Human-Centred approach to ship and equipment design

Guide to resources

Contents

1.   General material and introduction

1.1   Purpose of this document

This document provides pointers to the resources collected to support the application of the guides produced by the Ship Creation project. This section provides pointers to general material, starting with practical material on user feedback mechanisms and Human Centred Design (HCD) approaches before identifying general background material, and material on Human Factors Integration (HFI) or Human System Integration (HSI) for the more advanced organisation.

Where possible, the main referencing system used is the "he" number, which refers to the Alert! database (www.he-alert.org). For use by or with LR staff, there is access to the resources identified. For more general use, sufficient information has been given to enable the user to find the material with a search engine.

The set of resources described in this document is growing and changing. Readers are invited to send updates to jonathan.earthy@lr.org.

1.2   Introductions to user feedback

Alert! document ref. **he00625** by Joiner is on obtaining user feedback by means of Post Occupancy Evaluation (POE). This article serves as a general introduction in a ship context. More technical articles on POE are available from the Usable Buildings Trust.

Steve Krug's book '**Rocket Surgery Made Easy**' http://www.sensible.com/rsme.html is aimed at web sites but the approach is applicable to starting usability testing. It does not address usability testing to professional standards, but emphasises the importance of doing something rather than nothing, and provides the means to do this.

The internet has transformed user feedback in many sectors, e.g. the impact of TripAdvisor on the travel sector. This disruption has still to reach the maritime sector. Possibilities (for the future) include:

- GCaptain - http://gcaptain.com/forum/engineering/ very little used

- http://www.marine-cafe.com/ might be a place to discuss design with seafarers, though this has not been done as yet.

- http://www.imarest.org/OurCommunity/SpecialInterestGroupsSIGs.aspx - online feedback or input may be possible. Try RINA LInkedIn groups (if still in operation). European Naval Architects Network http://www.linkedin.com/groups?home=&gid=1984725&trk is a possibility.

- https://www.facebook.com/pages/The-Royal-Institution-of-Naval-Architects/275119132757?ref=stream might be useful.

- (Note: Shiptalk and Safety4Sea do not have forums at the time of writing).

There are some good sources of user input:

- UK P&I Club http://www.ukpandi.com/loss-prevention/on-board-practical-advice/ gives good ideas found on Club ships. Many of these could be built in at the design stage at low or zero cost.

- Nautical Institute forums http://www.nautinst.org/en/forums/index.cfm email inputs.

- MARS http://www.nautinst.org/en/forums/mars/index.cfm is a searchable source of known risks for designer. The NK guidelines on prevention of human error give worked examples of how to move from an incident report to design changes.

ShipServ has good facilities for customer feedback, but not for user feedback. An enquiry on the topic was unanswered.

The paper 'User Involvement in Service Innovations' has guidance on user involvement and the use of 'lead users'.

1.3 Introduction to HCD

The Fable of the User-Centred Designer by David Travis is based on the One-Minute Manager, and has a strong appeal to some readers in the critical early stage of awareness, motivation etc.

he00700 'Launching the Tamar' is a short article on a practical human-centred approach that worked. he00500 describes the integrated computer system on the Tamar. Section 11 of this article addresses the human-centred development.

he00940 Summarises the comprehensive set of standards that now underpin the human-centred approach, enabling a mature engineering and management set of processes, as described in the Guides.

Nigel Bevan's website http://www.nigelbevan.com/ has a large number of useful papers. Criteria for selecting methods in user-centred design is a good starting point for thinking about how to go about HCD. http://www.usabilityplanner.org/#home may prove a useful, or thought-provoking, resource to consider the implications of adopting HCD. http://www.usabilitynet.org/home.htm has a large set of useful practical resources. Martin Maguire's 'Methods to support human-centred design' (2003) is also useful doi:10.1006/ijhc.2001.0503. LR has a useful guide to Understanding the Context of Use.

