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Unravelling causal factors of maritime incidents and accidents

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ABSTRACT

Lessons from maritime accidents are conventionally used to inform safety improvements in design and operation of ships. However, this process is only as good as the core understanding derived from accident analysis is. The current explanation of accidents is limited to direct and contributing causal factors, whereas the role of a wider socio-technical context that has given rise to causal mechanisms behind major maritime accidents in recent years is left unexplained. The paper describes analysis results of maritime incidents and accidents occurred over the last decade with passenger ships, with the purpose to illuminate the prevailing causal factors, not least the systemic ones. The results show where the weak links in maritime safety control are (e.g., interactions between ship operators and equipment manufacturers), what their role in accident causation is, and how they can be strengthened. The study seeks to provide valuable input for enhancements in overall maritime safety control and proactive safety management at the ship and shipping company levels.

1. Introduction

Good safety records are prerequisite for achieving strategic goals, including profits and continuous existence, of any shipping company. However, serious maritime incidents and accidents remain rife. The last decade was replete with dreadful calamities, not least the sinking of cruise ship *Costa Concordia* and ferry *MV Sewol* (KMST, 2014; MIT, 2013). The decades before, were equally depressing (e.g., *MS Herald of Free Enterprise*, *Estonia*, and *Express Samina*). At the same time, the safety assurance on modern ships is getting more complicated, partly due to the conventional safety strategy *defence-in-depth* (Carroll, 1998), which requires redundancies and multiple layers of protection, and partly due to new digital technologies, e.g. dynamic barrier management (Pitblado et al., 2016), which introduces extra layers of defence, new interactions and weak couplings (Twomey, 2017).

Given the mediocre safety records, it can be argued that the answer lies in currently used fundamentals and practices of accident analysis. As in other similar industries such as aviation, maritime accident investigations serve to inform evolutionary improvements in design and operational practices. This means that high quality of accident investigations is instrumental in improving safety. The accident analysis process, its outcome and response to the accident are dependent on an accident model assumed, i.e. the conceptual understanding of how accidents occur (Benner Jr, 1985; Svenson, 1999). The currently used investigation manuals are based on the *Swiss cheese* model by Reason (1997), i.e. a complex linear accident model where the importance of unsafe acts is accentuated and the underlying causes of the events are practically ignored other than a lack of safety barriers (slices of the cheese) aimed to prevent their propagation (Lundberg et al., 2009). Thus, the accident investigation remains mostly confined to the context in which proximate events occurred, barriers failed and the organisational factors involved (Schröder-Hinrichs et al., 2011).

It, hence, appears that the importance of wider systemic issues in accident etiology is insufficiently recognised, despite the evidence from many maritime incidents and accidents, as shown in this and other publications (Johnson and Holloway, 2007), and the solid theoretical basis, e.g. (Carroll, 1998; Leveson, 2011; Rasmussen, 1997), for them. Such evidence, for instance, points to systemic factors that insidiously degraded safety barriers, acting as their common cause failure and making the defence-in-depth ineffective. For instance, Kim et al. describe the accident with passenger ferry *MV Sewol* where commercial pressures and lax regulatory control had disabled vital organisational and technical barriers, making the accident imminent (Kim et al., 2016). According to the systems approach, accidents are a result of poor functioning of the safety control system as a whole, i.e. the presence of dysfunctional interactions between system elements and, therefore, inadequate enforcement of safety requirements and constraints (Leveson, 2011). Such inadequate interactions within the socio-technical system must be identified, analysed and remedied, regardless of whether their effect is direct and easily explainable, or it is uncertain or extra-organisational, as it happens with nonlinear, more distant—in time and space—causal factors.

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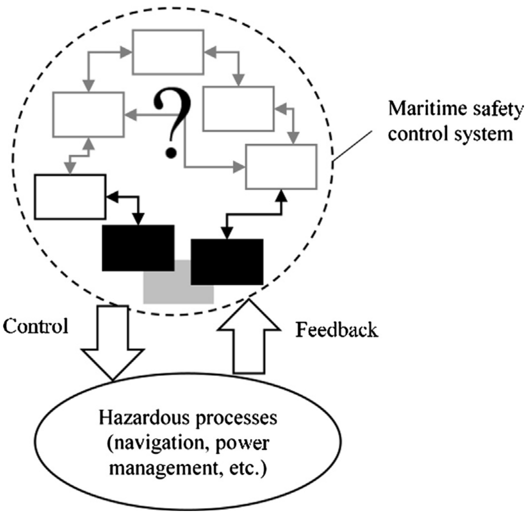

Fig. 1. Dysfunctional interactions (inadequate safety enforcement) within the overall system.

