SOLAS V/22 - Navigation Bridge Visibility

# Regulation 22 - Navigation Bridge Visibility

1 Ships of not less than 55m in length, as defined in **regulation 2.4**, constructed on or after 1 July 1998, shall meet the following requirements:

.1 The view of the sea surface from the conning position shall not be obscured by more than two ship lengths, or 500 m, whichever is less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo;

.2 No blind sector, caused by cargo, cargo gear or other obstructions outside of the wheelhouse forward of the beam which obstructs the view of the sea surface as seen from the conning position, shall exceed 10°. The total arc of blind sectors shall not exceed 20°. The clear sectors between blind sectors shall be at least 5°. However, in the view described in .1, each individual blind sector shall not exceed 5°;

.3 The horizontal field of vision from the conning position shall extend over an arc of not less than 225°, that is from right ahead to not less than 22.5° abaft the beam on either side of the ship;

.4 From each bridge wing, the horizontal field of vision shall extend over an arc of at least 225°, that is from at least 45° on the opposite bow through right ahead and then from right ahead to right astern through 180° on the same side of the ship;

.5 From the main steering position, the horizontal field of vision shall extend over an arc from right ahead to at least 60° on each side of the ship;

.6 The ship's side shall be visible from the bridge wing;

.7 The height of the lower edge of the navigation bridge front windows above the bridge deck shall be kept as low as possible. In no case shall the lower edge present an obstruction to the forward view as described in this regulation;

.8 The upper edge of the navigation bridge front windows shall allow a forward view of the horizon, for a person with a height of eye of 1,800 mm above the bridge deck at the conning position, when the ship is pitching in heavy seas. The Administration, if satisfied that a 1,800 mm height of eye is unreasonable and impractical, may allow reduction of the height of eye but not to less than 1,600 mm;

.9 Windows shall meet the following requirements:

.9.1 To help avoid reflections, the bridge front windows shall be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°;

.9.2 Framing between navigation bridge windows shall be kept to a minimum and not be installed immediately forward of any work station;

.9.3 Polarized and tinted windows shall not be fitted;

.9.4 A clear view through at least two of the navigation bridge front windows and, depending on the bridge configuration, an additional number of clear-view windows shall be provided at all times, regardless of weather conditions.

2 Ships constructed before 1 July 1998 shall, where practicable, meet the requirements of paragraphs 1.1 and 1.2. However, structural alterations or additional equipment need not be required.

3 On ships of unconventional design which, in the opinion of the Administration, cannot comply with this regulation, arrangements shall be provided to achieve a level of visibility that is as near as practical to that prescribed in this regulation.

4 Notwithstanding the requirements of paragraphs 1.1, 1.3, 1.4 and 1.5, ballast water exchange may be undertaken provided that:

.1 the master has determined that it is safe to do so and takes into consideration any increased blind sectors or reduced horizontal fields of vision resulting from the operation to ensure that a proper lookout is maintained at all times;

.2 the operation is conducted in accordance with the ship's ballast water management plan, taking into account the recommendations on ballast water exchange adopted by the Organization; and

.3 the commencement and termination of the operation are recorded in the ship's record of navigational activities pursuant to **regulation 28**.

**Annex B**

Process Contracting Limited - *Ergonomic aspects of an aerodynamic ship bridge design*

**Process Contracting Limited**

*Human Factors Consultancy*

# Ergonomic aspects of an aerodynamic ship bridge design

## City of Rotterdam IMO 9473468

### Report to MAIB

### 04 Feb 2016



Process Contracting Limited
[redacted]
Registered Office:20 Springs Park, Coylton, Ayr KA6 6QQ
Registered in Scotland No SC 191175 VAT Registration No. 724 2067 58

# Summary

The report has been produced to assist the MAIB investigation into an incident involving CITY OF ROTTERDAM. It provides background ergonomics material relating to the bridge design, and to the use of off-axis windows. It provides an examination of the scientific literature around the distorted spatial perception that occurred, and reviews relevant aspects of the unconventional bridge design against regulations and good practice.

Author..............................................................Date.................................................
[redacted] 04 Feb 2016

Version Number................................

## Version history

23 Jan First draft for review of content, scope, approach, main points.
04 Feb Expanded and corrected initial draft.

# Acronyms, abbreviations and definitions

This section provides a number of definitions, with some explanatory material. The definitions from ISO 8468:2007 have been selected to help avoid ambiguity. The definitions relating to spatial orientation are intended to clarify some of the jargon and to give a small amount of introductory explanation.

## 1.1 Acronyms and abbreviations

## 1.2 Selected definitions from ISO 8468:2007

3.1.8
bridge arrangement
location and interrelation of workstations and equipment on the bridge
[Note: IACS Rec. 95 uses equipment arrangement as broadly equivalent to this.]

3.1.9
bridge configuration
shape of the bridge comprising the outer bulkheads and windows of the bridge area
[Note: IACS Rec. 95 uses bridge design as broadly equivalent to this.]

[Note: SOLAS regulations, and various guidance documents use the term 'bridge layout' which seems to encompass both the above terms.]

3.1.12
bridge system
total system for the performance of bridge functions, comprising bridge personnel, technical systems, man-machine interface and procedures.

3.1.14
catwalk
extension to a deck outside the wheelhouse wide enough to allow the safe passage of a person

3.1.17
commanding vision
view without obstructions which would interfere with the operator’s ability to perform his immediate task.

3.1.19
conning position
place in the wheelhouse with a commanding vision and which is used by operators when monitoring and directing the ship’s movements,
NOTE The conning position is frequently at the workstation for navigation and manoeuvring.

3.1.45
primary bridge function
function related to the determination, execution and maintenance of safe course, speed or position of the ship in relation to the waters, traffic or weather conditions.
EXAMPLE Voyage planning functions, navigation functions, collision avoidance functions, manoeuvring functions, docking functions, monitoring of internal safety systems, external and internal communication related to safety in bridge operation and distress situations.

## 1.3 Expanded definitions related to spatial orientation

**Attentional Tunneling**. (Wickens & Alexander [R1])
"We operationally define this construct as the allocation of attention to a particular channel of information, diagnostic hypothesis, or task goal, for a duration that is longer than optimal, given the expected cost of neglecting events on other channels, failing to consider other hypotheses, or failing to perform other tasks. This concept is closely related to what others have referred to as attentional fixation or cognitive tunneling (Prinzel, 2004; Regal, 2000; Stuart, McAnally, & Meehan, 2001). In this regard, attention is assumed to be a commodity that can be either focused on a perceptual channel or a cognitive representation or belief (Wickens & McCarley, 2008). Often these two reinforce each other, as when attention is focused on a perceptual cue or channel with content that supports that particular belief. The preceding definition must include both the forces that "lock the tunnel" to its current channel, as well as a definition of a channel of neglect; that is, the channel that is not attended to (but should be). Such a definition can account for more specific mishaps in a wide variety of circumstances. For example, automobile accidents while drivers are talking on their cell phone can be attributed to "undesirable engagement" in the process of generating and understanding conversations (Horrey & Wickens, 2006; Strayer & Drews, 2007; Strayer, Drews, & Johnston, 2001)."

**Cognitive Tunnelling** (Thomas [R2])
"We define cognitive tunneling as the effect where observers tend to focus attention on information from specific areas of a display to the exclusion of information presented outside of these highly attended areas. Previous research suggests that cognitive tunneling is induced by more immersive or egocentric visual displays and results in poorer information extraction and situation awareness as compared to an exocentric display of the same information. "

**Cost** in the Multiple Resource Theory of Wickens, C.D. (Personal, using examples from Wickens [R3])
Multiple Resource Theory is a fairly simple theory of cognition and action, that proposes a set of finite resources for perception and for action, that need to match availability and task demand. The model has a good match to the data in many experimental settings. In discussing frames of reference, Wickens discusses 'cost' which appears to be the demand on cognitive resources. Examples include: Human performance costs in making transformations between frames of reference, which he terms mental rotation costs, scanning costs, and costs of cognitive integration across planes. When a user compares a forward view of what is actually seen (an ego-reference), with a map view (world reference), to determine if these are congruent, there is an increasing cost as a function of the angular disparity. "to the extent that

the frame of reference defining the axis of control is misaligned with the axis of display, such that some form of mental rotation must take place, there is typically a cost, either in the time to choose which way to tum at a particular tum point (Shepard & Hurwitz, 1984), or in the error measured when "tracking" a desired target course for the controlled vehicle or cursor to follow". 3D displays incur "spawned costs" "The two most serious costs are those of "line of sight ambiguity" and of a "favored orientation". Both of these costs are task dependent."

**Egocentric Frame of reference** (1. Wiktionary [R4] 2. Ruggiero [R5]) – see Figure 1.
1. Relating to spatial representations: linked to a reference frame based on one's own location within the environment (as when giving the direction as "right" rather than "north"); opposed to allocentric.
2. Egocentric frames of reference specify location and orientation with respect to the organism, and include eye, head, and body coordinates... Egocentric representations have a special relevance in controlling movement in surrounding space such as avoiding obstacles or reaching objects. All these actions are performed in near/peripersonal space, i.e. the space within arm-reaching distance and require fine-grained metric information.

