Risk-Based, Sensor-fused Emergency Response in Flooding Casualties

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ABSTRACT

The research presented in this paper emanates from Ph.D. research (Karolius, 2019), directed at the development of a framework where sensors and analytics serve to improve the quality of information in risk assessment and, hence, provide means for a more comprehensive life-cycle flooding risk management framework for large cruise vessels. This paper outlines the developed framework with focus on application in flooding emergencies, determining with high confidence the extent and location of damage following hull breach in a collision incident using probabilistic multi-sensor data fusion techniques. This provides supportive evidence for quantified decision making, providing improved survival assessment that enables the crew to implement emergency response in a timely, targeted and efficient manner. This will prolong the time available for safe and orderly evacuation, potentially facilitate safe return to port.

KEY WORDS: Damage stability, Flooding emergency response, Life-cycle flooding risk management, Multi-sensor data fusion.

INTRODUCTION

The ability of a vessel to survive a flooding incident is not only a function of the vessel design but also the quality of damage control employed. Incidents that lead to flooding tend to erupt unexpectedly, with little or no warning, thrusting the vessel’s crew into the damage control evolution. The effectiveness of the ensuing damage control process relies heavily on the crew ability to make fast and correct damage control decisions and to execute damage control measures in a timely manner. Any delay could result in further spread of damage and degradation of vital ships systems. The influence the vessel crew can have in surviving a given damage, depends largely on three primary aspects of damage control, namely detection, assessment and implementation. The effectiveness of each stage depends largely on the quality of the former, with information from one stage feeding into the next. This paper places focus on the first two of these stages and outlines a methodology that provides both a means of detecting and assessing flooding damage in complex ships, resulting in the provision of the information required for the ship crew to enact appropriate and effective damage control measures.

Complex flooding process

The intrinsic complexity of the flooding process on ships renders accurate quantification of flooding risk a highly arduous task, particularly in the context of emergency management, where convolution stems from a multitude of variables, their dependencies and interactions. This is especially true for large cruise vessels, with ever-growing number of passengers, innovative designs and complex internal subdivision. This augments the uncertainty and imposes further challenges on the crew in obtaining a complete overview and making informed decisions, following a given flooding event. Recent studies identify the human cognition and lack of situational awareness as leading factors in some high-profile accidents (e.g. MIT, 2013). Recognition of these problems in combination with the relentless upsurge of the cruise segment has led to an intensive pursuit for more optimal design solutions and has facilitated the introduction of risk-based ship design methodologies and subsequent cost-effective risk control options aiming at both prevention and post-accident mitigation and control (Papanikolaou et al., 2009). The latter is directly related to emergency response but is, however, largely dependent on human intervention to perform their intended function, focusing mainly on controlling and containing situation-specific flooding processes. In the absence of proper situational assessment, the process being controlled is rather hypothetical and may be significantly different from the actual one. This may result in implementation of suboptimal or even wrong mitigation measures. In