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**Ships and marine technology —  
Virtual reality and simulation training  
systems for lifesaving appliances and  
arrangements**

*Navires et technologie maritime — Systèmes de formation en réalité virtuelle et en simulation pour engins et dispositifs de sauvetage*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 8, *Ships and Marine Technology*, Subcommittee SC 1, *Maritime safety*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

This document provides the criteria for how virtual reality (VR) and simulator technologies can support training and maintenance of lifesaving appliances such as those required by the International Maritime Organization (IMO) International Convention on the Safety of Life at Sea of 1974 (SOLAS 74), Chapter III.

The use of VR and simulator technology is already a mainstay in many traditional maritime schools for bridge management and navigation, and the market is growing for this type of training specific to lifesaving appliances (LSA) installed onboard vessels, mobile offshore drilling units (MODUs) and offshore installations. Through interactions with the virtual world, students develop knowledge, skills, and attitudes related to a wide array of competencies.

This document supports the VR and simulator equipment used in training and drills for operators and maintainers of LSA, where “live” training with the LSA is limited or restricted due to operational factors, company policies, inclement weather, sea-state, operating schedules and port restrictions. This is particularly advantageous for the mariners undergoing pre-arrival training to their next assignment as well as for onboard survival craft and associated appliances and arrangements such as free-fall lifeboats and davit-launched liferafts that are traditionally limited in their “live” training usage.

Additionally, LSA that are technologically advanced and novel may not be practicable for both live training and traditional deployment frequencies. Due to the nature of such alternative designs and arrangements, the need for VR and simulator training equipment for these types of LSA is particularly valuable to provide the necessary, consistent training frequency and familiarity for the mariners who operate them.

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# Ships and marine technology — Virtual reality and simulation training systems for lifesaving appliances and arrangements

## 1 Scope

This document provides general provisions and minimum criteria for using virtual reality and simulator equipment and systems instead of live training and drills with lifesaving appliances and arrangements, such as those required by SOLAS and MODU Code. This document is not intended to provide a generic training programme for the purposes of meeting International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) requirements.

This document serves to support the use of training devices (TD) onboard vessels that can deliver training and drills required by regulation, as well as additional non-obligatory training to crew. It is understood that training devices described in this document are used as an alternative to actual participation with and operations of lifesaving appliances (LSA) products during drills to meet mandatory training requirements.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

*International Life-Saving Appliance (LSA) Code* [Resolution MSC.48(66)], International Maritime Organization, as amended

*International Safety Management Code (ISM Code)* [Resolution A.741(18)], International Maritime Organization, 1993, as amended

*International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974)*, as amended

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in, SOLAS III, the IMO LSA Code and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <https://www.electropedia.org/>

### 3.1

#### augmented reality

##### AR

interactive experience of a real-world environment whereby the objects that reside in the real world are augmented by computer-generated perceptual information

### 3.2

#### behavioural realism

ability of the *training devices* (3.6) to replicate the functional characteristics of the lifesaving equipment

**3.3**  
**degree of freedom**

measurement of motion of an object in space when constrained by fingers with or without considering friction forces at contact points

**3.4**  
**fidelity**

degree to which a model or simulation reproduces the state and behaviour of a real-world object or the perception of a real-world object, feature, condition, or chosen standard in a measurable or perceivable manner

**3.5**  
**haptic**

input or output device that senses the body's movements by means of physical contact with the user

Note 1 to entry: This includes any technology that can create an experience of touch by applying forces, vibrations, or motions to the user, e.g. providing a "sense of touch" (the sense felt by humans upon touching an object).

**3.6**  
**training device**

TD  
replica of a lifesaving equipment's instruments, equipment, panels, and controls in an open area, an enclosed replica, augmented reality environment, or virtual reality environment

Note 1 to entry: It includes the equipment and computer hardware, firmware, and software necessary to represent some or all of the full range of operations of the actual lifesaving equipment in a simulated environment.