**Exocentric or Allocentric Frame of reference** (1. Wiktionary [R4] 2. Ruggiero [R5]) See Figure 1
1. Relating to spatial representations: linked to a reference frame based on the external environment and independent of one's current location in it. For example, giving the direction as "north," as opposed to "right" (egocentric).
2. Allocentric frames of reference specify location and orientation with respect to elements and features of the environment independently of the viewer's position...allocentric representations have an important role in recognizing objects, scenes and planning future movements (i.e. the space outside arm-reaching distance) ...Tasks that seem to require allocentric processing show no evidence in favor of automatic processes ... whereas tasks requiring more egocentric processing highlight the automatic nature of the processes involved

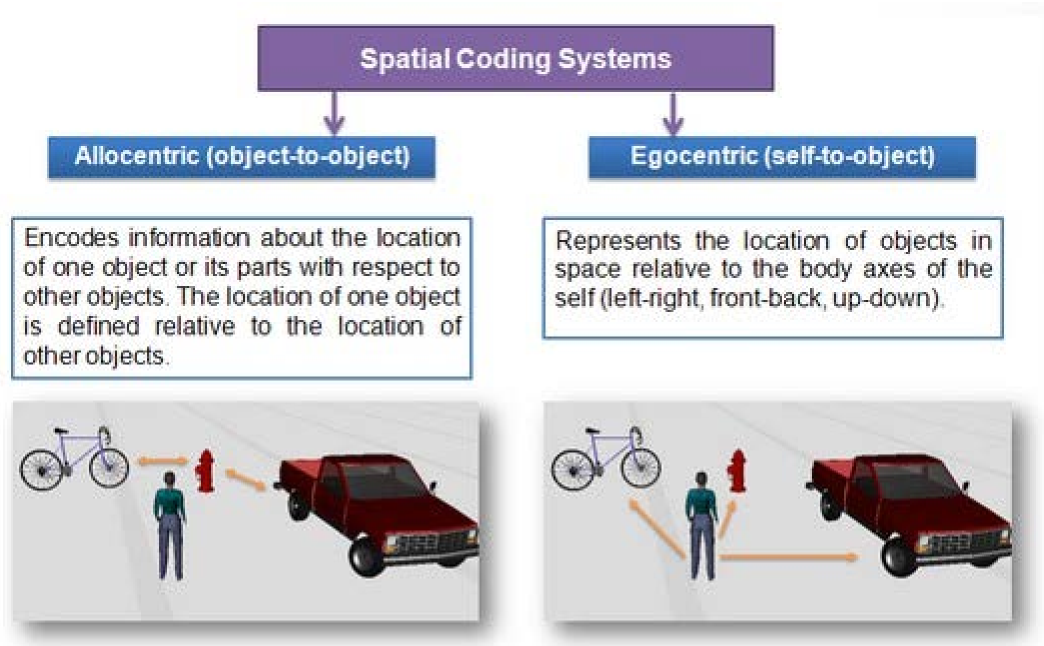



Figure 1 Frames of reference (spatial coding) From [R6]

Frame of reference is discussed in ISO 1503:2008 Spatial orientation and direction of movement -- Ergonomic requirements [R11]

*4.4.4.6 Frame of reference*

*"When a virtual object space (display screen) is placed and viewed within the user's/operator's field of vision, the display frame and its surrounding environment should serve as a frame of reference through*

*which the viewed object is recognized. The movement of an object or several objects in the display frame in one direction can induce the perception of movement of the display frame or viewer themselves in the opposite direction. Care should be taken in the design of the virtual target object space that the frame of reference does not cause unintended effects of motion perception or motion sickness that impede task performance for which the object space is intended."*

*4.4.4.11 Egocentric and exocentric views*

*"If appropriate for the task, user/operator characteristics and/or user/operator preference, egocentric views (i.e. from the user/operator perspective or inside-out) and/or exocentric views (i.e. from an external perspective or outside-in) of the virtual object space, should be provided to users/operators. Users/operators should be able to identify their current view and to choose the preferred view easily and quickly."*

**Field of View**

Diagrams showing field of view are shown below. They are phrased in terms of use of displays rather than windows, but the visual aspects will apply to both.

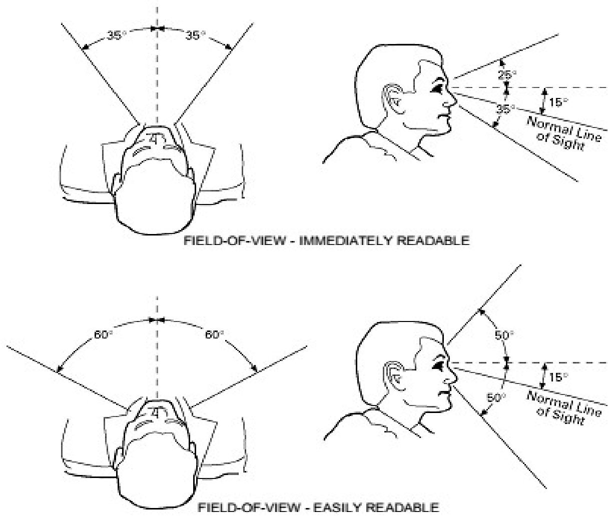
3.3.1 Field-of-View – Primary Displays

Primary displays include those used frequently, those used for obtaining precise readings or those used in emergencies. These should be located within personnel's immediately readable field-of-view as indicated in Figure 2, "Field-of-View".

3.3.2 Field-of-View – Secondary Displays

Secondary displays include those used for normal operations and those not requiring accurate readings. These should be located within personnel's easily readable field-of-view as indicated in Figure 2, "Field-of-View". Reference displays that are used infrequently may be located in an area outside personnel's easily readable field-of-view.

**FIGURE 2**
**Field-of-View***




* Dimensions are based on North American males.

Figure 2 From ABS Guide [R7]

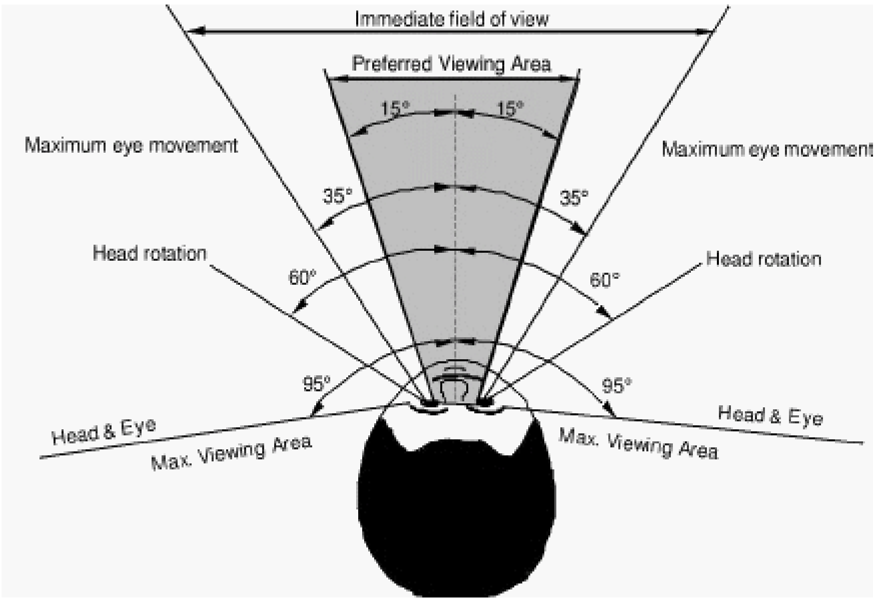
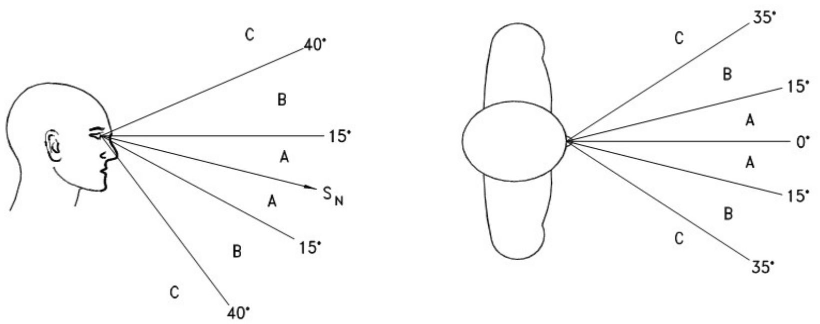



Figure 3 From MSC Circ. 982 [1]

**EN 894-2:1997+A1:2008 (E)**




Vertical field of vision for monitoring

Horizontal field of vision for monitoring

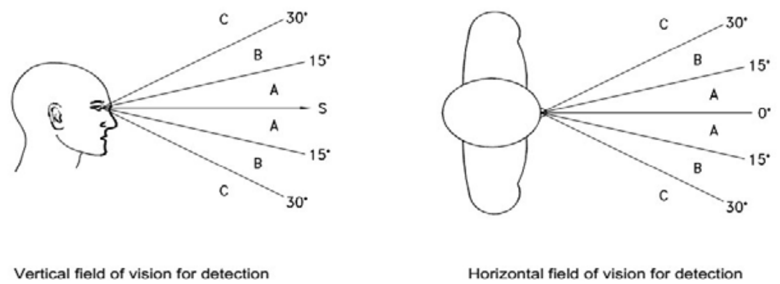
Legend: $S_N$: Normal line of sight, 15° to 30° below the horizontal

**Figure 2 — Monitoring tasks**

Figure 4a From EN 894 [R8]

**Table 1 — Levels of suitability**

| Level of suitability | Significance |
|---|---|
| A: Recommended | This zone shall be used wherever possible |
| B: Acceptable | This zone may be used if the recommended zone cannot be used |
| C: Not suitable | This zone should not be chosen |




Vertical field of vision for detection

Horizontal field of vision for detection

Legend: S: Line of sight, direction is imposed by external task requirements

**Figure 1 — Detection tasks**

Figure 4b From EN 894 [R8]

**Perception/Action model of** Milner & Goodale[R10] (from Ruggiero [R5])
Overall, the two Experiments confirm the primacy of the egocentric frames which represent the primary inter-face between the organism (the body's viewer) and the environment (Millar, 1994). In clarifying some aspects of the perception\action model, Milner and Goodale (2008) hypothesize close link between the egocentric and allocentric processing and the functions of visual streams. The model proposes a distinction between two visual streams: a dorsal stream that processes information useful to control action, and a ventral stream that processes information useful to recognize objects. The ventral stream should transform visual information into allocentric perceptual representations, while the dorsal stream should use on-line information about the egocentric organization of objects.

