SIGTTO

Society of International Gas Tanker & Terminal Operators Ltd

Recommendations for Designing Cargo Control Rooms

First Edition

Human Element Series

Recommendations for Designing Cargo Control Rooms

SIGTTO

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The Society of International Gas Tanker and Terminal Operators (SIGTTO) *is a non-profit making organisation dedicated to protect and promote the mutual interests of its members in matters related to the safe and reliable operation of gas tankers and terminals within a sound environment. The Society was founded in 1979 and was granted consultative status at IMO in November 1983.*

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Navigation House,
3 Almondvale Business Park,
Almondvale Way,
Livingston EH54 6GA,
Scotland, UK

+44 (0)1506 463 227
info@witherbys.com
witherbys.com

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Part – 1

Introduction

1. Introduction

This document recommends the application of ergonomic design principles to cargo control rooms (CCRs) on liquefied gas carriers. It recommends that ship owners work with system designers, Classification Societies and shipyards to create an operational philosophy to guide the implementation of these design principles in the development of CCRs. The information in this document is based on established practices, such as *ISO 11064 – Ergonomic design of control centres* (Reference 1).

This document promotes the integration of different information and control systems within the CCR into an efficient layout that is centred around the operators. This human-centred approach focuses on identifying the tasks that the operators will be required to undertake and ensuring that they have the information and control functions best arranged to assist those tasks.

Part 1 of this document provides a general introduction to this topic. Part 2 provides an overview of ergonomic design philosophy and the process that can be followed to develop the control philosophy that will underpin the design process.

2. Scope

This document provides guidance for all types of liquefied gas carriers. The purpose of these recommendations is to encourage owners, designers and shipyards to consider ergonomic principles and the cargo system control philosophy when designing the CCR, consoles and the human machine interface (HMI).

This guidance is aimed at new ships only. These recommendations do not apply to existing ships and there is no suggestion that existing ships should be altered in any way. Owners of gas carriers may consider these recommendations if planning significant upgrades to the CCR of an existing ship.

3. Key Publications

Control room design and ergonomics is a vast subject. This document cannot, and does not attempt to, address all areas of this subject. There are many useful publications that should be considered, such as:

- *ISO 11064 – Ergonomic design of control centres* (Reference 1)
- *ISO 26800 – Ergonomics — General approach, principles and concepts* (Reference 2)

The design principles from *ISO 11064 – Ergonomic design of control centres* are applied throughout this document. *ISO 11064* sets up a generic framework for applying ergonomic design requirements and recommendations when designing and evaluating control centres. This aims to eliminate or minimise the potential for human errors.

Part – 2

Recommendations

4. Framework for an Ergonomic Design Process

ISO 11064 – Ergonomic design of control centres (Reference 1) provides a framework for an ergonomic design process made up of five design phases, as shown in Figure 1. Each phase uses the output of all the previous phases, which should be documented at each step:

Phase A: Clarification – this stage occurs at the start of the design process. The purpose, constraints, resources and context of the project are clarified, while considering existing situations which could be used to influence the design.

Phase B: Analysis and definition – the functional and performance requirements of the CCR are analysed to arrive at allocation of preliminary functions and job design.

Phase C: Conceptual design – communications interfaces, controls and displays, furnishing designs and an initial room layout are developed to meet the requirements identified in Phase B.

Phase D: Detailed design – the conceptual design is developed into the detailed design specifications that will guide the construction and procurement of the CCR, including its content and operational interfaces.

Phase E: Operational feedback – in this stage, a post-commissioning review is used to identify successes and shortcomings in the design of the CCR. This review can then contribute to future designs.

This document focuses on Phase A *Clarification*, Phase B *Analysis and definition*, and Phase C *Conceptual design*.