**3.7**  
**maintenance**

activities, excluding repairs, requiring disassembly of equipment, or any other activities outside the scope of the instructions for onboard maintenance and for emergency repair of life-saving appliances

Note 1 to entry: These activities shall be prepared in accordance with SOLAS 1974 regulations, Chapter III/36.2 and III/35.3.18, respectively.

**3.8**  
**multiphysics simulation**

simultaneous simulation of different aspects of a physical system

Note 1 to entry: This includes the mathematical models used by the *training device* (3.6)/simulator to replicate the performance of shipboard equipment and systems.

**3.9**  
**operating environment**

virtual environment simulating the actual environment and conditions in which the lifesaving appliance would be operated

**3.10**  
**physical realism**

ability of the *training device* (3.6) to replicate the physical appearance of the lifesaving equipment

**3.11**  
**positive learning transfer**

application of the knowledge and skills acquired from using the *training device* (3.6), whereby the user of the training device can demonstrate increased performance when using the lifesaving equipment

**3.12**  
**sensory cue**

features of the *training device* (3.6) that can stimulate the senses of the user

### 3.13 simulation

use of a similar or equivalent system to imitate a real system, so that it behaves like or appears to be the real system

### 3.14 virtual reality VR

artificial environment presented in the computer

## 4 Design

The TD shall be “fit for purpose” by applying the necessary physical equipment, equipment control realism, behavioural realism, fidelity, and operating environment realism to achieve the desired category of learning.

The TD manufacturer shall determine the appropriate training categories of the device and LSA applications to demonstrate that the system has sufficient realism to produce the positive learning transfer desired.

## 5 Safety

Regardless of the category of training, the training setup may include simulating the real environment including the use of virtual reality (VR) or augmented reality (AR), physical or virtual controls, motion platforms or any moving training equipment. It is important that the trainee can safely train in the training setup even when the trainee performs the wrong action or gets disoriented. Safety measures shall be in place to ensure trainees cannot get physically hurt during training.

## 6 General requirements of the TD

### 6.1 General

A TD shall address the following:

- a) the TD shall have a unique identifier (i.e. name, model number);
- b) training category or categories provided by the TD shall be clearly stated;
- c) TD configuration;
- d) TD software name and version;
- e) equipment operation;
- f) equipment and facilities for instructor/evaluator functions when included in the TD;
- g) motion system, if applicable, e.g. number of degrees of freedom;
- h) visual system;
- i) sound system, if applicable;
- j) power requirements;
- k) internet connectivity requirements to include using the TD, evaluating results, and recording training, etc;
- l) Recording or other record keeping of the training performed. If electronic record keeping is used, it shall provide for the preservation and retrieval of information with appropriate security or

controls to prevent the inappropriate alteration of such records after the fact. See DNVGL-ST-0033: 2017, 2.2.1.4 for an example.

Records of drills and training shall be stored in logs and generated automatically from the TD at the completion of each session. Records shall include at a minimum:

- 1) TD unique identifier;
- 2) start and completion date and time of the drill, muster, or training session;
- 3) LSA used in the drills;
- 4) identification of crewmembers participating in drills or training sessions;
- 5) subject of the onboard training or drill session:
  - EXAMPLE 1: Abandon ship drill, lifeboat lowering, full drill,
  - EXAMPLE 2: Abandon ship drill, lifeboat preparation, part of the full drill,
  - EXAMPLE 3: Abandon ship drill, liferaft davit operation, full drill;
- 6) the role/assigned duty to which the drill or session corresponds (i.e. lifeboat muster or boat crew); and
- 7) optionally, the TD can manually record any feedback by the participant, trainer, supervisor or assessor.

When a TD shall be used for additional non-regulatory training onboard, more records may be stored such as:

- assessment score, and
  - fail/pass result;
- m) Where a TD requires training area and space to deploy, an installation and deployment manual shall be supplied. This includes installation requirements, the TD layout and training area space layout, and required space, weight, and force to the floor;
  - n) operation and maintenance manual.