**Relative Motion Illusion** (also known as vection illusion) (Based on Antuñano [R9])
This illusion happens when the brain interprets peripheral visual information making an individual confused in his/her situation. It refers to the falsely perceived self-motion in relation to the real motion of another object. For example, when stopped at a traffic light in a car, the car next to you edges forward slowly. Vection illusion might occur which an individual might perceive as he/she is rolling backwards and he/she will apply harder on brakes. Such illusion can happen while taxiing an aircraft at an airport .

**Visual illusions**
A key point about visual illusions is that they return in full after being unmasked and explained. This illustrates the likely ineffectiveness of measures to mitigate the distortion of spatial perception when navigating from an off-axis window.
Dan Ariely has shown this effect in his videos: See the start of
https://www.youtube.com/watch?v=5oHIfeCB3z8 or for a fuller demonstration
https://youtu.be/9X68dm92HVI?t=2m28s

# 2. Introduction

This document reports an ergonomic assessment of the bridge design of CITY OF ROTTERDAM. The MAIB accident investigation formed the background to the assessment, but this report does not comment directly on the incident.

The CITY OF ROTTERDAM has an unconventional bridge configuration to reduce wind resistance. The bridge design (e.g. windows, visibility) and arrangement (e.g. consoles, equipment) were examined. The report draws conclusions and makes recommendations as regards the specifics of CITY OF ROTTERDAM and as regards the design and approval of unconventional bridges in general.

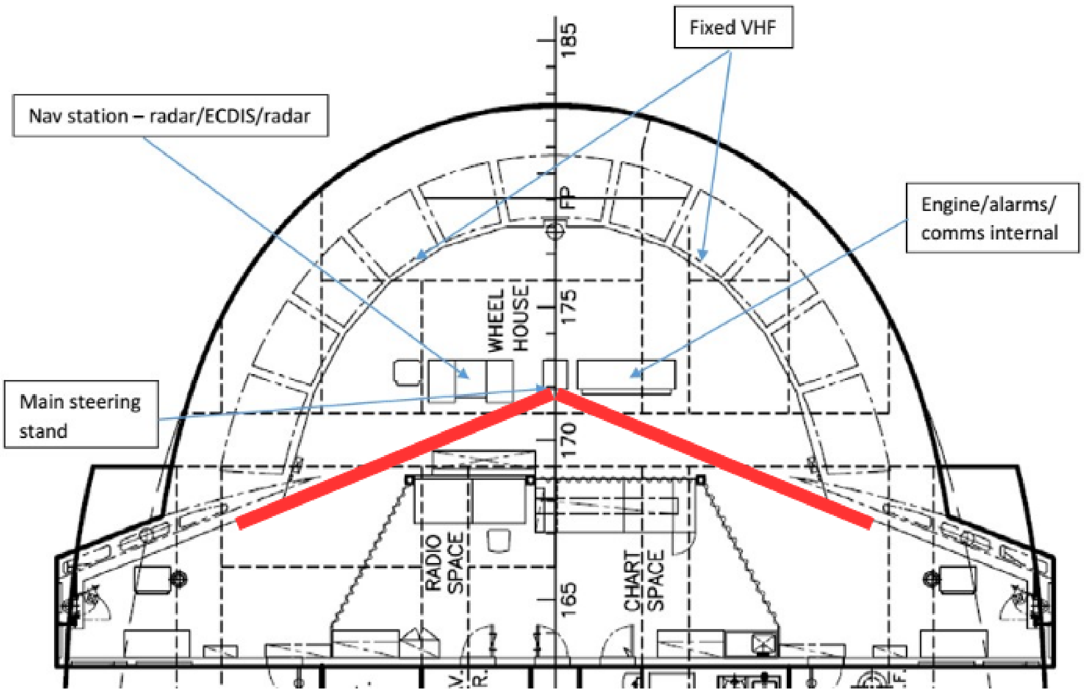



Figure 5. CITY OF ROTTERDAM bridge configuration and arrangement with red lines at 22.5° abaft the beam from the steering stand. Note the positions of the Fixed VHF sets.

The document comprises the following sections:

- Definitions relating to good practice, and extended definitions relating to spatial perception (above.
- This introduction.
- A discussion of the visual illusion experienced on CITY OF ROTTERDAM.
- A summary of the extent to which the bridge configuration and arrangement met regulatory compliance.
- A summary of issues of good practice relating to the bridge configuration and arrangement.
- A discussion of the use of principles and operational design in bridge design.
- Conclusions and recommendations.
- Annexes with tables of compliance against regulations and good practice.
- A note about the author's credentials.
- References, divided into references relating to bridge design [n], and to spatial perception [Rn].

# 3. Relative motion illusion

This section examines an aspect of the CITY OF ROTTERDAM bridge configuration, namely windows that are not aligned to the ship. As can be seen from Figure 5, there are a number of windows that are effectively identical to the operator at different angles relative to the ship, such as the one shown below at Figure 6. The consequences of this design for navigation are discussed.

Figure 6 The off-axis window at a fixed VHF set. (28mm focal length lens from further back than would be the position when using VHF)

## 3.1 The illusion

The effect of standing at an off-axis window is that the observer loses all sense of orientation relative to the ship. Objects in the scene are positioned relative to the observer (an egocentric frame of reference), including relative motion. The consequence of this for navigation is that objects are considered to move as though the ship were headed in the direction of the window.

This section discusses a number of approaches to understanding how the illusion comes about:

- Basic consideration of the field of view and the absence of cues for ship heading.

- Consideration of the cognitive cost of changing from an egocentric frame of reference, using Multiple Resource Theory.
- Consideration of the different streams of visual processing used by vision for action and vision for perception.

The extended definitions section above introduces the terminology.

## 3.2 Field of View, and cues

The size of the window is such that it covers the field of view vertically and horizontally (see Figures 7 and 8 below), based on relevant guidance (see expanded definitions above). Effectively, the field of view is framed by the window framing.

Any items of ship structure within the field of view do not give a clue as to orientation relative to the ship. The VHF set gives a sense of being at a control position, especially at night, which heightens the illusion.

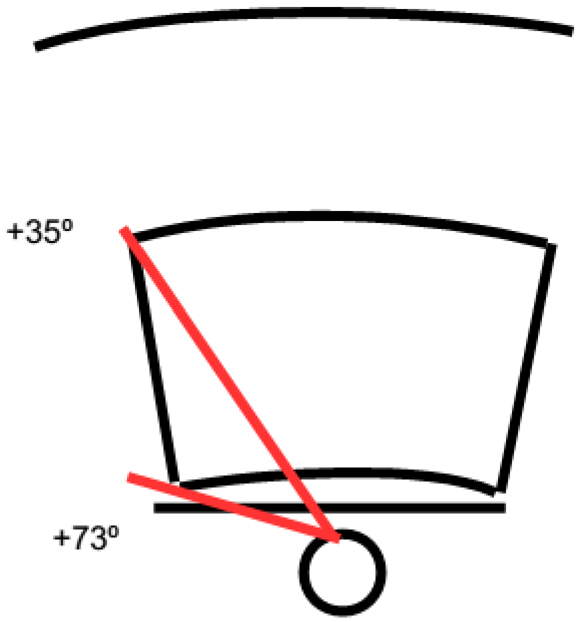



Figure 7. Horizontal field of view through window at fixed VHF.

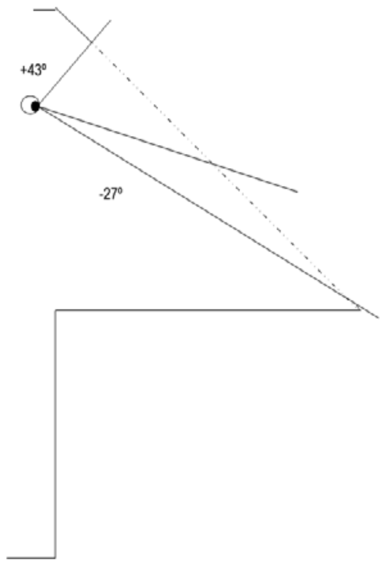



Figure 8. Vertical field of view at window at fixed VHF, showing upper and lower limits, and normal direction of gaze.

The observer's frame of reference becomes aligned with the window ledge, window frame, window glass. The view becomes egocentric, rather than platform-centric (an exocentric frame of reference). The absence of platform-centric cues will allow this view to be maintained.

## 3.3 Cognitive cost of changing frame of reference

The egocentric frame of reference is overwhelmingly the dominant one. In the case of navigators, this is what is normally used when looking out of the windows for ship control and manoeuvring.
There is a cognitive cost in translating between frames of reference.
It would be reasonable to say, from the perspective of Multiple Resource Theory, that an observer looking through a bridge window will adopt an egocentric frame of reference, and would revert to this whenever possible. This could be described as attentional or cognitive tunneling (see expanded definitions).

