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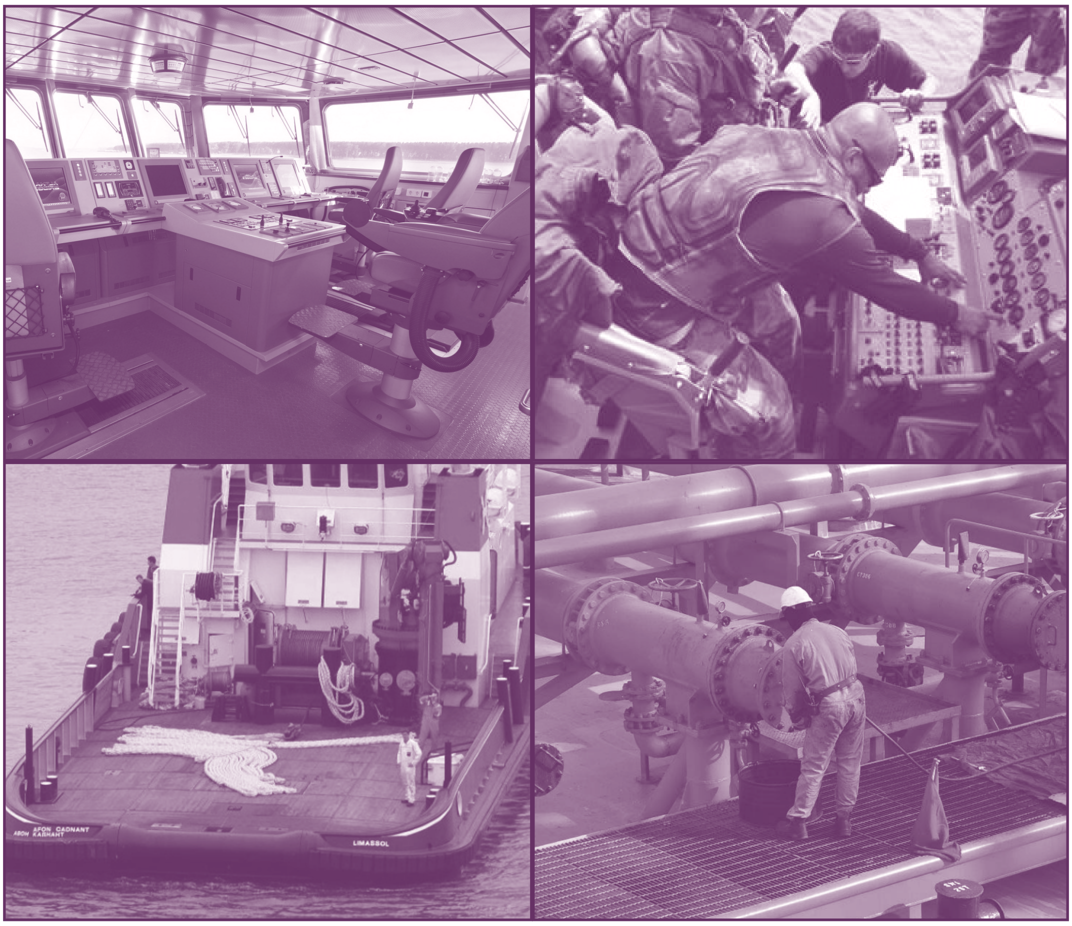

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Towards the Development of Ergonomic Classification - A Case Study in Safe Access and Egress

