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Shipboard Manning
– Alternative Structures for the Future?

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Abstract

This paper reports the results of the first phase of a research project to explore alternative shipboard manning structures. A review was conducted of relevant literature, although since the STCW revision in 1995, earlier studies are no longer as relevant as they were. It was clear from this review that few organisations have explored the potential of Chapter VII of the Convention for alternative structures and certification.

A research study was conducted that involved the use of three focus groups and an electronic Delphi discussion group of twenty volunteer maritime experts. The focus groups identified a series of feasible manning structures and these scenarios formed the basis for the electronic Delphi phase of the study. The paper provides a full analysis of the exercise, which was successful in showing where there was consensus and where there were major differences of opinion. One major conclusion of the participants was that, although technically feasible, unmanned vessels were unlikely to appear in the foreseeable future for commercial and political reasons. The majority favoured a human presence on board but there were significant differences of opinion on its main function and how that presence should be organised.

Key words: manning, manning structures, watchkeeping, shipboard roles, automation

1 Introduction

The current manning and certification system for the operation of merchant ships is firmly anchored in a role-based structure and offers little flexibility. Furthermore, the requirements for specialised qualifications such as Dangerous Cargo Endorsements reduce a company's ability to move officers easily between different ship types. With the potential expansion of the world's LNG fleet in the next decade, the issues of shipboard manning requirements and appropriately qualified officers and crew have become pressing problems.

Notwithstanding this requirement, the international maritime industry is facing a general shortage of qualified officers and is struggling to attract a sufficient number of high calibre recruits. In the UK, a number of solutions to the problem are being suggested, for example, employing "fast-track" graduates at sea. However, there are a number of issues with this philosophy that are common to all nations providing a supply of maritime labour:

- Is the current employment situation attractive to a graduate?
- Is there a genuine demand for graduate level entrants to the industry?
- Is graduate recruitment a cost-effective training route?
- Will the retention rate be too low to make this part of a viable strategy?

An objective method for comparing and evaluating the costs and benefits of alternative manning and qualification systems would help to provide the answers to these and similar questions. This paper is a result of a research study, which used focus groups and an electronic Delphi technique, to investigate expert opinion on alternative scenarios for future shipboard manning.

2 Background

The revision of the STCW (Standards of Training, Certification and Watchkeeping for Seafarers) Convention through Chapter VII allows for greater flexibility with regard to job role and specialisation. In order to investigate the possibilities for alternative manning structures, it is necessary to consider shipboard roles and jobs within a functional framework. For example, this may result in setting to one side the traditional manning structure so that the specialist nature of Deck and Engine departments may be combined. There is also the possibility of splitting some shipboard tasks, so that these may be reallocated to other roles and at different levels in the shipboard manning structure.

During the past two to three decades there have been several attempts in the OECD countries to investigate alternative manning structures for shipboard organisation in merchant vessels. For example, an examination of maritime skills was carried out for the US Department of Transportation that produced a detailed catalogue of shipboard jobs, which were confirmed by interviews with shipboard and shore personnel[1]. Part of the Norwegian 3S project also looked at shipboard organisation[2]. However, neither study resulted in any firm proposals or recommendations for alternative manning structures or changes in shipboard organisation.

Other research studies have centred mainly upon dual certification for officers and the use of General Purpose (GP) ratings. As early as 1977, a polyvalent training programme

1 Stanwick Corporation: *Merchant Marine Shipboard Crew Skills and Discipline Study*. Report No. MA-RD-900-7202701. Washington D.C.: U.S. Department of Transportation, U. S. Coast Guard, Office of Merchant Marine Safety, 1971.

2 Norwegian Maritime Directorate: *Systems for Safe Ships*. Oslo: NMD,1980.

was introduced in France[3,4] and a conference organised jointly by the Nautical Institute and the Netherlands Maritime Institute in the same year produced a number of papers relating to different forms of dual certification[5,6]. The driving force behind these studies appears to have been the requirement to cut costs in the climate of low freight rates, competition from foreign labour sources and the impact of modern technology.

Studies in 1979 and 1980 examined the role of ratings in an attempt to identify areas where they may take on extra responsibility[7]. They also introduced the idea of a shipboard organisational matrix that gives added skills, almost a second specialisation, to those on board as a back-up function to the specialist skills of others.

Further studies examining shipboard manning and organisation include those carried out in the United States [8] and Norway[9]. In the same year, a UK research project also examined shipboard functions[10]. In the section of the report referring to alternative manning a number of recommendations were made. All of these were based upon the traditional roles of senior and junior officers and clear departmental divisions on board. There were a number of trials carried out by various maritime nations at this time and the report reflected these experiments. However, all these studies were carried out prior to the revision of the STCW Convention, so the findings are not as relevant today as they were at the time of the research.

Some earlier, pre-STCW revision studies also examined the impact of reduced manning on safety[11,12,13]. They did not, however, consider changing the whole structure of

3 Logerot, F.: *Nautical Education and Training in France*. London: Nautical Institute, 1977.

4 Cheval, R.: *The Dual Purpose Officer – a new approach to ships' operation.* In: *Conference papers Conference on Education and Training for Sea-going Officers in Europe.* London: Nautical Institute and Netherlands Maritime Institute, 1977.

5 Swanevald, J.: *Comparison of Marine Educational Objectives and Task Requirements on Board.* In: *Op. Cit 5.*

6 Binkhorst, D.: *Innovation in Maritime Education and Training – strategy and management.* In: *Op. Cit.* 5.

7 Roggema, J. & Smith, M.H.: *Emerging Organisational Values in Shipping, parts 1 to 4.* In: *Maritime Policy and Management*. Vol. 6 (1979), No. 2, and Vol. 7 (1980), No. 4.

8 Denny, M.: *Shipboard Productivity Methods, Vols 1–3*. Washington D.C.: U.S. Department of Transportation, Maritime Administration, Office of Research and Development, 1988.

9 Larsen, P.: *Optimal Manning for Rational Ship Operation – Paper 88-P008*. Hovik: Det Norske Veritas, 1988.

10 Technology and Manning for Safe Ship Operations in the 1990s, research project sponsored by UK Department of Transport.

11 Yamanaka, Keiko & Gaffney, M.: *Effective Manning in the Orient*. Report from American President Lines to U.S. Department of Transportation No. MA-11727: Report no. MA-RD-770-87052. Washington D.C.: U.S. Department of Transportation, 1988.

12 American President Lines: *Labour Contract.* Report to NRC committee on the Effect of Smaller Crews on Maritime Safety. Washington D.C.: US National Research Council, 1989.

13 US National Research Council: *Committee on the Effect of Smaller Crews on Maritime Safety*. Washington D.C.: National Academy Press, 1991.

shipboard organisation by eliminating the distinctions of specialisation or rank. The American studies do consider the social implications in relation to crew reduction and this perspective is relevant to any new shipboard organisation. In fact any alternative manning structure will have to consider such human factors. A UK study considered the psychological difficulties of modern seafaring and examined a socio-technical re-design of the shipboard system[14]. This was mainly directed toward the effects of reductions in crew size using a conventional structure. Other researchers have considered the navigation officer of the future and linked the advance of technology with the need for a different type of person to fulfil this role in the future[15]. They drew upon earlier work[16] that considered the linking of success to suitability for this future role. Again neither of these studies considered a total reorganisation of the traditional role on a functional basis.

In 1995, the revision of the STCW Convention fundamentally changed the emphasis for standards of training for merchant vessels by requiring competence-based skills for all shipboard tasks. It also takes a functional approach by dividing the shipboard organisation into three levels: support, operational and management. Functions relating to these three levels are clearly defined. As a result of STCW '95, it is now possible to consider shipboard organisation on a purely functional basis at different operational levels. This radical new approach has made much of the previous research work in this field less relevant.

Kurt Rye Damkjaer of the Svendborg International Maritime Academy in Denmark presented a paper at the ISF Manning and Training conference in September 2001[17] that considered alternative certification for seafarers to reflect the functional approach of the revised STCW Convention. Further evidence of the Danish interest was again shown in 2001 through an article reporting comments made by the president of the Danish Engineers Association[18]. He described what he considered a new concept, which could eventually lead to the abolition of masters and engineers who would be replaced by a single officer, or ship manager, able to perform dual functions. He stated:

> "We've come so far that there will only need to be one manager on board. He may well be called the captain but will not be like the captain that we know today."

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14 Dyer-Smith, M.B.A.: *Shipboard Organisation – the Choices for International Shipping*. In: *Maritime Policy & Management*. Vol. 45 (1993).

15 Lambert, J.A.I., Pourzanjani, M. & Dove, M.J.: *The navigation Officer of the Future*. In: *Maritime Technology*. September 1994.