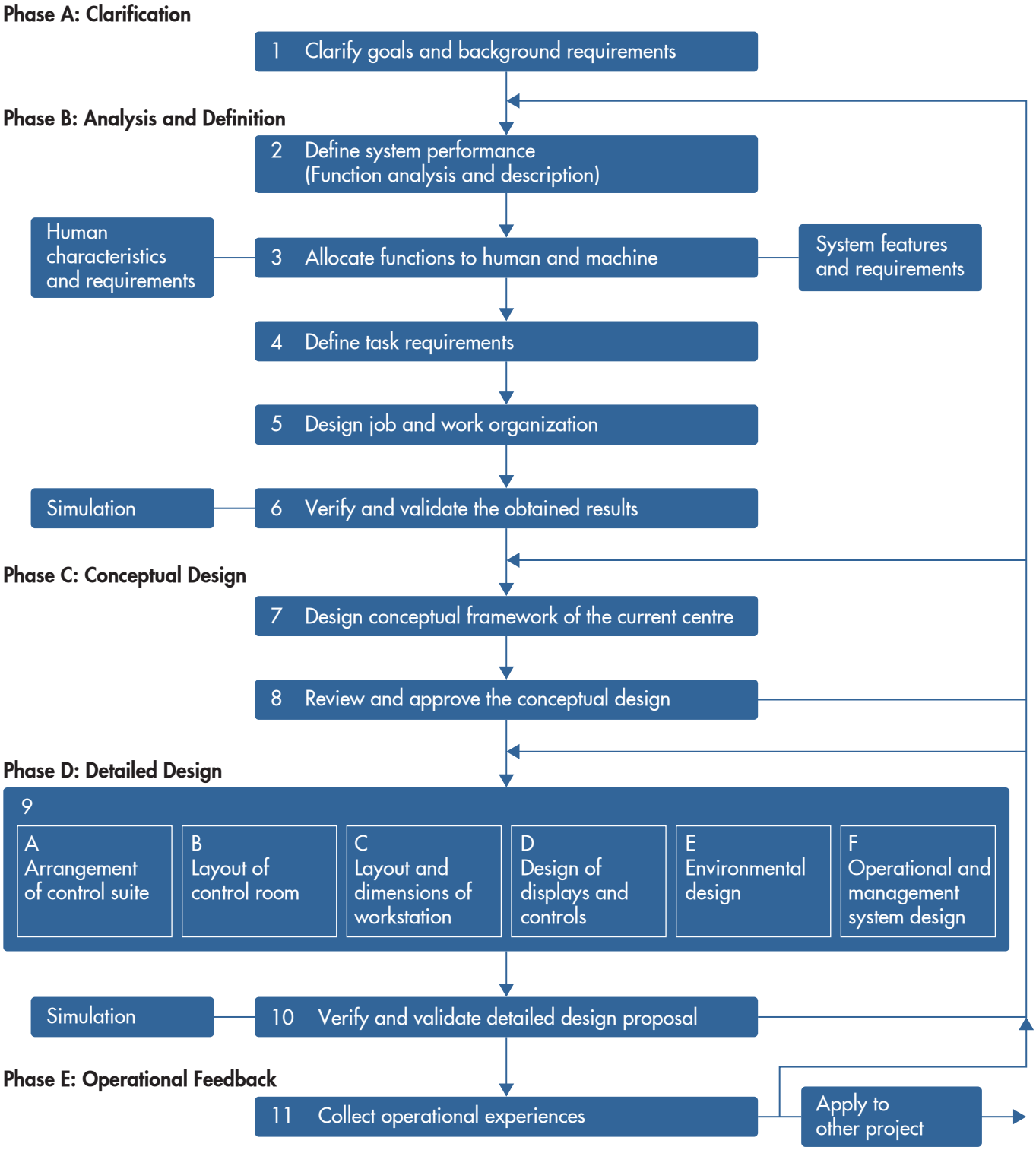


Figure 1: Ergonomic design process for control centres, from *ISO 11064 - Ergonomic design of control centres,* (Reference 1)

5. Phase A: Clarification

The aim of this phase is to clarify the operational goals and requirements of the CCR, along with any constraints that may affect the design. This may include the type and size of the ship and cargo, type and location of the space available, and the number of CCR operators. This phase should also consider feedback from operators and lessons learnt from incidents and near misses, including those from other industries.

Inputs that should be considered in this phase include regulations, industry guidance and the requirements of the CCR operators and other users in the control room. Any inputs considered in this process should be documented.

The output for this phase should show a clear understanding of the operational goals of the CCR, along with the constraints of the project and acceptance criteria.

6. Phase B: Analysis and Definition

The purpose of this phase is to determine the control philosophy of the cargo system. To place the human at the centre of the CCR design, it is recommended that the work organisation is defined first. This includes the number of operators and observers, their levels of training and what oversight may be required.

In this phase all operator tasks in the CCR should be listed, such as planning, loading and discharge. For each task the functions, including required information and control elements, should be clearly defined and allocated between humans and systems.

6.1 Functional Analysis

A functional analysis should be used to identify the ergonomic requirements of the CCR throughout its projected lifetime. These should meet the operational goals identified in *Phase A*.

