Safer Positioning of Electronic Fishing Aids

Stella Mills

(*Cheltenham & Gloucester College of Higher Education*)

Bridge design has undergone changes in the last few decades resulting in increased awareness of the need for safety while maintaining the minimum of personnel. The concept of the one-person bridge has been studied fairly extensively with respect to military and large merchant vessels, but much of this work has been ignored by those designing for smaller ships, particularly fishing vessels. This paper derives principles for positioning the electronic fishing aids of 'single ticket' fishing vessels while applying, where applicable practically, the ergonomic principles developed from the wider community. The paper then applies the principles to the wheelhouses of two fishing vessels and suggests modifications for greater compliance. A conceptual wheelhouse design is given that satisfies all the principles while including the usual suite of electronic aids typically carried by such fishing vessels.

KEY WORDS

1. Bridge Design. 2. Fishing Vessels. 3. Ergonomics.

1. INTRODUCTION. Fishing is the most dangerous occupation in the world (EEC, 1993) despite the fact that wheelhouses of fishing vessels carry sophisticated equipment for finding fish and navigating a safe passage. The variety of equipment required can lead to problems of positioning the Visual Display Units (VDUs) so that visibility, for example, is not compromised. Design principles can be derived from both the legislative and academic literature so that the positioning of the VDUs is ergonomically satisfactory. In the UK, the legislative literature is essentially issued as Acts of Parliament, Merchant Shipping Notices (M Notices) and EC Regulations, and the principles derived from such literature will be designated by the prefix 'L'. Likewise, principles derived from the ergonomic literature that are not legally binding in the UK will be prefixed by 'E'. Only fishing vessels of between 16·5 metres and 24 metres registered length (commonly known as 'single ticket') will be considered in this paper, but most of the principles derived are applicable to all wheelhouses fitted with electronic aids. First, it is necessary to consider the different types of electronic aids carried.

2. ELECTRONIC AIDS CARRIED. In addition to electronic navigation and communication aids carried by most commercial vessels, fishing vessels may carry one or two radars, echosounders, and sonars each being of a different frequency to allow for maximum data feedback and also emergency back-up. Demersal (seabed) trawlers may not carry a netsonde (for indicating the position, attitude and state of the net), and older vessels frequently do not carry a horizontal sonar. Pelagic (midwater) trawlers usually do use both a horizontal sonar and netsonde to facilitate

positioning the net for optimum catch. Thus it can be seen that the main electronic fishing aids are the echosounder, sonar and netsonde with the plotter being used to track the vessel's, and it is assumed, the net's course. Standards of manufacture exist for the compass, radar, echosounder, log, direction finder, homing device, rate of turn indicator (i.e. rudder indicator) and the Automatic Radar Plotting Aid (ARPA) (M.1513, 1993), but these are not applicable to fishing vessels. Although not directly relevant here, since radio equipment is not used directly for fishing, there are UK standards for radio communications equipment carried on fishing vessels (M.1573, 1994). More sophisticated systems, known as integrated trawl systems, are available that allow the skipper to know the exact position and status of the net, but these are very expensive (Mills, 1995). The autopilot or, more rarely, the wheel is used to assert the vessel's course.

3. DERIVATION OF LEGAL AND ERGONOMIC PRINCIPLES.

Some of the tasks the fishing skipper is required to complete by law impinge directly on the positioning of the equipment in the wheelhouse. For example, the legally required task that 'A proper lookout is kept all round the horizon at all times including while at anchor' (TM/INF/023, 1993) requires 360 degrees visibility from the wheelhouse. Thus we have:

Principle L1: *There must be all round* (*360 degrees*) *visibility from the wheelhouse at all times.*

Visibility can also be reduced by the positioning of 'electronic equipment … fitted for navigation and fish detection' (M.1111, 1984). Consequently, 'care should be taken in planning the layout of the wheelhouse to ensure that any additional installation does not reduce visibility through the wheelhouse windows' (M.1111, 1984). Thus we have:

Principle L2: *The positioning of the electronic fishing and navigational aids must not reduce the visibility from the wheelhouse.*

Concerning the equipment in the wheelhouse, the legal requirement that 'A listening watch is kept on MF 2128KHz and VHF Channel 16' (TM/INF/023, 1993) implies that the officer on watch must be able to hear the radio at all times. Thus:

Principle L3: *The radio equipment must be positioned so that the skipper can hear Channel 16 and the frequency 2128 KHz at all times.*

It should be noted that, while Channel 16 is to be continued for the time being, this rule will soon be replaced by the need to respond to alerts sent via Digital Selective Calling (legal in Area A1 of the Global Maritime Distress and Safety System).

