Perceptions of technology at sea amongst British seafaring officers

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The use of Information Communication Technology is growing in the maritime industry as more systems become monitored remotely and new technologies are introduced to aid environmental awareness and increase safety. An exploratory survey was conducted as part of the EU project ‘FLAGSHIP’ to assess how seafarers perceive the current state of technology onboard ship and to identify areas of resistance to advancements in this area. Only 5.8% of the sample of British officers (overall n = 805) reported feeling resistant to new technology either ‘quite a lot’ or ‘a great deal’ at a general level compared to 82.8% when asked about the specific issue of training. Logistic regression analysis revealed older seafarers and those with low computer literacy to show greater resistance to new technology. Resistance was also higher on vessels with smaller crews, although a confound with vessel type is likely. Technology training for seafarers should be improved but not as a means of compensating for equipment developed without reference to user-centred design principles. Around 90% of all goods are transported by ship yet ergonomic research into the onboard environment is extremely limited. New technology is being introduced to substitute for the human element but little has been done to investigate how work processes have adapted. Seafarers’ perceptions of new technology are examined here.

Keywords: technology; seafaring; training; user-centred design; ships

1. Introduction
As technology becomes increasingly more sophisticated in modern society it is important that the understanding of human–computer interaction keeps pace. Technology developed without reference to key human factor principles has the potential to be counter-productive, not least in safety-critical industries where mistakes can lead to disastrous consequences. The maritime industry is one such safety-critical industry where mistakes can lead to what have been termed ‘low probability-high consequence accidents’ (Koshland 1989).

Reducing accidents at sea has been a key focus for the introduction of new technology onboard ship. Disasters such as that of the Exxon Valdez in 1989 where 1100 miles of shoreline were polluted by oil (Maki 1991) or the Herald of Free Enterprise in 1987 where 188 passengers and crew died (Department of Transport 1987) highlight the huge economic, human and environmental cost when maritime disasters occur.

In parallel with safety advancements, technology at sea has been used to reduce crew numbers and reduce costs in an extremely competitive market. By using technology to automate many tasks, particularly in navigation, it has been possible to dramatically reduce the number of crew required to sail a vessel (National Research Council 1990). Similarly, technology has been used to increase efficiency at an operational level. At the port of Sandhaven, UK, Kahveci (1999) provides a clear example of how efficiency has increased significantly in recent times. Between 1970 and 1998 the sum tonnage size of vessels visiting Sandhaven increased by over four times whilst turnaround times decreased nine-fold over the same period (Kahveci 1999). Technology is largely responsible for such dramatic efficiency gains.

By striving to increase automation, the assumption is that time and resources will be freed up as crew are no longer required to manually perform tasks. Research conducted in other fields, however, suggests such an assumption should not go unchallenged. In the aviation industry, for example, Funk et al. (1999) reviewed a number of sources, including a survey of pilots and aviation experts and compiled a list of 92 automation-related flight deck issues. Similarly, Wiener (1989) asked 166 pilots their response to the statement ‘Automation does not reduce total workload since there is more to monitor now’ and found an equal number of participants agreeing and disagreeing with this statement. Where the role of the human changes from operator to monitor, evidence suggests that rather than freeing up resources, new vigilance demands are introduced, which may be extremely
taxing (Parasuraman 1987). Complex new automated systems may therefore give the illusion of reducing workload and introducing redundancy, but in reality this may not necessarily be the case (Palmer and Degani 1991).

As well as increased monitoring requirements, Kantowitz and Campbell (1996) identify a number of other problems associated with the move to increased automation in modern flight decks. Wherever new technology is introduced, training needs to be increased as crews are required to be competent in both manual and automated modes of operation. Furthermore, if crew become familiar with working in an automated mode of operation there is concern about how they will respond should the requirement be made to switch back to manual operation in, for example, an emergency. One problem is that automation is often seen as ‘all or nothing’, prompting calls for a more integrated and flexible approach to human–computer interaction (Wiener and Curry 1980, Endsley 1996). Concern is also raised about how technology is designed and introduced with the process of selecting and automating tasks at risk of following machine-centred rather than user-centred principles.