The analysis may use one or more of the following:

- Step through of operation modes with experienced operators
- safety and reliability requirements
- process diagrams that show the top-down function.

6.2 Allocation of Functions and Tasks

Functions and tasks should be allocated to humans and systems and all required interactions between the operators and systems should be determined. At this stage it is important to understand the capabilities of machinery and equipment through dialogue with manufacturers.

For further information on allocation of functions and tasks, see *ISO 11064 - Ergonomic design of control centres,* Table 1 (Reference 1).

6.3 Task Analysis

The tasks allocated to the operator should be analysed to determine their fundamental characteristics. This should include:

- Manual and cognitive activities, bearing in mind operator fatigue and possible distractions
- task frequency and duration
- complexity
- communication requirements
- environmental and physical conditions
- any other factors required for one or more operators to perform a given task.

This stage should identify the tasks to be performed to satisfy the functional requirements and their associated ergonomic performance requirements.

6.4 Role Requirements

Role requirements should be determined and tasks assigned to the operators. This should include defining work tasks and flow that satisfy operator and regulatory requirements for information and control, such as:

- Requirements for communication between operators (if more than one)
- communications between the control room, other relevant local control locations and personnel
- tasks to be carried out by other personnel in the CCR, such as observers and surveyors, and their frequency of attendance.

A key consideration in the role definition process is the type and number of tasks assigned to an individual, including observers and auditors.

6.5 Analysis of Task Performance

The performance of each task should be analysed, including the information and control functions that the operator may require. All high-level tasks should be broken down into the steps required to achieve their goal. Each step should then be considered in detail to identify the information and control functions required.

For example, a simplified range of high-level tasks is shown in Figure 2. The *Loading* operation has been expanded to show individual steps. Individual tasks are divided into those which require information only, and tasks that require both information and control. The *Valve position* item is broken down further, showing the information and control functions required in more detail.