IMO Resolution A.1047(27) 'Principles of Minimum Safe Manning' has lists of required capabilities and functions. These can be used as the starting points for task analysis, and other HCD activities.

The science of human factors: separating fact from fiction by Russ et al in BMJ Quality and Safety Online 21 June 2013 gives a science-led explanation for a human-centred approach, which complements the design-led approach in the Guides.

UK P&I Club has a wide range of useful resources http://www.ukpandi.com/fr/loss-prevention/risk-management-advice/the-human-element/ http://www.ukpandi.com/loss-prevention/books-pamphlets-library/ including Human Element, Getting to grips with HF, Slips, Trips and Falls, Loss of power, (UK P&I Club video: *No room for error*). A number of other P&I Clubs also have useful posters, guides and reports.

A proposal for a joint industry effort at improving bilge oily water separator operation and design by Van Hemmen, 2005 published by SNAME gives a good indication of what happens when a human-centred approach is not adopted, and may serve as a case study of the problems that arise.

More generic human-centred web resources include:

- Kathy Sierra: creating passionate users http://headrush.typepad.com/creating_passionate_users/
- Johnny Holland http://johnnyholland.org/
- Service design tools http://www.servicedesigntools.org/

Steve Blank http://steveblank.com/tools-and-blogs-for-entrepreneurs/ has useful material on customer discovery and customer development. His focus is on start-ups, but the material is relevant to new product development within more established organisations. This material is not strictly HCD, but complements HCD and helps link it to business need. In the context of innovation http://strategyn.com/customer-needs/ has useful resources. Milkshake Marketing by Clay Christensen gives a link between HCD and marketing.

Testing can evolve from being the simple approach in Steve Krug's book above through to good practice in the standards below. Jakob Neilsen's book 'Usability Engineering' http://www.nngroup.com/books/usability-engineering/ gives practical guidance on heuristic evaluation and usability testing that is between these two levels.

Defining user requirements is not easy. Neil Maiden's RESCUE method, e.g. https://www.city.ac.uk/__data/assets/pdf_file/0005/81437/RESCUEchapter.pdf is somewhat ambitious but gives a

target to aim for. In general, for software systems, it is important to find a method that is user-friendly to the development team; this might involve use cases, user stories etc.

Tools to support innovative design are necessarily difficult to produce. TRIZ, and SCAMPER http://www.flashbulbinteraction.com/ are techniques that are general rather than specific to human centred approaches, but which may be helpful in e.g. devising solutions to reduce human error potential. Working Through Screens by http://www.flashbulbinteraction.com/ is a remarkable design aid for user interface design.

1.4 General background

The human-centred approach is backed up by a sizeable quantity of material. The scope of supporting material is perhaps captured in the following selection.

The Alert! Bulletin http://www.he-alert.org/ contains material relevant to the guides in the following issues: 1, 2, 3, 5, 7, 8, 10 - 15, 17, 19, 22, 24, 26, 27.

he00860 – Is the basic introduction to the human element.

he00580 on risk perception and reality, risk control hierarchy.

he00320 dependable systems competent people.

he00545 how complex systems fail; this is a short summary of a large and practical literature.

he00350 David Squire on the human element in shipping.

he00190 Human Factors and Safety at Sea by Allan Graveson.

The ABS Guides and/or ASTM F-1164

MCA has useful posters and guides http://mca.ecgroup.net/browse.aspx

Intertanko has useful resources for those with access to them.

SIRC publishes relevant research http://www.sirc.cf.ac.uk/

1.5 HFI type websites, guides

There is material in other sectors that may be helpful. Mostly, these sectors are further advanced with the application of a human-centred approach, and have tended to adopt quite sector-specific terminology, tools and methods.

The Energy Institute has a useful set of resources http://www.energyinst.org/technical/human-and-organisational-factors , including practical briefing notes. **Human Factors Briefing Note 1** sets out their scope. **Briefing Note No. 8** is about ergonomics. The RSSB http://www.rssb.co.uk/improving-industry-performance/human-factors also has useful material.

