Thema:

ERGONOMIC ASPECTS OF SHIP DESIGN, IN PARTICULAR WITH REGARD TO SHIP'S BRIDGES AND WHEELHOUSES

General Ergonomic Aspects applied to Maritime Conditions

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Introduction

A ship represents one of our most complex and sophisticated man/machine systems. Just with the growth of automation aboard ships, the task of the man is concentrated more and more upon controlling functions. Consequently, a ship designer is increasingly confronted with ergonomic problems where the man'machine relationship involves the operator as controller. The desired increase of performance is achieved only if man's possibilities are put to their best use in this relationship. To obtain this, both man and the technical systems must be subjected to research.

Knowledge must be gained about the way in which they affect one another both in a favourable and in a unfavourable sense. In many cases a very advanced technical development does not live up to expectations because adaptation to human capabilities has been neglected. It is therefore important to consider the human perceptual and control capabilities when designing each particular system. Those capabilities are indentified with basic human limitations in perception, decision making and handling.
If one analyzes what man has to perform when he is accomplishing his task, let say: on the bridge, it appears that we are dealing with a cycle: man perceived information from his environment (outside picture and instrument information), processes the information and decides on the basis of this information what to do and finally acts. The effect of this action is once more perceived to see if it served its purpose.

The ergonomic problems dealing with this cycle will be discussed under the major headings perception, decision making and handling.

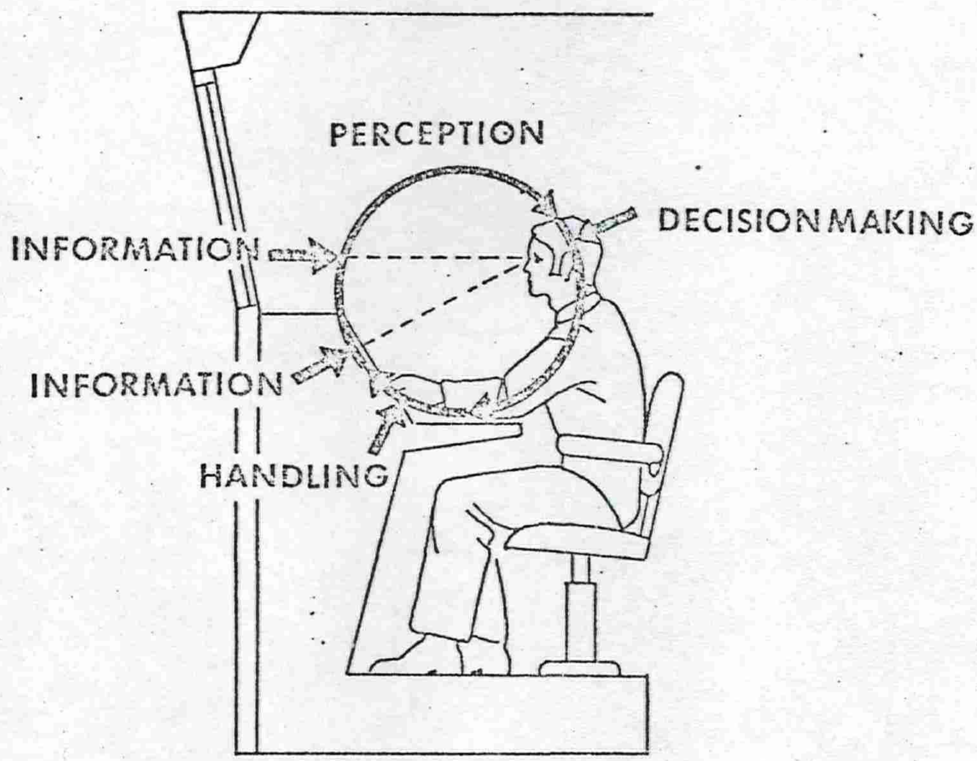


Fig. 1. The cycle: perception, processing, action and perception again.

Perception

The main part of the information input to the man on the bridge is visual about 70 per cent. Good visual acuity is for the navigator an absolute necessity. Visual acuity is expressed by the visual angle, in minutes of arc, or as the reciprocal of this angle.

Visual acuity is best when the eyes have not been exposed to high levels of luminance. For example, if the navigator has been out on the bridgewing scanning the sunlit ocean and then steps into the bridge, he is momentarily "blinded", but in a few seconds he is accustomed to the light level in the bridge. On the other hand for night observation eyes must be accustomed to the dark: "night-adapted". This dark adaptation takes much longer time than light-adaptation. Owing to the qualities of the retina of the eye this night-adaptation is not affected by red light, provided that this light is of the proper spectral composition and the degree of lighting is not too high.