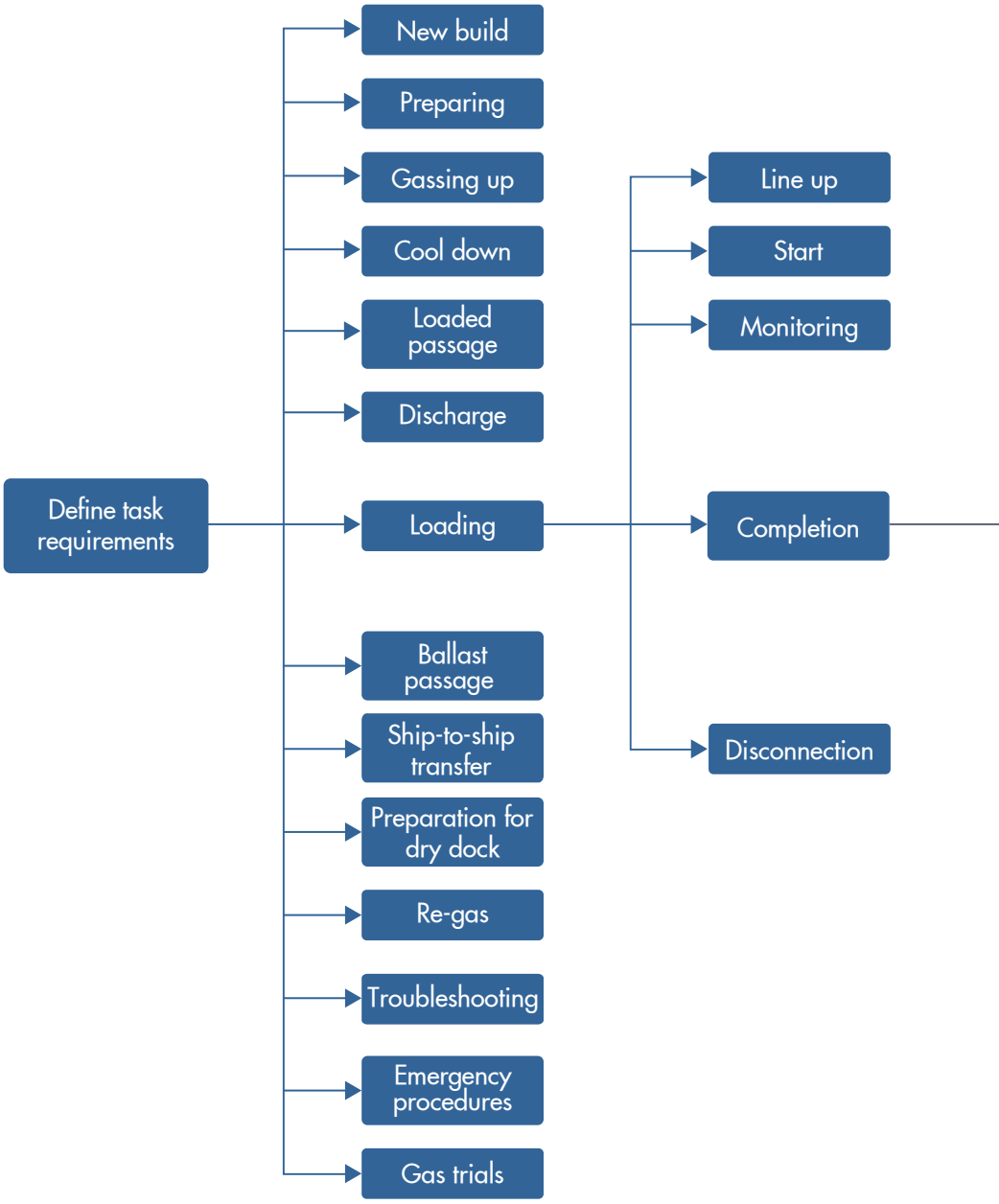
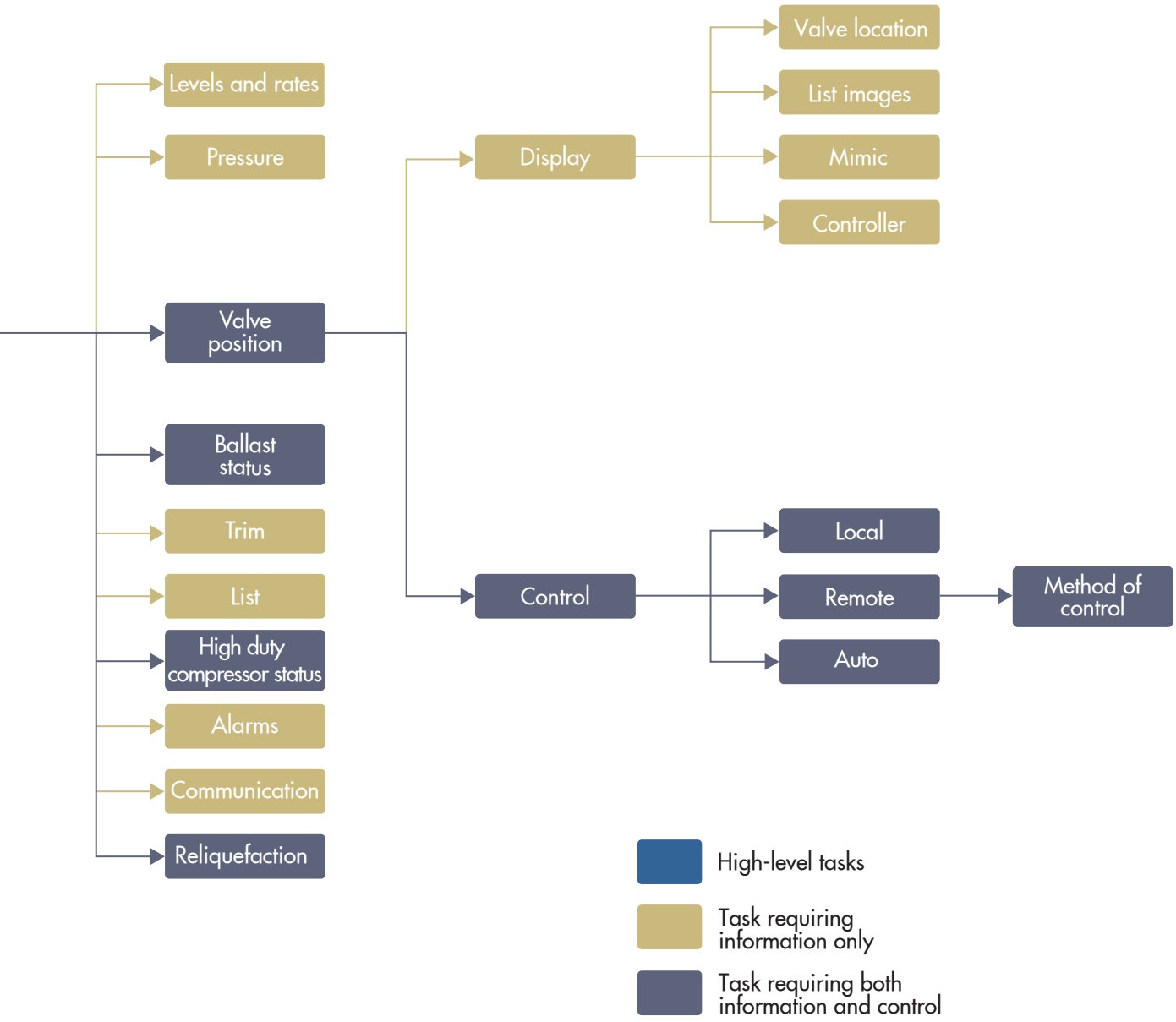