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A ship is a hazardous working environment in which inadequate access and egress arrangements are a leading cause of injuries and fatalities amongst seafarers. In fact, slips, trips and falls represent 52% of fatalities resulting from occupational accidents on board ships (EMSA, 2018). There is a growing awareness in the maritime industry that the human element needs to be considered during design and build to mitigate risks to crew safety. It is further recognised that inclusion of human element requirements in Class Rules has the potential to make a credible impact and far-reaching improvement to seafarer safety on a large scale (Walker, 2011). This paper describes a recent development by Lloyd's Register in addressing the Human Element within Class Rules. The paper outlines the process of developing ergonomics guidance for safe access and egress, building on lessons learnt from previous Lloyd's Register ergonomics Rule sets. The paper provides a background to the current regulatory environment and demonstrates the need for improved guidance on access and egress in the maritime industry. It continues with an outline of the development process including a technical justification of the scope, key criteria and application of ergonomics guidance for improved safety. The paper concludes with a critical analysis of the development process and a brief discussion on the challenges still facing rules ergonomists today (Walker, 2011).

Perceptions of the West and the East and National Culture on the Human Factors

Y. Kwon, Chosun University, Republic of Korea

Safety is a matter of culture before of technology. Most of the modern civilization, including technologies, institutions, and skills relevant to maritime safety issues, is western products which are then imported by the rest of the countries. Such know-hows are based on western culture and if it does not work properly or even does not attract active interest in other countries, we may speculate upon the differences of culture between the countries. This paper compares between the wetern and the oriental civilization and incorporates Hostede's dimensions on the national culture in order to work for transportation safety. The tools are also discussed for the provision for national policy as well as for the international agenda at IMO.

Human Factor and Automation: A STPA Approach to Enhance Ship Safety

C. Bongermino, P. Gualeni, University of Genoa, Italy

Ships complexity is continuously increasing and lots of actions controls, traditionally carried out by crew members, are now managed and executed by the on-board automation systems. Since in many occasions automation performs safety critical controls, the relation among humans and automation system shall be studied with specific attention to their mutual interface and interaction issues, in order to better pursue safety itself. It is recognized in fact that ship safety cannot rely exclusively on the reliability of each system component, but it has to be addressed as an emergent property of the whole system.
Thanks to its systemic, top-down approach, STAMP (System-Theoretic Accident Model and Processes) has been already identified in literature as a very effective and "conductive" reference when dealing with the operational safety of complex system. The STAMP-based tool named STPA (System Theoretic Process Analysis) establishes the following steps: identify system hazards; draw functional control structure; identify unsafe control actions (UCAs); identify accident scenarios; formulate decisions and recommendations. In this paper an approach to model, during the preliminary design, the relations among human operator and automation will be proposed. An application case will be developed considering a large passenger ship and the specific hazard of dead ship condition (energy black-out). In case of navigation close to the shore and in heavy weather condition, this situation can rapidly evolve into a loss. UCAs enables the identification of possible disruptive events responsible of safety performance degradation of the ship system. Based on what above, for a selected UCA relevant to human-automation interaction, suggestions will be discussed aiming to prevent or mitigate the UCA itself. A metric for ship resilience, as a means of improving system safety, will be proposed as well with the aim to allow comparisons among different design solutions.

Improving Human-centred Design application in the maritime industry – challenges and opportunities

V. Dung Vu, M. Holtensdotter Lützhöft, Western Norway University of Applied Sciences, Norway

Ergonomic issues with the design of ships and on-board equipment have been reported to hinder the crew's performance, increase the chance of erroneous actions and, consequently, lead to negative outcomes of maritime operations. A solution to such issues is following a human-centred approach in system design and evaluation, which helps improve usability. While being widely applied in other sectors such as in designing aviation systems, medical equipment, or consumer electronics, HCD practice is still limited within the maritime field. This paper describes a project coordinated by the Nautical Institute to improve HCD practice in the design of ships and systems onboard. Thirty people representing main stakeholder groups, namely naval architects and manufacturers of marine electronics, ship owners/operators, and the seafarers, participated in a focus group. The group identifies the most significant challenges to the adoption of HCD. The group also propose solutions to overcome such challenges and improve HCD practice in the maritime field.