The defence sector has many resources; many of these are sector-specific and not cheap to apply. http://www.hfidtc.org/ may offer some useful resources. A similar situation exists with Air Traffic Control; resources for advanced organisations tackling major projects.

he00750, HSC HFE design guide has good material aimed at high-performance craft and gives an indication of what a comprehensive HFI programme might comprise.

The ILO has good resources and publications – perhaps best found using a search engine. These include an Encyclopaedia of Occupational Health and Safety, and some ergonomics publications, including '**Ergonomic Checkpoints**'.

The ILO publication '**Barefoot Research**' is a worker's manual. Because of this, it contains simple practical tools and methods that can be used as part of a human-centred approach.

The 'smart buildings' initiatives may produce resources relevant to ships. An initiative that may offer support to yards wishing to use usability to commercial advantage is the 'Soft Landings' initiative. Materials are available from e.g. http://www.usablebuildings.co.uk/Pages/UBPublications/UBPubsSoftLandings.html and http://www.designingbuildings.co.uk/wiki/Soft_landings .

1.6   Human error

The formal analysis of human error is a serious matter requiring specialists. There are less formal approaches that are helpful. The IMO Human Error Analysing Process (**HEAP**) has a useful flowchart. Technique for Human Error Assessment (**THEA**) from York University is fairly practical and could be applied by non-specialists with care. Work by Kathleen Mosier on 'automation bias' is useful for understanding the effects of automation on human error, and countering popular myths such as automation eliminating human error.

1.7   Core standards

Perhaps surprisingly, the human-centred approach is fully underpinned by a set of International standards. There are also some specific National standards that are valuable support to the Guides. To be sure of using best practice, it would be necessary to adopt some of these standards. For organisations focusing on improvement, the Guides can be considered tailored versions of the standards.

The Guides are based on the following standards:

> ISO 9241-210:2010 Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems

> ISO/CD 9241-220 Ergonomics of human-computer interaction – Part 220: Processes for enabling, executing and assessing human-centred design within organizations

> ISO TR 18529:2000 Ergonomics of human system interaction – Human-centred lifecycle process descriptions

> ISO/TS 18152:2010 'Ergonomics of human-system interaction – Specification for the process assessment of human-system issues'

The process improvement approach is underpinned by:

> ISO/IEC 15504:2004 Information technology – Process assessment [1]

The high level principles behind the human centred approach are described in:

> ISO 26800 Ergonomics – General approach, principles and concepts

> BS EN ISO 6385:2004 Ergonomic principles in the design of work systems

Specific aspects of the human centred approach are supported by:

> ISO 16982 Usability methods supporting human-centred design.

> BS EN IEC 62508 Guidance on human aspects of dependability

> ISO/IEC NP 25066 Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – Common industry Format for Usability – Evaluation Report

> ISO/IEC NP 25065 Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – Common industry Format for Usability – User Requirements Specification

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[1] This series of standards is being revised and renumbered as ISO/IEC 33000.

BS EN ISO 11064 Ergonomic design of control centres

BS EN 292 Part 1 1991 Safety of Machinery Basic concepts, general principles for design Basic terminology, methodology

ISO 17894:2005 Ships and marine technology — Computer applications — General principles for the development and use of programmable electronic systems in marine applications

In addition, there are the following, which may be directly relevant.

F1166-07 Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities. This is largely equivalent to the ABS ergonomics guides.

ANSI/ISA-18.2-2009 Management of Alarm Systems for the Process Industries, or The Alarm Management Handbook by PAS http://www.pas.com/Technical-Books/Alarm-Management-Handbook.aspx

PAS also publish the exceptionally practical book Hollifield, B. et al, 'The High Performance HMI Handbook', Plant Automation Services, 2008 ISBN-13: 978-0977896912

2. Ship design guide – guidance by section

Table 1 lists the reference material described above against the relevant section in the Ship Design Guide.