Figure 2: Example of a simplified range of high-level tasks


Levels and rates
Pressure
Valve position
Ballast status
Trim
List
High duty compressor status
Alarms
Communication
Reliquefaction
Display
Valve location
List images
Mimic
Controller
Control
Local
Remote
Auto
Method of control
High-level tasks
Task requiring information only
Task requiring both information and control

6.6 Task Review

Once all the tasks have been defined, a full review should be carried out using high workload and critical tasks, such as emergency shut down and accident scenarios, to check whether acceptance criteria are met. Mock-ups, virtual reality walk throughs or other forms of simulation can be useful validation tools.

6.7 Output

The output for *Phase B* should be documented to show a clear understanding of the operator tasks and required system functions.

7. Phase C: Conceptual Design

The purpose of this phase is to develop CCR design concepts that support the performance of all tasks and functions defined in *Phase B*. This should include conceptual design specifications and preliminary layouts. *Phase C* is an exploration of alternative concepts and ideas for a CCR, and a more detailed design will be developed in *Phase D*.

The output of this phase should be the conceptual design of the CCR. This should include any revisions to the documented tasks and functions from *Phase B* and should outline requirements for the CCR space.

The conceptual design of the CCR should include its physical layout and functional characteristics, including:

- Shape
- displays
- controls
- communications
- closed-circuit television (CCTV)
- lighting, including glare
- ventilation
- noise and vibration
- furnishings
- environment
- storage.

During this phase, any design policies, standards or regulations that will affect the project should be clearly documented. This may also include equipment chosen, classification requirements or system design.

A simplified outline of typical areas to be documented for the CCR space is shown in Figure 3. This is a simplified outline for illustration purposes only and is not a definitive list.