The probability of detecting a ship or other obstacles depends on its size and of course on the lighting and weather conditions. Therefore, an unlimited view from the bridge is absolutely necessary as well as unlimited view of the displays. To reach this coal an good ergonomic design of the bridge is necessary.

The windows of the bridge have to be placed at an angle of at least 10^{o}, to promote an excellent view. Inclination of panes of windows is already very useful for the observation of the deck. For night viewing, however, sloping panes are a necessity as this prevents reflections of instruments from the consoles and of outside lights which can easily be mistaken for ships passing on the other side. Just when passing ships, jetties etc. it is essential that it be possible to see the water surface on both sides from navigation position. With present designs of bridge-wings this is not possible. It is therefore recommended that when these bridge-wings are broad they should be located further aft than usual.

Because an operator on the bridge needs more visual information than his unaided senses can gather and present to him, other sources of information, such as decca, radar, compasses, speed log, etc. have been created as adjuncts to the human senses.
The presentation of this visual information is very important. The displayed information must be understandable so that correct decisions can be made without unacceptable delay. The display should not contain more information than is necessary,nor should it be more accurately displayed than necessary.

Out of the window observation might define the primary visual task of the navigator, a secondary task would be to monitor the displays.
The navigator should see all important displays from his normal position, without excessive shifting of his head or body. When placing the displays in a console against the front bulkhead it is possible to combine both tasks.

The use of radar in day-time by means of a viewing hood is quite difficult. The radar repeater can be seen by one person at a time and then only correctly after the eyes have become adapted to darkness. Visual comparison between environment, and radar would be much easier without a hood.

However, one could create a separate radar cabin. This cabin must have large window frames with movable filters. Depending on the brightness outside it is possible to use one or two filter or no filter. With this method it is possible to use the radar without a hood. By using a separate radar cabin it is possible to instal two radars side by side, so that one can observe both screens from the same position. It is also possible to observe simultaneously different range scales and make comparison between relative and true motion. But the real solution for radar screens is a day-light picture in which case direct comparison with the real world is possible.

Another problem with light/dark adaptation is the chart table lighting. At night the navigator must be able to see other ships or obstacles, which requires complete dark adaptation of his eyes. But he must also be able to consult the chart and chart-working requires a rather high intensity of light. Only red light has minimal effect on dark adaptation. Unfortunately, red light does not allow discrimination of the different colours used on the chart, special the Decca lattices. On orange filter of suitable transmission characteristic seems to be a possible solution, but it is still necessary to have a low level of light.

Another important information is auditory information. When the navigator moves about the bridge he can easily miss a visual warning signal, but hearing is omnidirectional and cannot be involuntarily shut off. Therefore an acoustic important warning signal is much better for calling attention. The major advantage of auditory signals is in the fact that an operator can act upon the information he receives without physically facing the source of the signal.
And of course, the most important auditory information is communication.