Ship design guide	Document	Comment
1. Corporate strategy.	he00895	Gives the insurer's business point of view.
	he00125	On the systems approach. Pictures at end showing the hazards of 'integration work' from inadequate design. Scale of problem.
1.1 Business strategy for QOU	MSC/Circ 1091 Issues to be considered when introducing new technology on board ship (2003)	These are issues the owner will face with a ship with new technology.
	he00145	Good advice on mature procurement of large systems
	he00415	Thoughtful piece on robust ships.
1.2 Embedding the human element	he00150	Practicing what we preach; ATC rather than shipping, but very sound material. The book 'Institutionalization of Usability' by Eric Schaffer may appeal to some organisations.
2. Managing design [and support]	UK Design Council '**Leading Business by Design**' **Staying Competitive through Strategic UX Design** from Human Factors International HBR report 'Closing the Gap: How companies achieve smarter new product development and make better decisions with technology.'	Business case for investing in design and a customer focus. Books and papers by Eric von Hippel make the business case for involving users in innovative design. The HBR paper makes a similar case
2.1 [Implementing the human element in] Quality, Standards	MSC/Circ 813 / MEPC/Circ 330 **The Impact of Contracts on Ship Design Preparation** from Fisher Maritime	List of human element common terms to help standardise terminology. Context for considering how to embed the human element into contracts.
2.2 [Implementing the human element in] Build planning		
2.3 [Implementing the human element in] Proposals		

Ship design guide	Document	Comment
2.4 [Implementing the human element in] Research		The HCD introductory material is appropriate to the research activities of understanding the context of use, defining requirements, etc.
3. Technical Management, System integration Manage HCD	A.1047(27) Annex 5 Framework for Determining Minimum Safe Manning. he01125 MSC-MEPC.7/Circ.3 Framework for IMO Consideration of ergonomics and the work environment (2006)	The Rough Guide to interpreting the principles of safe manning Lists priorities for IMO. Sensible list for naval architects .1 manual valve operation, access, location and orientation; .2 stairs, vertical ladders, ramps, walkways and work platforms; .3 inspection and maintenance considerations; .4 working environment; and .5 the application of ergonomics to design. Of relevance to naval architects are consideration of passenger ship safety, ballast water management and security
	MSC-MEPC.7/Circ.2 Strengthening of human element input to the work of IMO	3.1.2 Ship-specific factors: level of automation; reliability of equipment; motion characteristics; vibration, heat and noise levels; quality of working and living environment; cargo characteristics/requirements; ship design.
	MSC.1/Circ 1253 Shipboard technical operating and maintenance manuals 2007 IACS Recommendation No.71 Res A.772(18) Fatigue factors in manning and safety 1993	The need to specify and check the quality of technical documentation requires management. List of questions (and a list of resources)
	RESOLUTION MSC.337(91) Noise levels on board ships 2012 he01010 he00710 he00265 p44 on environmental recommendations	The need for Human Factors Engineering skills. on Slips, Trips, Falls (STF) – seriousness of problem and some material on where STF happen

Ship design guide	Document	Comment
4. Ship design activities - technical HCD	he01120	Situation Awareness. Technical material is identified in the introductory section above.
4.1 Naval Architecture		The Nautical Institute book 'Improving Ship Operational Design' is useful and practical, and in the process of being updated.
Structure and arrangement General arrangement, deck & superstructure, compartments, stores, holds, tanks, machinery spaces, voids Compartment outfit; control rooms, offices, accommodation, catering, sanitation, workshops, HVAC	MSC.1/Circ 1251 Guidelines on the control of ships in an emergency 2007 Guidance on the command and control structure and activities MSC/Circ.1014 Module 7. Shipboard fatigue and the naval architect SN Circ 288 Guidelines for bridge equipment and systems, their arrangement and integration (BES) 2010 SN.1/Circ 265 Guidelines on the application of SOLAS Regulation V/15 to INS, IBS and bridge Design (2007) MSC/Circ 982 Guidelines on ergonomic criteria for bridge equipment and layout 2000 MSC/Circ 834 Guidelines for engine room layout, design and arrangement Res A.757(18) Standards for the calculation of the width of stairways forming means of escape on passenger ships 1993 MSC/Circ 1056 / MEPC/Circ 399 Guidelines for ships operating in Arctic ice-covered waters 2002 See also Res A.1024(26) for polar waters MSC/Circ 846 Guidelines on human element considerations for the design and management of emergency escape arrangements on passenger ships he00805 on claustrophobia he00420 on motion sickness, vibration	