Whilst the issue of automation has seen extensive research in the field of aviation, automation in shipping has received considerably less attention. First, it must be acknowledged that automation has undoubtedly led to considerable improvements in the shipping industry, which can be easily overlooked in discussions of this nature (Wiener 1988). In parallel with the automation of previously manual tasks, the introduction of Information Communication Technology (ICT) onboard ships has involved enriching the environmental information available to the seafarer, primarily to aid safety. An example is the automatic radar plotting aid (ARPA), which makes it possible, in conjunction with radar, to track the course of a vessel and calculate how close it will pass to other objects and ships in the area. ARPA would appear to have had a significant impact in terms of helping collision avoidance since its mandatory introduction onboard all vessels over 10,000 tons (Tiblin 1990). A more recent example is the automatic identification system (AIS), which allows a ship to identify other vessels in its vicinity and gather information on ship name, course and speed. Despite the benefits of these systems, however, it is clear that the role of the seafarer is increasingly changing to that of a monitor. Where the value of the human operator is thus called into question, controversy is inevitable (Committee on Advances in Navigation and Piloting 1994).

From the limited literature evaluating automation onboard ship, concerns can be identified similar to those in aviation. Regarding the changing role of the seafarer to that of a monitor, for example, Lee and Sanquist (1996) highlight how the task of controlling multiple remote systems may require high levels of cognitive ability and skills distinct from those originally learnt during qualification. There is also evidence that introducing new electronic systems onboard may reduce levels of communication on the bridge (Gould et al. 2009). Wider concern is expressed in the seafaring industry, however, towards how new technology is designed and implemented. In the case of AIS, for example, Norris (2007) highlights how many of the problems identified with this equipment could have been overcome through better end-user involvement. Similarly, in her thesis entitled ‘The technology is great when it works’, Lützhöft (2004) shows how the design of equipment on vessels often contradicts the seafarers’ conception of how things should function.

Coupled with design criticisms, shortcomings have also been identified in terms of the training given to seafarers to operate new equipment. It has been suggested that there is currently a lag between the introduction of new technology and the provision of training to operate it (Committee on Advances in Navigation and Piloting 1994), with many seafarers only receiving training ‘on the job’ (Lützhöft 2004) or during regular operation.

A study was conducted as part of the European Community’s Sixth Framework programme known as ‘FLAGSHIP’ in a sub-project looking at resistance to new technology onboard ship. The study was an attempt to explore current perceptions towards technology at sea and to evaluate the extent to which concerns raised in the literature are reflected in seafarer opinion. The focus in the current study was upon ICT, reflecting both the aims of the FLAGSHIP project and a key direction in which the seafaring industry is heading. In the maritime domain, ICT refers primarily to systems that are designed to enhance the environmental and contextual perception of the seafarer. Examples would therefore include radar, satellite navigation and equipment to aid the remote management and monitoring of engine room equipment. By focusing on ICT, it was possible to look at an area both of significant development in the shipping world and one of comparability with other industries.

In the absence of other data and in parallel with work conducted 20 years ago in the aviation industry (Wiener 1989), a questionnaire was used as an exploratory means of assessing the seafarers’ experience of marine technology and the ‘end-user’ perspective. By surveying seafarers, the aim was to evaluate how successfully technology is being
implemented in the maritime industry and to identify where potential problems might exist.

2. Method

2.1. Pilot study

In order to design a questionnaire addressing the most important areas of concern for seafarers, a pilot survey was first conducted. In an earlier British survey looking at the issue of fatigue at sea (Smith et al. 2006), participants were given the opportunity to volunteer for future research studies. Those participants who had volunteered were contacted via email concerning the technology at sea pilot study. In total, 175 invitations to take part were sent out with 34 online surveys completed (response rate 19.4%). The pilot survey included a number of open questions designed to give participants space to express their opinions on technology at sea.

