everything"		
	#6	"För att det underhållssystem på PDA ska vara användbart måste det vara integrerat på ett bra sätt med det system som ska användas. Om jag sitter vid datorn i kontrollrummet och letar upp reservdelar/sammanställer en lista över jobb eller något annat i underhållssystemet så vill jag inte behöva öppna en ny session i underhållssystemet på handdatorn och leta upp samma saker igen, då kommer det sluta med att jag skriver ner det hela/skriver ut ett pappersark istället. Jag vill i så fall snabbt och enkelt kunna "skjuta över" information till handdatorn så att jag kan "fortsätta där jag slutade" och ta med mig det hela ner i maskin, lika smidigt som att skriva ut ett papper. På samma sätt vill jag smidigt kunna skjuta information från handdatorn till den stationära datorn i kontrollrummet när ett jobb ska skrivas av. Omständiga synkningar med tredjepartsprogramvaror förstör det hela, det ska finnas integrerat i själva underhållssystemet på ett bra sätt. I idealfallet hamnar jag i precis samma session när jag loggar in på handdatorn som när jag precis lämnade den stationära datorn. De gånger man behöver ta med sig larm/övervakningssystemet ut i maskin är det inte lika kinkigt, då väger fördelarna med att kunna ha kontrollrummet med sig ut i maskin ändå upp nackdelarna såpass mycket att det inte behöver vara lika smidigt utformat och integrerat med resten"		
	#8	"Good idea perhaps to minimise paper amount on board"		
	#10	"Risken med den här typen av hjälpmedel är alltid att det sunda förnuftet blir lidande om man drar det för långt. Om en dator alltid talar om för dig vad du ska göra och kontrollera, så behöver man ju inte tänka själv. Då behöver du inte ha en dyr besättning, det går ju bra med vem som helst som kan läsa. Säkerheten blir lidande, men fartyget är väl försäkrat, och ny besättning som kan läsa går ju alltid att få tag på"		
	#12	"I believe that simplicity is important. Not too many bugs in its software, otherwise it will be forgotten in a locker somewhere"		
	#16	"It should be investigated which RF frequencies are best to use on board so that they won't' affect other systems like, or that other ship borne systems like UHF doesn't affect RFID. Wifi is easy and inexpensive to set up on board. PDA will be easy to connect to servers and systems via Wi-fi. Cloud should be used via Wi-fi instead of internal memory of the device. Telecommunications transmit/receive bandwidth shouldn't be a problem as the cloud server would be on board. Keyboard should be available for cases that longer reports should be written on scene. Otherwise display pen is sufficient"		
	#17	"I (vessel A) hade man en gång i tiden streckkodsläsare i maskin för att läsa av gångtidsmätare, inte så att man läste av gångtiden utan man läste av identiteten på enheten man skulle ta tiden från och sedan skrev man in		

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		tiden för hand läsaren. Jag vet inte hur länge man höll på med detta men vad jag förstod så fungerade det så där. Om PDA:n blir lagom stor så kan man ju kanske koppla den till maskinlarmet så att man kan se och kvittera maskinlarm i från enheten, fast då behövs det ju en PDA till varje tekniker. Det pipgökssystem som finns i (vessel B) är ju väldigt smöget, att kunna läsa och kvittera larm på göken, fast merparten av alla chiefar i Svenska handelsflottan skulle väl sätta kaffet i halsen ifall fartygsingenjörerna kunde kvittera maskinlarm någon annanstans i från än kontrollrummet"
	#19	"RFID would be less useful than QR, it could however complement it. Without an ID scanner it's so much less useful that it probably won't be used at all"
	#20	"It's a very interesting topic. I think the future will prove your idea and these devices will come in use onboard ships in a near future. but as usual all the special regulations in shipping will slow things down"
	#22	"I see this PDA as contribution to already existing systems onboard, but I should be constructed in the software so it will save time and effort regards to paper work. In my job it would benefit really good regarding digital log book, PMS on deck. also you can bring risk assessment with you"
	#23	"I think this is a very god idea, if this could be implemented a lot of time could be saved. When you have all parts/components stored"

APPENDIX B1

Questionnaire study

Today there are handheld devices, both IP- and ATEX-classed, used in industrial- and process-industries to gather information and to keep track of different components. These handheld devices are also referred to as Personal Digital Assistant (PDA). Using these PDAs have become more and more common in commercial organisations. With your answers to the questions in this survey, we hope to know if this is equipment that could be used in daily working situation on board ships. And if it is considered to be useful equipment, what tasks could it then be used for?