## 3.4 Vision for action vs. vision for perception

In the normal situation of ship control while looking forward, a navigator is using vision for action, effectively an extension of how we move around ourselves (visually guided locomotion). This is an egocentric frame of reference. The nature of the task (a visual transit, estimating time to collision etc.) is bound to an egocentric frame of reference.

## 3.5 Can the illusion be broken?

The nature of illusions is such that they return immediately after having them broken (see extended definition above). Even with regular reminders, the illusion is likely to return.

It is very unlikely that ship motion would have the effect of overriding the visual illusion; vision normally dominates motion. Perhaps heavy roll could lead to a motion sickness feeling because of the conflict between visual cues and vestibular inputs but this would not be a specific clue to the observer.

In terms of relevant theories, it is very unlikely that the illusion can be broken – certainly not for anything other than a very temporary basis.

## 3.6 Are there remedial measures?

Remedial measures could perhaps be considered in terms of the risk control hierarchy (design-remove-guard-warn-train), in a bottom-up manner.
The current situation is at the bottom of the hierarchy. The Master addresses this problem by not standing at off-axis windows and discouraging his crew from doing so.
Warn: In terms of design it is very hard to see how cues of ship orientation or warnings about being off-axis can be introduced without causing distraction.
Guard: Putting barriers round the off-axis windows would lead to other limitations in ship operation
Remove: removing the need to stand at off-axis windows by moving the VHF sets sounds an effective way of reducing the time at risk.

# 4. Regulatory compliance

This section discusses aspects of regulatory compliance. Tables with specific regulatory requirements against the design are provided at Annex A. The topics discussed in this section are :

- Radio installation.
- Bridge visibility.
- Bridge arrangement.

## 4.1 Radio installation

The locations of the fixed VHF radios do not meet the requirements of SOLAS IV. The interpretation of the SOLAS IV clauses requires some interpretation of operational use, which might require an hour's discussion with pilots and bridge staff. There are situations where hand-held VHF is not adequate, and the fixed VHF needs to be used. Placing the VHF sets by the off-axis windows forces the pilot (or navigator) into an isolated position away from information and communication with the rest of the team (and the illusion discussed above).

## 4.2 Bridge visibility

The unconventional bridge configuration has resulted in a number of shortfalls as regards required visibility from SOLAS V/22.

### 4.2.1 General

The cumulative blind arcs in the fwd. horizontal $180^0$ view is excessive i.e. non-compliant because of the size of the window framing. Vertically, the view does not allow a view of the horizon in heavy seas, because of the distance from the operating positions (e.g. steering stand, Radar/ECDIS console).

The view aft does not provide $360^0$ coverage. The location of the compass repeaters at the bridge wings (see Figure 11. below) means that there is a considerable arc where bearings cannot be taken. Use of CCTV (artificial means in ISO 8468) would ameliorate this considerably.

### 4.2.2 View from navigating, conning positions

The view fwd. from off the centreline is affected by the angling of the window frames. It is difficult to get an accurate perception of ships heading looking straight ahead, and gaze needs to be directed to the centreline. The angling of the window frames also has the effect of making them functionally wider e.g. the time for a pattern of lights to pass a window frame increases.

Figure 9. View fwd. from a navigating position. Note difficulty in establishing the centreline.

The view abaft of the beam is obstructed by the structure of the window frames and stiffeners for the bridge wing windows. This structure is considerably more obscuring than that for a conventional bridge.

Figure 10. view abaft of the beam from the steering stand.

### 4.2.3 View from bridge wings

To obtain a view of the ship's side when berthing, it is necessary to put one's head through the window. See Figure 11. Whether or not this is compliant is arguable.


Figure 11. Operation at the bridge wing when berthing.

#### 4.2.4 Catwalk to maintain visibility

The catwalk, and access to it, appear to be hazardous, and unlekely to be usable with safety. [Note: the report does not include comments made by the crew]

Figure 12. Catwalk and steps

## 4.3 Bridge arrangement

The bridge consoles are all set back a considerable distance from the windows as part of a successful scheme to avoid reflections. The consoles in Figure 2. are (from left to right in the diagram) Radar and ECDIS positions, the steering stand, a console with propulsion controls and indicators. Essential information is presented at the deckhead. The wire in the centre of the fwd. window provides a centreline in the absence of a foremast. At night, reflections of two green LEDs behind the wire can be seen in the window.

### 4.3.1 Pilot facilities

The pilot plug for a portable pilot display is near the centreline compass repeater. As a location, this is not a bad position for the pilot as regards view. However, it puts the pilot a long way from the ship bridge team. It is not possible to see 'essential information' from this position. It is not possible to operate the fixed VHF from this location.

Figure 13. Pilot plug, and centreline compass repeater.

# 5. Use of good practice

This section discusses the findings of an ergonomic assessment of the CITY OF ROTTERDAM bridge against good practice. Tables of the extent of compliance are given at Annex B.

## 5.1 Visibility

There is no practical view of seamanship activities such as mooring, anchoring, from the bridge, limiting the ability of e.g. the Master to supervise.

## 5.2 Bridge arrangement

The workstation concept is the basis of all the good practice guidance. As can be seen in Figure 14 below, the crew is adequately resourced to man the arrangements provided.

Figure 14. Console manning during pilotage

Given the traditional nature of the control consoles, it might be argued that such an approach does not require the workstation concept. Examining the 1973 Code of Practice [5] however, indicates that it was considered good practice then.

# 6. Use of principles and operational design

This section discusses the option of taking a more top-down or functional approach to design and assessment. It makes use of IACS Rec. 95 [2] and SN.1 Circ. 265 [4]. The section uses the tables at Annex B.

## 6.1 Principles

SOLAS Regulation V/15 specifies a set of principles relating to bridge design, design and arrangement of navigational systems and equipment and bridge procedures. The principles are entirely operational and not easy to translate into design requirements. Support for this translation have been made by IMO, with SN.1 Circ.265 [4] , by IACS with Rec. 95 [2], by Lloyd's Register [7], and by the EC Project ATOMOS [8]. The use of such good practice would seem especially important when designing an unconventional bridge.

## 6.2 Operational design

Operational design takes a human-centred approach to ship design, focussed on how the ship will be used, see [9]. The good practice guidance for bridge design places considerable emphasis on the ability to perform bridge functions. Simple, cheap, methods to support design and operational test are available. A design review / walk-through/ talk-through with some crews and pilots, a simple mock-up or line-out evaluation, interviews with crews about operational/ functional requirements would have potentially influenced the ‘decisions’ affected by SOLAS V/15. Such an approach would have highlighted the operational issues concerned with operating under pilotage, and of obtaining an undistorted view during normal watchkeeping, especially in confined waters.

SN.1 Circ. 265 [4] places requirements on the design process at 5.6 and 5.9 (See Annex B).

IACS Rec. 95 [2] does not set out specific design process requirements. However, it does spell out the ‘decisions’ affected, the functions to be considered, the operating conditions to be considered, and the design approach.

# 7. Conclusions

This section draws conclusions about the bridge ergonomics of CITY OF ROTTERDAM, and about the design and approval of unconventional designs.

## 7.1 Bridge visibility

The unconventional design of the bridge structure and windows, aimed at reducing wind resistance, has introduced a number of shortfalls as regards ship visibility.

Shortfalls that appear to be non-compliances against SOLAS V/22 include:

- Total forward blind arcs in the horizontal field of vision from navigating positions.
- Blind arc around 22.5° abaft the beam.
- The view of the horizon is not possible from the steering stand in heavy seas.
- Arguable compliance with view of the ship's side from the bridge wing.
- 360° view from within the bridge is not possible. Taking bearings aft is very limited.

Shortfalls against good practice that affect the safe and effective operation of the ship include:

- The supervision of 'additional functions' such as anchoring, mooring, berthing, is hampered by the lack of visibility. CCTV could go some way to improving it.
- Insofar as it is possible to get close to the windows, this does not improve the view of the sea surface.
- Facilities to maintain visibility e.g. adequate catwalk from which to clean windows, maintain wipers etc.

## 7.2 Bridge arrangement

The radio installation does not meet the requirements of SOLAS IV.

The arrangement of consoles and equipment does not make use of the workstation concept. This makes it very difficult to demonstrate compliance with regulations or good practice.

## 7.3 Design and approval of unconventional designs

The windows do not meet the requirement to be inclined out at the top, and the bridge configuration would be described as 'unconventional'.
It is hard to see that the design meets SOLAS V/22 for unconventional designs "arrangements shall be provided to achieve a level of visibility that is as near as practical" to the regulation, or that it was 'impossible' to meet the regulation. Documentation that would be submitted to meet good practice would show considerable non-compliances.

The guidance for compliance with SOLAS V/15 includes the needs of the pilot and bridge team interaction with the pilot. It is hard to see how this could have been considered in design and approval.

# 8. Recommendations

This section provides recommendations relating to the specific ship, and to the design and approval of unconventional bridge designs.

## 8.1 Specific to CITY OF ROTTERDAM

As regards ship operation, it is recommended that:

- Company documentation reflects the manpower-intensive nature of the design (if it does not do so already).
- Adequate watchkeepers are provided/ continue to be provided within ship manning.
- The hazards of using off-axis windows are recognised in Company documentation.

As regards operation with an embarked pilot

- The hazards of viewing from off-axis windows are stressed.

As regards ship design, it is recommended that:

- A set of facilities for an embarked pilot are provided at a suitable location, including access to fixed VHF.
- Fixed VHF is provided at the conning position.