The obvious and legally required intention that 'An adequate freeboard is always maintained' (TM/INF/023, 1993) requires that the depth indicator of the echosounder be visible to the skipper at all times so that the depth of water under the vessel is always known. Consequently we have:

Principle L4: *The depth indicator of the echosounder must be visible to the skipper at all times.*

The legal requirement that 'The vessel is not within the safety zones of offshore and subsea installations and that the location of suspended wellheads and submarine cables is known to the skipper' (TM/INF/023, 1993) means that the chart should be visible to the skipper while fishing since this information should be displayed on the chart in use. Thus:

Principle L5: *The chart in use must be displayed to the skipper at all times throughout any fishing operation.*

From Principles L4 and L5 an ergonomic principle can be derived:

Principle E1: *The output from the echosounder, the compass and the chart must be visible from the wheel.*

For some time, it has been recognised that tiredness can diminish capable watchkeeping (MGN 84(F), 1998). Indeed, even if the watch-keeper is certified, 'there will be occasions when he will be unable to cope successfully with steering, navigation and keeping a proper lookout' (M.1190, 1986). This is an example of cognitive overload and considering that the skipper often acts as the watch-keeper while doing other tasks, such as supervising shooting the net, it is essential that computer-related tasks reduce cognitive load wherever possible. Indeed, recent legislation (MGN 84 (F), 1998) stipulates that 'no other duties should be undertaken which could interfere with that task (watch-keeping)'. Thus we have:

Principle E2: *Computer related tasks should reduce cognitive overload.*

Direct vision is in constant use by the skipper as he monitors 'instruments (speed, rudder angle, course to steer), chart reading, communications (VHF etc.) and radar observation…' (Lazet and Schuffel, 1977). Clearly, with too much visual information, critical information may be missed because of inattention, or because he is just not looking in the right direction. When decision-making is necessary from interpretation of the meaning of displayed information 'the presentation … is … of great importance' (Lazet and Schuffel, 1977). This implies that the presentation of the data from the display screens should facilitate decision-making and hence reduce cognitive load:

Principle E3: *All information from display screens should facilitate the associated task by reducing cognitive load.*

Turning now to more general ergonomic principles of positioning fishing aids, Witty (Witty, 1984) suggested that the 'sophisticated array of fish-detection and navigational instruments' that many fishing vessels carry, should be 'grouped together in functional areas'. Immediately, we have:

Principle E4: *The equipment in the wheelhouse should be positioned in task-related groups.*

Witty (Witty, 1984) (correctly) classes the (colour) echosounder as a navigational aid although the reason given is that this helps the fishing skipper avoid wrecks and an uneven seabed as well as discriminating between hard and soft ground as against the truly navigational use of depth of freeboard. Witty points out that echoes may be recorded on tape for playback in the light of catches obtained. Thus the sounder must 'often fulfil three functions – to determine the depth of water below the ship (and, in mid-water trawling, below the net), to detect and discriminate fish both in mid-water and close to the seabed, and thirdly to determine the nature of the seabed'. These three functions require switching through multi-frequencies and often vessels are fitted with two or more sounders to avoid this (MacLennan and Simmonds, 1992). In order to monitor the fish entering the net, particularly in a mid-water trawl, headline transducers are provided that

> …enable the skipper to position accurately his net a certain distance below the water surface and clear of bottom obstructions. The datum level of net sounder displays is the headline of the net, so that as the net changes height in response to the towing pull, a distorted view of the seabed (or sea surface) is obtained (Witty, 1984).

Headliners are usually connected by a cable to the VDU in the wheelhouse, and this link generally monitors temperature as well. In the last few years, a cableless transducer has been available for single-ticket fishing vessels, but unless the vessel is engaged in total pelagic trawling, the cost outweighs the advantage of not having the cable snag in the trawl warps.

Witty (Witty, 1984) mentions that a number of hybrid navigation systems are available such as Loran-C, Decca and Omega. Although these are now being replaced with (Differential) Global Positioning Systems (DGPS), when combined with ARPA, the point that 'the advent of more diverse, accurate and compact navigational aids, at a price that the fisherman can afford, have [*sic*] led to an upsurge in his training requirements' is still valid. Navigational training using both radar and electronic aids is available in many nationally recognised training establishments in the UK since the *Electronic Navigation Systems* (*Fishing*) *Certificate* is a requirement for all three classes of *Fishing Vessel Certificate* (Olsen, 1999).

Turning to other general ergonomic matters, Stoop (Stoop, 1990a) suggested that in order to improve safety in fishing vessels there is a need to redesign the bridge and as a start in that direction advocated that instrumentation should be automated and linked so that data could be easily transferred from one component to another. In addition, he was concerned that there were too many displays in the wheelhouse and that information should be integrated on one display if possible. This is discussed more fully at the end of this section when the principle of centralisation is considered.

From these design requirements of Stoop the following ergonomic principles can be formulated:

> Principle E5: *Automatic transfer of information between displays should be optimised to facilitate task completion.*
> Principle E6: *Information should be integrated whenever possible.*

In a later publication (Stoop, 1990b), Stoop reiterated the points above, but added examples for clarity; thus radar and autopilot can be combined 'to detect and correct bias errors' and a guard zone could be made on the radar 'to warn against approaching ships during fishing gear operation'. Interestingly, Stoop advocated the introduction of an Automatic Radar Plotting Aid (ARPA) but concedes that 'at present this equipment is far too expensive'; this is indeed so, although ARPA is becoming more common in wheelhouses with one UK company advocating mini-ARPA sets for the leisure market.

In order to arrive at the best ergonomic solution for positioning and use of VDUs, it is worthwhile considering the literature for non-fishing vessels such as that relating to military and merchant ships' bridge design. This literature is large compared with that for fishing, but much of it is irrelevant to the small wheelhouses found on fishing vessels. However, there are some general design principles that carry over, and these will now be discussed.