2.2. The survey

From the pilot study, areas of potential importance in terms of seafarers’ interaction with new technology were identified. A questionnaire that focused primarily on general perceptions of technology was then designed. This mirrors the approach adopted by Wiener (1989), who surveyed pilots using a questionnaire when attempting to access general attitudes towards automation in the aviation industry. Participants were told to base their responses on their experiences with ICT. In order to help clarify what is meant by ICT in the seafaring context, the following description was provided for participants in the questionnaire:

Where ship systems used to be monitored directly, seafarers are now often faced with computer screens reporting back from parts of the ship remotely. We are particularly interested in your experience with such Information Communication Technology (ICT) in this questionnaire.

Beyond this, no other specification was given. This approach was adopted as an exploratory means of evaluating general perceptions of technology onboard ship. Alongside questions addressing perceptions of technology, demographics and work-related items were also included (e.g. age, sex, nationality, marital status, rank, vessel type).

Resistance to technology at sea was first addressed with the question: ‘To what extent do you generally feel resistant, for whatever reason, to the introduction of new technology onboard ship?’ Participants had the choice of responding ‘not at all’, ‘a little’, ‘moderately’, ‘quite a lot’ or ‘a great deal’. When studying pilots in the aviation industry, Wiener (1989) used 36 statements that participants were asked to state their agreement with on a 5-point scale, e.g. ‘I miss the good old days of simpler aircraft’. In parallel with this approach, statements were given in the present study relating to specific reasons why seafarers might feel resistant to new technology at sea, as follows:

1. I feel technology is putting seafarers out of work.
2. I feel technology tends to be introduced without sufficient training.
3. I feel the introduction of new technology undervalues the skills of the seafarer.
4. I feel technology is often too unreliable to be of practical use.
5. I feel cadets and new seafarers rely on technology too much.

Participants were asked to mark on a 5-point scale to what extent they agreed with each statement responding either: ‘not thought this at all’, ‘thought this a little’, ‘thought this occasionally’, ‘thought this quite a lot’ or ‘thought this a great deal’.

In order to identify where seafarers feel technology could be improved, the following question was asked: ‘If you were given money to increase the usefulness of technology onboard ship where would you consider the best place to spend it?’ Participants were asked to mark one of the following options:

1. Introduction of new technology and the most up-to-date equipment.
2. Increased integration of different pieces of existing technology.
3. Better training of crew in terms of how to use ship technology.
4. Other.

In order to assess resistance to new technology relative to their working experience, participants were also asked about the level of technology installed on their present vessel as follows: ‘Would you generally like to see more or less technology onboard the ships you work with?’ Participants were given the options: ‘Would like to see less’, ‘About right’ or ‘Would like to see more’.

2.3. Analysis

Questions addressing resistance to new technology were analysed at the descriptive level. A multivariate technique was then used to assess whether different factors might be associated with resistance to new technology. Logistic regression analysis was conducted
using a backwards stepwise likelihood ratio technique. All variables were entered into the analysis and then non-significant variables removed to produce a model of best fit. The variables included in this analysis were as follows.

2.3.1. Dependent variables
Six outcome items were used to measure resistance to new technology. Principle components analysis was conducted on these items (Varimax rotation) with one factor extracted. A mean score was therefore calculated for all participants across the five statements relating to specific reasons why seafarers might feel resistant to new technology and the one item assessing general resistance to new technology (see above). The new derived variable was labelled ‘resistance to new technology’ and was used as the outcome measure in the logistic regression analysis.

2.3.2. Independent variables
Below is a list of the independent variables entered into the regression analysis. Rank was not included as the sample was almost exclusively made up of officers.

2.3.2.1. Age. In addition to being a standard covariate for regressions analysis, age has been recognised as an important factor in terms of the adoption of new technology (Morris and Venkatesh 2000). A tertiary split was made of age with the groupings falling as follows: up to and including 38 years old (n = 265); 39 to 52 years old (n = 284); 53 years and older (n = 251).

2.3.2.2. Department. The technology installed and operated by crew working in different departments of a vessel will vary greatly and therefore this was included as an important factor in the analysis. Seafarers working on the bridge (in the deck department) will primarily use navigation, cargo handling and ship administration technology whilst those working in the engineering department will primarily use systems relating to engine management and maintenance. Department was grouped into three as follows:

(1) Deck (n = 337).
(2) Engineering (n = 421).
(3) Other (n = 34).