16 Böhm, H.: *Psychological Selection of Seafarers*. In: *Proceedings of CEG Workshop*. Bremen: Bremen Polytechnic, 1985.

17 Damkjaer, K.R.: *Alternative Certification for Seafarers: Revisiting the Functional Approach*. In: *Conference Papers ISF Manning and Training*, August 2001.

18 Lloyd's List: *New Model to Abolish Ship's Master*. Interview with Leif Dolleris, President of Danish Engineers Association, 2001.

He gave the opinion that a new generation of ship officers would not put up with "outdated organisational structures" that are not adapted to their abilities and aspirations. Perhaps the most interesting point made by Leif Dolleris was:

> "There will not be fewer jobs, they will just be different. People will be able to do many functions".

It is interesting to note his use of the word 'people': he does not differentiate between officers and ratings and this is possibly the starting point to examine relevant shipboard organisational structures for the future.

In summary, it is clear from the literature that although several studies have been carried out over the years into manning, these have been based upon anticipated reductions in crew size, technical advances and the implication of these factors upon personnel. Those that examined the actual job role have not offered any alternative structures to improve upon the traditional form. The revision of the STCW Convention clearly allows for new radical thinking with the opportunity to review traditional shipboard organisation and think outside the confines of both rank and specialisation.

3 Methodology

Our research study involved the use of focus groups and an electronic Delphi discussion group of twenty volunteers.

The purpose of the focus groups was to generate and exchange ideas in order to identify significant issues relating to alternative shipboard manning in a structured way, by bringing together a number of those with expertise in both shipboard and shore-based functions. These group discussions also led to the creation of the scenarios that were then used as the basis for the exercise with the Delphi group.

Three focus groups were used. The first group consisted of a group of eight experienced shore-based ex-seafarers, one of whom was ex-Royal Navy, in addition to the research team. The second focus group consisted of one researcher, three serving seafarers and four shore managers. The third focus group consisted of two researchers, three shore managers and a maritime consultant. All were ex-seafarers.

The Delphi technique is, broadly speaking, a structuring of the group communication process. This is a useful method of producing a detailed critical examination and discussion of a number of different policies or, as in this case, alternative scenarios, among the major stakeholders and experts in a particular field. The main advantages of using an electronic Delphi system (by e-mail) are:

- the anonymity of those participating;
- the reduction of bias or direct influence from the research team upon the participants;

- the removal of bias or influence from peers in a group setting; and
- participation not being limited by the physical location of the experts.

A list of experts was drawn up from expertise within the International Ship Managers' Association (ISMA) membership, maritime researchers, national and international maritime bodies and those involved in ship operations at a senior level. A total of 20 volunteers agreed to take part and each provided or was given a pseudonym to guarantee anonymity. The project team facilitated an electronic discussion between the members of this group with the purpose of achieving the following specific objectives:

- To collate and analyse the subjective judgements of the participants to produce a clear presentation of the range of views and considerations with regard to alternative manning.
- To identify areas of consensus on alternative manning scenarios.
- To identify genuine differences of opinion and schools of thought and to seek clarification of these positions.
- To detect missing information or cases of ambiguity in interpretation by different participants.
- To identify critical items that require further consideration and discussion.

4 The Focus Groups

4.1 Method

In the first focus group, a broad concept was developed, without identifying specific scenarios, which used the conventionally manned vessel as a starting point for developing a range of alternative manning structures. These alternative scenarios were dependent on the extent to which certain functions were carried out on board or could be devolved to the shore.

Other points discussed were:

- The necessity to have a single shipboard manager with overall responsibility. It was considered possible that this person might come from departments other than the Deck department, and that it might be possible to fast-track a graduate entrant to this position.
- The communication role once carried out by the Radio Officer could be carried out by anyone as an additional function to their main role.
- The issue of present-day cadets' training being very front-ended with regard to acquired knowledge and whether this was the best system with regard to training costs in particular.
- The levels of administration on board.
- The possibility of reduced manning levels for automated ships.

The second focus group was a mix of shore-based managers and serving seafarers. This combination produced considerable conflict within the group along ship versus

shore lines. Whereas it had been hoped to build upon the outcomes of the first focus group, it proved difficult to reach consensus. However, certain issues were discussed that built upon the discussions of the first group:

- The idea of some functions being reallocated to 'support' level from 'operational' level was accepted by all as a principle, but the seafarers in the group considered this should only be as additional support.
- The idea of a 'support' level administration function being introduced was generally agreed as a way of alleviating the administrative functions of the senior officers on board.
- It was generally agreed that the principle of the ship manager/master coming from either Deck or Engine speciality was desirable. However the idea of fast-tracking a graduate who had no seafaring experience was considered unacceptable.
- The seafarers present felt that there were certain functions that are at present carried out on shore, which could usefully be deployed to the ship. The reverse was considered non-efficient.
- There was some discussion regarding the desirability of dual certification but little support for this was apparent as a way forward.
- The third focus group built upon the results from the two previous focus groups and successfully identified specific alternative manning scenarios. A useful concept that emerged from this group was the setting of an average manning level for a standard conventional ship as a benchmark against which any identified alternative manning structures could be compared. By the end of this session, three viable alternative manning structures had also been agreed and defined. These scenarios are referred to as:

  1. The "conventional" manning scenario.
  2. The "shipboard specialist" manning scenario.
  3. The "shipboard generalist" manning scenario.

They are illustrated in Appendix 1.

The focus groups were generally successful in identifying the major issues to be taken into account in adopting alternative manning structures. The idea of running successive groups on the cumulative knowledge gained from the first group did avoid repetition and did mean that by the third group, the basic concepts were understood and agreed by the research team. This gave more time for the participants to develop the concepts into distinctive scenarios based on the different issues raised.

4.2 Analysis

The focus groups began with the basic functional premise that the purpose of commercial shipping is to transport cargo from one location to another. In functional terms, this leads to three further functional divisions:

- The navigation of the vessel *en route*

- The propulsion of the vessel from one location to another
- The care of the cargo at all stages of the voyage.

Such basic functions can now be reduced to further sub-functions. For example, the process of navigation can be seen as comprising two separate functions:

- The function of fixing the position of the vessel at any time; and
- The avoidance of traffic and other obstacles on passage.

All three basic functions of navigation, propulsion and cargo care share similar functions, such as:

- Communications with external agents
- Administration – log-keeping, paperwork, purchasing and stock control etc.

There is also an additional function relating to catering and hotel services to the crew although this is outside those functions covered by STCW 95.

Using similar processes, all the functions that are necessary to operate a commercial vessel can be listed and described. This includes all functions traditionally performed both ashore and at sea. These functional elements can be linked to the various competencies required by STCW. The broad aim in developing alternative scenarios was to see to what extent these functional elements could be re-arranged in a more effective manner.

It should be emphasised that, at this stage of the exercise, no account was taken of the ***numbers*** required to perform the functions satisfactorily; the only interest is in what these functions are and how they might be re-grouped within the constraints of STCW.

Because of the shared nature of some sub-functions, one of the issues which was addressed is the extent to which it is possible and desirable to strip certain functions, such as administrative processes, out of the traditional departmental systems. Part of the discussions centred on how the traditional administrative systems might be replaced with a general administrative function, which might serve management and operational level requirements across the whole shipboard operation.

A second issue that was identified early on in the focus group process is the role of the Master. This issue is of interest because one of the implications of the STCW revision is that the management and commercial competencies required of the Master and Chief Engineer are broadly similar. With a shift to a functionally based shipboard organisation, it raises the notion that perhaps the Master, as the owner's legal representative, could be drawn from other disciplines other than the traditional navigation department. This idea, that of the ship's manager coming from one of three possible routes i.e. navigation, engineering or hotel services, is probably one of the least understood by observers, and indeed, proved to be the most controversial.

Another major issue to be considered is the level of specialisation required to be able to operate a modern vessel. Traditionally, merchant navy bridge watch keepers have often all been qualified to navigate the vessel as well as keep a bridge watch. Experience from the Royal Navy suggests that a model in which there are basic watch keepers with technical specialists offers an interesting alternative manning structure.

These three concepts, separate administrative function, the Master from any department, and specialists to perform some functions with general watch keepers for both bridge and engine monitoring is summarised in Appendix 1 as Scenario 2: "shipboard specialist" manning.

The idea of general watch keepers, capable of keeping a watch over both navigational and engineering functions raises the issue of the level of technology employed on vessels. For example, for a single watch keeper to preside over both navigation and engineering functions, there is an implied requirement for technical conditions such as unmanned machinery spaces and bridge control of engine functions.