Human Factors Related to Autonomous Ship Operations

E. Aa Dahle, Deck officer, Norway
K. Bentzrod, Master Mariner, Hoegh LNG, Norway
N. H. Lund, Master Mariner and Maritime Government Pilot (Ret.), Norway

Test operation of autonomous small cargo ships, in short, restricted inshore lanes is presently undertaken in Norway. The goal is to eliminate onboard crew and associated cost components, and human failures committed onboard. The running of the ship will to a large extent be taken over by automation, and the ship will be operated by remote control from shore. Hence, human errors committed by remote operation ashore may be restricted to ship and cargo damage. A notable exception is passenger ships, where evacuation must be assisted by a trained crew. Also, the danger classification of the cargo may restrict the degree of remote operation. For all ships, the most prominent human errors committed by the crew are related to navigation. Here, powered grounding dominates. It is considered that the main reason is a lack of structure and control in the operation of ships, i.e. leaving too much freedom to the ship officers. There is a reluctance to restrict this traditional freedom to act in accordance with a personal judgement. However, on coastal areas with dense traffic, as well as in sea areas with e.g. oil installations and wind farms, traffic regulations schemes and VTS surveillance may be necessary. Combination of autonomous ship with traditionally navigation regimes in a fairway, is considered to increase the accident frequency.

The operator's stake in shore control center design: a stakeholder analysis for autonomous ships

E. Veitch, NTNU, Norway

Technology driven innovation has been advancing the development of autonomous ships and their shore control center counterpart. In this paper, we use a product design methodology to map out a Stakeholder Value Chain Analysis based on a workshop with six (6) Subject Matter Experts (SMEs) and semi-structured interviews with a further three (3) individual SMEs. The results serve to identify key stakeholders and their interconnected relationships with the technology, with the shore control center placed in the center. Insights from the qualitative data also highlight the value propositions and potential gaps in the value chain. The contribution is a tool designers can use towards a better understanding of the business model and needs of the technology developer. Furthermore, the needs and responsibilities of the operator in the shore control center are brought into central focus in the contex t of the operator's stake in the overall structure. In light of the operator's roles and the human factors issues that are expected on the job, the case is made for a human-centered design process to run concurrently with the technology innovation.

Development, test and selection of a shock mitigation seat for an all-weather lifeboat

T. Gunston, A. Clarke, SHOXS, Canada

Shock and vibration exposures in fast boats at sea can be more severe than in any other mode of transport. Shock mitigation seating plays a key part in reducing the possibility of injury, but seats must be suitable for the boat and for the way the boat will be used. An innovative sea trial programme was recently conducted by a search and rescue organisation to assess the performance of eight seats, from three manufacturers, for use in an all-weather lifeboat. The trials were designed to maximise data capture while minimising crew exposure. Seat performance was measured with a range of occupants and operating conditions and the final seat selection was based on analysis of over 2,500 wave impacts. These "wave by wave" trials involved normal boat operation and were much more efficient to carry out than the more conventional, but often impractical, approach of attempting to carry out controlled, timed runs at specific speeds in specific sea states. Ahead of the trial, SHOXS used information on the boat crew demographics and operating conditions to optimise the seat. The seat configuration was determined from laboratory drop-tests at the SHOXS facility, with parameters chosen that were most likely to perform well in the Severn. The laboratory test procedure followed the methods defined by the UK's Ministry of Defence Protocol 1&2 and the US Navy's NSW/CCD-080-TR-2015/010 seat testing requirement. This paper describes the sea trials approach and seat design optimisation that led to the Shoxs 4800S seat being selected.