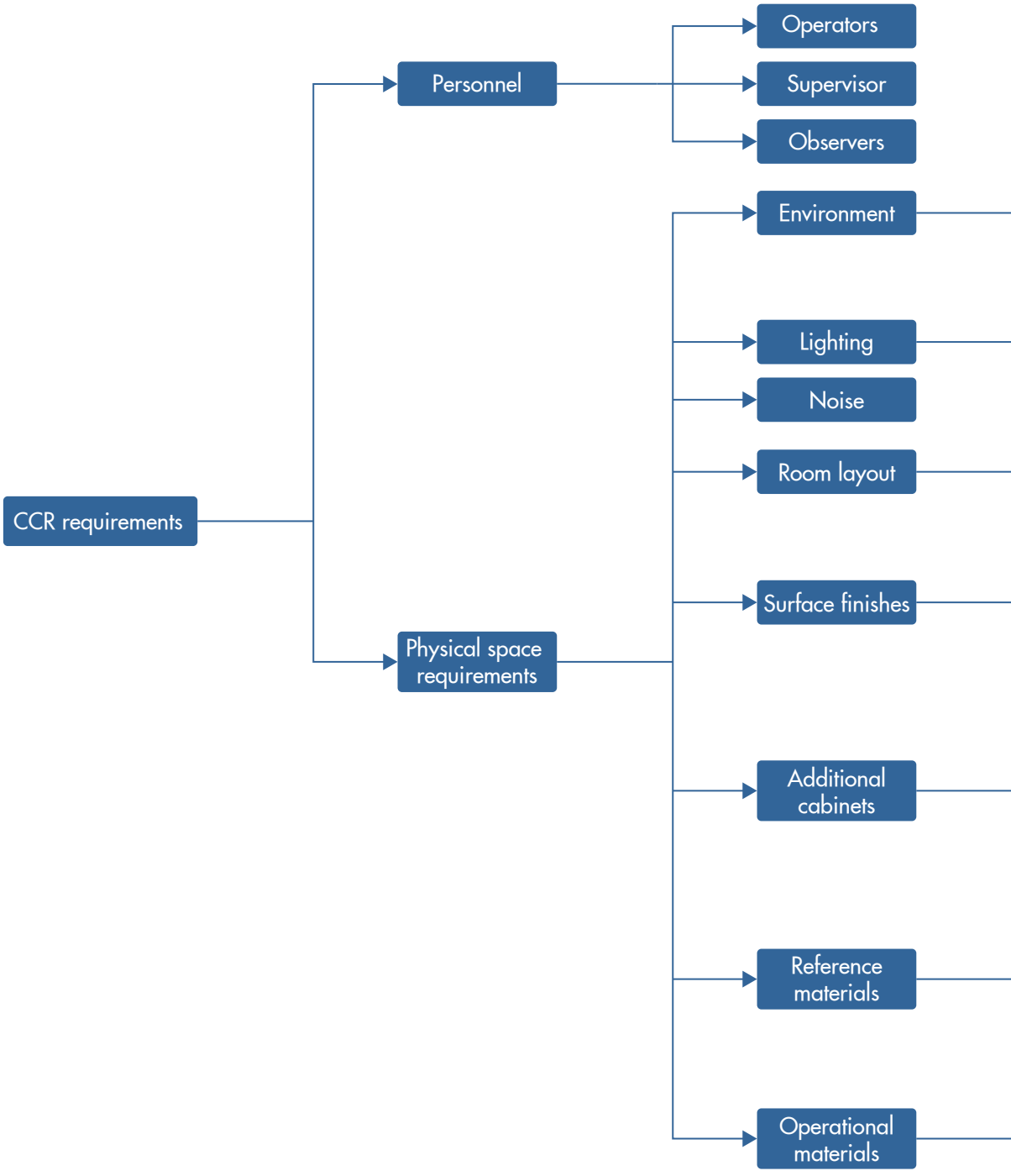
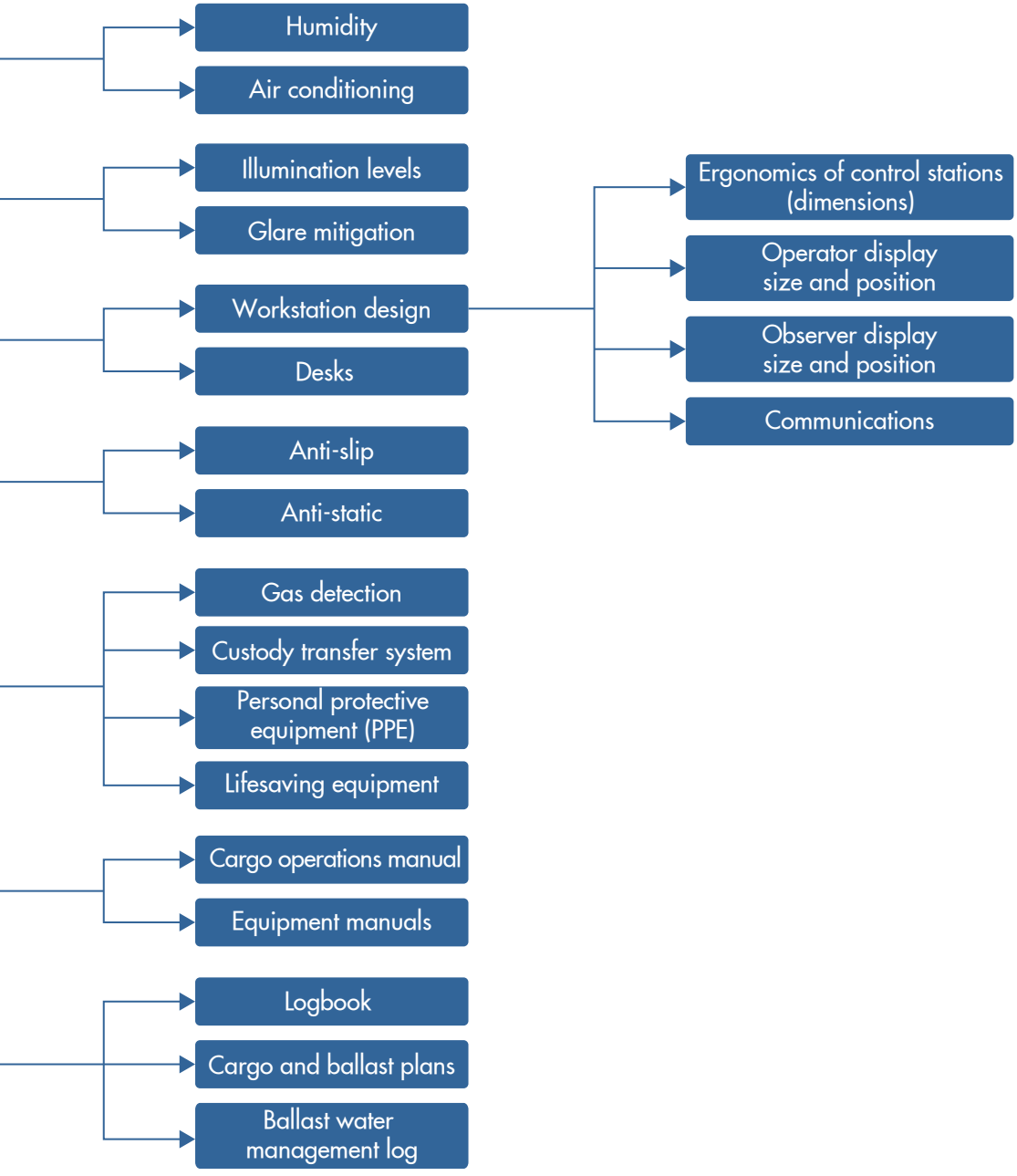