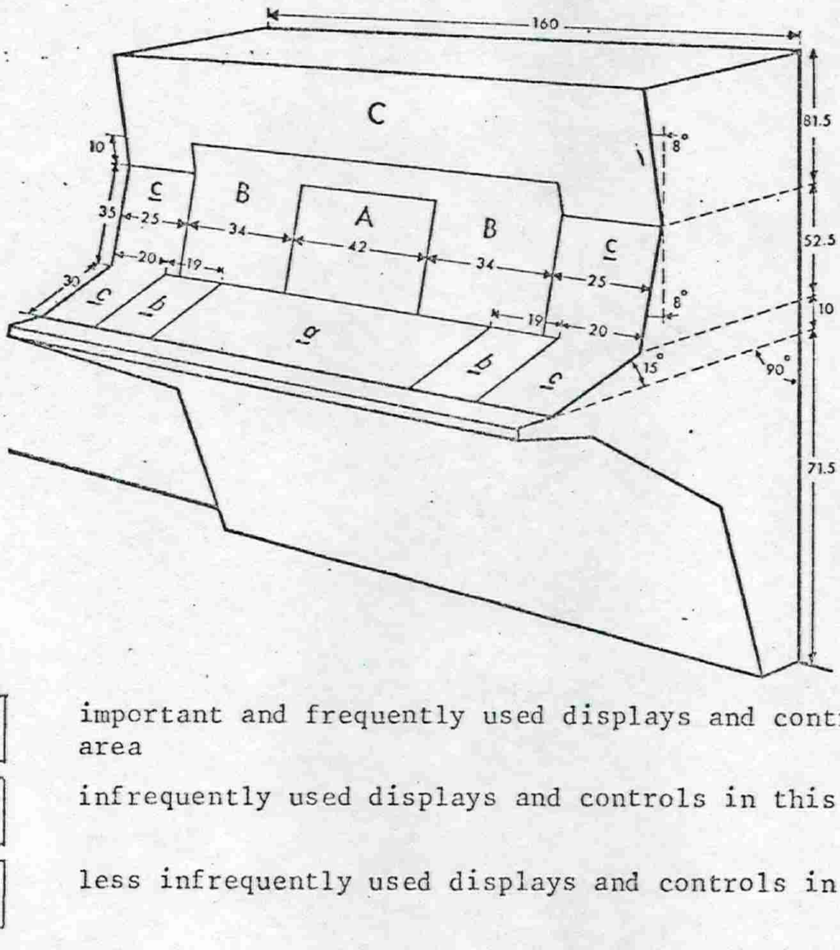
Decision making

Manoeuvring in restricted waters and during berthing for example, involves the navigator in extensive and many times critical decision making problems. The amount of information from direct vision, instruments as speed, rudder angle, course to steer (chart reading), communication (VHF etc.), and radar readings is sometimes just the threshold of which he can transmit.
Man's rate of perceived input seems to be not much greater than 10 successive

items per second.

There is a tendency to overload the navigator's visual input channel. With too many things to look at, it is quite possible he may miss a critical informational input because of inattention or because he is just not looking in the right direction.

When displays are used for decision making, the nevigator will decide the meaning of information presented to him. The way of presentation this information is therefore of great importance.
The efficiency with which an operator used the displays will be affected by the complexity of the instrument panel. The position of visual displays must optimize the input of information to the operator: relevant message



A	a	important and frequently used displays and controls in this area
B	b	infrequently used displays and controls in this area
C	c	less infrequently used displays and controls in this area

↑ displays ↑ controls

Fig. 2. Lay-out of a console with different areas for displays and controls.

must be readily discriminated from the irrelevant and have maximal intelligibility. The controls must be accessible and operable.

Figure 2 shows a console with different area's for displays and controls. Fastest visual attention and handling times are found in Area A-a, because eye movements are not necessary. In area B-b eye movements are necessary and in area C-c eye and head movements are necessary, therefore the visual attention decreased. Operating controls in area c inquire shoulder extension and trunk rotation.

The grouping of displays and controls by sequence of use is an aid in reducing operator errors of omission. Normally a pane is read and worked, as in reading or writing, from left to right, and top to bottom.
Often it is helpful to supplement a group of specific dials with a background of colour in arrow shape or in a outline arrow which is shown in Fig. 3. For check-reading dials in a horizontal row, normal operating position of the pointers should be located at the 9-o'clock position; for vertical group, orient the position at the 12-o'clock position.

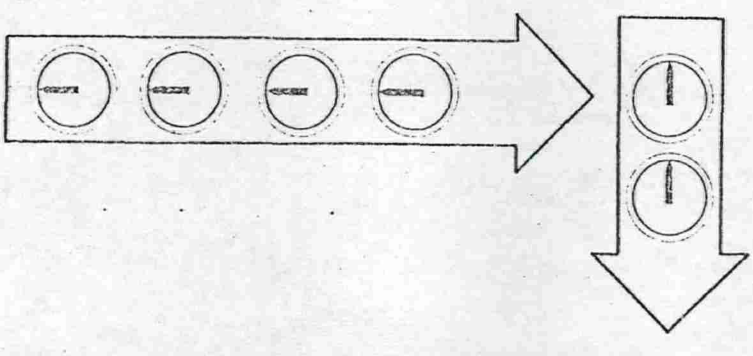


Fig. 3. Grouping dials in reading and check direction.

Handling

When using a rotary control such as a steering wheel, the helmsman orients himself on the compass indicator and rudder angle indicator and of course looking outside. When the steering whell is only one/third of the circle open, the helmsman can orient himself also on the state of the wheel itself.

The compass indicator is an example of "non natural" information for the

helmsman. When the wheel is moved over to starboard, the compass indicator moves to port, and not to starboard as expected. This is because the ship is moving round and the compass is realy stationary.
Control movements that seem "natural" for the operator are more efficient and less fatiguing than those that seem awkward or difficult.

A principal difference in rudder controls exist between follow-up or non-follow-up steering. The research on the control of the rudder as input in relation with course as output is limited with respect to the position of the ship. An ship with great-time-constants the influence of this relation is negligible.

