THE JOURNAL OF NAVIGATION (2020), **73**, 421–432.
doi:10.1017/S0373463319000687

The Impact of Bridge Alerts on Navigating Officers

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New navigation-related technologies and complex ships' systems are associated with a considerable amount of information and alerts on navigational bridges. Each alert triggers a process conducted by the Officer Of the Watch (OOW), which includes data collection and interpretation, decision making, as well as appropriate actions. In the case of too many alerts or poorly managed alerts, the workload of the OOW may significantly increase, and situational awareness may be compromised, increasing the risk of errors. The main goal of this research is to analyse OOW actions triggered by the alerts. The research methods included an experiment on a bridge simulator with experienced officers, a questionnaire survey and a series of interviews. The main outcomes encompass the frequency of the alerts and the number and the processing times of single actions conducted upon an alert. The results indicate that, on average, during one watch, an OOW spends 22·4 minutes conducting 64 actions triggered by 16 alerts. However, officers consider 45% of the alerts as over-prioritised and distracting at the moment of their notification.

KEYWORDS

1. Human Element. 2. Workload. 3. Man Machine Interface. 4. Bridge.

Submitted: 6 November 2018. Accepted: 29 June 2019. First published online: 14 August 2019.

1. INTRODUCTION. An alert is defined as information indicating a circumstance or condition on a ship that requires the attention and possibly a specific task carried out by the Officer Of the Watch (OOW). The visual intensity of the alert and audio signal frequency are regulated by the International Maritime Organization (IMO, 2009). The alerts are classified as emergency alarms, alarms, warnings and cautions. Emergency alarms indicate an immediate danger to human lives, the ship or machinery, requiring immediate actions. The alarms are high-priority alerts indicating a condition requiring immediate attention and action. Warnings indicate potentially hazardous conditions requiring attention and, possibly, actions, while cautions indicate a low-priority non-ordinary condition, requiring only the attention of an OOW (IMO, 2009; 2010). Alerts can be generated on any device/system (according to the decentralised, "old" approach) or through the Central Alert Management Human-Machine Interface (CAM-HMI) as a part of the Bridge Alert Management (BAM) System (IMO, 2010). BAM recognises three alert categories: A - alerts acknowledged on the alert-generated device only where the proper procedure is required; B - alerts whose information provided on CAM-HMI is considered as sufficient; and C - alerts which cannot

be acknowledged on the bridge (for example, many engine related alerts). It may be said that BAM aims to improve alert management by listing alerts as sorted by their priority, grouping alerts triggered by the same cause and a systematic record. One of BAM's disadvantages is the fact that many B and all C category alerts are actually duplicated on the CAM-HMI unit.

Generally, in integrated bridge systems, engine related alerts are sounded and displayed almost as frequently as the alerts in the engine control room. Nevertheless, the OOW's actions are very limited, often restricted to acknowledging and verifying the message (Motz et al., 2009). Further actions are the responsibility of the duty engineer officer. The cargo related alerts depend on the type of ship, the level of automation, and the onboard equipment. For example, in most cases, the cargo systems of tankers can be controlled from the bridge and the OOW has the responsibility of responding to cargo alerts.

According to IMO MSC.252(83) (IMO, 2007), and IMO A.1021(26) (IMO, 2009), altogether there are 69 mandatory navigation-related alerts and other essential ship systems' alerts defined for ships in international trade. However, the total number of alerts exceeds this number and the IMO recognised this issue 15 years ago in Maritime Safety Committee (MSC)/Circular 1091, stating that more than 200 alerts may be found on a ship's bridge (IMO, 2003). The Transas Marine Navi-Trainer Professional 5000 bridge simulator has 202 different navigational equipment alerts (Transas MIP, 2012a; Transas MIP, 2012b; Furuno Electric, 2010). In addition, the Kongsberg MC 90-IV engine simulator (MAN B&W MC 90 slow motion diesel engine) generates 482 different alerts (Kongsberg Maritime, 2014). Finally, 164 alerts can be generated by the cargo simulator CHT 2000-VLCC-II for a Very Large Crude Carrier (VLCC) with 16 cargo tanks and four discharging pumps (Kongsberg Norcontrol, 1997). It is estimated that on ships having engine and cargo systems integrated on a bridge with unrestricted access through computer systems, approximately 850 different alerts in total may be sounded on a bridge.