In general, the fishing skipper needs to divide his attention between a number of displays, and Wilkinson (Wilkinson, 1974) pointed out that 'inconsistencies in the manner of presentation can confuse or slow his perception'. For example, those VDUs showing similar but different information, such as one might obtain from two radars of differing frequencies, should be placed apart as errors could arise from confused readings. Thus we have:

Principle E7: *Displays with similar interfaces, but giving different information, should be placed apart.*

Froese (Froese, 1981) and Harre (Harre, 1987) both suggested a policy of integrating the information from different VDUs in order to reduce the number that the skipper must monitor. However, while the integration of systems is beyond the scope of this paper, it is worth noting that in order to integrate systems, the positioning of the VDUs should be as consistent as possible (Mills, 1999). Thus we can add:

Principle E8: *The wheelhouse layout should be as consistent as possible.*

This work of Harre is supplemented by the *Health and Safety Guidelines* [Health & Safety, 1992] which, although not a legal obligation for fishing vessels since 'modes of transport' are exempt, are pertinent for good practice. Thus we can add [Health & Safety, 1992]:

Principle E9: *VDUs should be positioned so as to avoid glare and distracting reflections on the screen.*
Principle E10: *Screens should swivel and tilt easily and freely to suit the needs of the skipper.*

It is assumed that all display screen equipment satisfies those requirements of the *Health and Safety Guidelines* [Health & Safety, 1992] concerning brightness and contrast controls since these are fitted as standard to displays. Such controls, which may be manually or automatically adjusted, are needed to accommodate the wide range of ambient lighting, from exterior (and sometimes interior) darkness to direct sunlight, that can be found at sea.

Most of the design principles derived so far have been specific, but Abramowski (Abramowski, 1976) took an approach to bridge design based on total systems requirements analysis. While emphasising the need for ergonomic design and deploring those based on 'a double row of straight consoles…', he advocated using the three generic principles of utilisation, functionality and centralisation.

Utilisation requires that 'each instrument should be fully utilised, that is to say used in all necessary phases of information presentation and command function' (Abramowski, 1976). This means that information required in various stages of a task should not be duplicated for each of those stages but remain on one VDU throughout the task. This principle is important for integration of information but is generally adhered to in fishing wheelhouses since skippers usually switch on the VDUs at the beginning of a fishing trip and leave them on until back in port. However, for completeness we can add:

Principle E11: *Information should only be duplicated when necessary*.

Examples of necessary duplication could be the need for repeaters on a large bridge or one that is divided and the carrying and using of two or three Global Positioning Systems in order to obtain consolidated data and for use as back-ups.

Functionality means that 'the information supplied should be easy to receive and absorb and clear in all respects, to the point, and in a condensed but completely descriptive form' (Abramowski, 1976). The information should be instantaneously understood and equipment should not require further adjustment after being set in operational mode. In other words, the information on the VDUs should be as easy to understand as possible, thus reiterating Principle E4 that cognitive load should be reduced wherever possible. We should note that this concept of functionality is different from that of Witty and functional grouping (Principle E4).

Abramowski (Abramowski, 1976) insisted that any wheelhouse design should 'incorporate the idea of possible total centralisation of the presented information' since the 'main factor in instantaneous decision making is the immediate receipt of all the information needed, and in such a way that it is possible for the operator to register it continuously'. Thus centralisation complements functionality in that the information is readily to hand, while the latter is concerned with its comprehension. In terms of integrating information, Abramowski foresaw the use of a video plotter overlaid with information necessary for fishing and navigation as can be seen in many fishing wheelhouses today. Thus centralisation is already being observed, in spite of the legal misgivings of such principles. For example, 'assessments or assumptions made on video plotters alone are dangerous and unreliable' (MGN 84 (F), 1998) and the same paragraph of the same document refers to the use of paper charts for safe passage. Even so, centralisation is an important principle in that it removes the need for a large number of VDUs which, in turn, removes duplicated information and reduces cognitive load. In all cases, the reliability of the information is assumed to be total. Given the sensitivity of centralisation, a formal principle beyond Principle E4 will not be stated, but a general observation will be made when applying the principles to the designs of the wheelhouses discussed below. Even so, utilisation, functionality and centralisation remain sound criteria on which to base design principles.

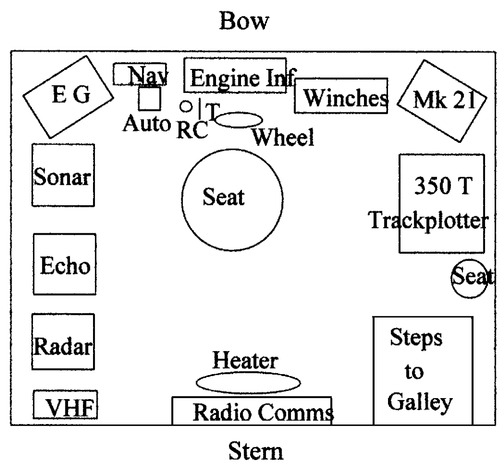
Having formulated principles for design and evaluation, these will now be used as a checklist to discover the compliance or otherwise of two wheelhouses of fishing vessels. These have been chosen so that an ageing vessel and a modern one are represented.

