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A study of reliability-centred maintenance in maritime operations

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Abstract

This paper has identified specific problems likely to be encountered in endeavour of implementing reliability-centred maintenance (RCM) on ships. These stem out of the cultural differences between the aviation and maritime industries. In the maritime industry, RCM is often considered resource demanding. It is however possible to make the project manageable by starting with a critical system. Considerable savings in time and effort can also be achieved by using a reverse logic where the failure modes are identified by analysing the maintenance tasks. A subjective qualitative approach has been proposed to overcome the limitations of the definitive logic used by the decision trees and the demand for failure data imposed by quantitative methods. A fuel oil purification system has been used as a test case to demonstrate its use. There is appreciation amongst both classification societies and equipment suppliers of the principles of RCM in the maritime industry. This makes the application of the RCM concept feasible. Finally it is the seafarer, who will have to be on the forefront of this endeavour and total productive maintenance can be used to create the right work environment to achieve this. It is concluded that rather than looking at RCM as a methodology and trying to use it as such, it makes more sense to consider it as a philosophy and use its guiding principles to help the seafarer plan his maintenance strategy.

Keywords: Maintenance strategy; Marine operations; Reliability-centred maintenance

1. Introduction

Maintenance costs form a significant part of the overall operating costs in ship operations. Maintenance also affects reliability and can thus have environmental and safety consequences. The International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code) addresses the management aspects. These are considered to be closely associated with human error, which is responsible for up to 80% of the marine accident cases. The importance of maintenance is demonstrated by the fact that it is the only shipboard activity to have one whole element assigned to it (i.e. ISM Code element 10) [1].

ISM Code element 10 focusing on maintenance of ship and equipment inter alia states that "The Company should establish procedures in its SMS (Safety Management System) to identify equipment and technical systems the sudden operational failure of which may result in hazardous situations. The SMS should provide for specific measures aimed at promoting the reliability of such equipment or systems". This is consistent with what reliability-centred maintenance (RCM) delivers. RCM focuses the maintenance resources only on those items that affect the system reliability, thereby making the maintenance programme cost effective on the long run.

However, most of the attempts to implement RCM on ships have been done by shore-based consultants or academics. To really benefit from the process the ship staff should be able to use it in their onboard maintenance analysis. This is because RCM results are based on the operating context, which keeps changing with the type of cargo, voyage, crew, etc.

RCM was initially developed by the aviation industry where it has delivered excellent results. This has encouraged various other industries to use it to improve their maintenance practices [2]. However, applying RCM to ships could have some hurdles. These include:

(1) Lack and portability of failure data: There is no easy access to failure data as there is no composite

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databank, which shares information with every one. Commercial sensitivity has often been the reason for this. Ships operate in different and continuously changing environments making it difficult to use failure data from one ship on another.

(2) Basic equipment condition cannot be taken for granted: Certain equipment conditions like tightness, lubrication and cleanliness, which can be taken for granted in other industries, are constantly a source for concern in the maritime industry.

(3) Shipboard personnel are rarely trained in maintenance management or risk assessment techniques, especially those that require a statistical approach.

Shipboard personnel have to be "jacks of all trades" which also means that they are not likely to have any specialised background, particularly mathematical.

(4) Shipboard personnel are already overburdened: Shipboard personnel are operators as well as maintainers. A complex and long methodology is not likely to find favour with them.

(5) Ships operate in isolation from repair and spares facilities: The failure mode analysis should give special attention to consequences resulting from the above.

(6) Lack of "adequate" redundancy: Traditionally RCM assigns equipment with redundancy "run-to-failure". While this makes sense in other industries with its multiple redundancies, it may not be desirable in shipping where critical systems usually have only single redundancies failure of which could be catastrophic.

(7) Rigid prescriptive requirements of various regulatory bodies: Ships come under the purview of different regulatory bodies including Port State, Flag State, Classification Society, etc. All these have to be accommodated in the maintenance plan.

(8) Recommendations from equipment suppliers have to be followed in the guarantee period: Non-compliance with the recommendations during this period could remove the supplier from any obligations in case of a claim.

(9) Equipment suppliers do not give a FMEA: Some industries and organisations require their suppliers to submit a FMEA of the equipment. This greatly helps implementing RCM. However, this is not the case in ship operations.

(10) RCM analysis results are unique to each operating context: The same pump working on a ship or in a system may have different functions, operating conditions, redundancies or even failure detection probabilities elsewhere. Hence the analysis has to be carried out individually for each ship and system.

(11) Ships crew keeps changing: There is a need to lay down explicit guidelines on the way analysis is to be carried out to prevent inconsistent outcomes of the analysis of the same system carried out by different teams.

There is therefore a need for a streamlined approach, which the onboard crew can use to identify and analyse their maintenance problems.

2. Reliability-centred maintenance

Maintenance management has undergone considerable change in the past 15 years [3]. Maintenance is now aimed at, based on the operating context, preserving the functions of assets rather than their condition. There is more awareness of the failure characteristics of components. This coupled with frequent lack of accurate failure rate data has caused a shift towards condition-based (predictive) maintenance from schedule-based (preventive) maintenance. These changes are best reflected in the RCM philosophy.

2.1. History of RCM

RCM has its origins in the findings of the Maintenance Steering Groups (MSG), that were formed in the aviation industry to develop a maintenance programme for the Boeing 747 and Lockheed L1011 [4]. Having considered the size, passengers' carrying capacity and technological advances of these aircraft, it was initially recommended that a maintenance programme was so extensive that it would have made the aircraft a commercial failure. This led representatives of various airlines, aircraft manufacturers and the US government to form these committees with the intention of reviewing the prevailing practices and analysing their impact on the life cycle of the components. United Airlines were one of the biggest contributors to this study.

The MSG suggested a system-based approach derived from the curves that used a logic tree for decision making. In 1975 the US Department of Defence directed the MSG concept to be labelled "reliability-centred maintenance" and to be applied to all major military systems [5]. RCM has gained considerable recognition in the armed navies. Besides the Nowlan and Heap report [6], which was a product of the US Navy, the UK Ministry of Defence has published Defence Standard 02-45 (NES 45) [7] that is based on RCM-II [8]. The US Naval Aviation also uses RCM [9]. However, the approaches seem too resource demanding and may not be suitable for an unorganised industry like maritime without modification.

2.2. RCM Principles

RCM has been formally defined by John Moubray [8] as "a process used to determine what must be done to ensure that any physical asset continues to do whatever its users want it to do in its present operating context". Richard B. Jones in his definition of RCM [4] has added