Human Factors Integration in submarine spatial design
J. Clarke, BAE Systems Submarines, UK

BAE Systems Submarines undertakes many large scale, highly complex design programmes and this paper provides a summary of the work undertaken by the Human Factors Team to integrate their role into the spatial aspects of the design process into one such programme. The spatial work of the Human Factors Team is primarily model based with design issues needing to be identified and addressed prior to progression of the programme into build phase. The challenges of this are being addressed from four key directions i.e. Leadership & Infrastructure, Interdisciplinary Engagement, Supporting Processes and Tools & Techniques. This multidirectional approach has improved collaboration between the Human Factors Team and a wide variety of stakeholders and consequently, design outputs. Lessons learned relating to the approaches taken and outcomes will inform Human Factors Integration Plans for future projects as well as improve related activities, especially the design and completion of relevant documentation. Some aspects of the work such as the formal non-compliance process are being applied to other areas of the programme and have the potential to be rolled out across the wider business. In addition, they may have applications in a diverse range of industries where programme complexity can make traceability of decision making and customer acceptance challenging.

Cybersickness and evaluation of a remediation system
L. Andre, Naval Group, France

Many questions arise regarding the use of virtual reality (VR) in the naval military field. This is particularly the case from a human factors' perspective, where system usability is supposed to guarantee user performance. Cybersickness, resulting from a sensory conflict between visual and vestibular systems, is one of the major limitations to the development of VR. It can lead to nausea, oculomotor discomfort and disorientation. The major aim of the current study was to evaluate the efficiency of a remediation system for cybersickness. Designed on the same basis as motion sickness remediation systems, this solution recreates a virtual horizon thanks to LEDS inside the head-mounted display (HMD) to remedy the sensory conflict. For the present study, eighteen subjects were confronted with a dynamic video game in VR, equipped with a HMD. Electrocardiogram, galvanic skin response, condition rate (on a scale between 1 "feeling very bad" to 10 "feeling very good") and Romberg's posture and symptoms (thanks to the simulator sickness questionnaire - SSQ) experiment due to symptoms like nausea. Every subject showed effects of cybersickness, most of them from approximately eight minutes after the beginning of the experiment. Results showed that the system is effective in some situations, like to limit the increase in the SSQ score of young people, but further studies will be necessary. Human factors assessments are conducted to evaluate the effectiveness of a system, improvement cases, and potential limitations. It also provides feedback to improve the solutions to increase their acceptability, usefulness and usability.

Moving Havens: an application of the e-Navigation service route-exchange
T. Porathe, NTNU, Norway

In the early morning hours of July 2018 the 139 meters long car carrier Makassar Highway grounded on the Swedish east coast. The vessel had deviated from its planned track and approached the coast in order to get better phone coverage. As the ship was approaching the coast and the watch officer was at the back of the bridge doing administrative work the vessels grounded. Two more similar groundings has since then happened in Swedish waters. Swedish territorial waters in monitored by three different authorities: the Swedish Maritime Administration's Vessel Traffic Service, the Coast Guard and the defence. None of these entities raised any alarm the morning the Makassar Highway grounded. e-Navigation is a concept launched by the IMO in 2009. The point is to share digital data to the benefit of safety and the environment. Every ship must make a voyage plan before leaving berth. Sharing such voyage plans between ships and between ships and shore is called route exchange and such a feature would allow alarms to be triggered both onboard and ashore if a ship deviate too far from its planned route, or when a route intersects with shallow water. If the voyage plan is timed, an alarm could be triggered when two ships plan to be at the same place at the same time. The concept of sharing of time planned voyage plans are called Moving Havens and is suggested as a means of increasing safety by reducing a single point of failure. The concept is presented in this paper.

The community of ship-handlers and pilots: training together
R. Wild, Solent University, UK
M. Holtensdotter Lützhöft, Western Norway University of Applied Sciences, Norway

Collective learning and knowledge sharing takes place by a group of people, with similar interests, customs, language and repertoire, within a specific domain. Much of the community knowledge or memory bank is based on shared narratives and task norms developed over time and there is a constant thread of working and learning collaboratively, also known as a 'community of practice'. A survey was undertaken, designed to illuminate opinion and ascertain facts in a number of areas regarding community of practice theory. Ship-handlers and pilots were asked how they learned and acquired their skills, and the effectiveness of the various methods applicable to them. The survey and questionnaire yielded 113 responses with 61% fully completed. The respondents indicated that the majority of knowledge and skills is acquired onboard ship, which highlights the importance of onboard training methods and tools.