The ‘Other’ category was primarily made up of those working in the hotel and catering department (n = 11) and integrated officers who work in both the deck and engineering departments (n = 13).

2.3.2.3. Tour type. Crew working in different areas of trade can potentially have very different working experiences. Whilst short sea work will often involve short voyages and frequent port turn-arounds, those working on deep sea vessels will have extended periods of sailing not found in the coastal sector. Where port turn-arounds involve more intensive use of cargo handling, navigational and ship manoeuvring technologies, this operational distinction was considered important to include in the analysis.

The groupings for tour type from the questionnaire were used, as follows:

(1) Deep sea (n = 283).
(2) Short sea and coastal (n = 228).
(3) Middle sea (Baltic and Mediterranean)/middle trade (n = 45).
(4) Offshore (n = 199).
(5) Other (n = 37).

The category ‘offshore’ relates to those working in the offshore oil support industry. This includes offshore support vessels, supply vessels, stand-by vessels and some types of tanker (e.g. shuttle tanker).

2.3.2.4. Flag of registration. Flag of registration relates to the country in which a ship is registered and therefore determines the rules and regulations under which a vessel will operate. This is an important factor to consider as it can have a significant impact on everything from crewing numbers to working hours and technical standards. Of key significance in terms of the analysis groupings is the concept of a ‘flag of convenience’. A flag of convenience, as defined by the International Transport Workers’ Federation (2009), is as follows: ‘Where beneficial ownership and control of a vessel is found to lie elsewhere than in the country of the flag the vessel is flying, the vessel is considered as sailing under a flag of convenience’.

Flags of convenience attract considerable attention, much negative (Alderton and Winchester 2002), as they allow a ship owner/operator to effectively pick and choose between different legislative regimes in order to find the one of best advantage, in most cases economically. Flags of convenience were therefore grouped together and compared with the other most represented flags. The flag groupings were as follows:

(1) Flags of convenience (Bahamas, Barbados, Bermuda, Liberia, Marshall Islands, Panama) (n = 187).
(2) British/UK/Isle of Man (n = 489).
(3) Netherlands (n = 44).
(4) Other (n = 78).
The categorisation of ‘Flags of Convenience’ was taken from a list produced by the International Transport Workers’ Federation Fair Practice Committee (International Transport Workers’ Federation 2009).

2.3.2.5. Ship size (crew). In order to represent ship size, number of crew was used. This avoided the complication of having to compare vessels measured using two different units of size (gross tonnage (GT) and deadweight tonnage (DWT)). The size of a vessel’s crew is important as it determines how a ship operates from shift schedules to automation requirements. It might be expected that larger vessels would have more or better technology as the cost of installation can be more easily justified against the value of operations. A tertiary split was made of ship size, as measured by number of crew, with the groupings falling as follows: up to and including 18 crew (n = 272); 19 to 50 crew (260); 51 or more crew (n = 266; in terms of distribution, 84 of these were from ships with 500 or more crew members). Using two alternative groupings of crew size results stayed the same (analysis not shown).

2.3.2.6. Age of vessel. Age of vessel is important as it impacts on the level of technology installed onboard a ship. A tertiary split was made of vessel age with the groupings falling as follows: up to and including 6 years old (n = 250); 6–17 years old (n = 273); 18 years and older (n = 260).

2.3.2.7. Computer literacy. When comparing which factors might affect resistance to new technology, an important confounding variable to consider is computer literacy. It might be reasonable to postulate, for example, that those who are less computer literate might show higher levels of resistance when it comes to the introduction of increased amounts of technology onboard ship. In order to assess computer literacy, four questions were included in the questionnaire. In these questions, participants were asked to indicate their level of confidence in terms of email, word processing, spreadsheets and Internet searching. Spreadsheets and word processing have been used as dimensions of self-appraised computer literacy elsewhere (van Vliet et al. 1994) and email and Internet were included following feedback from the pilot study revealing these to be important to seafarers. In line with Murphy et al. (1988), a 5-point scale from 1 (not at all confident) to 5 (very confident) was used for each dimension of computer literacy. All four variables were entered into a factor analysis using Varimax rotation with one factor extracted. A derived variable was therefore calculated representing each participant’s average score across all four questions. A tertiary split was then conducted on this factor dividing respondents into one of three groups from 1 (low computer literacy) to 3 (high computer literacy).