4. TWO PRACTICAL EXAMPLES.

4.1. *Vessel 1.* Vessel 1 was fabricated in wood and registered in 1957. Her overall length is 18·19 metres. She is used as a stern trawler with the catch being landed on deck over the side, generally the starboard side, but the vessel may be used for both demersal and pelagic trawling. The ceiling height of the wheelhouse is 1·98 metres, with the compass at ceiling height over the wheel. The current wheelhouse layout of Vessel 1 is shown at Plan 1. Table 1 summarises the compliance of the current layout in Plan 1 with the design principles discussed earlier.

This vessel carries a sonar and uses a netsonde with a paper output when pelagic trawling and, consequently, it is an excellent example in that the outputs from the sonar, echosounder and netsonde are all capable of being viewed simultaneously in

Plan 1 - Wheelhouse of Vessel 1 (Scale 1:35)

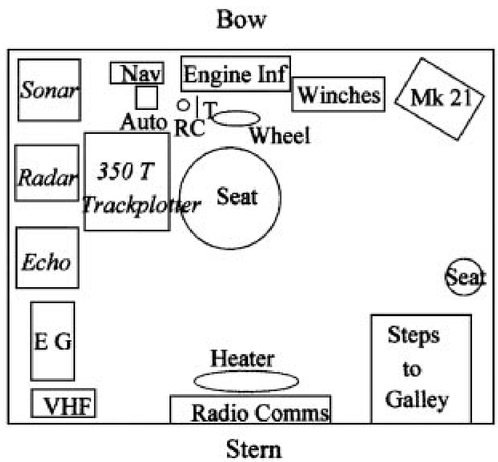


Key:
Mk 21 – Decca Navigator Mk 21
Echo – Colour Echosounder
EG – Monochrome paper-plot of netszonde
Eng. Inf – Engine Information (dials etc.)
Auto – Autopilot
Nav – Navigator
RD – Rudder control
Comms – Radio Communications
T – Engine Throttle
VHF – SSB Transmitter

Table 1. Compliance of Vessel 1 with the design principles.

Principle	Compliance	Remarks
Legal		
L1	Yes	Scuttle surrounds are wide
L2	Yes	
L3	Yes	
L4	Yes	
L5	Yes	
Ergonomic		
E1	Yes	Some head movement needed
E2	Yes	
E3	Yes	
E4	No	Chart and echosounder apart
E5	Yes	
E6	Yes	
E7	No	Sonar and echosounder together
E8	Yes	
E9	Yes	Tilting could decrease reflection further
E10	Yes	
E11	Yes	

Plan 2 - Modifed Wheelhouse of Vessel 1 (Scale 1:35)
(*Italics* indicate positional changes)



Key:
VHF – SSB Transmitter
Mk 21 – Decca Navigator Mk 21
Echo – Colour Echosounder
EG – Monochrome paper-plot of netszonde
Eng. Inf – Engine Information (dials etc.)
Auto – Autopilot
Nav – Navigator
RD – Rudder control
Comms – Radio Communications
T – Engine Throttle

order to position the net for maximum effect when pelagic trawling (satisfying Principle E4). Thus the close positioning of the output from these fishing aids is good but needs some re-arranging in order not to contravene Principle E7. The trackplotter, which here is used as a chart, should be nearby for navigational purposes. Certainly, the trackplotter should be nearer to the autopilot, to which it is linked, also for navigational purposes. One solution to this would be to place the trackplotter where the sonar is presently positioned and to place the sonar where the echogram of the netsonde is positioned and to remove the radar to the present position of the sonar. The radar could be placed behind the trackplotter with the echogram being placed where the radar is at present. Thus Principle E7 would be satisfied. In addition, this would reduce the necessary amount of movement by the skipper and operation of these aids could be carried out from the chair. Plan 2 shows the modified layout of the wheelhouse equipment.

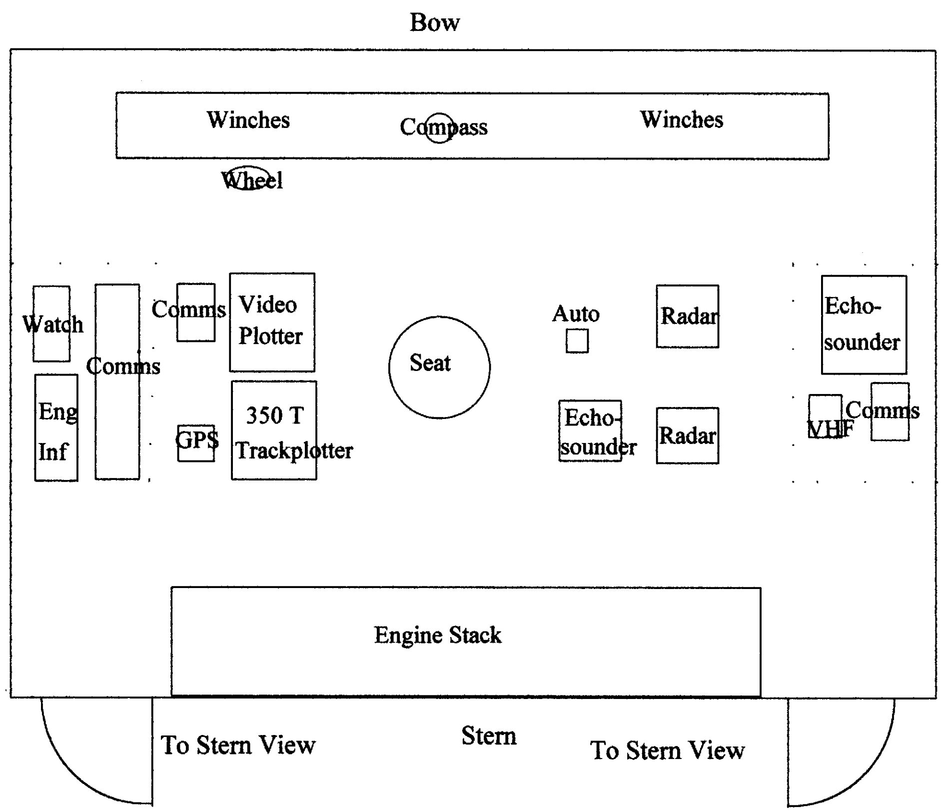
Abramowski's Principle of Centralisation is difficult to use in this design as it requires a VDU to act as the centre of integration and here the chart is paper-based. However, the radar is a possibility with the sonar and echosounder outputs being displayed as small windows.