Another series of unfortunate events: A failure of Situational Awareness
M. Cook, BAE Systems, UK

Grech, Horberry and Smith (2002) identified issues with a lack of situational awareness as a significant contributor to many maritime accidents, evidenced by analysis of accident investigation reports (supported later by Hetherington, Flin and Mearns, 2006). Fundamental to this view is the acceptance that maritime control rooms, on the bridge of ships, in engine control rooms, or even ashore in remote control is based on a socio-technical system. The concept of Situation Awareness is a very useful and a valuable vehicle for understanding performance failure in these kinds of dynamic situations with its three level analysis (Endsley, 1995; Endsley and Garland, 2000). Operators responding to events as they happen are often lagging behind event development and may struggle to comprehend the significance of the events they currently perceive. The vast majority of accidents occur as a result of failures in perception situation awareness and this is evidenced by the failure to start taking appropriate actions to pre-empt the future hazard realisation. Once the significance of events has been comprehended the successful prediction of outcomes and required responses become obvious, a fact that is implied by the proportional accountability that identifies 75% of accidents with initial perception failures. Rothblum (2000) suggests that between 70-90% of collisions at sea involve some form of human error as a contributor, the exact figure is inconsequential but the magnitude is. It is important to note that human agency is critical to the operation of maritime vessels and so the contribution to accident occurrence should not be surprising. The problem is that current proposed methods of investigating human errors may not reveal design-based failures on human errors as some commentators suggest (Celik and Er, 2007). Applying situation awareness to the collisions of the USS John McCain and MV Alnic MC, the USS Fitzgerald and MV ACX Crystal (Department of the Navy, 2018) and the KNM Helge Ingstad with the oil tanker SOLA TS (Defence Accident Investigation Board Norway, 2018), supports the view that situation awareness had failed. In addition, this identifies team or bridge situation awareness as an emergent property of human activities, sensemaking (Weick, 1995) from information that they receive. Thus, in protecting against such failures in future it requires more than an additive analysis of behaviour because of the non-linear nature of the interactions between people, technology, operational guidance and training. It can be argued that failures and situation awareness describe the failed responses to equipment failure like that seen in the collision of the Savannah Express and the portside bridge construction in Southampton, UK. This suggests a failure by designers to appreciate that information availability does not guarantee transformation into knowledge, and the operator's tendency to resort to using poor seamanship in cases where such incidents occur is not helpful. This does not exclude the possibility of loss of situation awareness through relatively simple equipment failure as has happened with electronic charting systems or GPS inputs to mapping/navigation systems.

Future skills in the maritime industry - the ecosystem perspective
A. Hynnekleiv, Western Norway University of Applied Sciences, Norway

The maritime industry is facing a technological evolution that will restructure contemporary sociotechnical systems. There remains a question of what will be the role of humans in these systems. Who are they and what skills do they need? It is still unclear what kind of skills are essential to interact with advanced ICT, perform remote control or monitor automated processes. Due to the increasing complexity of systems, it can be a challenge to find all the required competences in one person. There is a need for specialists from different fields working together as one team. Thus, an ecosystem approach to describing skill requirements seems more appropriate than the conventional individual perspective. The purpose of this study is to contribute to the discussion about skills needed in the future maritime ecosystems. To explore this topic, we use two different qualitative methods: 1. Table -top simulations with experienced seafarers, investigating future scenarios and the relevance of STCW requirements, 2. Expert workshops organised in a focus group style, gathering relevant stakeholders from the maritime industry and discussing the human related aspects of autonomous/higly automated shipping. The results are intended to be a foundation for guidelines on how to enable the technological change with consideration of human factors.

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