## 6.2 TD administration mode

### 6.2.1 General

The TD shall have an administration mode that allows the designer/instructor to create or modify a training scenario. It also allows the designer/instructor to administrate the access of the systems and other parameters required to manage the training.

The following functions shall be provided:

- a) launch of a training scenario;
- b) stop of a training scenario (this function should be accessible to trainers and trainees);
- c) use of communications between the instructor/administrator and the trainee or trainees;
- d) how to use the simulator;
- e) retake the last training scenario;
- f) training scenario log; and

g) assessment report.

The following functions shall be optional:

- h) replay the last training scenario; and
- i) replay a stored training scenario.

### 6.2.2 TD maintenance administration mode

The TD shall have a maintenance administration mode that allows the users to monitor the performance of the simulator system including the states of the simulator equipment and review simulator logs. It also allows for remote maintenance functions, software and training scenario updates by local or remote means.

### 6.2.3 Maintenance and upgrades to the TD

The maintenance and updating method of the TD software and hardware shall be defined by the manufacturer with a reference in the maintenance manual, including:

- a) spare parts;
- b) periodic replacement parts;
- c) inspection items;
- d) methods, interval, instruments and tools for each inspection item;
- e) internet connectivity and computer support requirements.

### 6.2.4 Technical assessment of a TD vs a real LSA product

The TD maker seeking an approval (see [Annex A](#)) to replicate a specific product (make and type, series or model) shall receive a technical assessment comparing the system to the exact LSA product. That technical assessment should be evaluated by a third party (e.g. classification society member), irrespective of whether the LSA maker (original equipment manufacturer) is in business or no longer in business. The focus of this assessment shall be on objectives affecting training and drill requirements and no other technical similarities. The systems or components listed below shall be given particular attention in category 2 and category 3 TDs (see [7.2.3](#) and [7.2.4](#)):

- a) release gears;
- b) marine evacuation system;
- c) launching appliances; and
- d) novel LSA.

### 6.2.5 Functionality and competence compliance verification

Before seeking approval of a TD (see [Annex A](#)) for meeting any training requirement, the TD shall be practically assessed by a third party (e.g. classification society member or Administration). The TD maker when applying for this assessment shall list the training requirements which the TD is expected to fulfil and the tables showing the grades of realism for each learning objective, and shall submit evidence that positive learning transfer occurs from the use of the TD.

If changes are made to training or drill requirements and learning objectives or any upgrades on software or hardware to a certified TD onboard, a new assessment shall take place according to the relevant technical assessment (see [6.2.4](#)) and a new TD certificate should be issued.

## 7 Training with TD systems

### 7.1 General

This document is intended to ensure the TD provides sufficient training to the trainee in place of a real emergency. This document defines four categories of simulation system training to achieve specific competencies and skills in the use of life-saving appliances and arrangements onboard a vessel or installation in order to meet specific training and drill objectives. The categories are not hierarchical and shall be viewed as different applications of the technology. A TD can meet the requirements of more than one category.

This document is intended for systems that provide virtual or augmented reality with physical realism. The categories in this document are intended to augment or even replace live training and drills based on the actual, intended, or expected operating environment of the installation.

This document applies to the competency of and training on actual equipment onboard and in the marketplace. It is not intended to address STCW competencies explicitly.

The goal of the simulation systems defined in this document is to augment onboard familiarization, and foster competency and confidence with the specific life-saving appliances through training with a TD when traditional live training is limited or not possible.

### 7.2 Categories of simulation system training

#### 7.2.1 General

Each category of the training provided by the TD shall be sufficient to demonstrate that the user can use the TD to meet the learning objectives and demonstrate positive learning transfer.

#### 7.2.2 Category 1: Familiarization training

A category 1 TD shall provide sufficient training so that the user is familiar with the operating procedures to use the lifesaving appliances and the context in which the LSA equipment is used. A category 1 TD shall also illustrate the operational limitations and hazards associated with using the LSA equipment. This category requires realistic depiction of the LSA equipment and an understandable explanation of how it functions, and in which situations it shall be used. Therefore, the equipment depicted in the TD shall have a substantially similar function to the real device but may meet the generic grade of realism as per 7.3.5. This category shall contain visual and aural depiction requirements but does not require any specific requirements on the haptic component.