## 8.2 Unconventional bridge designs

SOLAS V/22 has specific provision for unconventional bridge designs. There is a body of good practice that could be used to support the design and assessment of such designs. It is recommended that Administrations and Classification Societies use such good practice, and that innovations that introduce non-compliance with Regulations are treated with extreme caution.

# 9. Annex A – Compliance tables

The tables in this section

## 9.1 SOLAS IV – Radio installation

| **SOLAS Chapter IV - Radiocommunications - Part C - Ship requirements - Regulation 6 - Radio installations** | **Compliance** |
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| 2. Every radio installation shall:<br>2. be so located as to ensure the greatest possible degree of safety and operational availability; | Very hard to see how compliance could be demonstrated. |
| 3. Control of the VHF radiotelephone channels, required for navigational safety, shall be immediately available on the navigation bridge convenient to the conning position and, where necessary, facilities should be available to permit radiocommunications from the wings of the navigation bridge. Portable VHF equipment may be used to meet the latter provision. | Non-compliant. First function achieved during pilotage by using portable VHF.<br><br>Note: One of the VHF positions on CITY OF ST PETERSBURG had an extended lead, which introduces additional problems. |

## 9.2 SOLAS V/15 – Bridge design

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| 1. All decisions which are made for the purpose of applying the requirements of regulations 19, 22, 24, 25, 27 and 28 and which affect bridge design, the design and arrangement of navigational systems and equipment on the bridge and bridge procedures* shall be taken with the aim of:<br>* Refer to Guidelines on ergonomic criteria for bridge equipment and layout (MSC/Circ.982) and the Performance standards for IBS (resolution MSC.64(67); annex 1); and for INS (resolution MSC.86(70); | Compliance with MSC/Circ. 982 is given at Annex B. |

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| annex 3), as amended by resolution MSC.252(83). | |
| 1.1 facilitating the tasks to be performed by the bridge team and the pilot in making full appraisal of the situation and in navigating the ship safely under all operational conditions;<br>1.2 promoting effective and safe bridge resource management;<br>1.3 enabling the bridge team and the pilot to have convenient and continuous access to essential information which is presented in a clear and unambiguous manner, using standardized symbols and coding systems for controls and displays;<br>1.4 indicating the operational status of automated functions and integrated components, systems and/or sub-systems;<br>1.5 allowing for expeditious, continuous and effective information processing and decision-making by the bridge team and the pilot;<br>1.6 preventing or minimizing excessive or unnecessary work and any conditions or distractions on the bridge which may cause fatigue or interfere with the vigilance of the bridge team and the pilot; and<br>1.7 minimizing the risk of human error and detecting such error if it occurs, through monitoring and alarm systems, in time for the bridge team and the pilot to take appropriate action. | It is not clear what steps were taken to meet these aims. A positive aspect of the design was to avoid reflections in the windows by placing almost all light sources well away from the windows.<br>Compliance with these aims is discussed in Annex B. |

## 9.3 SOLAS V/22 Visibility

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| 1.1 The view of the sea surface from the conning position shall not be obscured by more than two ship lengths, or 500 m, whichever is the less, forward of the bow to 10° on either side under all conditions of draught, trim and deck cargo; | Compliant. Calculation:<br>From photographs of the ship, bridge deck is 23.6 m above the water. From measurement, the bottom of the window is 0.57 + 3.0 + 1.23 m fwd. and 1.0 m above the deck. Gives a view of the sea surface at about 1 ship length or 148 m. |
| 1.2 No blind sector caused by cargo, cargo gear or other obstructions outside of the wheelhouse forward of the beam which obstructs the view of the sea surface as seen | Measured on CITY OF ROTTERDAM<br>Generically the windows are 1340 mm. Spacing between frames is 1540 mm. Without frame thickness, this gives fwd. blind arcs of |

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| from the conning position, shall exceed 10°. The total arc of blind sectors shall not exceed 20°. The clear sectors between blind sectors shall be at least 5°. However, in the view described in .1, each individual blind sector shall not exceed 5°; | 23°.<br>Measured on CITY OF ST PETERSBURG Window width at VHF position 1.60 m, with frame of 110 – 120 mm either side.<br>I cannot explain differences in measurement. Examining pictures of the two bridges, it is not clear that they have different framing.<br>Calculation; Radius from steering stand = 0.57 + 3.0 + .6 (say)<br>Framing = 10 frames of 2 x .11<br>Percentage blind arc = 16.7%<br>The window frames are not vertical from most viewing positions (see Figure 9). This has the effect of increasing their obstruction. Consider a transiting set of navigation lights; the time between seeing a complete set in one window and it reappearing in the next has increased significantly. The acute angle corners have the effect of providing only a keyhole view into that part of the external scene, which must reduce its usefulness. |
| 1.3 The horizontal field of vision from the conning position shall extend over an arc of not less than 225°, that is from right ahead to not less than 22.5°, abaft the beam on either side of the ship; | Additional blind arcs fwd. of 225°, shown in Figure 10. |
| 1.4 From each bridge wing the horizontal field of vision shall extend over an arc at least 225°, that is from at least 45° on the opposite bow through right ahead and then from right ahead to right astern through 180° on the same side of the ship; | Non-compliant (but see MSC1//Circ. 1350 below). |
| 1.5 From the main steering position the horizontal field of vision shall extend over an arc from right ahead to at least 60° on each side of the ship; | Compliant: no obstructions (e.g. cranes) – just window frames. |
| 1.6 The ship's side shall be visible from the bridge wing; | Non-compliant (but see MSC1//Circ. 1350 below). |
| 1.7 The height of the lower edge of the navigation bridge front windows above the bridge deck shall be kept as low as possible. In no case shall the lower edge present an obstruction to the forward view as described in this regulation; | Compliant cf. 1.1 |
| 1.8 The upper edge of the navigation bridge front windows shall allow a forward | Compliance is arguable here because of the distance from the steering stand. |

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| view of the horizon, for a person with a height of eye of 1,800 mm above the bridge deck at the conning position, when the ship is pitching in heavy seas. The Administration, if satisfied that a 1,800 mm height of eye is unreasonable and impractical, may allow reduction of the height of eye but not less than 1,600 mm; | The top edge of the window is 2.05 m above the deck at 0.57 + 3.0 + 0.16 (est.)<br>For an eye height of 1.8 m this only allows 3.8° downward pitching. For an eye height of 1.6 m, it allows 6.9° downward pitching. |
| 1.9 Windows shall meet the following requirements:<br>1.9.1 To help avoid reflections, the bridge front windows shall be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°.<br>1.9.2 Framing between navigation bridge windows shall be kept to a minimum and not be installed immediately forward of any work station.<br>1.9.3 Polarised and tinted windows shall not be fitted.<br>1.9.4 A clear view through at least two of the navigation bridge front windows and, depending on the bridge configuration, an additional number of clear-view windows shall be provided at all times, regardless of weather conditions. | 1.9.1 Non-compliant. Arrangement has taken steps to avoid reflections.<br>1.9.2 Framing significant.<br>1.9.4 Heaters added as retro-fit as way of meeting functional requirements of ice class. |
| MSC.1/Circ.1350 UNIFIED INTERPRETATIONS OF SOLAS CHAPTER V 1 The requirements of SOLAS regulation V/22.1.6 are accomplished when:<br>.1 a view from the bridge wing plus a distance corresponding to a reasonable and safe distance of a seafarer leaning over the side of the bridge wing, which needs not to be more than 400 mm, to the location vertically right under the maximum beam of the ship at the lowest seagoing draught is not obscured; or<br>.2 the sea surface at the lowest seagoing draught and with a transverse distance of 500 mm and more from the maximum beam throughout the ship's length is visible from the side of the bridge wing.<br>(See Figure 15.) | Because the bridge wings are enclosed, it is not possible to lean over the side of the bridge wing, but would involve sticking one's head through a bridge wing window. Compliance is arguable. See Figure 15. |

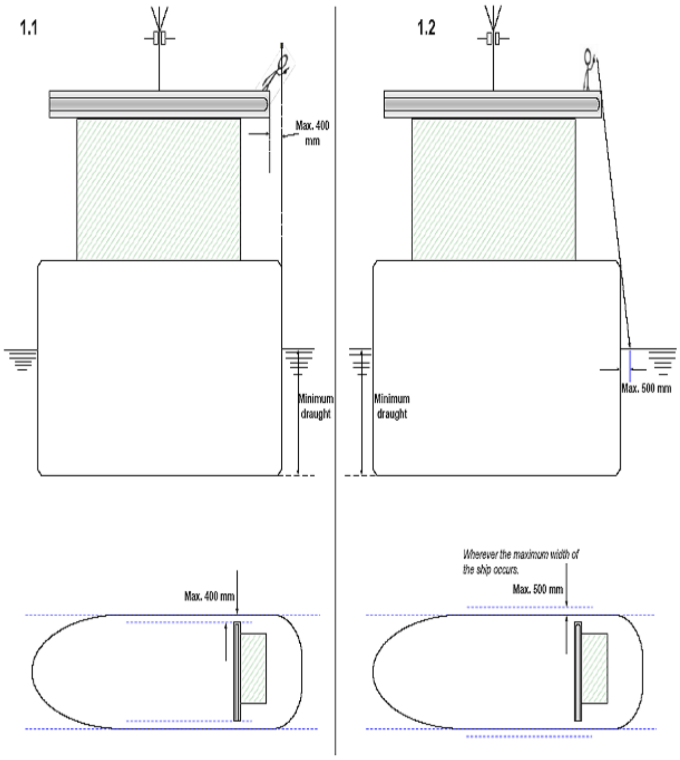


Figure 15.Figure from MSC.1/Circ.1350

# 10. Annex B – Good practice tables

The tables below show selected items of good practice, related to the issues involved with CITY OF ROTTERDAM. Repetition has been avoided where possible.