It is worth noting that the new systems provide significant information that may be more or less important in a particular case. In addition, sophisticated systems can display that information in different ways, visually and audibly, thus significantly increasing an OOW's workload (Tzannatos, 2004; Embrey, 2006; Nachreiner et al., 2006; Earthy, 2006; Goel et al., 2017; Mišković et al., 2018). The issue may easily be recognised on ships without the CAM-HMI (IMO, 2013) and on ships where the bridge layout does not comply with ergonomic standards. The OOW's workload may also increase if the execution of the task is interrupted by different distracters. (Krystosik-Gromadziñska, 2018; Maglic et al., 2016). In many cases, different alerts may act as distracters, interrupting the OOW.

In this paper the term workload is defined as a level of mental ability required to process information during the performance of a task (Kum et al., 2007). The level of mental ability may be affected by numerous factors, but the most important ones refer to the amount of information to be processed and the tasks to be carried out within the given time. An increased workload as well as distractions (non-essential information, as particular alerts, which divert an OOW's attention towards the less important or non-relevant elements in the environment) may reduce situational awareness. A reduced level of situational awareness may lead, in general terms, to human error or improper decision-making (Crowch, 2013), or more precisely to a deviation from a known procedure of actions for which the OOW has been trained (Øvergård, 2015). According to some research, most accidents at sea have involved human error to at least some degree (Rothblum et al., 2002; Rowley, 2006; Dhillon, 2007).

In certain situations, the workload may be observed as a sum of all the mental resources assigned to various working processes in a given time. Each working process (including those triggered by an alert) requires certain mental resources to carry out the collection of data and their interpretation and decision-making, as well as the task execution. The first two sub-processes, that is, data collection and interpretation, and decision-making, are highly individual mental processes and their execution cannot be easily observed. On the other hand, task execution can be perceived as if carried out in a controlled environment. In the case of an OOW, the characteristics of the navigational workload caused by task execution, in particular that caused by alerts, can be assessed by using navigational simulators.

Each executed task consists of a sequence of actions, intentionally carried out by the OOW. The action is defined as the smallest, clearly distinguishable and measurable individual action made by an OOW. Although these actions are highly individual, it can be assumed that their main characteristics are similar, therefore measurable, and may be described by using statistical distributions.

In order to measure these characteristics and to understand the underlying drivers, a 'three-phase experiment' has been designed. The first phase includes collecting data on OOW's actions in a representative situation by simulating navigation and observing all the procedures on a bridge simulator. The second phase consists of interviews with officers and masters in order to clarify certain unclear actions and instances of unrecognised behaviour during the navigation simulation. These two parts of the experiment were used to obtain the first two main indicators, that is, the number of single actions conducted by the OOW upon each alert and the associated processing times, such as the time spent by the OOW conducting each alert related action. Finally, the third phase uses a questionnaire in order to make an inquiry regarding the experience and perception of experienced OOWs on the subject matter to gather information which was not obtainable during the experimental phase. The main result of the questionnaire is the third important indicator, showing the estimated total number of alert occurrences on the bridge. Other questionnaire results include the ratio of different alert types sounded on the bridge and an opinion as to how many and which alarms are overrated, thus acting more as a distraction than being useful.

2. RESEARCH METHODS.

Three sources were used for collecting the data appropriate for analysis of the OOWs' actions. The first and main one was an experiment conducted on a navigational bridge simulator. The goal was to identify and measure the actions carried out by experienced officers during a watch. The actions triggered by the alerts were scrupulously analysed. Additionally, the processing time spent on each action was recorded. The experiment was carried out on a Transas 5000 full mission bridge simulator. Sixteen participants, all of them navigating officers holding a valid Certificate of Competence for a Master of Ship of 3,000 gross tonnes or more, joined the experiment voluntarily after familiarising themselves with the simulator.