2.3.2.8. Level of technology installed onboard ship. Seafarers’ perceptions towards new technology will arguably be affected by what level of technology they are currently accustomed to using. If, for example, a seafarer has successfully worked on a vessel with a high level of technology it might be less likely that this individual will show resistance compared to a seafarer with no such experience. In order to account for this potential confound, the following question was entered into the analysis: ‘Thinking about your present/most recent ship, what was your general perception of the level of technology installed?’.

Respondents were given the following three response options, which were used as the analysis groupings:

1. I would class it as a fairly ‘low tech’ ship.
2. I would class it as a fairly average technology ship.
3. I would class it as a fairly ‘high tech’ ship.

2.4. Distribution
The questionnaire was distributed as part of the EU project ‘FLAGSHIP’ through the National Union for Marine Aviation and Shipping Transport Officers, now known as Nautilus UK. A paper version of the questionnaire was posted to 3000 Nautilus UK members with a freepost return envelope. The questionnaire was also placed online (www.technologyatsea.com) with an advert placed on the Nautilus UK website inviting seafarers to take part.

3. Results
3.1. Sample
In total, 819 questionnaires were returned with 81.1% completed on paper (n = 664) and 18.9% completed online (n = 155). The response rate for the paper questionnaires was 22.1%, which can be considered largely typical for surveys conducted in this industry (Wadsworth et al. 2008). Due to the mode of advertisement it was not possible to calculate a response rate for the online questionnaires. This has been acknowledged as a drawback of conducting surveys online (Rhodes et al. 2003).

Only a small number of questionnaires were received back from non-seafarers or personnel not
working onboard ship (1.7%, n = 14). It was therefore decided to exclude these respondents from the main analyses so that conclusions would relate to currently active seafarers.

3.2. Demographics

The sample was almost exclusively male (96.8%, n = 779) with 59.5% married (n = 477) and the largest remainder either living with a partner (12.8%, n = 103) or single (20.7%, n = 166). The average age of respondents was 44.2 years old (SD 12.0, max = 69, min = 20) with 61.8% (n = 495) reporting having children. The sample was almost exclusively British (97.5%, n = 785).

3.3. Vessel type

A large range of different vessels were represented in the sample including tankers (14.6%, n = 115), passenger/high speed ferries (12.8%, n = 101), cruise ships (12.6%, n = 100), support vessels associated with the offshore oil industry (8.2%, n = 65) and container ships (6.7%, n = 53). The average crew size was 131.8 (SD 274.6, max = 1800, min = 2).

3.4. Rank and department

The sample was made up of almost exclusively officers (98.7%, n = 782) with 53.2% (n = 421) reporting working in the engineering department and 42.6% (n = 337) reporting working in the deck department (on the bridge and deck with responsibility for navigation and cargo handling).

3.5. Resistance to new technology

Overall, only 5.8% (n = 46) reported feeling resistant to new technology either ‘quite a lot’ or ‘a great deal’, with the majority indicating little or no resistance (74.5%, n = 595). On the specific statements 1, 3 and 4, the majority of participants responded towards the lower end of the scale (i.e. ‘thought this occasionally’, ‘thought this a little’ or ‘not thought this at all’) (82.6%, 71%, 84.5% respectively). On statements 2 and 5, however, the majority of respondents either responded ‘thought this quite a lot’ or ‘thought this a great deal’ (82.8% and 69.8% respectively). This trend indicated training to be an area of potential resistance towards new technology.

Considering the role of training further, Table 1 shows opinion was overwhelmingly in favour of better training of crew when compared with other options for spending money.

3.6. More or less technology

Table 2 shows most respondents thought the amount of technology installed onboard ship to be about right (54.8%, n = 431). Interestingly, 36.1% (n = 284) responded that they would like to see more technology onboard ship and only 9.1% (n = 72) responded that they would like to see less. Resistance is therefore not evident towards technology per se, but towards the way in which it is brought in and supported.