## 10.1 MSC Circ. 982

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| Workstation for navigating and manoeuvring:<br>Main workstation for ship's handling conceived for working in seated/standing position with optimum visibility and integrated presentation of information and operating equipment to control and consider ship's movement. It should be possible from this place to operate the ship safely, in particular when a fast sequence of actions is required. | The bridge does not adopt a workstation concept. |
| Workstation for monitoring:<br>Workstation from which operating equipment and surrounding environment can be permanently observed in seated / standing position; when several crew members are working on the bridge it serves for relieving the navigator at the workstation for navigating and manoeuvring and/or for carrying out control and advisory functions by master and/or pilot. | The bridge does not adopt a workstation concept. |
| Workstation for manual steering (Helmsman's workstation):<br>Workstation from which the ship can be steered by a helmsman as far as legally or otherwise required or deemed to be necessary, preferably conceived for working in seated position. | A standing steering position on the centreline is provided. |
| Workstation for docking (bridge wing):<br>The workstation for docking operations on the bridge wing should enable the navigator | Bridge wing consoles are provided. The configuration means that control is not possible for a single person looking out of a |

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| together with a pilot (when present) to observe all relevant external and internal information and control the manoeuvring of the ship. | side window. Operation by the navigator and pilot is possible, see Figure 11. When pilot not present, operation would require the navigator plus an additional watchkeeper. |
| 5.1.1.1.2 Field of Vision around the Ship<br>There should be a field of vision around the vessel of 360° obtained by an observer moving within the confines of the wheelhouse. | Not fully compliant. At the stbd. bridge wing, it is possible to see past the centre line aft. At the port bridge wing, the funnel is an obstacle. |
| 5.1.1.1.3 Navigating and Manoeuvring Workstation<br>The horizontal field of vision from the navigating and manoeuvring workstation should extend over an arc of not less than 225°, that is from right ahead to not less than 22.5°, abaft the beam on either side of the ship. | This visibility is arguably possible from the steering stand but not from the radars, ECDIS, or propulsion control. |
| 5.1.1.1.4 Monitoring Workstation<br>From the monitoring workstation, the field of vision should extend at least over an arc from 90° on the port bow, through forward, to 22.5° abaft the beam on starboard. | This is arguably achievable from the radars, ECDIS, or propulsion control. |
| 5.1.1.2.5 Rear and Side Window Inclination<br>To help avoid reflections, rear and side windows should be inclined from the vertical plane top out, at an angle of not less than 10° and not more than 25°. Exceptions can be made for windows in bridge wing doors. | Not compliant. |
| 5.1.2.1 Wheelhouse Dimensions<br>The clear ceiling height in the wheelhouse should be designed with regard to the installation of overhead panels and devices. The clear height between the bridge deck surface covering and the underside of the deck head beams should be at least 2.25 m. The lower edge of deckhead mounted equipment should be at least 2.1 m above the deck in open areas, passageways and at standing workstations. | Clear ceiling height around the edges of the bridge (away from the central area) is 2.18 m. (Operationally not a significant difference). Deckhead with fiddle boards is at a higher level. |
| 5.1.2.3 Position of the Workstation for Navigating and Manoeuvring<br>The workstation for navigating and manoeuvring should be laid out if practicable, at the starboard side close to the centre-line. | N/A so not compliant. |

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| 5.1.2.5 Position of the Workstation for Monitoring<br>The workstation for monitoring should be laid out if practicable, at the port side close to the<br>centre-line. | N/A so not compliant. |
| 5.1.3.2 Adjacent Workstation Distances<br>The distance between adjacent workstations should be sufficient to allow unobstructed passage to<br>persons not working at the stations.<br>The free passage in passageways between different workstation areas should be at least 700 mm. The workstation operating area should be part of the workstation not of the passageway. | Gap between Radar/ECDIS console and the steering stand is 670 mm. Gap between steering stand and other console smaller, not passable. |
| APPENDIX 2<br>PROPOSED EQUIPMENT FOR WORKSTATIONS<br>Workstation for navigating and manoeuvring | N/A so not compliant. |
| Workstation for monitoring | N/A so not compliant. |
| Workstation for manual steering (helmsman's)<br>steering wheel / steering lever<br>• rudder pump selector switch<br>• indications for<br>* gyro compass heading<br>* magnetic compass heading<br>* pre-set heading<br>* rudder angle<br>* rate of turn<br>• talkback to bridge wing workstation<br>• controls for windscreen wiper, washer, heater | No windscreen wash, wipe, heat, controls. |
| Workstation for docking (bridge wing)<br>controls for main engine(s)<br>• controls for thruster<br>• controls for rudder<br>• controls for whistle<br>• steering position selector switch<br>• indications for<br>* gyro compass heading<br>* propeller revolutions<br>* main engine revolution in the case of reduction geared engine<br>* propeller pitch in the case of controllable | No fixed VHF. |

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| pitch propeller<br>* lateral thrust<br>* rate-of-turn<br>* rudder angle<br>* longitudinal and lateral movement of ship<br>* wind direction and velocity<br>• talkback system to the workstations navigating and manoeuvring, monitoring, manual steering, and to manoeuvring stations, except muster stations<br>• system for external communication with tugs, pilot boat (VHF point)<br>• controls for morse lamp and searchlight<br>• acknowledgement of watch alarm | |

## 10.2 IACS Rec. 95

**Bridge design**

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| B 5.5.1 A workstation for monitoring located close to the forward centre window, not required by the ship's personnel during pilotage may serve as the conning position specified in B 5.5.<br>Note:<br>a) The Panama Canal Commission (PCC) requires that the conning position be located "directly behind and next to" the centre front window and the nearest window thereto on each side that provides a clear and unobstructed view ahead for conning during canal transit. A minimum of 1 metre clearance from consoles or obstructions should be provided. Special requests for relaxation of this requirement may be considered on a case-by-case basis.<br>b) PCC requires that the conning position shall provide a view of the sea surface forward of the bow from 1.5 ship's length when at ballast load line and 1 ship's length at full load line. | The location of the pilot plug is compliant with this. However, at this position, it is not possible to see the essential information on the fiddle boards. |
| B 5.8.1 The total arc of additional blind sectors between the beam and 22.5° abaft the beam on either side should not exceed 10°, allowing a total of 30° within the required total field of vision of 225°. To ensure a total field of vision of 225° for proper look-out and | Depending on the location selected for the conning position, it would appear that the clear 5° sector has not been provided. In addition, the blind arc of the structure for the bridge wing windows would appear to be about 7°. |

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| safe conning, a clear sector of at least 5° shall extend from 22.5º abaft the beam and forward on either side of the ship. See also B 5.5. | |
| B 7.8 The bridge design should permit installation of chairs allowing operations in both seated and standing working positions at dedicated workstations without degrading the required navigation visibility, even if the newbuilding is not to be equipped with chairs at the time of delivery. | Consoles are really designed for standing operation. Seated operation would probably not provide adequate visibility. |
| B 5.3.1 Guidance note:<br>On a bridge with enclosed bridge wings it should be possible to obtain the view of 360˚ from inside the bridge area by using two positions, one on each side of the workstation for navigating and manoeuvring, not being more than 15 m apart. This guideline may also be applicable for providing the required field of vision within the confines of wheelhouses with a total breath of more than 18 metres. | Something approaching a 360˚ view can be only obtained at the edges of the bridge wings. |
| B 5.4 Guidance note:<br>In general, it should be possible to achieve the view required forward of the bow from a sitting eye height of 1400 mm. If this is found unreasonable due to constructional matters related to carriage of cargo, a standing eye height as specified in B 6.3 may be accepted. See also B 7.8. | Unlikely to be compliant with the 1400 mm guidance. |

**Design process**
The author has no data on the design process used for CITY OF ROTTERDAM. The items selected here raise issues for the design process of unconventional bridges.

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| Annex B 2.1 ...Harmonization of decisions to be made for the purpose of applying SOLAS regulations V/19 and 22 is needed in order to safeguard that common aims are fully met by both regulations for the benefit of the user and safety of navigation. | The design process needs to make decisions that support V/15. Resolving any differences between V/22 and V/19 is part of this. The bridge configuration and arrangement have had some steps made to accommodate each other, but it is hard to see that either have been done well. |
| Annex B 3.1.4 Bridge design criteria – Overall requirements<br>The overall design requirement is to enable | It is very hard to see how this has been achieved during design, given the measures taken operationally. |

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| efficient and safe performance by the officer in charge of the navigational watch as well as by two navigators in close co-operation, the pilot and any other identified member of the bridge team who may be allocated specific functions and tasks. Furthermore, that the bridge layout, including location of workstations and outfitting, enables effective and safe bridge team management. | |
| Annex B 3.3 Bridge functions<br>Navigation functions, meaning the groups of tasks, duties and responsibilities necessary for safe bridge operation are basically the same for all ships. They are related to planning of the route prior to departure, keeping the ship on the course along the planned route from departure to destination, deviating from the route and adjusting speed for avoidance of collision and heavy weather damage while under way, and harbour manoeuvring.<br>Additional functions may include extended monitoring of machinery and domestic systems, tasks related to the carriage of different types of cargo and radio operations, or other relevant functions, all of which are regarded secondary to navigation functions if not carried out by a person additional to the officer of the watch. | Additional functions are problematic, and could have been improved with CCTV. Such functions include berthing, mooring, anchoring. |
| 3.4 The workstation concept<br>A workstation should provide all basic information required and controls needed for safe performance of the function dedicated the workstation. The different workstations should be arranged and located for efficient co-operation by any number of a bridge team.<br>3.4.1 The workstation concept to be used on all SOLAS regulation V/15 bridges<br>The principles of the workstation concept are similar for all ships irrespective of ship types and sizes, operational conditions and methods of navigation. Should the special purpose of a ship cause a need to deviate from regular performance of navigation functions and bridge team management, the operational procedures need to be reviewed | The workstation concept is strongly supported in guidance. |

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| in relation to the bridge layout drawings. Ice-breaking,<br>bow-mooring and dynamic positioning system may be some examples of special primary functions. | |
| 3.9 Compliance at the time of delivery of the ship - Responsibility of the shipbuilder<br>It is regarded the responsibility of the shipbuilder to deliver the ship with valid certificates ascertaining that the ship is "seaworthy". This includes verification of compliance with SOLAS regulations V/ 19 and 22, based on a specification agreed to by the owners and the shipyard taking into account the aims of regulation 15 and location of equipment for the purpose of simplifying procedures related to SOLAS regulations V/24, 25, 27 and 28. | It is hard to envisage how the verification process was carried out. |

**Approval**

The author has no data on what was submitted. Issues with compliance with the specified documentation are discussed.