The first focus group discussed the issue of automation at some length and it was agreed that manning structures could differ depending on the level of automation employed. This linkage between manpower and automation can be seen as a spectrum ranging from complete automation at one end, i.e. with no crew on board at all, to a "full" complement at the other end of the spectrum, ie a crew capable of performing all functions on board, including full fabric maintenance of the vessel.

This debate led to the development of a scenario, in which the major concept is the devolution of functions from the vessel itself to shore support. This concept is illustrated in Appendix 1 as Scenario 3: "shipboard generalist" manning and represents a situation in which the system monitoring function is performed onboard by basic watch keepers with little technical knowledge and the vessel is supported by technical services based ashore.

Throughout the discussions in the focus groups, one issue became paramount when debating some of the issues raised above. This concerned the nature of the vessel and its trade. Many participants qualified many of their views and ideas by stating that it all depended on the ship type and trade.

The third focus group grappled with this issue and sought to arrive at a consensus that would allow meaningful scenarios to be developed, which were independent of the type of vessel and its trade. The first step was to identify the requirements for a 'standard' vessel with a conventional manning structure, which could be used as a benchmark against which cost comparisons might be made for any alternative manning structure.

The key to the success of this idea is the realisation that the concept of cargo care can be applied generically to *any* cargo, irrespective of its nature. The principle of cargo

loading, maintenance on passage and discharging are common to all cargoes, be they passengers or bulk ore. This led to the notion that the over arching principle that differentiates between trades is the customer requirement for each trade and not the nature of the commodity. However, the nature of the commodity will determine the number of personnel required. For example, the number of hotel and catering service staff on a passenger ship will be very different from that required for a small cargo vessel.

The third focus group worked on this idea and produced the following matrix, which illustrates how different trades may be differentiated through the focus on customer centred criteria. This matrix enables a match to be made between the requirements of the ship type and customer centred criteria and any alternative manning scenarios, which have been developed.

Table 1. Ship Type and Trade

Ship type	High speed of delivery of cargo	Cargo to be delivered to a "liner" schedule	High level of cargo care on passage	High loss value of perishable cargo
Cruise liner		✓	✓	✓
Ferry	✓	✓	✓	✓
Container vessel	✓	✓		✓
Bulk carrier		(✓)		
Tanker			✓	✓

In addition to the standard conventional manning structure and the two scenarios discussed above, one further structure was discussed but discarded as impracticable. This was the idea of having the work on-board based upon a conventional '4 on', '8 off' watch keeping schedule. Each watch would comprise a team consisting of a watch keeper and technician with support members plus catering services. These three teams would be identical and would provide the advantage and efficiency that teams bring to the workplace. However, this structure was discarded because it was considered that it would not be flexible nor cost-effective enough to react to the periods of high and low activity that are part of shipboard operations.

5 The Electronic Delphi Group

5.1 Method

The overall goal of the project, of which this study was the first phase, was to investigate the impact that various alternative systems of shipboard manning might have on the training and qualifications of seagoing personnel. A functional approach to manning had been adopted as the basis for this investigation and the broad methodology has been to seek the opinions of maritime professionals using a number of techniques.

Two major issues stemmed from the focus groups that influenced the way the Delphi rounds were conducted.

- The type and level of manning is inextricably linked to the level of technology available.
- The type and trade of vessels are highly significant factors in determining the manning strategy on vessels.

As a consequence, it was decided to structure the Delphi rounds on the basis of a spectrum of available technology ranging from the totally automated vessel at one end and the status quo position at the other end. In effect, this produced two broad scenarios within which the respondents were questioned:

- A future scenario in which vessels were totally unmanned.
- A scenario in the near future where alternative manning was possible using available technology.

In the former case, the questions were posed in order to elicit the respondents' views on the likelihood of unmanned vessels within a specified timeframe and the justifications for their arguments. Questions were also directed at attempting to reveal the respondents' views on what are the major influences that determine the introduction of such a concept.

In the second scenario, a functional approach to manning levels was taken. Respondents were asked to list the functions that they considered essential to be carried out on board. Decisions had to be made on the balance of manning between ship and shore. A composite list of shipboard functions was produced and respondents were then invited to propose job descriptions and specifications for these functions.

A modified Delphi technique was used for this exercise. The prime characteristic of the Delphi technique that was considered to be particularly useful was the anonymity of response. It was also decided not to provide feedback on the rounds as they were being conducted so that bias could be kept to a minimum.

The difficulties of running such an exercise electronically should not be underestimated. Twenty correspondents agreed to take part initially, and the first two rounds

were completed by all participants. However, by the final round, less than 50% of the original participants were still providing responses. This may have been due to the protracted length of the exercise, which was due mainly to the difficulties of busy respondents meeting the response deadlines. The lack of feedback on the rounds may also have been a contributing factor with the result that respondents may have felt a lack of motivation in the absence of communication with other participants.

The wording of the questions caused some concern among a few participants. Some questions were designed specifically to elicit a policy decision although the use of an odd-numbered Likert scale did allow respondents to "sit on the fence" if necessary. One respondent dropped out because it was felt that there were ethical issues in using such a technique to gather information. This criticism was taken seriously by the team, but concluded that the use of the Delphi technique in this way was acceptable as a means of gathering opinions on this issue.

5.2 Analysis

5.2.1 Scenario 1: The unmanned vessel

The following scenario was given:

A ship is taken from its berth to the outer harbour limit by a pilot and other shore-based port personnel. At the fairway buoy, the pilot sets automatic navigation, propulsion and communications parameters and disembarks, leaving the vessel to proceed on its voyage with no one on board. At its destination, a pilot boards and the vessel is navigated to the berth by a pilot and docked with the assistance of tugs and a mooring gang as necessary. The voyage is controlled from pilot to pilot from ashore. All propulsion, cargo care, navigation and fire control systems can be monitored and fully controlled from the shipping company's shore office and/or an "ocean control centre".

In Round 1, respondents were asked to indicate their opinion of this scenario becoming a reality within 25 years, on a Likert scale of 1–7, from "strongly disagree" to strongly agree" against three criteria: likelihood of adoption, desirability and technical/organisational feasibility. The respondents' answers are shown in the three graphs in Appendix 2. The total number of respondents was 20 and the responses are shown as percentages for each score on the scale.

The graph for technical/organisational feasibility shows that the great majority of respondents were of the opinion that a fully unmanned vessel was technically feasible within the time period. Over 80% thought it was feasible in the timeframe – one respondent thought it more likely in 50 years. One respondent differentiated between technical feasibility and organisational feasibility, rating the technical aspects as feasible but not the organisational aspects.

Considerable consensus was thus achieved on this criterion. However, the opinion of the respondents was split on both the desirability and the likelihood of adoption. In addition to marking their responses on the scale, respondents were also specifically

asked to comment on their reasons for or against desirability and likelihood of adoption.

25% of the respondents were neutral about the desirability of complete automation with two roughly equal and opposite schools of thought emerging – 40% thought it undesirable and 35% thought it desirable. This ambivalence may result from one expressed view that the issue is not really one of desirability, in the sense of any moral or aesthetic definition, but a combination of technical and economic factors.

Views on the likelihood of adoption were more consensual with 60% of respondents arguing that complete automation would not be likely within the 25 year period. There were a number of different reasons given for this. Several respondents considered that, although technically feasible, it would not be possible due to global political, environmental and public acceptability. Two respondents cited the case of the difficulties in getting the principles of One Man Bridge Operation (OMBO) accepted at IMO as evidence of the problems associated in gaining acceptance. Most respondents recognised that, in any case, the introduction of such vessels would be a staged process and that there would need to be a period of tests and experimentation. In this respect, one respondent recalled the Japanese experiments in this area and others suggested that such a system would first be tested in a controlled "sea area" or enclosed system, for example, replicating the 1980s Soviet trials in the Caspian Sea – or perhaps on the Great Lakes.

Not surprisingly, our North American colleagues (and others too) cited security, to include piracy and terrorism, as the single main reason why totally automated vessels were unlikely to be adopted.

There were concerns too about the safety and reliability of a totally automated system. There was a widespread recognition that technical redundancy was essential and the need for human monitoring from ashore in the form of surveillance as well as routeing systems similar to Air Traffic Control. A particular concern was how natural hazards such as cargo shifting, fire or machinery breakdown would be handled. The potential hazard to the environment if this were to take place close to land in heavy weather was also mentioned, although those who favoured total automation recognised that the unmanned vessel would be used for trans-oceanic voyages and boarded while still some way from land. Legal implications for the liability of the owner were also mentioned.

Finally, the costs involved in attaining the required level of technical reliability and the necessary infrastructure were also considered. In addition, one respondent foresaw complete automation severely reducing the second-hand value of a vessel.