A category 1 TD shall meet the onboard training requirements of SOLAS 1974, III/19.2, 19.4, 19.4.1 or the ISM Code, 1993, 6.3, as applicable to the needs of the crew using the characteristics and grades in Table 1. Examples of category 1 training include a “walk-around” with capability to see the equipment from all angles and with virtual hands, that can “point” and “touch” objects in the simulation; and LSA procedural training for a particular LSA or class of LSA.

#### 7.2.3 Category 2: Technical training

A category 2 TD shall provide sufficient training so that the user is familiar with the maintenance of LSA equipment, such as those found in IMO MSC Resolution 402(96). A category 2 TD main objective as a training device is to teach the requirements of operational readiness, weekly and monthly inspections. A category 2 TD shall also illustrate failure modes and hazards associated with maintaining the LSA equipment. A category 2 training device shall provide sufficient training for a single device or limited functionality of a set of devices consistent with its make and type. The equipment depicted in the TD shall be sufficiently identical in function to the real device. The context in which the task shall be performed need not be part of category 2 training. Therefore, simulating the maritime environment in which the LSA is to be maintained is not required at this category. Equipment simulated in the TD may

be at the representative or specific grade of realism as per [7.3.5](#), depending on the nature of the training required.

A category 2 TD shall provide sufficient virtual training to learn the maintenance and inspection requirements in accordance with SOLAS 1974, III/20, as applicable to the needs of the crew using the characteristics and grades in [Table 2](#). A category 2 TD may also provide a learning environment to gain competency with the instructions for onboard maintenance required by SOLAS 1974, III/36.

#### 7.2.4 Category 3: Operational training

A category 3 TD shall provide sufficient training so that the user is able to operate the LSA equipment under realistic emergency conditions. A category 3 TD shall also present the user with failure modes and allow the operator to perform operational troubleshooting of the LSA equipment. This TD requires a training setting in which LSA equipment and arrangements are applied in a whole task setting.

Category 3 requires simulating the applicable maritime working environment expected for the vessel or offshore installation using the characteristics and grades in [Table 3](#). The LSA equipment, its controls, and its behaviour after an operator action or influence in the maritime environment, shall be simulated in the simulation environment. The maritime context in which the device is expected to be operated shall be simulated as far as it impacts the task of the operator. Simulation includes depiction of weather, sea state, shipboard hazards such as fire, and list and vessel dynamics including trim, roll, pitch, and heave. Equipment simulated in the TD shall be at the specific grade of realism as per [7.3.5](#) and other limitations, related to corresponding equipment in use.

A category 3 TD shall provide sufficient virtual training in accordance with the requirements of SOLAS 1974, III/19.3, 19.4, or 37, as applicable to the needs of the crew. A category 3 training device shall provide sufficient training for the whole task setting. Physical and virtual controls which can be operated shall be available and the result of the actions shall be visible, audible and possibly able to be felt. As such, requirements in category 3 include the haptic component.

#### 7.2.5 Category 4: Incident training

A category 4 TD shall provide sufficient training so that the user is able to interact with other emergency teams, individuals, and/or passengers who are also responding to the emergency situation. The TD shall focus on teamwork, decision-making, communications, management and related skills required for leading teams or cooperation amongst or within teams. A category 4 TD may achieve these objectives with or without simulating haptics, physical realism, behavioural realism and sensory cues.

A category 4 TD shall provide sufficient virtual training in accordance with the requirements of SOLAS 1974, III/17-1, 29, 37. The physical characteristics and grades of realism of a category 4 shall be defined by the TD maker. As such, no table is provided for the grades of realism on a category 4 TD.

### 7.3 Characteristics of the TD environment

#### 7.3.1 Physical realism

##### 7.3.1.1 Control systems

Examples of control systems which are touched (i.e. physically manipulated) by the operator include switches, levers, and valves.