With this in mind, the understanding of the contribution of the entire safety control system—regulators, insurers, manufactures and supplies, shipping companies, ships, equipment, etc.—becomes essential for prevention of accidents, incidents and other unwanted events. This requires going beyond proximate failures and flawed interactions at the ship and shipping company levels, as well as unhelpful assumptions that unfortunate events are mainly random and caused by "human erroneous actions", e.g. (EMSA, 2017). Hence, the exploration should seeks to answer the question why accidents could occur, extending the frontiers of current knowledge about the underlying causal mechanisms thereby (Fig. 1). Attempts have been made to bridge this knowledge gap (Section 2), but the problem, alas, remains under-researched.

Hence, the purpose of this paper is to illuminate dysfunctional interactions within the entire system of maritime safety control, the interactions that gave rise to direct, contributing and systemic causal factors behind significant incident and accidents. To this end, we adopted the Systems-Theoretic Accident Model and Processes (STAMP) and its method for causal analysis called CAST (Leveson, 2011). We applied CAST to analyse 188 incident and accident reports, retrieving 1250 instances of dysfunctional interactions in the system. We classified

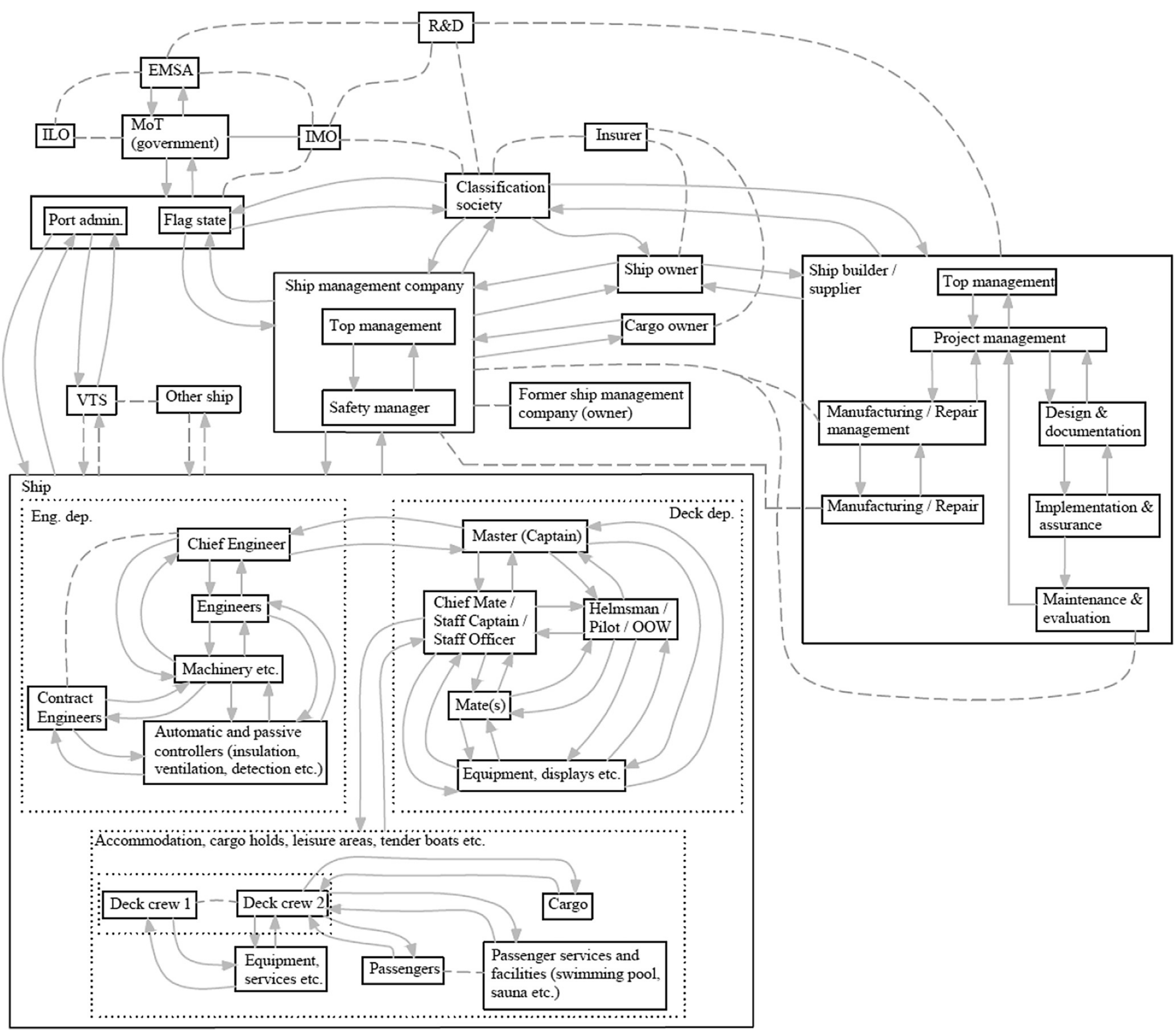

Fig. 2. Generic safety control structure (maritime safety control system).