Views were also sought on whether complete automation might be possible in some trades and/or some cargoes but not others.

Some respondents thought that complete automation was best suited to bulk cargoes travelling long distances – for example, iron ore or coal from Australia to Europe, or regular liner trades, for example, on the North Atlantic. There was also agreement that it was less likely where hazardous cargoes like LNG were concerned, although one respondent was an exception in seeing complete automation working in liner trades but not on spot market vessels, tankers and bulk carriers. There was an equal diversity of opinion on whether complete automation would be better suited to deep-sea operations or whether it would be more useful in terms of short-sea trades. The position for the cruise industry was summarised with the comment: "Undesirable for most cruise products since interaction with the crew (in the nicest possible way!) is usually part of the attraction for customers".

The general consensus view was neatly summarised with the comment:

> "Complete automation will come earlier in bulk trades, later in high value and hazardous trades, much later and perhaps in only a limited way (e.g. short sea ferries) in passenger trades and perhaps never with cruising."

Using the same scenario, a second round attempted to confirm these views on ship type and trade and also to probe more deeply what respondents thought were the main levers for change, i.e. is it technical reliability, public acceptability, or commercial cost-effectiveness? Round 2 explored these issues through a series of direct questions requiring the respondents to indicate their agreement or disagreement with a series of statements on a scale of 1–7, with a score of 7 representing strong agreement.

There were three main issues:

- What did the respondents see as the main driving force that instigates such change in the shipping industry? Is the mechanism for change *primarily* a technical, commercial or a political lever?
- Did the respondents consider that there are some cases where total automation will never occur because of the hazardous nature of the cargoes?
- Did the respondents view the human presence on board as the best means of preventing harm to the vessel, cargo and environment, or the main cause of the problems!

The respondents' answers to Round 2 are shown in the graphs in Appendix 3 of this paper. The total number of respondents was 20 and the responses are shown as percentages for each score on the scale. Respondents clearly had some problems with the style of the questions. One respondent summarised the problem thus:

> "My answers are conditioned by the phrasing of the question. I consider each of the possible reasons listed … to be important, but the question asks which is the single most important".

The first three graphs relate to the responses given to the first three statements concerning whether commercial cost-effectiveness, technical reliability or political and public acceptability is the ***single*** most important factor in determining whether complete automation is likely in the foreseeable future. In general, each of the three factors has its supporters and detractors, so the strength of opinion has also been taken into account in making the following conclusions.

Respondents seem to be fairly evenly split in enthusiasm about commercial cost-effectiveness as the single most important factor in determining whether complete automation is likely in the foreseeable future (35% are quite strongly supportive). On the other hand, technical reliability as a factor has considerable mild support and not many are violently opposed. However, there does seem to be *stronger* support (45%) for political and public acceptability being the single most important factor and this is borne out by an examination of the individual "marks" and the additional comments made by respondents.

In general, it must be conceded that all three factors have an influence. One respondent argued that *"technical reliability is but a constituent part of commercial cost-effectiveness so the three choices are not entirely distinct".* The majority view was expressed as follows:

> "I suppose I keep coming back in my mind to the fact that technical factors can be comparatively easily overcome, and it will eventually be a combination of commercial/economic (sic: factors) and public perception which will decide."

The respondents' views on which trades may be more likely to adopt complete automation are shown in the next two graphs in Appendix 3, but are difficult to interpret. However, from their comments, five respondents were clearly of the view that complete automation was never likely in hazardous trades but only likely in liner trades. On the other hand, six respondents tended to think that, if complete automation were to happen, it was possible in either trade. The remaining respondents were either ambivalent in their answers or contradictory.

The final question attempted to address a fundamental debate about the value of the human presence on board. Put at its simplest, one view is that the human presence is needed on board at all times to protect the vessel and its cargo from the actions of others and also to protect the environment from the effects of the vessel and the release of its cargo. Given the current trend to remove the human presence as soon as something goes wrong anyway, the opposite argument is that automated technology will protect the vessel and its cargo on oceanic passage more reliably than a human presence and with less risk to that presence. Humans may board in the proximity of land for routine or emergency purposes.

As the final graph in Appendix 3 illustrates, opinion was split, and perhaps not surprisingly, along the lines suggested by earlier views on the benefits or otherwise of

automation. More respondents felt strongly that the benefits of the human presence outweighed the costs of fallibility. One group viewed the human presence as a necessary and beneficial presence on board and could not see a time in the future when there will be the need or will to have it removed. The other school of opinion saw an almost inevitable technological drive towards automation, only delayed by commercial considerations and public awareness and acceptability.

5.2.2 Scenario 2: Splitting functions between ship and shore

For Round 3 of the Delphi exercise, the following scenario was given:

It is the not too distant future. Current international legislation has not sanctioned unmanned vessels but it does allow for alternative manning structures and certification systems. Safe manning levels are determined by the Flag State Administration on the basis of a formal safety assessment (FSA) approach. The level of manning allowed takes into account inter alia the likely hazards of the trade, and the control measures you have in place to mitigate those hazards. You operate a fleet of ships in a trade with which you are very familiar. Current manning levels are consistent with your competitors and the practice in your trade. Your market analysts have predicted that the current costs and reliability of automation indicate that you could gain a competitive advantage in your chosen trade by taking full advantage of the available technology and by maintaining only a minimal human presence on board each vessel. The current state of technology means that full support for all shipboard functions can be provided from ashore as necessary. You have conducted a cost-benefit analysis on a number of shore-based control measures and the project is achievable and cost-effective. You are now preparing a case for the Administration.

Respondents were then asked to state the primary function that would be required to be carried out on board and also the secondary functions that those on board might usefully perform. Finally the respondents were asked what shore-based functions would have to be put in place to ensure a safe and cost-effective operation. The total number of respondents for this round was 15. The responses for the primary function included:

Vessel systems management and communications
Compliance with international legislation
Monitoring systems
Emergency response
Safeguarding ship owner's interests
On-board response
Management and damage control
Monitoring navigational safety
Navigational control
Vision

It may be seen from the list that several of the responses are fairly similar to others with 'monitoring' in one form or another accounting for 50% of the responses. The secondary functions included:

Vessel security
Maintenance
Well-being of those on board
Emergency repair
Compliance with Port State regulations
Cargo care
Accident evidence gathering/recording
Monitoring systems
Training
Communications

57% of the respondents referred to 'vessel maintenance and emergency repair' as being an important secondary function and 22% listed 'monitoring systems'. Shore-based control measures included:

Communication centre
Monitoring
Repair and maintenance
Piracy and sabotage
Provision of physical assistance to vessel
Contingency response
Shore-staff training
Emergency response
Control of shipboard systems

There was broad agreement by the respondents regarding the function of 'Monitoring and control of shipboard systems' with 86% listing this an important shore-based control measure.

Following the primary and secondary functions analysed in Round 3 a list of 14 main function and sub-functions was compiled. In Round 4, the respondents were invited to state where each of these functions should be performed, either on the ship or ashore. The total number of respondents for this round was 15.

There was close agreement for 50% of the 14 listed functions. A clear majority of respondents stated that 'Maintenance – running repairs' and 'Welfare' were functions required to be carried out on board ship whereas, 'Maintenance – full repairs', 'Maintenance – Specification', 'Administration', 'Regulatory Compliance' and 'Commercial Management' were functions required to be performed ashore. The performance of Commercial Management ashore was the only function of total unanimity.

In examining the remaining seven functions the split between performance ashore and on the ship was less clearly defined. They varied from a 50/50 split, 'Monitoring –watch keeping' to a 65/35 split, 'Management – system'. Of the remaining five of these seven functions, three split 49/51, one split 53/47 and the last 60/40. It is worth noting that the three monitoring functions all split evenly, which would appear to indicate that there is a clear difference of opinion as to where these functions should lie.

Table 2 summarises the split of functions with the left column indicating those functions which by consensus should be performed on board and the right column indicating those functions which most agree should be performed ashore. The middle column shows those functions where there was a difference of opinion on whether the function is best performed on board or ashore. These differences in opinion would appear to reflect the extent to which individuals consider that automation can replace the human element for particular functions.