##### 7.3.1.2 Information systems

Examples of information systems associated with the lifesaving appliance providing information to the operator include dials, gauges, meters and compasses.

### 7.3.1.3 Visual representation

Examples of visual representation demonstrate how the simulator visually mimics the real LSA product on shape, general construction and appearance (e.g. level of detail, perspective, scale, point of view, and colour).

### 7.3.2 Behavioural realism

#### 7.3.2.1 Physical characteristics

Examples of physical characteristics associated with the lifesaving appliance may include acceleration rates, discharge rates and revolutions per minute of an engine.

#### 7.3.2.2 Interaction characteristics

Examples of interaction characteristics associated with the LSA equipment interacting with the operating environment include leeway, cooling rates and dispersion rates. This includes the use of multiphysics simulation.

### 7.3.3 Operating environment

#### 7.3.3.1 Environmental variables

Examples of environmental variables representing the conditions under which the lifesaving appliance is operated may include temperature, pressure, oxygen and carbon dioxide categories, waves and other varying sea states.

#### 7.3.3.2 Virtual agents

Virtual agents may include boats, aircraft, avatars, verbal agents, or other elements which affect users while they are conducting operations in the TD. This may include all the external factors relevant to the simulation (e.g. third-party targets, visual cues, sound cues, motion cues).

### 7.3.4 Sensory cues

#### 7.3.4.1 Visual, auditory, haptic

This includes all methods to stimulate the somatosensory system including force-feedback systems and motion bases.

### 7.3.5 Grades of realism

For each category a TD system provides, grades of realism shall be determined for each of the characteristics defined in 7.3 for physical realism, behavioural realism, the operating environment, and sensory cues.

The four grades of realism are defined as follows:

- none (N): not required or not applicable;
- generic (G): functionality represents at least the minimum performance standards for certification of the LSA equipment being modelled;
- representative (R): functionality is representative of a class of similar LSA equipment but not necessarily product specific;
- specific (S): functionally similar to a specific product type or series of products that share the same technical characteristics.

The four grades of realism are indicated in [Tables 1 to 3](#) using their short form N, G, R, S.

Regulatory requirements regarding drills and maintenance can apply to the grades selected for category 2 and category 3. When grades of realism exceed the minimum requirements, this shall be stated on the TD certificate. The following are examples of drills that may exceed regulatory requirements and should be documented as such on the TD certificate: drills at night, simulating a drill in heavy weather conditions, and conducting a person overboard drill while the vessel is underway.

**Table 1 — Category 1 TD physical characteristics and grades of realism**

LSA equipment and emergency actions	Familiarization									
	Physical realism			Behavioural realism		Operating environment		Sensory cues		
	Cont <a href="#">7.3.1.1</a>	Info <a href="#">7.3.1.2</a>	Vis rep <a href="#">7.3.1.3</a>	Phys <a href="#">7.3.2.1</a>	Inter <a href="#">7.3.2.2</a>	Env <a href="#">7.3.3.1</a>	Agent <a href="#">7.3.3.2</a>	Vis <a href="#">7.3.4.1</a>	Audio <a href="#">7.3.4.1</a>	Haptic <a href="#">7.3.4.1</a>
Lifebuoys	N	N	S	N	R	N	G	N	N	N
Lifejackets	N	N	S	N	R	G	G	N	N	N
Immersion suits	N	N	S	N	R	N	G	N	N	N
Anti-exposure suits	N	N	S	N	R	N	G	N	N	N
Thermal protective aids	N	N	S	N	R	N	G	N	N	N
Visual signals	N	N	S	N	R	N	G	N	N	N
Search and Rescue locating devices	N	N	S	N	R	G	G	N	N	N
Radiotelephones	N	N	S	N	R	G	G	N	N	N
Liferafts	N	N	S	N	R	G	G	N	N	N
Marine Evacuation System	N	N	S	N	R	G	G	N	N	N
Lifeboats	N	N	S	N	R	G	G	N	N	N
Rescue boats	N	N	S	N	R	G	G	N	N	N
Novel LSA	N	N	S	N	R	G	G	N	N	N
Launching appliances	N	N	S	N	R	G	G	N	N	N
Release gears	N	N	S	N	R	G	G	N	N	N
Line-throwing appliances	N	N	S	N	R	G	G	N	N	N
<b>Key</b>										
Cont Control systems										
Info Information systems										
Vis rep Visual representation										
Phys Physical characteristics										
Inter Interaction characteristics										
Env Environmental variables										
Agent Virtual agents										
Vis Visual										
Audio Auditory										
N none										
G generic										
R representative										
S specific										