Time-dependent steering, however, demands constant attention. This system is not advisible for smaller ships, in particular when the helmsman performes other tasks. To keep a straight course an automatic course pilot is preferable to a helmsman. In all other cases a helmsman is indispensable.
Fig. 4 gives a survey of the control console in which we have tried to include the ergonomic aspects already discussed.

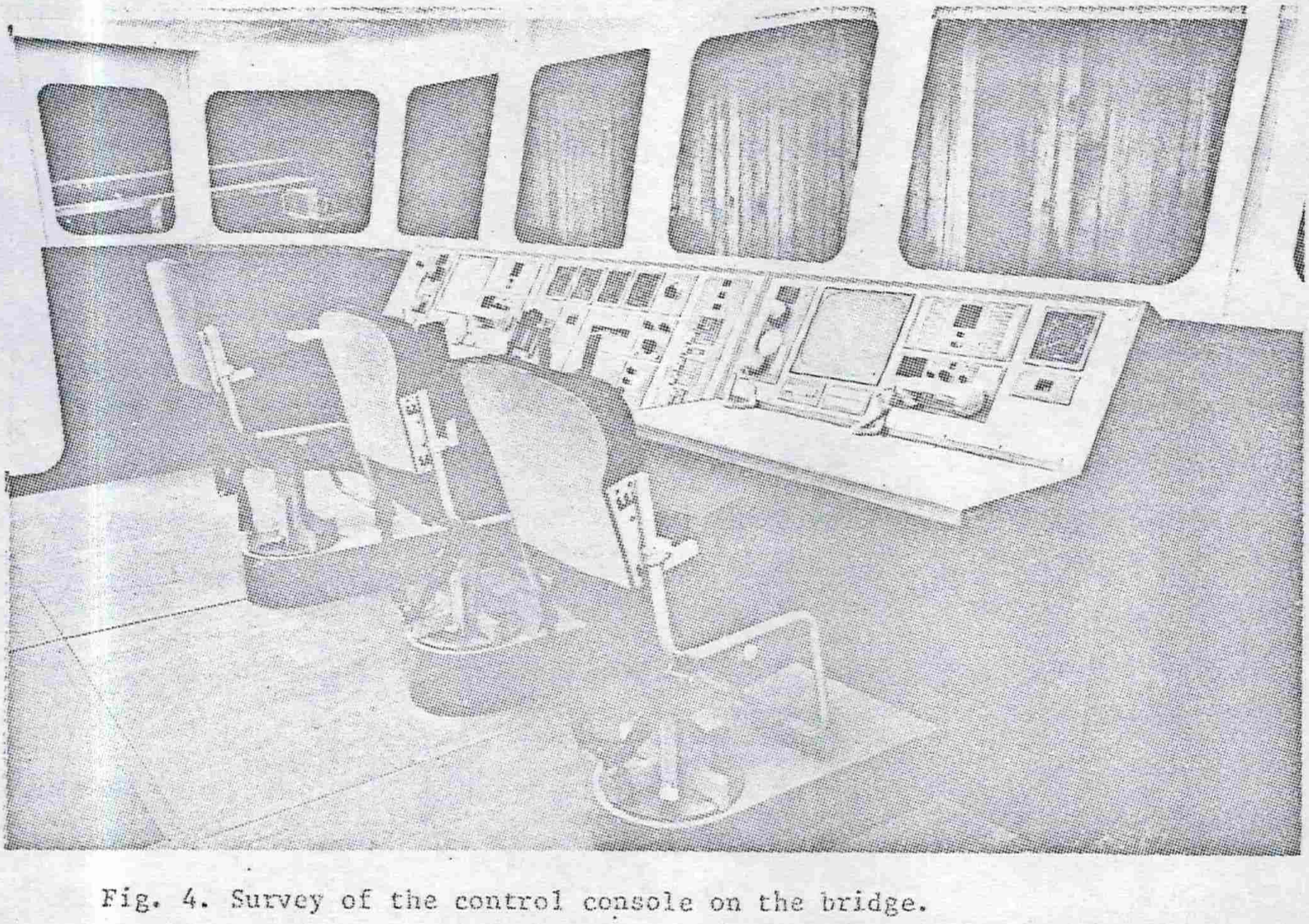


Fig. 4. Survey of the control console on the bridge.

Future research

It seems beyond dispute that automation and the full implementation of remote control will make great progress. Its development should be accompanied by an extensive and objective ergonomic research programme. From an ergonomic point of view the real ship is the ideal equipment for experiments as the experimental situation is completely "live". But most of the time, it is impossible to feet different technical systems aboard ship; and to carry out a research programme with different test subjects is also very difficult.

Therefore, a useful method for research on human behaviour in ship handling is the simulation of navigation bridges with a computer and visual display.

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