Each participant ran the same simulation scenario. The scenario included a one-hour sailing of an Liquid Natural Gas (LNG) carrier through the Dover Strait Traffic Separation Scheme (TSS) at a speed of 21 knots, sea state 5 and in good visibility. The Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA) alarms were initially set at 1 Nautical Mile (NM) and 10 minutes. The scenario included two overtakings by own ship (CPA < 1 NM), one overtaking by another ship (1 NM < CPA < 2 NM), one crossing encounter (CPA < 1 NM), and four ships at close range (2 NM < CPA < 4 NM). Although the simulation scenario was the same, the total number of alerts generated by navigational equipment depended on an OOW's decisions and manoeuvring. In addition to the system-generated alarms, two high priority alarms and two warnings of rather low priority were programmed. The key high priority alarms included steering gear pump failure (one pump in use) and a gyrocompass failure during steering on autopilot (set at 10° off course). Low priority warnings included Electronic Chart Display and Information System (ECDIS) over-scale and the loss of the differential signal on the Global Positioning System (GPS).

During the experiment, each participant experienced ten alerts, on average, generated by the equipment (mainly radar, for example, CPA/TCPA and Cross Track Error (XTE), and ECDIS, for example, approaching a "no go area" in the TSS) and four programmed alerts (two high priority alarms and two low priority warnings). The high priority alarms were triggered separately, thus giving participants enough time to cope with each one separately, that is, the first did not interfere with the second. This was required in order to clearly distinguish the particular trigger, the sequence of actions, and the number and duration of all the related actions. Before running the experiment, each participant was instructed to strictly follow all navigational rules and regulations. Every simulation session was recorded by using Closed Circuit Television (CCTV) cameras for subsequent behaviour analysis, including the handling of the instruments, movements around the whole bridge and direction of sight.

It is important to emphasise that the experiment scenario was developed in order to represent a possible real situation of navigation in an area of dense traffic. It is assumed that the navigation is performed by only one OOW, which implies that the presence and actions of other crew members (bridge team) were not considered. This experimental approach was used to observe the OOW's procedures in a clear and distinct way, to recognise and count each action for a specific alert and to measure the associated processing times. The alert frequency, that is, the number of alerts in the presented scenario, was not considered.

The second phase consisted of interviews with selected participants in the experiment after phase one. The interviews were conducted individually by the authors, using open questions (asking for an explanation) and taking selective notes. The objective was to clarify several instances of doubtful or uncertain behaviour by the participants and other uncertainties during navigation simulation (for example, the reason for showing "idle time" where participants obviously did nothing, performed the same actions twice, etc). Altogether ten chief mates and six second mates were interviewed.

The third phase was based on the questionnaire survey. The aim was to validate the collected data during the first and the second phase and to collect the missing data. The semi-structured questionnaire, using structured and open questions, was designed to investigate the following (Figure 1):

- the usual alert frequencies and their sources;
- which alert management system type is the most commonly used on board ships;
- the ratio of different alert levels;
- the identification of specific alerts influencing the situational awareness, that is, alerts which could be classified as distracting or as over-prioritised.

The survey encompassed 104 voluntary participants; 39% of them were masters, 26% chief mates, 25% second mates and 10% third mates. All collected data, from both phases, were used for quantitative data analysis, except the data from the tenth questionnaire question, used for qualitative data analysis.

General information about participants:

Holding Certificate of Competency: ____________________

Actual rank: ____________________

Years of experience as navigational officer: ____________________

Last boarding

Ship type: ____________________

Most frequent navigational areas (routes): ____________________

Please answer the following questions based on your experience from the last ship:

1. Does the ship have a Bridge Alert Management System installed? YES / NO
2. How often the alerts occur on a navigational bridge (all kinds)? Every______ minutes
3. Are engine related alerts sounded on a navigational bridge? YES / NO
4. How often the engine related alerts occur on a navigational bridge? Every______ minutes
5. Are cargo related alerts sounded on a navigational bridge ? YES / NO
6. How often the cargo related alerts occur on a navigational bridge? Every______ minutes
7. Are Alerts divided onto *Alarms*, *Warnings*, and *Cautions* ? YES / NO
8. What ratio (%) of the alerts had the status as:

   ALARM (action needed immediately): __________

   WARNING (no action required immediately): __________

   CAUTION (information only): __________
9. What ratio of ALARMS you consider overrated (acting as distracters at a time of occurrence): __________
10. Please write the most dominant examples of ALARMS which, at the time of occurrence, interfere with navigation (distracors): ____________________.