Table 2. The Splitting of Functions between Ship and Shore

Agreed onboard functions	Split agreemant on best locus of function	Agreed shore-based function
Maintenance: running repairs **Welfare**	**Monitoring:** visual **Monitoring:** watch keeping **Monitoring:** emergency response **Communications** **Security** **Management:** system **Management:** people	**Maintenance:** full repairs **Maintenance:** specification **Administration** **Regulatory** **Compliance** **Commercial** **Management**

5.2.3 Scenario 3: Shipboard functions and job roles

The final round attempted to build on the previous scenario by asking respondents to allocate consensual shipboard functions to job roles. In addition to the previous scenario information, the following was given:

> "*You operate a fleet of ships in a trade with which you are very familiar. You are putting together a case for your Administration to operate your vessels using an alternative manning structure based on a functional analysis of the jobs you require to be done on board. You have sought expert opinion from your company colleagues and external sources on which functions must be located primarily on board the vessel, although it is understood that some aspects may also be located ashore. There has*

been a reasonable level of consensus (although not complete) on this and the attached sheet shows a breakdown of these functions into tasks. (See Appendix 4)

You now have to decide how these tasks may be grouped into reasonable and consistent job descriptions for onboard staff and what levels of qualification you require of these staff.

Respondents were asked to consider the list and group the tasks into jobs. Job description forms and person specification forms were attached to help in this exercise. The final scenario was a step too far for many of the participants with the total number of respondents for this round being only 9. However, the Delphi technique was very successful in highlighting the significantly different schools of opinion. Even at this final stage, the participants were divided along traditional and alternative lines regarding the make up of the people on board, with four following traditional concepts and five favouring innovative ideas. The following paragraphs are a summary of these two schools of thought from the analysis of agreed shipboard functions and job roles.

One respondent produced a clear structure for the future ship personnel that incorporated some of the ideas that came from the researchers' early thinking. His ship would be run by a ship manager, whose background may be in navigation, mechanical or electrical engineering. However, he did not suggest that this position might be filled by a commercial person, with minimal or no sea experience, or from the purser/catering department. The other personnel consist of an assistant manager (watch keeping) and assistant manager (technical), watch keeper, technician and assistants to the latter two. Manning levels would be dictated by the length of voyage and the vessel type. One interesting point was that present manning consists of qualified personnel (officers) and several with few qualifications (ratings) who are, in general, under-occupied. He considers that the present demarcation of officers and ratings should disappear and that the present 'rating' personnel should have more responsibility. This, of course, is in line with the structure of STCW 95.

Another respondent produced a new structure for personnel which was also very much in line with STCW 95. He retained the title/position of Master with a Chief Executive Officer who takes responsibility for all technical operations. There are two personnel at operational level who take overall charge of the daily operational matters including acting as duty officers from 0600–1200 and 1200–1800. A further three personnel alternate as duty officers for six hours periods between 1800 and 0600 and carry out all other support level duties.

Turning now to the four other respondents who stayed along, broadly speaking, traditional lines, one respondent stayed with the traditional deck and engineer hierarchical system although included at the support level a role that appears to approximate to the Royal Navy Petty Officer rate. He included support level personnel and also indicated that there is a necessity for an administrative assistant, in this case, the duties being carried out by a senior cadet.

Another participant visualised a Captain supported by two chief officers, one operational and one technical, at the management level. These senior officers would be supported by three officers at the operational level. He also specified minimum sea-time requirements for all positions, something that no other respondent has mentioned, although one did specify minimum periods in a position before being promoted to the next level.

The results of the final round appear at first glance to be a little disappointing with only nine responses. However, on closer examination, there are some fascinating issues raised, particularly from the non-traditionalist viewpoint. Even those who have a strong traditional leaning might concede that there are some considerable changes that might be made to exploit the revisions evident in STCW.

6 Summary

The project commenced with a comprehensive review to identify any past or current work that is being carried out in the field of alternative manning for merchant vessels. Much earlier work has been made less relevant through the revision of the STCW Convention in 1995. It was clear from this review that few organisations have explored the potential of Chapter VII of the Convention for alternative structures and certification.

Three focus groups focussed upon issues that might impact upon alternative manning structures, considering the implication of various job role changes on board and identifying practical and achievable alternative structures. A series of identified manning structures were constructed and these formed the basis for the electronic Delphi phase of the study.

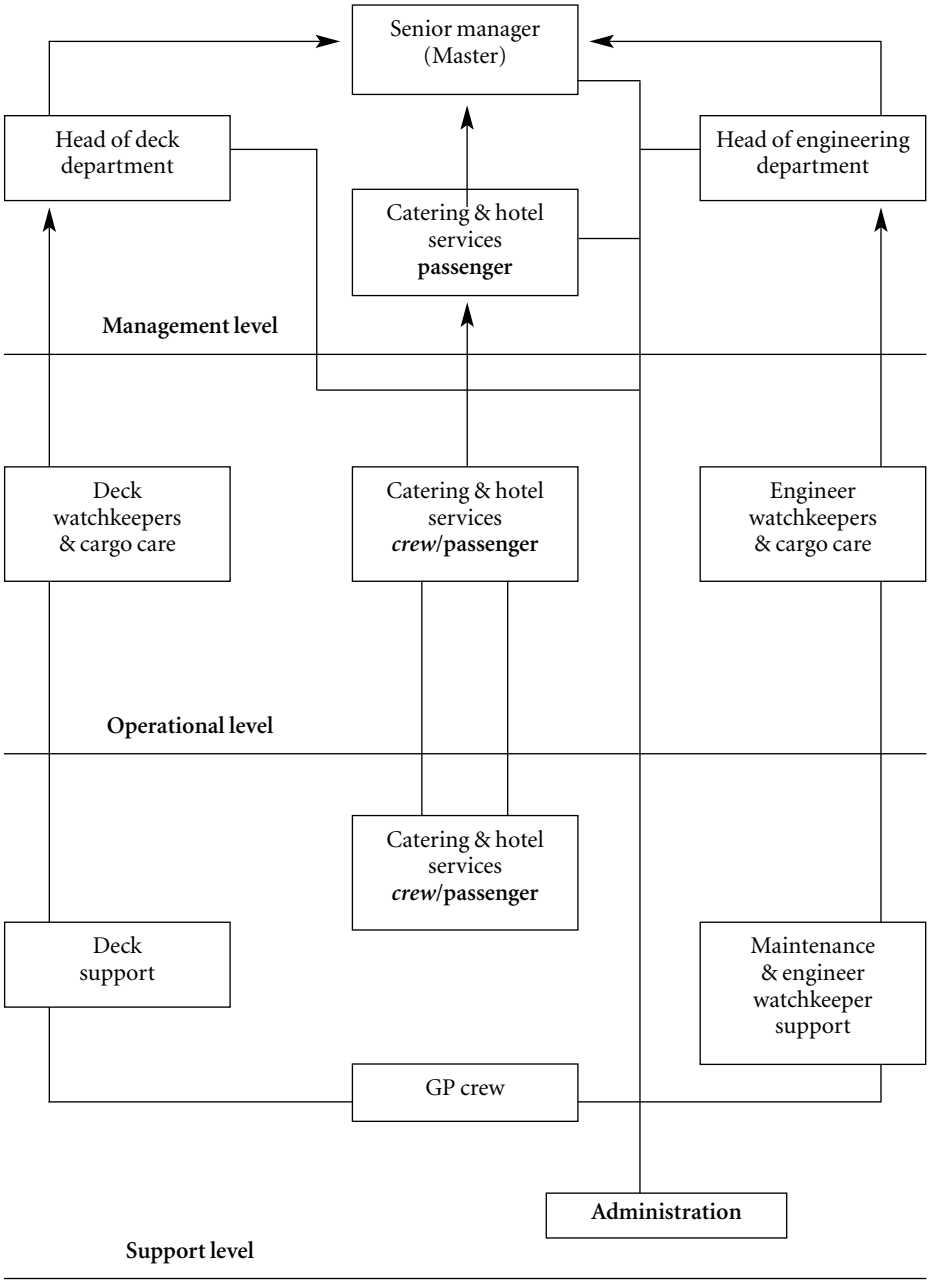
The Delphi exercise was successful in showing where there was consensus and where there were major differences of opinion. The group seemed to relish the opportunity to take part and expressed interest in the feedback that was produced for them at the conclusion of the exercise. Although there are no plans to continue this project, some volunteers have expressed interest in pursuing some of the findings further in their own organisations. The main conclusion of the participants was that, although technically feasible, unmanned vessels were unlikely to appear in the foreseeable future for commercial and political reasons. The majority favoured a human presence on board but there were differences of opinion on its main function and how that presence should be organised.

7 Acknowledgements

The authors gratefully acknowledge the support and encouragement of the Delphi participants. The volunteers must remain anonymous but we record them here under their pseudonyms – they know who they are! Our thanks to "R", "Clinton", "Taurus", "Dragonfly", "J", "Cosmic", "Ian", "Alan", "Balor", "Educator", "George", "Happy", "Trigger", "Fang", "Golf", "Halcyon", "Captain Whippy", "Simon" and "Sam Thute".