In general Vessel 1, in spite of its age, has ergonomically well-positioned fishing aids and the wheelhouse is well designed ergonomically.

4.2. *Vessel 2*. Vessel 2 built in 1991, is a beam trawler fabricated in steel of registered length 20·45 metres. The ceiling height of the wheelhouse is generally 1·73 metres but is raised to 1·83 metres over the fully adjustable seat. Plan 3 shows the position of the VDUs and other equipment. Table 2 summarises the compliance of the design in Plan 3 with the principles discussed earlier.

In spite of its relative modernity, the wheelhouse will need some structural alteration in order to satisfy Principle L1 since the stern view is blocked by the engine stack, and it is possible to view the stern only when positioned away from the forward

Plan 3 - Wheelhouse of Vessel 2 (Scale 1:35)



Key:
Auto – Autopilot
GPS – Global Positioning System
Comms – Radio Communications
Eng. Inf – Engine Information (dials etc.)
VHF – SSB Transmitter
• • Displays at coping level

Table 2. Compliance of Vessel 2 with the design principles.

Principle	Compliance	Remarks
Legal		
L1	No	Some lack of view to stern
L2	Yes	
L3	Yes	
L4	Yes	
L5	Yes	
Ergonomic		
E1	No	Lateral head movement needed to view any two together
E2	Yes	Head movement needed
E3	Yes	Head movement needed
E4	No	Radars and echosounders not visible from charts for navigation
E5	Yes	
E6	Yes	
E7	No	Radars placed side by side
E8	No	Echosounders placed apart; radars not so
E9	Yes	No positioning adjustment possible
E10	No	Displays fixed in wooden surrounds
E11	Yes	

part of the wheelhouse. Thus, all round visibility is not ensured. Concerning the equipment in the wheelhouse itself, the radar, which is indispensible in inclement weather, is used in conjunction with the video plotter and, in their present positions, require a movement of 180 degrees to view each sequentially contravening Principles E1 and E4. Better positioning of the clusters in terms of the content of each group would facilitate information assimilation (Principles E2 and E3) and could be achieved by placing the autopilot alongside the compass, moving the video plotter to alongside the lower placed echosounder and placing the forward radar where the video plotter is in Plan 3. The echosounder, at present placed at coping height, could be then placed above the video plotter as in Plan 4. As a consequence of this alteration, Principles E4, E7 and E8 would be satisfied. In addition, it is possible to have the VDUs fixed at the base but also to tilt and swivel (Principle E10). This would allow for avoidance of any glare, both direct and reflected (Principle E9), but would take up a little more space and probably would not be so aesthetically pleasing. Thus some modification is needed to make this wheelhouse ergonomically acceptable. Plan 4 gives such a design.

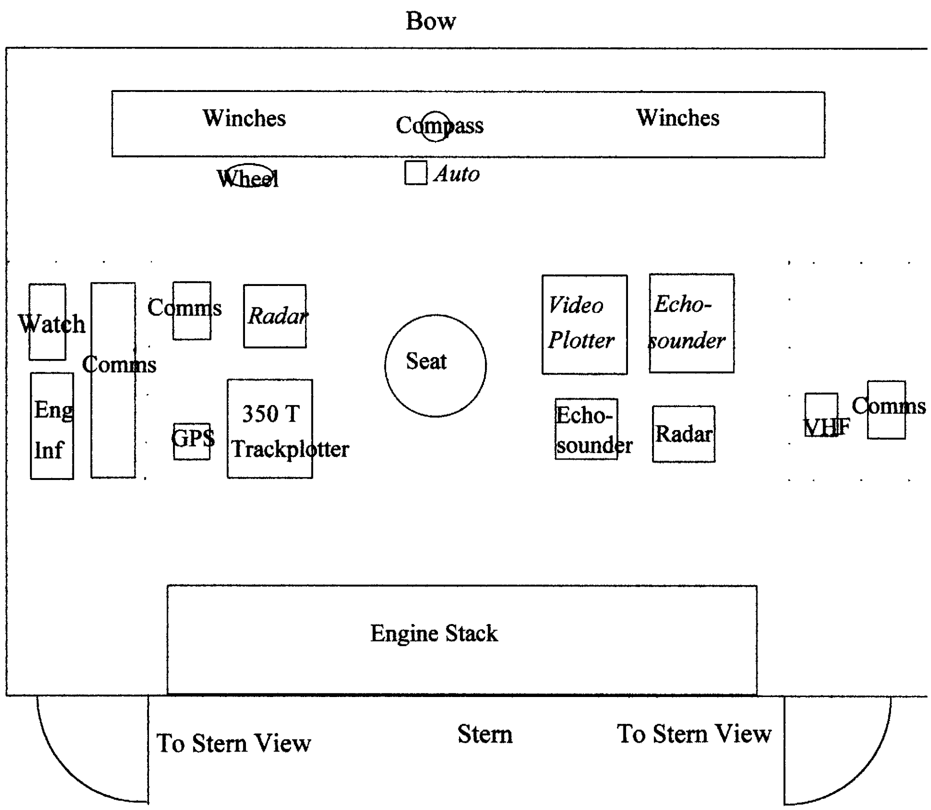
Clearly, applying Abramowski's *Principle of Centralisation* would allow a reduction in the number of VDUs since the information from the radar, chart and echosounder could easily be integrated. This would also ease cognitive load. However, the problems, already noted, which are associated with integration may pertain.