Figure 1. The survey questions.

3. RESULTS.

3.1. *Frequency of alerts.* The alert frequency is expressed as the average time between two consecutive alerts (of all kinds) and is estimated using the questionnaire survey. The collected data (statistical population) has the following parameters: Range = 58 (2–60 minutes), Mean = 14·87, Median = 10, Standard deviation = 15·56 with a 90% confidence interval [12·22, 17·52].

The collected data indicated that it was congruent with a lognormal distribution, the parameters being $\mu_l = 14{\cdot}72$, $\sigma_l = 17{\cdot}16$ (Figure 2). The lognormal distribution is expressed in the following manner:

$$\mu = \ln\left(\frac{\mu_l^2}{\sqrt{\sigma_l^2 + \mu_l^2}}\right) = 2{\cdot}26$$

$$\sigma = \sqrt{\ln\left[\frac{(\sigma_l^2 + \mu_l^2)}{\mu_l^2}\right]} = 0{\cdot}93$$

$$f\ (x) = \frac{1}{\sigma x\sqrt{2\pi}} e^{-(\ln(x)-\mu)^2/(2\sigma^2)} = \frac{1}{0{\cdot}93x\sqrt{2\pi}} e^{\frac{-(\ln(x)-2{\cdot}26)^2}{1{\cdot}72}}$$

$$x > 0; \quad \mu_l, \sigma_l \epsilon R^+ \tag{1}$$

The fitted distribution parameters are as follows: Mean = 14·72, Median = 9·58 and Standard deviation = 17·16.

https://doi.org/10.1017/S0373463319000687 Published online by Cambridge University Press

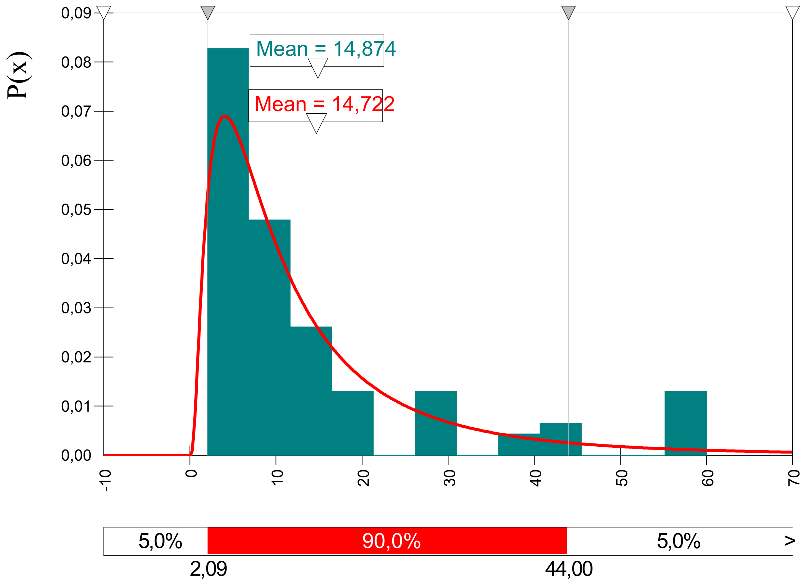

Figure 2. The time between two consecutive alerts on a navigational bridge.

The mean value of the distribution represents the average time between two consecutive alerts sounded on the bridge, being 14·72 minutes or a frequency of four alerts per hour. This value is quite general and represents the estimated average frequency considering different ship types in coastal navigation.

Based on the follow-up interviews, it generally seems that the frequency is higher on faster, more complex or modern ships (mainly container ships, different oil tankers and liquid gas carriers), around ten alerts per hour (every 5–6 minutes) while on simpler and slower ships (general cargo, bulk carriers and others) it is significantly lower. Similarly, one previous research project stated that 3·2 alerts per hour occur on ships in open seas, 10·8 in coastal navigation and 26·2 in confined areas (Baldauf et al., 2008).