**Table 1 (continued)**

Familiarization										
LSA equipment and emergency actions	Physical realism			Behavioural realism		Operating environment		Sensory cues		
	Cont <a href="#">7.3.1.1</a>	Info <a href="#">7.3.1.2</a>	Vis rep <a href="#">7.3.1.3</a>	Phys <a href="#">7.3.2.1</a>	Inter <a href="#">7.3.2.2</a>	Env <a href="#">7.3.3.1</a>	Agent <a href="#">7.3.3.2</a>	Vis <a href="#">7.3.4.1</a>	Audio <a href="#">7.3.4.1</a>	Haptic <a href="#">7.3.4.1</a>
Pilot ladder	N	N	S	N	R	N	G	N	N	N
Embarkation Ladder	N	N	S	N	R	N	G	N	N	N
General alarm and public address system	N	N	S	N	N	N	G	N	N	N
Muster list and emergency duties	N	N	S	N	N	N	G	N	N	N
Passenger assembly	N	N	S	N	R	N	G	N	N	N
Training manual	N	N	S	N	N	N	N	N	N	N
<b>Key</b>										
Cont Control systems										
Info Information systems										
Vis rep Visual representation										
Phys Physical characteristics										
Inter Interaction characteristics										
Env Environmental variables										
Agent Virtual agents										
Vis Visual										
Audio Auditory										
N none										
G generic										
R representative										
S specific										

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Table 2 — Category 2 TD physical characteristics and grades of realism

LSA equipment and emergency actions	Technical									
	Physical realism			Behavioural realism		Operating environment		Sensory cues		
	Cont <a href="#">7.3.1.1</a>	Info <a href="#">7.3.1.2</a>	Vis rep <a href="#">7.3.1.3</a>	Phys <a href="#">7.3.2.1</a>	Inter <a href="#">7.3.2.2</a>	Env <a href="#">7.3.3.1</a>	Agent <a href="#">7.3.3.2</a>	Vis <a href="#">7.3.4.1</a>	Audio <a href="#">7.3.4.1</a>	Haptic <a href="#">7.3.4.1</a>
Lifebuoys	N	N	S	R	R	N	R	R	N	N
Lifejackets	S	S	S	R	R	R	R	R	N	N
Immersion suits	N	N	S	R	R	N	R	R	N	N
Anti-exposure suits	N	N	S	R	R	N	R	R	N	N
Thermal protective aids	N	N	S	G	G	N	R	R	N	N
Visual signals	S	S	S	G	R	N	R	R	N	N
SAR locating devices	S	S	S	R	R	R	R	R	R	N
Radiotelephones	S	S	S	R	R	R	R	R	G	N
Liferafts	S	S	S	R	R	R	R	R	N	N
Marine evacuation system	S	S	S	R	R	R	R	R	N	N
Lifeboats	S	S	S	R	R	R	R	R	N	N
Rescue boats	S	S	S	R	R	R	R	R	N	N
Novel LSA	S	S	S	R	R	R	R	R	N	N
Launching appliances	S	S	S	R	R	R	R	R	N	N
Release gears	S	S	S	R	R	R	R	R	N	R
Line-throwing appliances	S	S	S	R	R	R	R	R	N	N
Pilot ladder	N	N	S	G	R	N	R	R	N	N
Embarkation ladder	N	N	S	G	R	N	R	R	N	N
General alarm and public address system	S	S	S	N	N	N	R	R	R	N
<b>Key</b>										
Cont	Control systems									
Info	Information systems									
Vis rep	Visual representation									
Phys	Physical characteristics									
Inter	Interaction characteristics									
Env	Environmental variables									
Agent	Virtual agents									
Vis	Visual									
Audio	Auditory									
N	none									
G	generic									
R	representative									
S	specific									