Figure 3: Simplified outline of a concept design


Humidity
Air conditioning
Illumination levels
Glare mitigation
Workstation design
Desks
Anti-slip
Anti-static
Gas detection
Custody transfer system
Personal protective equipment (PPE)
Lifesaving equipment
Cargo operations manual
Equipment manuals
Logbook
Cargo and ballast plans
Ballast water management log
Ergonomics of control stations (dimensions)
Operator display size and position
Observer display size and position
Communications

8. Phases D and E: Detailed Design and Operational Feedback

8.1 Phase D: Detailed Design

In this phase, the conceptual design is developed into a detailed design. This usually involves working with the shipyard and equipment suppliers to produce the outline specifications for the procurement and construction of the CCR. These specifications typically include its operational interfaces, content and facilities. They should be sufficiently detailed to allow any tender and contractual arrangements to be completed.

For further information on detailed design, see *ISO 11064 - Ergonomic design of control centres,* Part 1, Section 9 (Reference 1).

8.1.1 Further recommendations

It is recommended that the HMI, including the design of controls and on-screen mimics, should be based on the *Phase B* task analysis, with priority given to frequent and high-risk operations. For example, piping and instrumentation diagrams (P&ID) can be useful for the commissioning process but should not be used as operational mimics. Reference should be made to *Recommendations for Management of Cargo Alarm Systems* (Reference 3).

The following recommendations should also be considered:

1. Communications equipment should be easily accessible from the main workstations without the operator having to leave the control position.
2. If a large *overview* display is provided, it should be visible from all the main workstations.
3. Each workstation should allow sufficient space for an operator to simultaneously review or write on physical documents while operating the system. The workstation should provide locations for cups and pens and other items for operators.
4. An operator should be able to carry out a complete task from a single location utilising the same workstation.
5. Lights should be positioned to reduce glare and bright reflections from working and display surfaces.

8.2 Phase E: Operational Feedback

As part of a post-commissioning review, operational feedback should be documented to identify successes and shortcomings in the CCR design, which can then contribute to future designs. This should be continued throughout the life of the ship.

Annexes

Annex 1 – Glossary of Terms and Abbreviations

CCR Cargo Control Room

Ergonomics Scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance

Human-Centred Design An approach to interactive system development that focuses specifically on making systems usable and emphasising the role of human operators as control agents who maintain authority within a working system

HMI Human Machine Interface. A collection of hardware and software used by the operator to monitor and interact with the control system and with the process via the control system

ISO International Organisation for Standards

P&ID Piping and Instrumentation Diagram

Annex 2 – Reference List

1. ISO 11064 – Ergonomic design of control centres
2. ISO 26800 – Ergonomics — General approach, principles and concepts
3. SIGTTO – Recommendations for Management of Cargo Alarm Systems

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