5. A CONCEPTUAL DESIGN.

Having formulated the principles on which to evaluate a design, we now turn to creating an ergonomic generic design for the wheelhouse of a single-ticket fishing vessel. First, for convenience, the list of equipment needed in the wheelhouse will be re-iterated with the modification that certain equipment will be replaced by its current (2000) equivalent development. For

Plan 4 - Modified Wheelhouse of Vessel 2 (Scale 1:35)

(*Italics* indicate positional changes)



Key:
Auto – Autopilot
GPS – Global Positioning System
Comms – Radio Communications
Eng. Inf – Engine Information (dials etc.)
VHF – SSB Transmitter
• • Displays at coping level

example, the netsonde is replaced by an integrated trawl system (which has object-coded data output in place of colour-coded output), and the personal computer supports a Global Maritime Distress and Safety System.

5.1. *Equipment used in the Wheelhouse of a Single-ticket Fishing Vessel.* (Legal Requirements are shown in **bold** type)

5.1.1. *Fishing Aids* (may also aid navigation):
Echosounder(s),
Sonar(s) (horizontal or omni-directional),
Integrated Trawl System (usually only carried by pelagic trawlers),
Paper plots (printouts) from echosounder and/or sonar.

5.1.2. *Navigational Aids* (also used for fishing):

Echosounder
Radar(s),
Video Plotter (electronic chart),
Paper Plotter (paper chart),
Autopilot **(alarmed),**
Differential Global Positioning System,
Rudder Angle Indicator,
Compass.

5.1.3. *Other Equipment*:

Video Navtex (fascimile for weather).
VHF Communications including transreceivers and full (internal) intercoms,
Engine Information (dials etc.),
Personal Computer with information system including catch records,
Global Maritime Distress and Safety System (INMARSAT-C),
Keyboard for data entry to personal computer.

5.1.4. *Other Controls*:

Wheel,
Winch Controls,
Engine Throttle.

In single-ticket fishing vessels, the combination of fishing aids varies from vessel to vessel and consequently the design given in Plan 5 will allow for all the equipment listed above. The design is easily modified for variations of the equipment.

5.2. *Discussion*. The VDUs are to be mounted on bases that allow for rotation and vertical tilt as shown in Figure 1 (Principle E10). Sufficient space has been allowed for movement of the VDU in the positioning, which is essential to avoid glare (Principle E9) and problems of parallax from a distance.

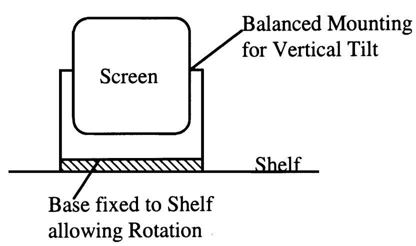


Figure 1. Vertical Profile of VDU.

By incorporating a stepped effect, the VDUs are easily accessible and can be cleaned or fitted with anti-glare screens or a daylight hood, in the case of the radar, if necessary. A holder is provided on the side of the video plotter for its light-pen (input device) when not in use. The shelving in Figure 2 is freestanding but fixed to the floor, allowing space behind for standing, exercise or better visibility (Principle L1).

This design has removed the frequently used wooden surrounds of the VDUs which are aesthetically pleasing, but which have the serious drawback of not allowing movement of the VDUs for better viewing and the avoidance of glare.