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| A 6 Documentation to be submitted by the ship builder for approval<br>A 6.1 Fields of vision drawings showing:<br>a) The overall horizontal field of vision from inside the wheelhouse (see B 5.4) and workstations for navigating and manoeuvring, monitoring, docking, manual steering and conning and any other workstation to be used by navigators. The drawings should include the arc of individual blind sectors and the sum of blind sectors forward of the beam and similar for the arc of 22.5° abaft the beam on either side of the ship.<br>b) The vertical field of vision over the bow under most unfavourable conditions of draught, trim and deck cargo seen from the conning station and workstations for monitoring and for navigating and manoeuvring. The drawing(s) should include the line of sight under the upper edge of the window from standing working position at the workstation and over the lower edge of the front window from sitting position if | The documentation specified here would show considerable non-compliances for each of a), b), and c). |

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| applicable.<br>c) Window arrangement, including inclination, dimensions, framing and height of lower and upper edge above bridge deck surface and the height of the deckhead. | |
| A 6.2 Bridge layout drawings showing:<br>a) The bridge layout, including the configuration and location of all bridge workstations, including workstations for additional bridge functions.<br>b) Configuration and dimensions of workstation consoles including console foundations.<br>A 6.2.1 Drawing of the chair with indication of min. and max. seat heights above the bridge deck surface should be submitted if chairs are to be installed for use at workstation consoles. See B 7.3.1. | The non-use of the workstation concept would give difficulties in presenting the information required. |
| A 8 Documentation to be submitted by the ship owners<br>A 8.1 Ship specific bridge procedures should be included in the ship's management plan, available on the bridge for ISM certification, covering:<br>- distribution of bridge functions and tasks (see B 1);<br>- manning and training requirements on the bridge at identified operating conditions, taking into account the requirements in B 1 and D 1;<br>- familiarization schemes applicable for bridge personnel as required by STCW, SOLAS<br>regulation I/14, para. 1.4;<br>- the use of the heading and/or track control system, operation of steering gear, updating of nautical charts and recording of navigational activities proving compliance with SOLAS regulations V/24, 25, 27 and 28. | |
| A 8.2 If outfitting and location of workstations and bridge team management do not conform to the principles and requirements set forth in this Recommendation, the ship owner or operator should provide the builder with information describing bridge functions and operational procedures, including bridge team | It would be reasonable to expect procedures to be submitted that address the issues arising from off-axis windows. |

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| management during different operational conditions (see D 1.1), which is to be included in the documentation required in A 6.2 and A 6.3 (See also A 6.9).<br>Note:<br>When required, the owner or operator should ensure that this information is provided in the context of the building specification. See Note to A 6.9. | |
| A 8.4 If operational procedures are required to compensate for accepted technical solutions interfering with the functionality of the bridge, such procedures should be included in the ship's specific procedures for bridge operations. (See A 6.6). | It would be reasonable to expect procedures to be submitted that address the issues arising from off-axis windows. |

## 10.3 ISO 8468:2007

The table below starts with MCA Guidance for SOLAS V/22, which calls up ISO 8468. The table continues with selected clauses.

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| MCA Guidance for SOLAS V/22: 3. For the purposes of the Regulation, the meaning of the term 'conning position' is taken to be the same as that defined in BS EN ISO 8468:1995 "Ship's Bridge Layout and Equipment - Requirements and Guidelines" i.e. a place on the bridge with a commanding view and which is used by navigators when commanding, manoeuvring and controlling a ship. | |
| MCA Guidance for SOLAS V/22: 6. Para 1.9.4 requires a clear view regardless of weather conditions through at least two windows. Further guidance on the use of windscreen wipers etc. is given in ISO 8468 (Ship's Bridge Layout and Associated Equipment - Requirements and Guidelines) | |
| MCA Guidance for SOLAS V/15: 10.<br><br>The MCA considers that MSC. Circ/982 is intended for guidance and documentation is not required to verify compliance with individual guidelines. However compliance is required with the international standards given in Appendix 3 of MSC.Circ/982. For | Note: The two ISO standards have now been merged into an updated ISO 8468. |

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| plan approval of bridge design compliance should be demonstrated with:<br><br>ISO 8468 (Ships Bridge Layout and Associated Equipment Requirements and Guidelines,) and if applicable<br>ISO 14642 (Ships and Marine Technology Ships Bridge Layout and associated Equipment additional requirements.) | |
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| 4.2.1.4<br>Guidelines:<br>There should be close physical access to at least one front window. The width of the close access should be sufficient to accommodate two persons. | 'Close access' was intended, I think, to provide a wider view e.g. of the sea surface. This is not possible with the windows angled in. |
| 4.2.3.7<br>Guidelines:<br>The height of the upper edge of front windows above the deck should be as high as practicable and at least allow a forward view of the horizon when the bow is 10o below its position on even keel. The minimum height of the upper edge of front windows above the deck surface should be 2 000 mm. See figure 4. | Non-compliant, see Annex A, SOLAS V/22 1.8 |
| 4.2.3.9<br>From the workstations for navigating and manoeuvring it shall be possible to use lights or marks in line astern of the ship as reference for steering the ship.<br>4.2.3.10<br>Guidelines:<br>The horizontal field of vision astern as seen from the workstations for navigating and manoeuvring should extend over an arc from dead astern to at least 5° to each side. See figures 6 and 7.<br>Artificial means approved for this purpose may be used to achieve the proper view. Artificial means should be sufficiently dependable. Their ability to perform assigned tasks in a usable manner and in all conditions should be assured. Artificial means should be assessed at a system level | Non-compliant. No artificial means (i.e. CCTV). |

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| e.g. including lighting, camera controls, and wiper. | |
| 4.3.2<br>Guidelines :<br>Windows, especially on the centre-line, should be as wide as possible. The divisions between front windows should not exceed 150 mm. If stiffeners are used, divisions should not exceed 100 mm in width and 120 mm in depth.<br>Note: The window frame width is designed based on the size of the ship, service area and material of the structure and windows. | Non-compliant. Divisions between front windows over 200 mm. Stiffeners 150 mm deep. |

## 10.4 SN.1/Circ. 265

The need to operate the fixed VHF from the positions by off-axis windows is a non-compliance with each of the requirements listed below, and so is identified here rather than repeated.

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| 4.1 The system should facilitate the tasks to be performed by the bridge team and pilot in navigating the ship safely under all operational conditions. The physical arrangement of the systems on the bridge and presentation of information should permit observation or monitoring by all members of the bridge team and pilot. | |
| 4.3 The system and its physical arrangement should facilitate the bridge team and pilot in maintaining a full appraisal of the situation by both observing information provided by the system and validating that information by actual observation of the surrounding environment. | |
| 4.4 The system and its physical arrangement should promote safe and effective exchange of information amongst the members of the bridge team and with pilots | Does not succeed in achieving information exchange with pilots. |
| 5.2 Recognizing that the bridge team and pilot are required to use 'any means available' to safely navigate the ship including visual position fixing and lookout as well as communications with external sources of information such as other traffic and VTS stations, the design of the system should therefore support the use of all means | |

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| and their correlation. | |
| 5.3 The system and its physical arrangement should enable the bridge team and pilot to conn (i.e., direct the movement of) the ship by verbal instructions from any position on the bridge while still having access to heading, rudder or azipod angle, and propeller RPM or pitch and, if available, rate-of-turn information. | Not compliant from fwd. compass repeater / pilot plug. |
| 5.6 The workload involved in navigation tasks employing the system should be analysed and tested during the design phase. Complex or error-prone interaction with the system should be avoided in its design. | It is hard to accept that workload and interaction during pilotage was considered. |
| 5.8 The system and its physical arrangement should support team working, including the assignment of tasks among the bridge team and pilot. | Operation needs a sizeable team. The arrangements for the pilot do not support team working. |
| 5.9 All navigation and watch keeping tasks required by the STCW, SOLAS, and COLREGs, as appropriate, should be considered in the system design phase. The usability of the system and its arrangement, when employed for such tasks should be assessed during functional and operational analysis and tests. | It is hard to see that this was done during design. Speculatively, one could reverse engineer the design to Japanese coastal waters, where it might be a better fit. |
| 7.1 The system and its physical arrangement should facilitate effective lookout by visual, audible and electronic means under all conditions. | It is hard to argue this has been met. The large distances, the restrictions on external view impose limitations on effective lookout. (Similar criticism could be made of e.g. large container ships). |
| 7.2 The system and its physical arrangement should provide means to acquire and maintain timely and accurate situational awareness of current and projected traffic conditions. | Standing near the Radar/ECDIS console, this is possible. |
| 8.1 The system and its physical arrangement should provide convenient and continuous access to essential information such as heading, rudder or azipod angle, and propeller RPM or pitch and, if available, rate-of-turn for both the bridge team and the pilot to information necessary for the safe navigation. If any auxiliary or separate console or workstation is provided for the | Essential information widely available, inc. audible rate of turn.<br>However, essential information not visible from fwd. compass repeater position with pilot plug. |