The ratio of different alert types occurring on a bridge is also estimated by analysing the questionnaire results. The analysis showed that alarms occur in 27% of the cases, warnings in 38% and cautions in 35%. Genuine emergency alarms (including false alarms caused by faulty equipment) occur extremely rarely. Based on the collected data, it can be estimated that emergency alarms occur in less than 0·1% of cases.

Furthermore, according to the questionnaire survey, engine related alerts are sounded on the bridge in 90% of the ships, whereas cargo related alerts (of any kind) in 56% of the ships. The full bridge alert management system is fitted in 66% of the ships under survey, categorising the alerts into alarms, warnings or cautions, while the "old" decentralised alert system is used on 34% of the ships covered by the survey.

3.2. *Number of single actions.* The number of actions has been estimated by using the data collected during the experiment. In general, the number of single actions triggered by each alert varies largely, depending on the type of alert, prevailing circumstances on a bridge, surrounding traffic and other tasks currently in process. Another significant factor is a personal approach and how the significance of each alert is perceived. This is highly dependent on the knowledge, experience and familiarity of the OOW with the ship's systems. In most cases, the actions taken by the OOW upon the sounded alert can be divided

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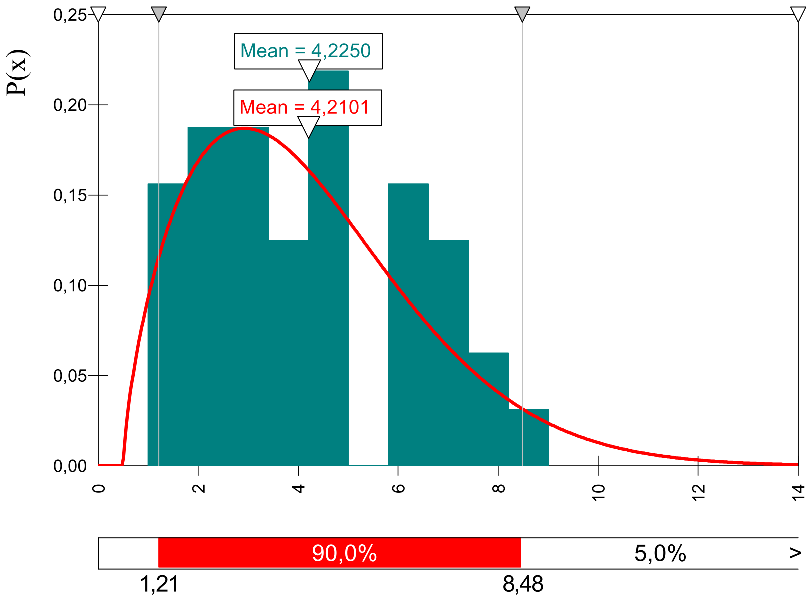

Figure 3. The number of actions triggered by alerts.

into four categories: acknowledgement (confirming and silencing the audio and visual signals), additional information collection and assessment, the execution of a procedure (tasks improving, repairing or rectifying the arisen circumstance) and record keeping (logging down or informing other subjects).

The actions were evaluated and recorded during the experiment on the bridge simulator, observing the participant's behaviour directly upon each alert notification. The actions caused by 220 alerts in total were analysed. The collected data (statistical population) has the following parameters: Range = 8 (1–9 actions), Mean = 4·22, Median = 4, Standard deviation = 2·22 with a 90% confidence interval [3·63, 4·81].

The results are congruent with the Weibull distribution, a continuous statistical distribution defined by random variable x, whose parameters are $\alpha = 1{\cdot}6796$ and $\beta = 4{\cdot}1547$. The distribution is given by the following expression (Figure 3):

$$f\ (x) = \alpha\beta^{-\alpha}x^{\alpha-1}e^{-\left(\frac{x}{\beta}\right)^{\alpha}} = 0{\cdot}1536x^{0{\cdot}6796}e^{-\left(\frac{x}{4{\cdot}1547}\right)^{1{\cdot}6796}} \qquad x > 0;\ \alpha, \beta \in R^{+} \tag{2}$$

where α is a shape parameter and β is a scale parameter.

The fitted distribution parameters are as follows: Mean = 4·21, Median = 3·84 and Standard deviation = 2·27.

