

Risk and Reliability Modelling for Multi-Vehicle Marine Domains

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Abstract—It is well-known that autonomous underwater vehicle (AUV) missions are a challenging, high-risk robotics application. With many parallels to Mars rovers, AUV missions involve operating a vehicle in an inherently uncertain environment of which our prior knowledge is often sparse or low-resolution. The lack of an accurate prior, coupled with poor situational awareness and potentially significant sensor noise, presents substantial engineering challenges in navigation, localisation, state estimation and control. When constructing missions and operating AUVs, it is important to consider the risks involved. Stakeholders need to be reassured that risks of vehicle loss or damage have been minimised where possible, and scientists need to be confident that the mission is likely to produce sufficient high-quality data to meet the aims of the deployment. In this paper, we consider the challenges associated with risk analysis methods and representations for multi-vehicle missions, reviewing the relevant literature and proposing a methodology.

I. INTRODUCTION

Traditionally, autonomous underwater vehicle (AUV) missions have consisted of a simple sequence of instructions, such as travelling between multiple waypoints, pre-defined by an operator to be within safe-working constraints [1], e.g. ensuring the vehicle maintains a safe distance from the sea floor. Consequently, previous applications of risk and reliability techniques to AUV operations has primarily focussed on attempting to quantify the general reliability of the physical vehicle and its component sub-systems, e.g. the propulsion or manoeuvring systems, through the use of mean-time between failures, fault-trees [2], [3] and expert elicitation [4].

In this paper, we present a review of existing risk and reliability techniques, both within the marine autonomy literature and other related fields. The suitability of each approach is evaluated in the context of our multi-vehicle application and we discuss our proposed risk and reliability methodology.

II. MOTIVATING PROBLEM: MULTI-VEHICLE MARINE DOMAINS

Multi-vehicle mission formats are becoming increasingly popular for a variety of applications [5], [6]. Multiple AUVs can survey larger areas, whilst autonomous surface vessels (ASVs) may act as communication hubs or provide navigational updates for AUVs. Whilst some of the traditional challenges associated with AUV operations may be reduced by the

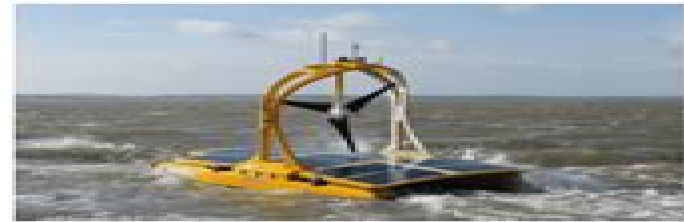


Fig. 1. C-Enduro [7] (Photo: Autonomous Surface Vehicles Ltd.)



Fig. 2. Autosub Long-Range [8]

presence of a second vehicle, this multi-vehicle marine domain brings new behaviour requirements and thus risks, which need to be further analysed and mitigated where possible.

As part of an Innovate UK funded project (Autonomous Surface / Sub-surface Survey System - ASSS) [9] with industry partners¹, we are researching the use of the C-Enduro [7] ASV (see Figure 1) as a navigation aid and communication link to the long-endurance AUV Autosub Long-Range (ALR) [8] (see Figure 2). As a long-endurance platform, ALR sacrifices power available to sensors to maximise vehicle range. Consequently,

¹Autonomous Surface Vehicles Ltd, Sonardyne International Ltd and Sea-Byte Ltd.

Risk And Reliability In Marine Technology

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Risk and Reliability in Marine Technology C. Soares Guedes, 1998-01-01 Experience has shown that introducing risk analysis in the initial phases of any design often has important beneficial effects on both safety and economy. It has also become well accepted that structural design can occur on a sounder basis if the concepts of structural reliability are applied in that they provide a consistent base to deal with uncertainties and to establish safety factors. Finally, the operational cost of running installations depends very much on the maintenance policies applied and these in turn can translate their efficiency in terms of reliability of the systems that are maintained. The mathematical tools available to deal with these different types of problems are somewhat different but they have several common features. The main one is the use of probabilistic models to predict the probability of failure or its complement, reliability. This book explores the complementarity that exists among these different types of formulations by presenting an overall view of the tools that can be used in the phase of conceptual design, detail design and in the operational phase. Emphasis is on Marine Technology in that most of the applications presented are related either to offshore platforms or to ships. However, the applicability of the methods presented is not restricted to this field. In particular, the contributions on reliability of systems are very general and applicable to any type of system, repairable or non repairable. The work is broadly organised in three sections dealing with risk assessment, structural reliability and system reliability. In the first section, the main methods of quantitative risk analysis are presented together with case studies that provide an illustration of how they can be applied. The section on structural reliability presents the probabilistic formulations that are required for the reliability assessment of the marine structures. The last section deals with reliability of systems, a formulation that is essential for the different types of equipment existing in ship and offshore platforms. Contributions are by a group of international experts in the field.

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West European Graduate Education Marine Technology, 1993

Marine Technology and Sustainable Development: Green Innovations Olanrewaju, Oladokun Sulaiman, Saharuddin, Abdul Hamid, Ab Kader, Ab Saman, Wan Nik, Wan Mohd Norsani, 2013-07-31 Water covers more than 70% of the Earth's surface making maritime influences an important consideration in evaluating modern global economic systems. Therefore, the efficient design, operation and management of maritime systems are important for sustainable marine technology development and green innovation. Marine Technology and Sustainable Development: Green Innovations examines theoretical frameworks and empirical research in the maritime industry, evaluating new technologies, methodologies and practices against a backdrop of sustainability. This critical reference encourages the discussion and exploration of diverse opinions on the benefits and challenges of new marine technologies essential for marine and maritime professionals, researchers and scholars hoping to improve their understanding of environmental considerations in preserving the world's oceanic resources.

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