Functions that could be found in today's PDAs are scanners to read tags or barcodes, keyboard, display pen, Bluetooth, camera, Wi-fi, calculator, text messages, email, speakers, microphone, USB-port, memory card and GPS. The equipment can also communicate by WLAN or mobile network (GSM). Do you find these functions necessary for a working situation on board?

We chose this problem for our thesis, and we have thought about what a PDA could be used for. However, we do not want to limit us to one department. Therefore all crew members, regardless of rank or department, have been invited to participate in this survey. If a PDA was available on a vessel, our first thought was the daily round in the engine room. Thoughts and ideas that have appeared during our work with the report has been to individually label extinguishers with tags or barcodes, hence it is possible to scan each fire extinguisher, which in turn can provide a “window" with fields for comments and a box to be filled in when the inspection is done. This field can also give detailed information about the specific fire extinguisher, where it is located and a description of the control that should be performed.
Similarly, individual tanks could be labelled and when scanning it, another window could appear where the sounded value could be entered. In that case, ASTM tables would have to be made available in a database, and with the sounded value it could automatically give the tank contents in volume. By inserting the liquid’s density it could also present the weight.
Another possible function would be in relation to safety issues such as checklists before bunkering, hot work situations and entering to void spaces etcetera. It should be noted that the above information is only presented as an example and not as an alternative to a final solution.

We are grateful if you can help us by answering these questions.

Personal Data

Nationality	SELECT ☐ Other Click here to enter text.	
Gender	☐ Male ☐ Female	
Current position	Deck dept	Engine dept
Work experience as a crew member (years):	#	
Current ship type:	SELECT. ☐ Other Click here to enter text.	

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	Questions	Options
6	**Should the PDA have a scanner function?** For example, it can be used to identify objects.	☐ Yes ☐ No
7	**If yes, should it be by conventional barcode, QR or RFID?** QR is a conventional barcode with an error handling function, while RFID uses electromagnetic fields to transfer information.	☐ Conventional barcode ☐ QR ☐ RFID
8	**Keyboard/touch-screen and/or display-pen?** The display-pen can be attached to the PDA.	☐ Keyboard ☐ Touch-screen ☐ Display-pen ☐ None
9	**Speakers and/or microphone?** For example, these can be used during calls or recording.	☐ Speakers ☐ Microphone ☐ None
10	**USB-port?** For example, a USB-port can be used for connecting external equipment or to transfer information.	☐ Yes ☐ No
11	**Memory card?** For example, this can be used for local storage of data, pictures and manuals.	☐ Yes ☐ No
12	**Camera?** For example, to document work and damaged components.	☐ Yes ☐ No
13	**Calculator?**	☐ Yes ☐ No
14	**Bluetooth?** For example, to connect and transfer information wirelessly.	☐ Yes ☐ No
15	**Wi-Fi?** Another technique for wireless transferring of information.	☐ Yes ☐ No
16	**Texting and/or Email function?** For example, to communicate with other crew members and ship's office.	☐ Texting ☐ Email ☐ None

	Questions	Options	Comments
17	**GPS?** Is this necessary, and for what purposes?	☐ Yes ☐ No	Click here to enter text.
18	**Additional software functions**	☐ History ☐ Trend display ☐ Other	Click here to enter text.

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	Questions	Comments	
19	**How can a PDA be used in a bridge department?**	Click here to enter text.	
20	**How can a PDA be used in a deck department?**	Click here to enter text.	
21	**How can a PDA be used in an engine department?**	Click here to enter text.	
22	**How should the number of PDAs be distributed on board?** For example, one per department or one per crew member.	Click here to enter text.	
23	**Can a PDA be applicable on board a ship?**	☐ Yes ☐ No ☐ Comments	Click here to enter text.
24	**What physical features of the PDA do you think is important?** For example, regarding size and shape.	Click here to enter text.	
25	**To what systems should the PDA be connected to?** For example, the PDA can be directly connected to the maintenance system.	☐ None ☐ Maintenance system ☐ Other	Click here to enter text.

26. **Additional comments**
If you have additional thoughts, please let us know!

Thank you for your participation! Your personal data will only be used for statistical purposes.