Since the results represent the number of single actions (n_t), they are determined by rounding up the Weibull distribution values to natural numbers (Figure 4), and expressed by:

$$f\ (n_t) = \left\lfloor 0{\cdot}1536n_t^{0{\cdot}6796}e^{-\left(\frac{n_t}{4{\cdot}1547}\right)^{1{\cdot}6796}} \right\rfloor \tag{3}$$

According to the results, the reactions of the OOW may vary between one and nine distinctive actions. Based on interviews and video recordings, two expected conclusions have

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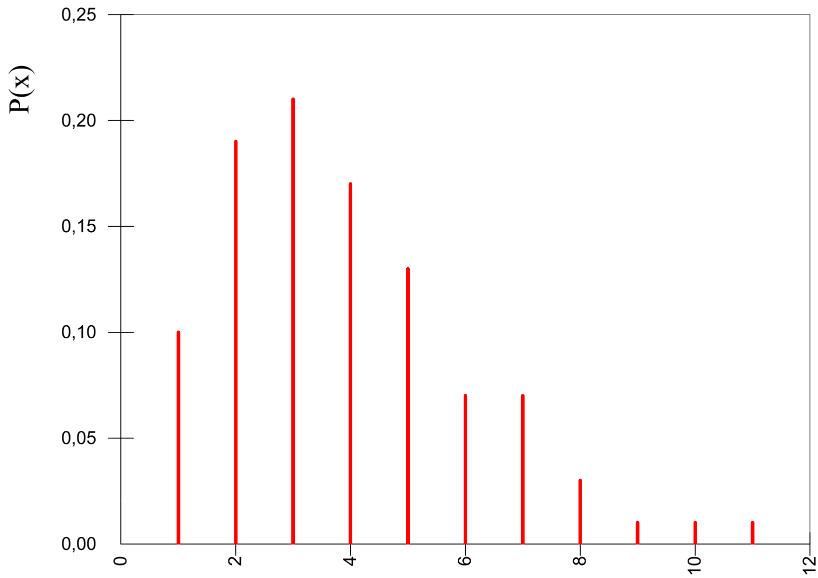

Figure 4. The number of actions triggered by alerts (rounded values).

arisen. First, in nearly all cases, low priority alerts (warnings and cautions - predominantly conning, ECDIS and GPS) triggered only a visual observation and alert acknowledgement (treated as one action). Secondly, uncommon and high priority alarms triggered more responsive actions. For example, high priority alarms (steering gear pump and gyro compass failures) in all cases triggered seven or more actions per alarm. For example, almost all participants acted similarly in the case of a steering gear pump failure: acknowledgement, turning off the autopilot, starting the second pump, rectifying heading, turning on the autopilot, setting the autopilot, calling the master, calling the helmsman, calling the duty engineer. On average, the OOW performed four single actions per each alert.

3.3. *Processing times.* Processing time (t_p [min]), that is the time spent by an OOW conducting an alert related action, was analysed using the CCTV records. The collected data (statistical population) has the following parameters: Range = 1·8 (0·06–1·86 minutes), Mean = 0·35, Median = 0·26, Standard deviation = 0·28 and 90% confidence interval [0·31, 0·39].

Analysed times are congruent with a lognormal statistical distribution with parameters being $\mu_l = 0{\cdot}311$ and $\sigma_l = 0{\cdot}353$ (Figure 5). The distribution is set in minutes and expressed by:

$$\mu = \ln\left(\frac{\mu_l^2}{\sqrt{\sigma_l^2 + \mu_l^2}}\right) = -1{\cdot}58$$

$$\sigma = \sqrt{\ln\left[\frac{(\sigma_l^2 + \mu_l^2)}{\mu_l^2}\right]} = 0{\cdot}91 \qquad (4)$$

$$f\,(t_p) = \frac{1}{0{\cdot}91 t_p \sqrt{2\pi}} e^{-(\ln(t_p)+1{\cdot}58)^2/1{\cdot}66}$$