Appendix 1
Alternative Manning Structures

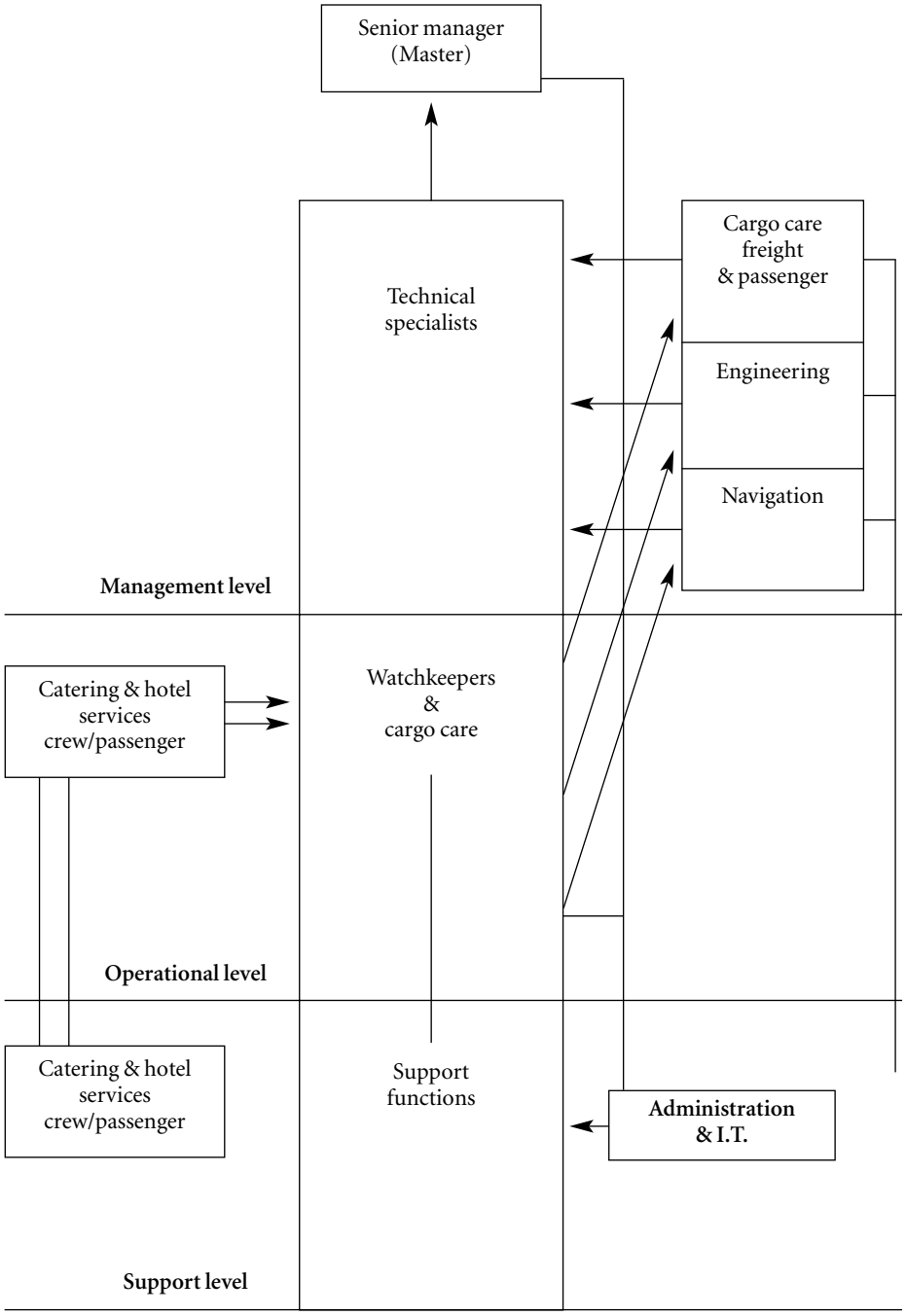
Scenario 1:
The "Conventional" Manning Structure



N.B. All departments carry out their own I.T.