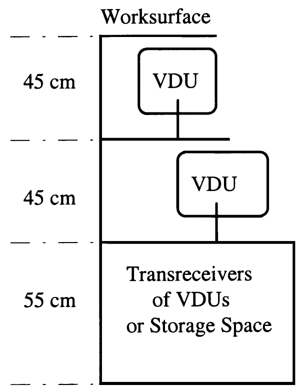


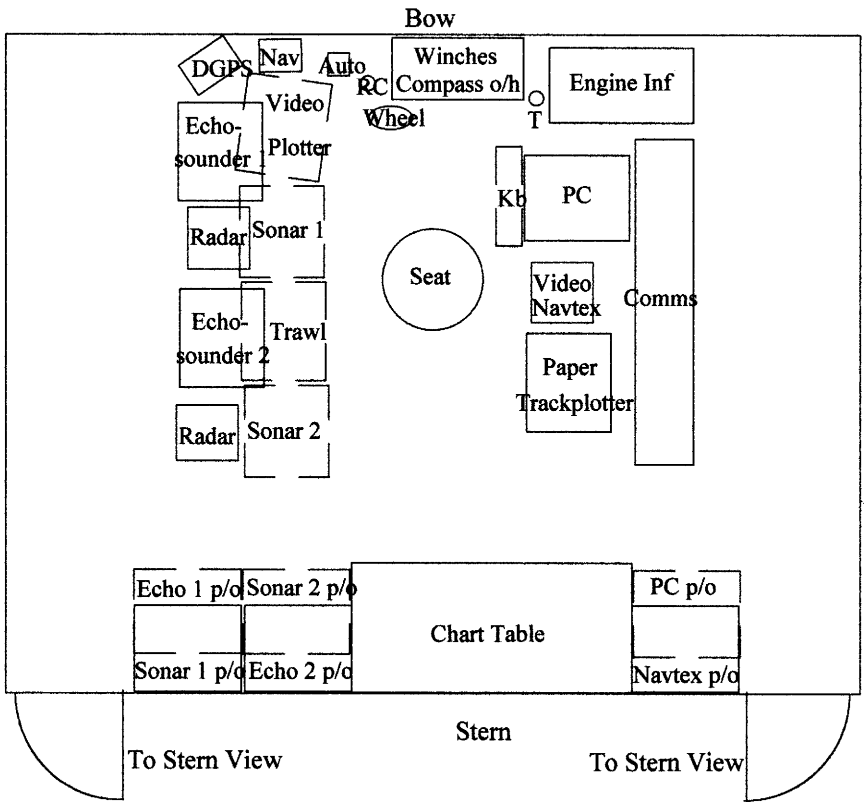
Figure 2. Vertical Profile of Port Side Equipment.

Considering now the starboard side of the wheelhouse, a similar stepped design to that on the port side, and shown in Figure 2, has been used, but beneath the Personal Computer (PC) there is an additional shelf on a lever arm that can be extended to the skipper's seat and raised or lowered to a convenient height for data input. The shelf is sufficiently large for a wrist-rest to be used if required. The keyboard is fixed to the shelf but has threaded feet, which allows the keyboard to be raised on the shelf to any angle between 10 and 20 degrees. The keyboard may be a conventional keypress type, or the skipper may prefer a touch-pad type that has a smooth surface for easier cleaning and can be supplied with a waterproof surface. However, with the latter type some tactile identification is lost that may be a hindrance to data input under difficult conditions. If the PC's system supports a graphical user interface, then the mouse should be incorporated into the keyboard, either as a trackball or as an isometric joystick of the type operated by the fingertip. This will prevent the pointing/selection device (conventionally a mouse) from unwanted movement while the vessel is under way.

Turning to the other equipment in the wheelhouse as shown in Plan 5, the seat is fully adjustible both in height and tilt as the back of the seat also tilts, thus satisfying the *Health & Safety Guidelines* (Health & Safety Executive, 1992). The chair is stable by being firmly secured to a small runner on the floor that allows adjustment in position along the bow/stern axis. Standing space has been provided in front of the seat and around the sides of the seat and also behind the units housing the electronic aids where there is sufficient room for two personnel to walk and look out of the windows (Principles L1 and L2). There is also sufficient space to allow access to the winches, which can be electrically operated to avoid manual fatigue if the skipper prefers. The compass is placed over the winches at coping height and is on an adjustable arm, which allows tilt for easier viewing (Principle E10).

From Plan 5, it can be seen that the design can be accommodated in wheelhouses as small as 3 metres by 2·5 metres, if the chart table and paper printouts of the fishing aids are not considered essential. However, by increasing the size of the wheelhouse by about two metres in each direction, the plotters and chart table can be easily accommodated. Practising skippers will note that the design does not include a television as vigilance must be reduced with such a VDU, since the cognitive load requires two-task processing if the skipper is watching the television and also keeping watch (contravening Principle E2).

Plan 5 - General Design of Wheelhouse (Scale 1:35)



Key:
Echo 1 p/o – Echo-sounder 1 Printer
Sonar 1 p/o – Sonar 1 Printer
Sonar 2 p/o – Sonar 2 Printer
Echo 2 p/o – Echo-sounder 2 Printer
Trawl – Integrated Trawl System
DGPS – Differential Global Positioning System
Nav – Navigator and Ship's Log
Auto – Autopilot
RC – Rudder Control
Compass o/h – Compass positioned overhead (in Bulwark)
Engine Inf – Engine Information
PC – Personal Computer
Kb – Personal Computer Keyboard
Comms – Communications Systems
PC p/o – Personal Computer Printer
Navtex p/o – Navtex Printer

Hatching indicates equipment placed under the upper equipment as in Diagram 2.

The displays have been grouped functionally (Principle E4) with the fishing displays to port (left) and the navigational equipment adjacent to the fishing displays but forward for easier use when steaming to and from the fishing grounds. Secondary equipment, primarily for backup, is placed apart (Principle E7). The winch controls are beneath an opening scuttle with good forward visibility for safer use (Principle L1). Communications and ancillary equipment is positioned to starboard (right) with the plotters to the rear of the wheelhouse since their output is usually used away from the plotters themselves.