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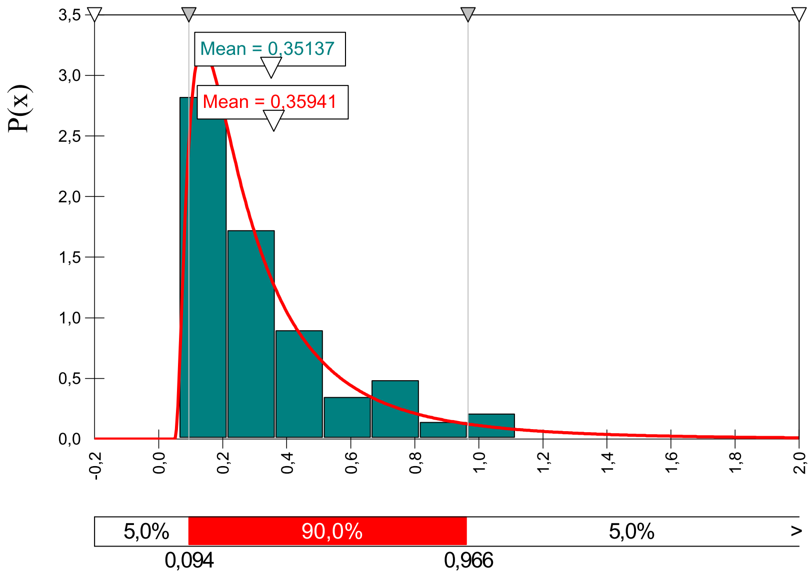

Figure 5. The processing time of actions triggered by alerts.

The fitted distribution parameters are as follows: Mean = 0·35, Median = 0·25 and Standard deviation = 0·35.

The results showed that different actions can last from less than 0·1 minutes (just a few seconds, usually the first action includes a visual check with acknowledgement) to more than 1 minute (for example, rectifying the heading by manual steering after gyro compass failure). Considering all the alerts, the average processing time for a single action is 0·35 minutes. Subsequently, after each alert an OOW spends 1·4 minutes conducting four actions on average. The longest total processing time recorded during an experiment, triggered by one alert, was 8·3 minutes. This included nine actions upon a gyro compass failure alarm.

There are two observations that should be emphasised. First, after some alerts, nearly all the participants in the experiment showed an *idle time* - the time they spent doing nothing, with no obvious focus, usually for a few seconds. During the interviews, they explained that this short period of time had been used for reflection and the planning of further actions. This time period was not taken into consideration and was therefore not presented in the results. However, it is estimated that, in some cases, this idle time can prolong the time of actions by up to 50%.

The second observation is that, in nearly all alert cases, the participants not only followed the intended procedure, but their actions were also interchanged with actions associated with other navigational tasks. The only exceptions recorded were two programmed high priority alarms, for which they strictly followed the intended action plan until complete rectification. During the interviews, the participants explained that it is rather easy when a simple task is interrupted with another simple task (medium or low priority alert), but that the situation changes significantly in more demanding situations, for example, collision avoidance or when one of the tasks is of high priority or occurs rarely, such as steering gear pump failure.

https://doi.org/10.1017/S0373463319000687 Published online by Cambridge University Press

Based on all the results, in one standard navigational watch during a coastal navigation, on average 16 different alerts were sounded (four per hour), generating in total 64 actions that an OOW executed in 22·4 minutes or 9·3% of the watch time.

It has to be emphasised that the findings do not consider specific ship types and different degrees of automation. Additionally, the results may differ significantly in other areas of navigation (for example, ocean or port approaches) where the actual number of triggered alerts could differ significantly. In addition, this research was conducted assuming that during navigation only the OOW is present on the bridge, meaning that the implications of having more than one crew member, that is, a bridge team (with master, helmsman or another OOW) were not considered. Therefore, the presented data has to be taken with caution and requires further study of the human processes and workload.

Considering the limitations, this research may further develop in two main directions, one being simulation of navigation in a different area of navigation, while the other one involves setting up the simulation with the whole bridge team and monitoring the performance (actions including communication interaction) of each individual.

4. DISCUSSION. Taking appropriate actions after receiving the alarm type alert should not be delayed. However, there are a great number of alarm type alerts on a navigational bridge, not only required by the rules and regulations but also by the equipment manufacturers. In fact, much information that should not have an alarm status or should not require an action by the OOW (mostly engine or cargo alarms) is included in bridge systems.