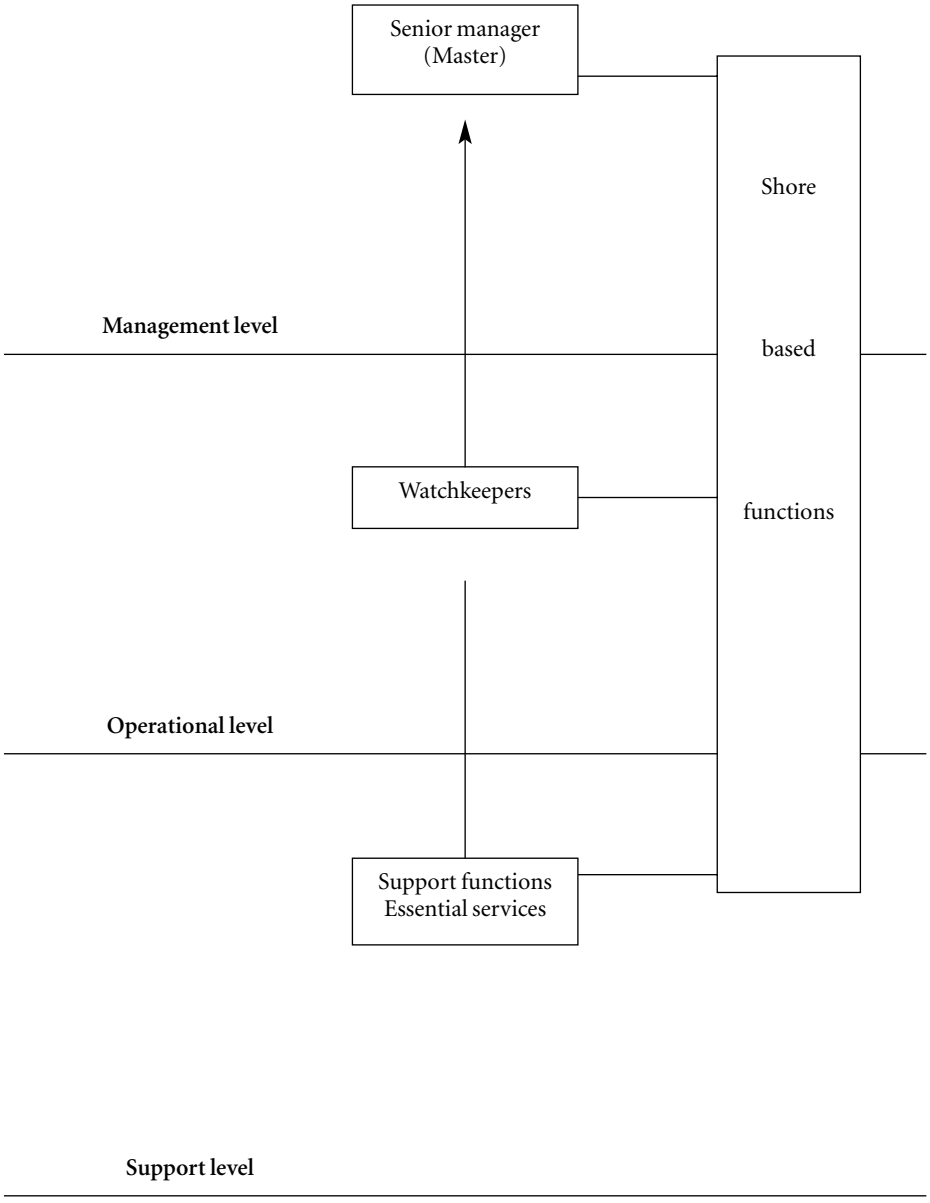
Alternative Manning Structures

Scenario 2:
The "Shipboard Specialist" Manning Structure



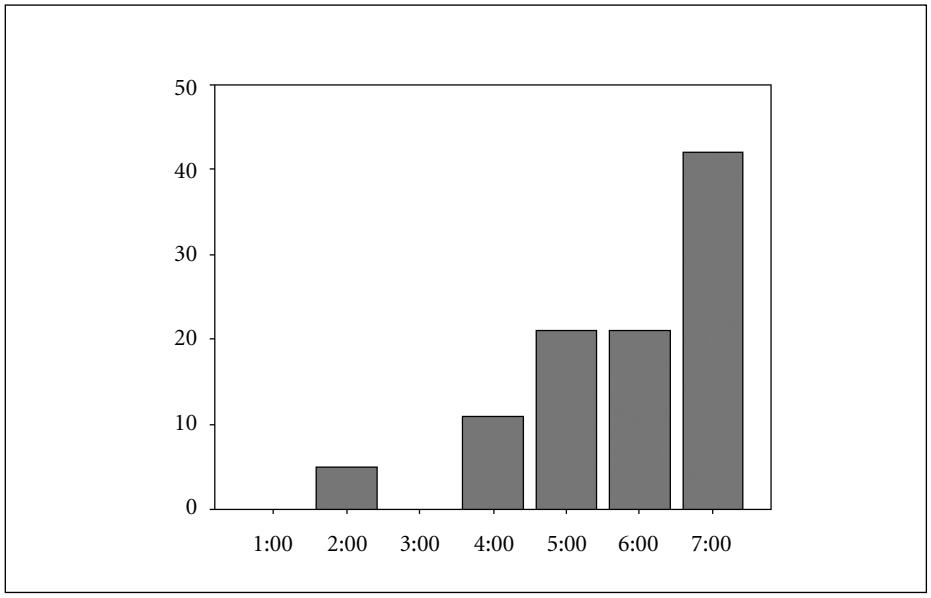
Alternative Manning Structures

Scenario 3:
The "Shipboard Generalist" Manning Structure

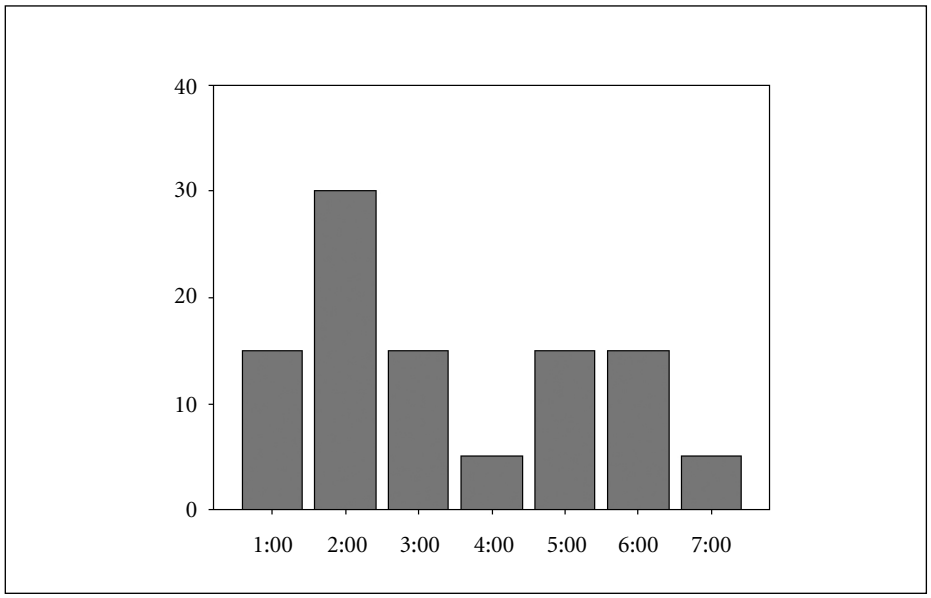


N.B. All possible I.T. and Administration from ashore

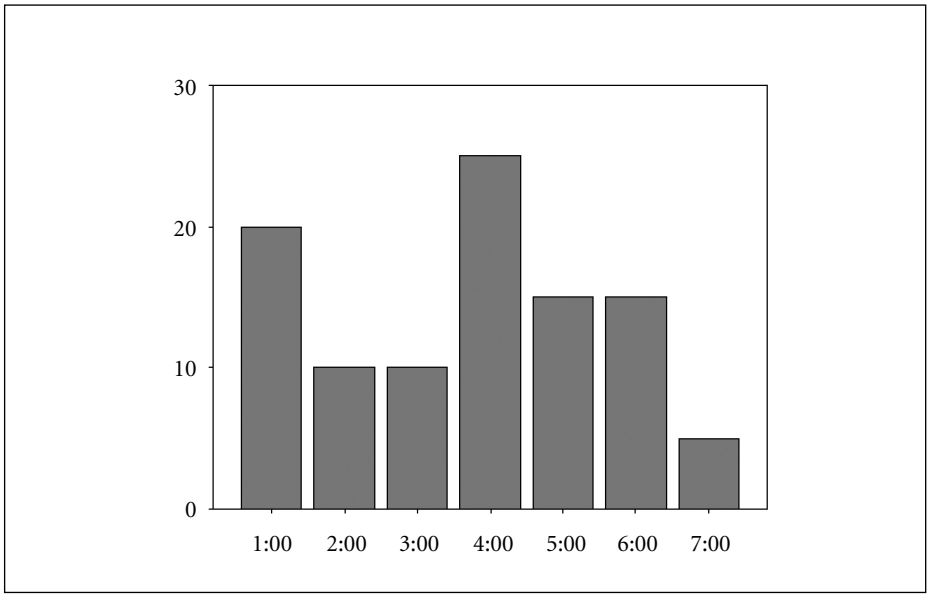
Appendix 2
Round 1: Graphs of Delphi participants' responses to Scenario 1 – the unmanned vessel