3.7. Comparative analysis

The results of the comparative logistic regression are shown in Table 3. As Table 3 shows, older seafarers were more likely to show high resistance to new technology and also those with low computer literacy. Working on a vessel with a large number of crew was also associated with lower resistance to new technology. These factors were found to be significant independent of the level of technology installed onboard ship, which also approached significance. Department, tour type, flag of registration and age of vessel were not found to be significant.

4. Discussion

The results from this study indicate that seafarers are willing to embrace technology but have specific and identifiable grounds for resistance. Specifically, training is an area where seafarers feel not enough is currently being done to support them. When questioned about where money should be spent, respondents overwhelmingly chose training compared with other options for improving onboard technology.

Table 1. ‘If you were given money to increase the usefulness of technology onboard ship, where would you consider the best place to spend it?’

<table>
<thead>
<tr>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction of new technology and the most up-to-date equipment</td>
<td>8.8</td>
</tr>
<tr>
<td>Increased integration of different pieces of technology</td>
<td>15.5</td>
</tr>
<tr>
<td>Better training of crew in terms of how to use ship technology</td>
<td>72.0</td>
</tr>
<tr>
<td>Other</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Table 2. ‘Would you generally like to see more or less technology onboard the ships you work with?’

<table>
<thead>
<tr>
<th>Percentage</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would like to see less</td>
<td>9.1</td>
</tr>
<tr>
<td>About right</td>
<td>54.8</td>
</tr>
<tr>
<td>Would like to see more</td>
<td>36.1</td>
</tr>
</tbody>
</table>
When attempting to address resistance to technology it must be acknowledged that resistance may be different amongst different seafarers and in different working situations. Knowing where resistance is likely to be greatest could help improve training and make it maximally effective.

Using logistic regression analysis, age, number of crew and computer literacy were found to be associated with resistance to new technology. These associations were significant independent of the level of technology installed onboard ship (as subjectively rated). Where a significant age effect in particular was found, concern needs to be raised in terms of how this generational division might manifest itself in a working situation. If older seafarers have diminishing faith in the training of their younger counterparts then safety issues may arise. Such generational conflicts have been identified in other professions (Smith 2005). Technology, however, may be an issue that crystallises such age divisions at sea.

The result in terms of number of crew suggests that those working on larger vessels are less resistant to new technology. This may reflect the fact that those working on larger vessels are working in an environment where technology has been more successfully integrated into working practices, although caution needs to be raised concerning a potential confound with vessel type. Certain types of vessel such as cruise ships and passenger ferries are associated with large crews from the bridge through to customer services and catering. The crew size result might not therefore reflect crew numbers or vessel size per se, but different types of vessel and operation. Studying resistance to new technology within one type of vessel would therefore be an interesting area for further investigation. By eliminating vessel-type confounds, it would be possible to investigate the effect of crew/vessel size in isolation.

Another area for future investigation would be the role of nationality in terms of perceptions towards technology, investigating beyond the current British sample. Where multi-national crews are commonplace onboard ship, it would be useful to investigate whether cultural and/or training differences impact upon perceptions towards technology at sea. Similarly, the sample was almost exclusively made up of officers. Investigating perceptions of technology amongst other ranks would be a valuable extension of this work.

Where perceptions of technology at sea were accessed using general attitude statements in a technique similar to Wiener (1989), it is likely that this technique also introduced an element of bias. The arbitrary selection and phrasing of the attitude statements is an acknowledged drawback of the study, which would need to be addressed in future work. Guidance for the statements was taken from comments received in the pilot study; however, this resulted in a list of statements that arguably focused more on issues of training than other areas. Furthermore, using comments from the pilot study as a starting point resulted in a number of negatively biased or potentially leading items. Future research in this area would need to develop a more balanced and subjectively neutral questionnaire than used in the current exploratory work.

A further drawback of the study was the way in which familiarity with onboard technology was assessed. Participants were asked to rate whether the ship they most recently worked on had a high, low or average level of technology installed. No benchmark was provided for participants against which to make this assessment, however, which limited the objectivity of this measure. Providing such a benchmark would be an important addition in future studies.

