Conceptual Design vs. Constructed Reality – Comparing General Arrangement Drawings to the Finalized Working Environment

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1. Introduction

The procurement of a new ship is a large-scale, multi-faceted project which can span multiple years from initial concept to deployment (Rawson & Tupper, 2001). With the opening of international marketplaces, increased domain specialization and economic competition, ship design and construction processes are often split between numerous multi-disciplinary stakeholders around the world (Stopford, 2009). The shipping industry’s international regulatory body has expressed the importance of the human element in operations and the advantages of human-centered design in crew safety and operational efficiency (International Maritime Organization, 2006). The earlier Human Factors and Ergonomics (HF&E) knowledge and end-user experience is utilized in a design project the easier and more effectively it can be successfully integrated (International Organization for Standardization, 2011; Mao, Vredenburg, Smith & Carey, 2001). This contributes to enhancing the working environment, crew efficiency, reducing future service and redesign costs over a ship’s operational lifecycle.

2. Purpose

The purpose of this investigation is to explore a practical approach to introduce HF&E knowledge in early ship design. Initial general arrangement (GA) drawings have been identified as a common platform for project stakeholders which can integrate HF&E knowledge early and continuously throughout ship development (Mallam & Lundh, 2014). This paper will investigate the usefulness of two-dimensional (2D) GA drawings for HF&E evaluation by comparing a cargo ship currently in operation to the design drawings it was based on. By better understanding the benefits and drawbacks of using GA drawings as a tool for evaluating the human element in shipping operations HF&E practitioners can become a more effective resource in complex engineering projects.

3. Ship Case Study

A Roll-On/Roll-Off cargo vessel built and operating since 2006 was used as a case study. This investigation specifically focused on engine room design and engine crew working demands. A comparative analysis between the ships 2D GA drawings, which the structure was built from and the actual constructed onboard working environment was performed. In addition to the comparative analysis the engine crew was job-shadowed and interviewed to gain insight into their work demands and how they work within the space. Data collection took place onboard over an eight day period while the ship was operating its normal route in Northern European waters.

4. Findings

Differences between the ship’s GA drawings and the actual onboard working environment were revealed. As the name suggests GA drawings are a general and incomplete representation of the finalized construction. They primarily detail the divisions of differing compartments throughout the ship and the location and type of major pieces of equipment. An abundance of minor equipment and installations are absent from GA drawings, which once added alter the finalized working environment. The design and placement of items such as piping and electrical systems, valves, flooring, stairways, passageways and overhead lifting aids impact finalized area dimensions and ease of access to equipment. This can ultimately impose operational and safety restrictions on crew. It was also found that the engine crew modified the working environment because the original design did not fully support their work demands. Throughout the engine department were examples of how crew retrofitted the work space to optimize elements which were either poorly designed or completely excluded in the original construction.
5. Discussion

GA drawings are advantageous for evaluating big picture physical ergonomic issues related to crew work demands: primarily, logistical flows of people and equipment throughout the engine room and ship. The mapping of critical links between differing areas and equipment of a ship optimizes layout for crew work procedures and can be implemented early in design. However, even finalized GA drawings do not allow for a comprehensive working environment or work station analyses because (i) the design has not advanced sufficiently to account for detail necessary for HF&E analyses, or (ii) naval architecture methods and GA development simply do not account for, or include design criteria necessary for HF&E analyses. The more common dangers for engine crew include slips, trips and falls, risk of musculoskeletal injuries and exposure to toxic substances. It is impossible to comprehensively evaluate the design for these types of micro-ergonomic criteria through 2D GA drawings and may not be considered until onsite installation at a shipyard during construction.

Implementing HF&E evaluation within GA drawings at a conceptual ship design level provides a common platform for project stakeholders at an early stage in ship development. GA drawings are incomplete and when directly compared to a finalized product indicate inaccuracies in design and overall working environment characteristics. However, GA analyses are able to map out frequent personnel and equipment routes and early evaluations can be used as a basis for further design support throughout ship development. Solving the rudimentary design concerns engine crew struggle with, including manual materials handling, physical maintenance tasks and logistics will provide a better foundation for the development of increasingly detailed ship design.

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References