**Table 2 (continued)**

Technical										
LSA equipment and emergency actions	Physical realism			Behavioural realism		Operating environment		Sensory cues		
	Cont <a href="#">7.3.1.1</a>	Info <a href="#">7.3.1.2</a>	Vis rep <a href="#">7.3.1.3</a>	Phys <a href="#">7.3.2.1</a>	Inter <a href="#">7.3.2.2</a>	Env <a href="#">7.3.3.1</a>	Agent <a href="#">7.3.3.2</a>	Vis <a href="#">7.3.4.1</a>	Audio <a href="#">7.3.4.1</a>	Haptic <a href="#">7.3.4.1</a>
Muster list and emergency duties	N	N	N	N	N	N	N	N	N	N
Passenger assembly	N	N	N	N	N	N	N	N	N	N
Training manual	N	N	N	N	N	N	N	N	N	N
<b>Key</b>										
Cont	Control systems									
Info	Information systems									
Vis rep	Visual representation									
Phys	Physical characteristics									
Inter	Interaction characteristics									
Env	Environmental variables									
Agent	Virtual agents									
Vis	Visual									
Audio	Auditory									
N	none									
G	generic									
R	representative									
S	specific									

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Table 3 — Category 3 TD physical characteristics and grades of realism

LSA equipment and emergency actions	Operational									
	Physical realism			Behavioural realism		Operating environment		Sensory cues		
	Cont <a href="#">7.3.1.1</a>	Info <a href="#">7.3.1.2</a>	Vis rep <a href="#">7.3.1.3</a>	Phys <a href="#">7.3.2.1</a>	Inter <a href="#">7.3.2.2</a>	Env <a href="#">7.3.3.1</a>	Agent <a href="#">7.3.3.2</a>	Vis <a href="#">7.3.4.1</a>	Audio <a href="#">7.3.4.1</a>	Haptic <a href="#">7.3.4.1</a>
Lifebuoys	N	N	S	R	R	R	R	R	N	N
Lifejackets	S	S	S	R	R	R	R	R	N	N
Immersion suits	N	N	S	R	R	N	R	R	N	N
Anti-exposure suits	N	N	S	R	R	N	R	R	N	N
Thermal protective aids	N	N	S	G	G	N	R	R	N	N
Visual signals	S	S	S	G	R	R	R	R	N	N
SAR locating devices	S	S	S	R	R	R	R	R	R	N
Radiotelephones	S	S	S	R	R	R	R	R	G	N
Liferafts	S	S	S	R	R	R	R	R	G	R
Marine evacuation system	S	S	S	R	R	R	R	R	R	R
Lifeboats	S	S	S	R	R	R	R	R	G	R
Rescue boats	S	S	S	R	R	R	R	R	G	R
Novel LSA	S	S	S	R	R	R	R	R	G	R
Launching appliances	S	S	S	R	R	R	R	R	G	R
Release gears	S	S	S	R	R	R	R	R	N	R
Line-throwing appliances	S	S	S	R	R	R	R	R	N	R
Pilot ladder	N	N	S	G	R	N	R	R	N	N
Embarkation ladder	N	N	S	G	R	N	R	R	N	N
General alarm and public address system	S	S	S	N	R	N	R	R	R	N
<b>Key</b>										
Cont	Control systems									
Info	Information systems									
Vis rep	Visual representation									
Phys	Physical characteristics									
Inter	Interaction characteristics									
Env	Environmental variables									
Agent	Virtual agents									
Vis	Visual									
Audio	Auditory									
N	none									
G	generic									
R	representative									
S	specific									