Where training was identified as the area of greatest concern in relation to technology at sea, it must be acknowledged that this may not represent the whole picture. Where a problem is identified in a system, Reason (2000) describes how two very different approaches may be taken in terms of identifying the

### Table 3. Logistic regression indicating factors associated with resistance to new technology.

<table>
<thead>
<tr>
<th>n</th>
<th>Variable</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>258</td>
<td>Age 1 (youngest)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>264</td>
<td>Age 2</td>
<td>2.19</td>
<td>1.52–3.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>233</td>
<td>Age 3 (oldest)</td>
<td>1.88</td>
<td>1.30–2.74</td>
<td></td>
</tr>
<tr>
<td>258</td>
<td>Number of crew 1 (small crew)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>248</td>
<td>Number of crew 2</td>
<td>0.87</td>
<td>0.61–1.26</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>249</td>
<td>Number of crew 3 (large crew)</td>
<td>0.59</td>
<td>0.41–0.85</td>
<td></td>
</tr>
<tr>
<td>216</td>
<td>Computer literacy 1 (low)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>256</td>
<td>Computer literacy 2</td>
<td>0.61</td>
<td>0.42–0.90</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>283</td>
<td>Computer literacy 3 (high)</td>
<td>0.48</td>
<td>0.33–0.70</td>
<td>0.08</td>
</tr>
<tr>
<td>120</td>
<td>Classed as low technology ship</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>306</td>
<td>Classed as average technology ship</td>
<td>0.60</td>
<td>0.38–0.94</td>
<td></td>
</tr>
<tr>
<td>329</td>
<td>Classed as high technology ship</td>
<td>0.73</td>
<td>0.47–1.14</td>
<td></td>
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</tbody>
</table>
cause. The ‘person’ approach focuses upon problems at the operator level, with the people performing the tasks. By contrast, however, problems may be recognised as stemming from failures in the ‘system’ and the environment in which people are required to work. Reason argues that the person approach is by far the most prevalent in society and therefore it is perhaps unsurprising that the participants in the current study focused upon training as their issue of greatest concern. Training represents a lack of knowledge or expertise on the part of the seafarer, but the problem could equally be identified as stemming from poor equipment design, developed without reference to important user-centred principles. This view is supported by Lützhöft (2004), who found the design of equipment on vessels to often contradict the seafarers’ conception of how things should function. Designing equipment that is considered universally intuitive, however, may be a challenging task. Amongst other potential variables, evidence suggests that culture can have a significant impact on successful interface design (Shen et al. 2006). This poses a particular challenge in the multi-national onboard environment.

One area to potentially prioritise in terms of equipment design would be standardisation. In contrast to the aviation industry, Aldridge et al. (1997) point out that very rarely will two bridges be the same in terms of the technology available and the way it is laid out. If seafarers are required to constantly adapt to new interfaces and ways of working, it is perhaps no surprise that they report feeling under-trained. A concern raised in other industries, however, is that excessive standardisation can be at the detriment of innovation (Edum-Fotwe et al. 2004). A useful means of potentially allowing innovation alongside standardisation is currently in discussion at the International Maritime Organisation under the title of ‘S-mode’, or standard mode (International Maritime Organisation E-navigation Correspondence Group 2008). The concept behind S-mode is that different pieces of equipment from different manufacturers will have a default mode, which seafarers will be able to switch to at any time. This will allow manufacturers to continue innovating and adding new features to their equipment, whilst also maintaining a standard mode that seafarers will be able to revert to should they wish. The implementation of such a concept would also be likely to reduce training demands.

5. Conclusion
Where Lützhöft (2004) titles her thesis, ‘The technology is great when we know how to use it’. The British seafaring officers in the study showed little generalised resistance to new technology, but clear resistance in relation to the specific issue of training. Comparative analysis also highlighted that seafarers’ resistance to technology may be related to age, number of crew and level of computer literacy. Targeting training alone, however, would fail to address the complexity of the situation. Interaction with technology requires adaptation and training on the part of the human operator, but also technology that is grounded in user-centred design principles. Evidence suggests an increase in standardisation would benefit the industry as a whole, but caution should be raised about innovation suffering as a consequence. The concept of an ‘S-mode’, currently in discussion at the International Maritime Organisation, would appear to be a constructive way forward.

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