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| pilot, it should provide the same quality and quantity of navigation information needed by the pilot as the main console or workstation. | |

## 10.5 Code of Practice for Ships Bridge Design

This Code of Practice dates to 1973 (approx..). It was consulted to see if guidance for conventional bridges adopted the workstation concept, or whether there was an assessment framework that pre-dated it. The Code of Practice adopted the workstation concept, as shown by the following extracts:
Workstation Definition
C125 A workstation is defined, for the purpose of this Code, as a position at which one, or a number of tasks constituting a particular activity, are carried out.
C126 Specific workstations are required for the following distinct activities, an equipment list for each workstation is shown in the corresponding tables.
C127 Navigation workstation - for normal navigating and watchkeeping
…
C128 Collision avoidance - for close quarter, berthing and restricted waters operation.
…
C129 The group alarm facility is intended as a central indication of an alarm condition.
…
C130 Manual Steering - supervised steering primarily for berthing and pilotage.
C131 Where the position of the bridge precludes the use of a normal steering post on the bow then the helmsman should be provided with a display of angular movement of ship's head or a line of sight mark on the ship's forward structure or on the window (See paragraph A312)
C132 Back-up services monitoring- for system control and indication, to back-up normal and emergency ship operation
…
C133 Voyage preparation and other paperwork charts, voyage planning, route changes and associated paperwork.
…
C134 Wing -berthing, restricted waters and lookout station.
…
C135 Bearing repeaters should be sited as to allow bearings to be taken off the bow and stern (See paragraph Al17)

## 10.6 SOLAS V/22 Unconventional design

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| 3. On ships of unconventional design which, in the opinion of the Administration, cannot comply with this regulation, arrangements shall be provided to achieve a level of visibility that is as near as practical to that prescribed in this regulation. | The 'cannot comply' has been answered by the yard itself, with its boxship design, which has bridge windows angled out at the top, and – it would appear – bridge wings that extend further out. See Figure 16.<br>The internal bridge arrangement has not been seen, but a more conventional arrangement would be possible. |

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| MCA Guidance: 7. Paragraph 3 covers ships of "unconventional design". This should be taken to mean ships of such a design that fixed structures or equipment, or the position of the bridge, renders it impossible to comply fully with the provisions of this Regulation. In such cases the MCA must be consulted in order to assess the alternative arrangements which have to be provided to comply with this paragraph. | The process of approving the unconventional design of CITY OF ROTTERDAM has not been seen. One would expect that 'impossible to comply' would be challenged, and that Flag would be provided with evidence that the alternative arrangements comply in operational practice e.g. against SOLAS V/15. |

Figure 16. Boxship design from the same shipyard as CITY OF ROTTERDAM

# 11. About the author

[redacted]

[redacted]

[redacted]

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# 12. References

## 12.1 Good practice

The following good practice was selected on the basis of relevance to the investigation.

1. MSC Circ. 982 Guidelines on Ergonomic Criteria for Bridge Equipment and Layout 20 December 2000
2. IACS Rec. 95 Recommendation for the Application of SOLAS Regulation V/15 Bridge Design, Equipment Arrangement and Procedures (BDEAP)(Oct 2007) (Corr.1 Mar 2009) (Corr.2 July 2011)
3. ISO 8468:2007 Ships and marine technology - Ship's bridge layout and associated equipment - Requirements and guidelines
4. SN.1/Circ. 265 Guidelines on the Application of SOLAS Regulation V/15 to INS, IBS and Bridge Design 19 October 2007
5. Code of Practice for Ships Bridge Design, Dept. Trade & Industry, 1973.
6. MSC.1/Circ.1350 Unified Interpretations of SOLAS Chapter V 1 June 2010

The following is an example of contemporary good practice, but would not have been used in design and approval of CITY OF ROTTERDAM:

7. Guidance for Ship Control Centres (SCC) on the Bridge, Lloyd's Register SKU/MTESGSCCB/14 22nd July 2014
8. The ATOMOS checklists:
HE00070 - SOLAS Regulation V/15 1 SHORT FORM TEMPLATE FOR MINOR CHANGE
HE00075 - ATOMOS IV Regulation 15 Template – Pocket Card
HE00080 - ATOMOS IV Regulation 15 Template – Short Form for minor change
HE00085-ATOMOS IV SOLAS Regulation V/15 Template 2013 Retrofit and Newbuild
HE00130 - ATOMOS IV REVISION WP8.5 RATIONALE FOR SOLAS REGULATION V/15 TEMPLATE
9. 'Improving Ship Operational Design' 2nd Edn. London, The Nautical Institute, 2015.

## 12.2 References related to the illusion

R1. Wickens, C.D., Alexander, A.L. Attentional Tunneling and Task Management in Synthetic Vision Displays The International Journal of Aviation Psychology, 19(2), 182–199
ISSN: ISSN 1050-8414 print / 1532-7108 online
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http://miwalab.cog.human.nagoya-u.ac.jp/database/paper/2012-03-05.pdf
R2. Thomas, L.C., Wickens, C.D., Visual Displays and Cognitive Tunneling: Frames of Reference Effects on Spatial Judgments and Change Detection. Proceedings of the 45th

Annual Meeting of the Human Factors and Ergonomics Society. Santa Monica, CA: Human Factors & Ergonomics Society. 2001.
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http://www.aviation.illinois.edu/avimain/papers/research/pub_pdfs/chapters/Design%20Applications%20of%20Visual%20Spatial%20thinking.pdf
R4. Wiktionary https://en.wiktionary.org/wiki/allocentric and https://en.wiktionary.org/wiki/egocentric
R5. Ruggiero, G., Iachini, T., Ruotolo F., et al In: Spatial Memory: Visuospatial Processes… ISBN: 978-1-61668-139-5Editors: Jacob B. Thomas © 2009 Nova Science Publishers, Inc.
R6. Mental Imagery and Human-Computer Interaction Lab, Harvard University http://www.nmr.mgh.harvard.edu/mkozhevnlab/?page_id=308
R7. Guidance Notes on the Application of Ergonomics to Marine Systems, ABS, April 2003
R8. EN 894-2:1997+A1:2008 Safety of machinery - Ergonomics requirements for the design of displays and control actuators - Part 2: Displays
R9. Antuñano, M.J. Spatial Disorientation Visual Illusions FAA Publication AM-400-00/1 (rev. 2/11) http://www.faa.gov/pilots/safety/pilotsafetybrochures/media/SpatialD_VisIllus.pdf
The primary reference for the Perception/Action model is:
R10. Milner, A. D. & Goodale, M. A. (1995). The visual brain in action. Oxford: Oxford University Press.
R11. ISO 1503:2008 Spatial orientation and direction of movement -- Ergonomic requirements

**Annex C**

Extract from Fairmont Shipping (Canada) Limited Investigation Report

[redacted]

<u>**Preventive Measures to Avoid Recurrence of such Accidents**</u>:

1) Monitor vessels positions though the channel frequently and adjust courses promptly to ensure that the vessel maintains her position on the correct side of a narrow channel in conformity with COLREGS,
2) Communicate concerns with respect to vessel's position and track within the channel and immediately draw the attention of the pilot and rectify the situation immediately even if there is no opposing traffic through the channel,
3) Acquire, track and monitor all targets in the immediate vicinity of the vessel, and keep a very close check on radar targets which have a small CPA,
4) Both Radars are required to be switched on and in operation for easy accessibility and use by all members of the bridge team, ( the X-Band Starboard radar was left in Stand-By mode as visibility was good, and only switched on after the collision)
5) Instead of plotting common courses through the middle of the channel, plot courses closer to the starboard side of the channel,
6) Assess prevailing weather conditions and forecasts very closely vis-à-vis the vessels draft and her freeboard, with special attention to the effects of the wind on courses to be steered whilst approaching and departing from ports, especially when such transits are via narrow channels on rivers, or safety fairways and Traffic Seperation Schemes.
   Should there be any cause or concerns with respect to the safe maneuverability of vessel, a decision to abandon port departure or arrival is to be made by the master , especially when winds are expected to blow in a direction across vessel's beam or from a direction of more than 4 points over either bows or quarters.
   In any case of winds blowing or gusting 33knots (Beaufort Scale 7) there should be no attempt made to approach ports or depart from a berth.

<u>**Further Corrective & Preventive measures to be implemented by office**</u>

The following additional corrective & preventive measures for advoiding such accidents were agreed upon during our meeting with [redacted] at EMC Amsterdam office:

1) Additional internal audits to be carried out by auditors sailing with the vessels, in order to evaluate 'Bridge Team' responses and attitudes during pilotages as well as to monitor 'Bridge Team' compliance with SMS bridge procedures during coastal navigation,
2) Arrange all masters & deck officers to attend refresher STCW BRM training courses,
3) Circular to all masters,
4) Training all 3 deck officers on sending emergency communications (SMS Initial/Final reports)