Scenario 1: Technical and organisational feasibility

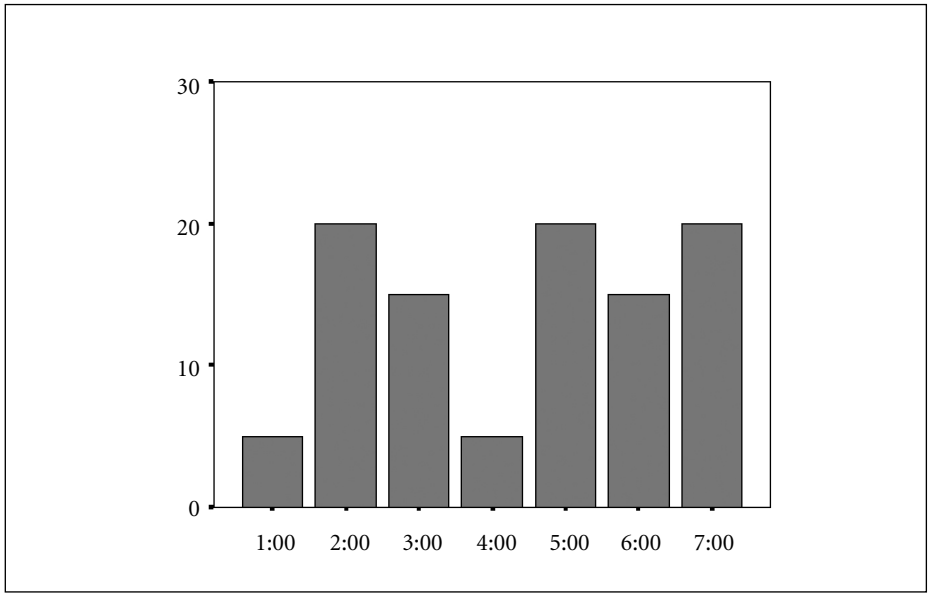


Scenario 1: Likelihood of adoption

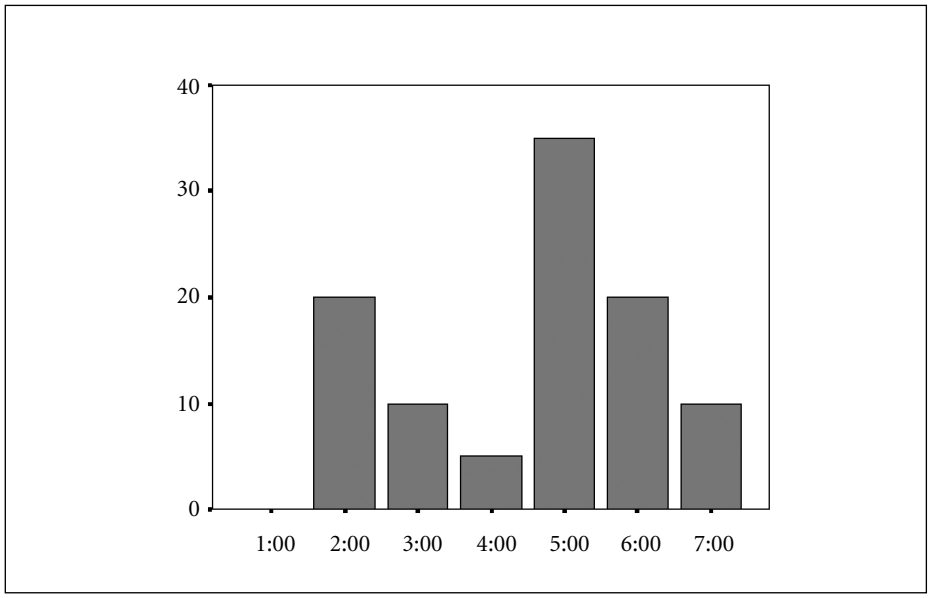


Scenario 1: Desirability

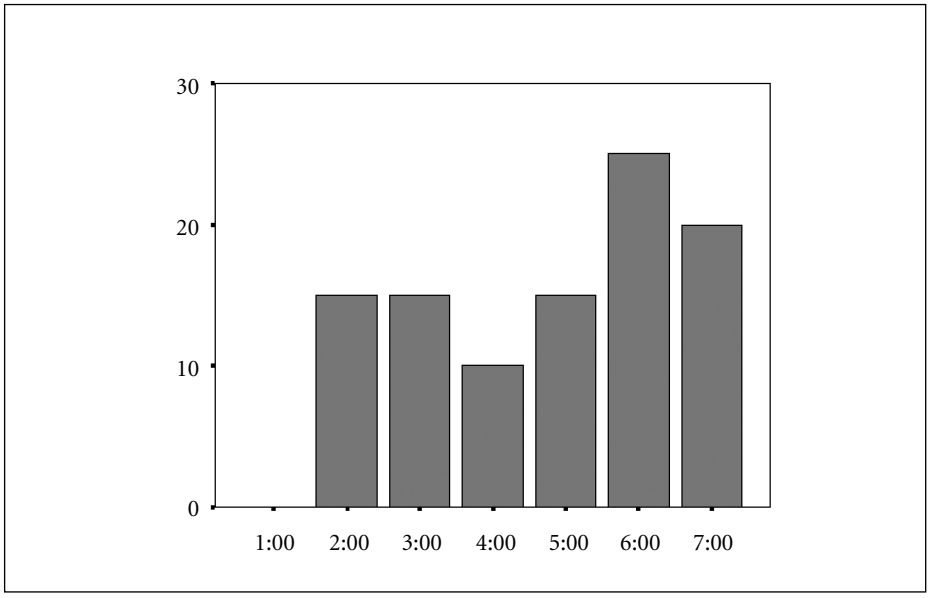
Appendix 3
Round 2: Graphs of Delphi participants responses – the unmanned vessel



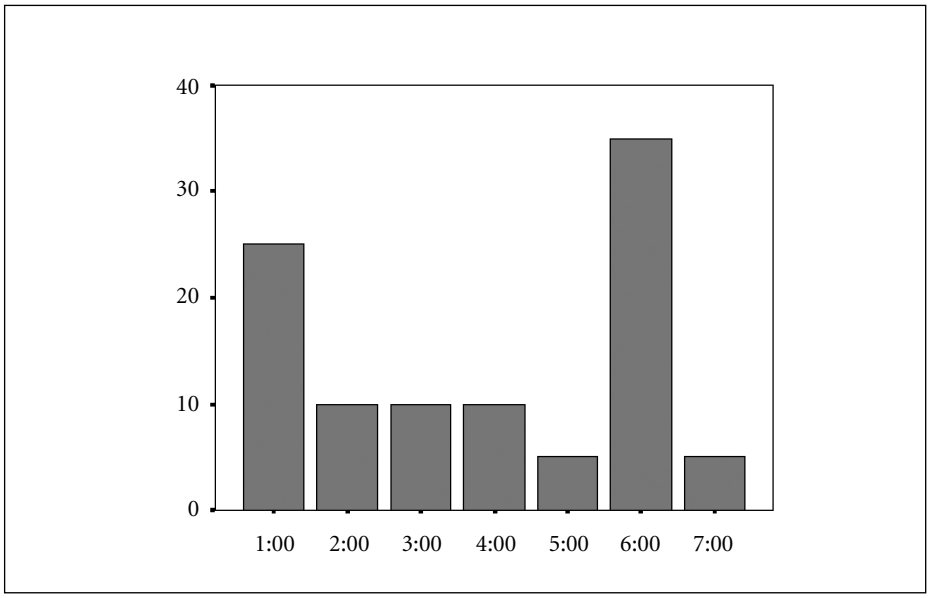
Commercial cost-effectiveness



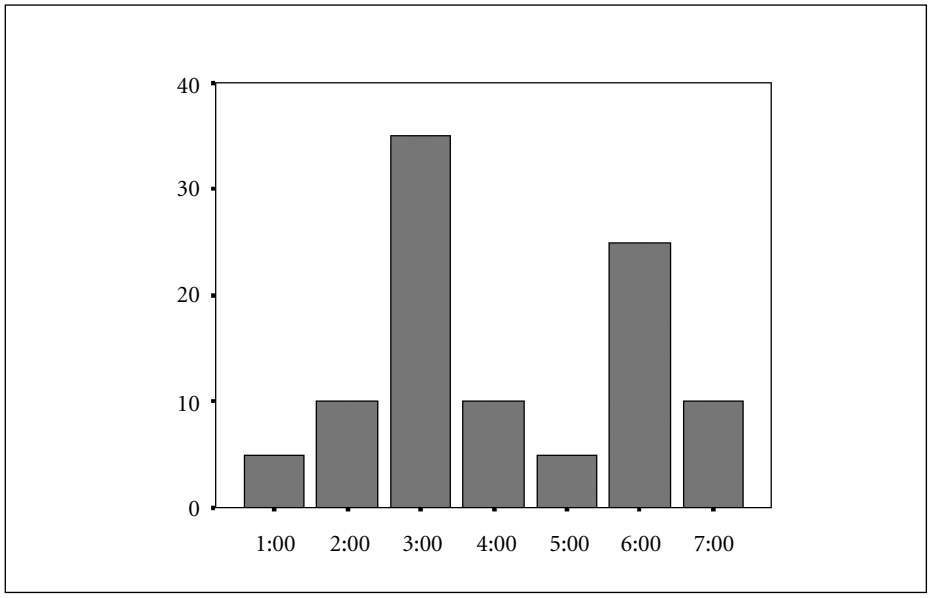
Technical reliability of complete automation



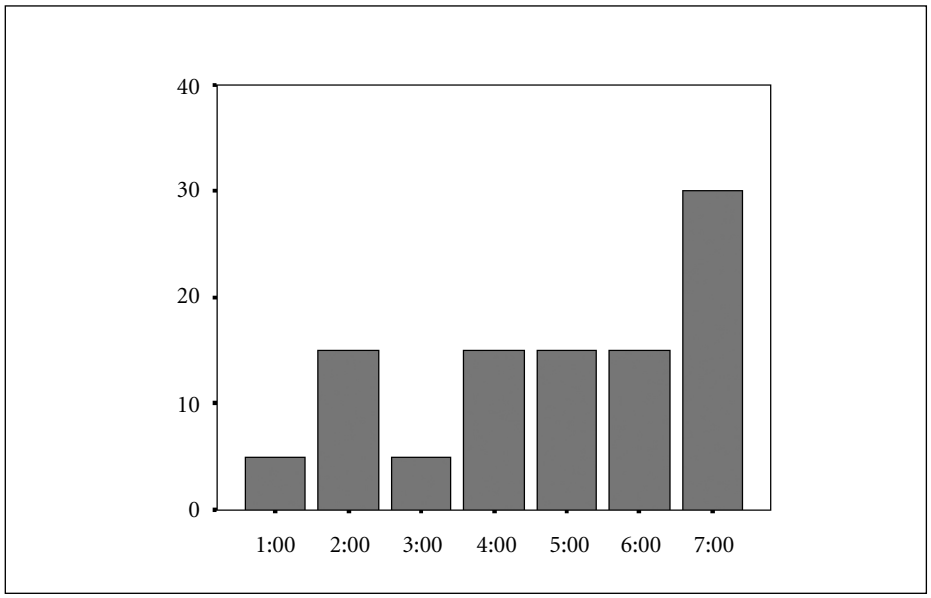
Political and public acceptability of complete automation



Complete automation only likely in "liner" trades



Complete automation never likely on vessels carrying hazardous cargoes



Continuous human presence on board outweighs costs of human falibility

Appendix 4
Primary onboard functions and tasks

Monitoring (inc. visual, watchkeeping and emergency response)
- *Monitoring vital systems to include main engines and auxiliaries, electrical systems, navigation systems, ballast and stability systems*
- *Monitoring of cargo to include safety and care*
- *Monitoring the progress of the voyage*
- *Monitoring the environment to include sea state, weather alerts and warnings, hazards to navigation etc.*
- *Emergency response to include fire-fighting, SAR, man overboard, stability*

Maintenance and running repairs:
- *Maintenance of vital systems as above*
- *Response to repairs as required*

Management of the technical systems involved in:
- *Navigation and pilotage*
- *Propulsion and power supply*
- *Stability*
- *Cargo safety and care*

Communications:
- *Related to navigation and safety to include ship to ship, ship to shore and internal*

Security measures:
- *Stowaway detection and detainment*
- *Sabotage to cargo or vital systems*
- *Piracy*
- *Hazardous and dangerous cargoes*