Ship design guide	Document	Comment
	ABS Guide on Permanent Means of Access	
	he00130. 00070, 00085 - ATOMOS templates	
Outfit Manoeuvring, anchoring & mooring, deck outfitting, closures, access, masts, lifesaving, firefighting, surfaces & labelling, hull piping, ballast, spares & stores	he00195 Lang on manoeuvrability ABS Guide on Permanent Means of Access	
Cargo handling, cranes, ventilation, refrigeration, heating etc	MSC.1/Circ 1263 Revised recommendation on safety of personnel during container securing operations (2008) ABS HAB notation	
4.2 Machinery	he01085 on hearing protection programmes	Needs linking to IMO Code and if poss., EU material on better noise levels
Propulsion		
Auxiliary systems	he00410 van Hemmen on OWS	
Environmental control systems (oily waste, ballast water, SOx & NOx etc.)		
Ship/shore interface, power supplies		
4.3 Electrical	Res. A.1021(26) Code on alerts and indicators, 2009 he00675 Paul Traub on rail/marine alarms he00650 Sherwood Jones slides on alarms papers on alarms incl. he00550, he00540,	
Automation, lighting, power generation & distribution		

Ship design guide	Document	Comment
Navigation, communication, office systems		
STAGES SNAPSHOTS		

Table 1. Resources cited in ship designers guide

3. Equipment design guide – guidance by section

Table 2 lists the reference material described above against the relevant section in the Equipment Manufacturers Guide.

Equipment design guide	Document	Comment	ABS/ASTM ref.
1. Corporate Strategy			
1.1 Business strategy for QOU			
1.2 Embedding the human element	he00150 Hazel Courtenay, CAA, practice what we preach		
2. Managing design and support			
2.1 Quality, standards			
2.2 Supply chain management, purchasing			
2.3 (business) Risk management	he00155 Courtenay on error		
2.4 Marketing, customer support			
3. Technical management, system integration	he00050 Lutzhoft & Dekker on Royal Majesty. Crown Princess incident[2]	What / how much to See core standards 1.7 on automation and human error	
4. System design activities - technical HCD			
Hardware	he01255 Human Factors criteria for hand held devices - With emphasis on devices for maintenance and diagnosis		F1166 sections 5-9. Workstations 10, F1166 Section 15 labelling 19 communications ABS ergo sections 2-5, workstations section 6, ABS ergo section 8 labelling
Software	he00155 Hazel Courteney on error	An area of growing concern is usability considerations for	F1166 Section 13

[2] http://www.powershow.com/view/30da2-MTM5N/MV_Crown_Princess_Heeling_Accident_powerpoint_ppt_presentation

Equipment design guide	Document	Comment	ABS/ASTM ref.
		multi-touch, multi-screen, big screens[3]	
Installation guidance			F1166 Section 12 on valve placement F1166 Section 15 labelling ABS ergo section 8 labelling Section 16 manual handling 17 maintenance
Documentation			F1166 Section 15 ABS ergo section 10 maintenance
Training material, services			
Product support Maintenance, diagnostics, spares Updates			F1166 Section 17 maintenance ABS ergo section 10 maintenance
STAGES SNAPSHOTS			

Table 2. Resources cited in equipment manufacturers guide

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[3] A useful source of practical information on modern user interfaces (multi-device, multi-touch etc.) is www.lukew.com. Material includes a Touch Reference Guide at http://static.lukew.com/TouchGestureGuide.pdf

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