In order to show that the design in Plan 5 is legally and ergonomically acceptable, it must satisfy the design principles formulated earlier. Table 3 summarises the compliance of the design in Plan 5 with these principles. As can be seen from Table 3, the design satisfies all the principles, whether or not a shelterdeck is fitted. The design is capable of easy modification should the vessel not carry all the equipment shown. Thus, for conventional fishing aids, the design is ergonomically acceptable.

Table 3. Compliance of conceptual design with principles.

Principle	Compliance	Remarks
Legal		
L1	Yes	
L2	Yes	All aids below window level
L3	Yes	
L4	Yes	
L5	Yes	
Ergonomic		
E1	Yes	
E2	Yes	
E3	Yes	
E4	Yes	
E5	Yes	
E6	Yes	Backups still necessary
E7	Yes	Backups placed well away
E8	Yes	
E9	Yes	
E10	Yes	
E11	Yes	Backups as needed

6. CONCLUSION.

This paper has presented some legal and ergonomic principles that can be used in the design and evaluation of fishing aids in the wheelhouses of fishing vessels in the UK. The evaluation, in turn, has highlighted some of the problems associated with the placing of electronic fishing aids and has shown that the age of a vessel is not necessarily a contributing factor to good equipment positioning in wheelhouse design. Further development of principles for other classification of fishing vessels as well as best practice from other countries' legal requirements could be used to focus further on principles relevant to the positioning of the fishing aids. In addition, the resulting designs should be tested in the real environment to ascertain whether the skippers think there is an improvement in safety through finding the fishing aids easier to use.

REFERENCES

Abramowski, C. (1976). An automated integrated ship's bridge layout. This *Journal*, **29**(1), 82–89.

Department of Transport. (1993). *Checklist TM/INF/*023. London: Her Majesty's Stationery Office.EEC. (1993). *Health and safety training in the fishing industry*, *Europe for safety and health at work*. Office for the Official Publications of the European Communities, Luxembourg.

Froese, J. (1981). Requirements for the bridge of the ship of the future. *ERGOSEA 81*, *Second International Conference on Human Factors at Sea*. Plymouth, October 5–8, 192–216, The Nautical Institute, London.

Harre, I. (1987). Functional area integration on merchant and research vessels. Paper 27, *Data Dissemination and Display – Electronics in Navigation*, *1987 Conference of the Royal Institute of Navigation*, *London*, 1987, Royal Institute of Navigation, London.

Health & Safety Executive. (1992). *Display screen equipment work*, *health* & *safety* (*Display Screen Equipment Regulations 1992*). Guidance on Regulations L26, Her Majesty's Stationery Office, London.

Lazet, A. and Schuffel, H.(1977). Some applications of human engineering to wheelhouse design. This *Journal*, **30**(7), 77–86.

M.1111. (1984). *Merchant Shipping Notice*, *visibility from the wheelhouse of fishing vessels*. Her Majesty's Stationery Office, London.

M.1190. (1986). *Merchant Shipping Notice*, *bridge manning*, *watchkeeping and the command of fishing vessels*. July, 1986, Her Majesty's Stationery Office, London.

M.1513. (1993). *Merchant Shipping Notice*, *navigational equipment: the standards for navigational equipment fitted on UK merchant ships*. Her Majesty's Stationery Office, London.

M.1573. (1994). *Merchant Shipping Notice*, *the merchant shipping* (*radio*) (*fishing vessels*) (*amendment*) *rules 1994: carriage and use of VHF equipment*. June 1994, Her Majesty's Stationery Office, London.

MacLennan, D. N. and Simmonds, E. J. (1992). *Fisheries* acoustics. Chapman & Hall, London.

MGN 84 (F). (1998). *Marine Guidance Note*, *keeping a safe navigational watch on fishing vessels*. October, 1998, Her Majesty's Stationery Office, London.

Mills, S. (1995). Usability Problems of Acoustical Displays. *Displays*, **16**(3), 115–121.

Mills, S. (1999). Bridge '99', in Noyes, Jan, ed. *Modern Interface Technology – The Leading Edge*, Research Studies Press Limited, Taunton.

Olsen. (1999). *Olsen's Fisherman's Nautical Almanack*. E T W Dennis & Sons Ltd, Scarborough.

Stoop, J. (1990a). Redesign of bridge layout and equipment for fishing vessels. This *Journal*, **43**(2), 215–228.

Stoop, J. (1990b). Redesign of bridge layout and equipment for fishing vessels. Chapter 17 in *Work Design and Practice*, ed. Haslegrave, C. M., Wilson, J. R., Corlett, E. N. and Manenica, I. (1989). *Proceedings of the Third International Occupational Ergonomics Symposium*, Zadar, Yugoslavia, 18–20 April, 1989, Taylor & Francis, London.

Wilkinson, G. R. (1974). Ergonomics in ship design. This *Journal*, **27**(4), 471–478.

Witty, J. H. (1984). Fishing vessel navigation. This *Journal*, **37**(2), 279–285; also reproduced in *Specialised Navigation*, *a seminar held on 1st December*, *1983 in London*, 26–32, The Nautical Institute, London.