According to the judgement of the participants (based on the questionnaire), 45% (mean = 45·4, σ = 29·03) of all alarms are over-prioritised or are just distracters. Such distracting alarms may affect the situational awareness of the OOW and may influence the safety of the ship. The seafarers that participated in the questionnaire have recognised the following as the most important distracters related to navigational equipment: Very High Frequency Digital Selective Calling (VHF DSC) non-distress or urgency safety messages, Inmarsat C and Navtex safety messages (particularly due to the large number of false or irrelevant messages for the current navigation area), navigational and meteorological warning messages (often occurring with extremely loud audible signals), automatic GPS-DGPS shift alarms, radar log errors, echo sounder signal losses (short-term signal loss with an intense alarm), navigation light bulb failure (intensive alarm although the spare bulb automaticallyswitches on), AIS system overload and speed error (short-term signal loss with an intense alarm).

The predominant examples of cargo system alarms (mainly on oil/product tankers and liquefied gas carriers) considered as distracters are: high and low level cargo alarms in cargo tanks (often occurring due to a ship's motion – deactivation is possible but forbidden according to the regulations); cargo heat exchanger alarm (some systems cannot deactivate some kinds of alarms even during a ballast voyage); low compressor oil temperature alarm (even though the device is not in use); alarms triggered during various tests which cannot be deactivated on the bridge during navigation.

The predominant examples of engine alarms considered as distracters on the bridge are: paper alarm for engine log; various alarms related to and during engine maintenance and frequent switching of the unmanned machinery space alarm during the day.

In general, officers stated that all cargo, engine and auxiliary systems alarms act as distracters, apart from those that inform the OOW on the bridge about conditions that could directly jeopardise the ship's propulsion or safety if there is no immediate action.

Therefore, the following question arises: is it acceptable that nearly 10% of the OOW's time should be spent on managing different alerts? If looking purely from a statistical point of view, the authors' opinion is that the answer is "yes". However, if superfluous and non-essential alerts dominate and especially if they occur during an especially demanding navigational situation, then the answer would be "no". The alerts are sounded at the moment of detecting of a certain state or situation, not when it is suitable for the OOW, that is, they do not "choose" a suitable moment for alert notification. Generally, even the low priority alerts, not requiring "real actions" sometimes require walking, reading, acknowledgement, information collection from a source and related equipment, event record, forwarding information to other crew members, etc. When looking at all the actions that an OOW conducts following each alert, it is not unusual that 45% of all the alerts are experienced as distracters by the watchkeeping officers, events which unnecessarily interrupt the processing of a previously started procedure.

5. CONCLUSIONS.

By definition, emergency alarms and alarms require immediate attention of an OOW, as well as the tasks to rectify the arisen state or circumstance. On the other hand, warnings and cautions are more of a "just indicating" type of alerts. However, all alerts, regardless of their type, require one or more actions to be taken by an OOW. The results of our experiment show that for one alert, an officer conducts four actions, lasting 0·35 minutes each or 1·4 minutes in total. Considering one watch, on average 16 different alerts may be sounded, upon which an officer spends an average of 22·4 minutes to conduct 64 actions. According to the seafarers in this study, 45% of alerts are experienced as overrated or act as distracters. This issue is particularly important during demanding situations in navigation such as collision avoidance, navigation in dense traffic or in restricted waters, during course changes at a waypoint, distress or urgency message receipt, another high priority alert state, etc. Some of these demanding situations, like collision avoidance, can last for several minutes, and in such situations, low priority alerts that require a few minutes of the OOW's attention may significantly reduce the situational awareness of the OOW.

One of the possible approaches to cope with this issue is to use the regulations to limit or decrease the number of alerts on a bridge. One method would be a careful selection of permissible cargo and engine related alerts, limiting the notifications only to alerts essential for the ship's safety or pollution prevention. The second approach could be developing an intelligent adaptive alert management system. Such a system could intercept low-priority alerts and postpone their dissemination for a short period of time. The delay would be justified only during recognised situations demanding the full attention of the OOW. Finally, the third approach includes a further development of automated systems and making them capable of carrying out remedial actions without the involvement of the OOW. Such systems could be introduced for the systems that are not essential for the ship's safety. In this case, the interaction with the officer should be limited to information about the situation after remedial actions.

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