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Naval Surface Ship In-Service Information Exploitation

Gary Ford[a]*, Chris McMahon[a], Chris Rowley[b]

[a]University of Bristol, Bristol BS8 1UB, England
[b]Babcock International, Keynsham BS31 2YH, England

* Tel.: +44-7748-666212; *E-mail address*: cegnf@bristol.ac.uk

Abstract

The Royal Navy operates a fleet of complex modern warships and submarines each comprising a system of systems often in harsh and potentially volatile environments. The maintenance of surface vessels is primarily undertaken by Babcock and BAe Systems in an alliance with the Ministry of Defence. The Ministry of Defence system engineering lifecycle is known as CADMID, this details the six phases of a projects' lifecycle from Concept through to Disposal. The "In-Service" phase of a naval vessel will typically constitute 70% of the artefact's through-life cost. During the "In-Service" phase the number and involvement of stakeholders will vary as the vessel cycles through Tasking, Upkeep and Regeneration. The paper considers the key stakeholders and their participation in each cyclical mode. Information to be exploited will be subject to two discrete drivers, firstly the information available for exploitation as a consequence the vessels' current cyclical mode, secondly, the characteristics of the information source..

Keywords: Naval; In-Service; Maintenance; Information; Exploitation;

1. Introduction

A modern warship / submarine will contain in excess of 100 integrated systems which are linked structurally, mechanically, electrically, hydraulically, pneumatically and electronically [1]; thus a warship / submarine may be viewed as a system of systems. Maintaining and enhancing the capability of modern warships and submarines is a strategic function undertaken by organisations working in partnership with the Royal Navy (RN) capable of providing "ultra-reliable engineering excellence". The maintenance of warships and submarines often necessitates the exploitation of vast quantities of information, Kane and Alavi define "exploitation" as "incremental learning focused on diffusion, refinement, and reuse of existing knowledge" [2], indeed, often what is learnt is an incremental enhancement of knowledge already gained. However, caution is fundamental when endeavouring to exploit information since it may exhibit some or all of the following [3]:

- Fuzziness: lack of detail
- Incompleteness: that which we do not know or leave out
- Randomness: lack of pattern

The approach of this paper is as follows. After outlining the background of the marine defence environment within the United Kingdom (UK) it explores the systems engineering methodologies applied to the domain followed by a review of "objective" and "subjective" information sources. The "In-Service" stakeholders are reviewed together with their association with the cyclical operational modes of surface ships and this is followed by exploration of the information available for exploitation and the associated characteristics of this information. The paper concludes with a discussion, further research and conclusion.

The paper presents a position statement, taken from the experience of naval and Babcock personnel within the surface ship domain; the purpose is to identify stakeholders,

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information sources and associated characteristics currently available and exploited.

2. Background

The RN fleet comprises approximately 95 vessels [4] varying in size and complexity, however, "taking the number of frigates and destroyers as an indicator, the RN is one quarter of the size it was in 1980" [5]. None-the-less, operational commitments remain high, with on-going operations in the Arabian Gulf, Indian Ocean and the South Atlantic in addition to providing the UK's continuous nuclear deterrence. The surface fleet is supported by a Surface Ship Support Alliance (SSSA), formed between Babcock, BAe Systems (BAe) and the Ministry of Defence (MOD) creating a Class Output Management (COM) organisation to maintain surface ships, based upon the premise of "contracting for availability" [6].

Naval vessels, i.e. surface ships and submarines, are data rich environments containing and creating large volumes of electronic and paper records, e.g. Operational Defects (OpDef), Marine Engineering Defect logs, etc. Each data source is often designed to satisfy a singular requirement within a singular cyclical mode; the consequence being the risk of data duplication and potentially a failure to record data that may be pertinent to exploiting the vessels' / system material state.

In addition to the numerous data sources local management will often vary, e.g. some vessels may record all defects in the maintenance management system, i.e. Unit Maintenance Management System (UMMS), whereas other vessels may only transpose into UMMS the most persistent defects as logged in the engineering logs

3. Literature Review

The International Council on Systems Engineering (INCOSE) defines a system as, "an integrated set of elements, subsystems, or assemblies that accomplish a defined objective" [7]. Naval vessels are complex and may be viewed as a system of systems, i.e. interrelated systems with emergent properties.

A variety of systems engineering standards exist (Table 1); the variation in definition and application of each standard reflects "the nature, purpose, use and prevailing circumstances of the system" [8].

Table 1. Systems Engineering Standards.

Standard (Year)	Description
ANSI/EIA-632 (1999)	Processes for Engineering a System
IEEE-1220 (1998)	Application and Management of the Systems Engineering Process
ISO 15288 (2008)	Systems and software engineering - System life cycle processes
CMMI® (2002)	Capability Maturity Model® IntegrationSM (CMMI®)
MIL-STD-499C (2005)	Systems Engineering

The acquisition and support of RN vessels by the MOD is defined by the "Acquisitions Operating Framework" [9]. The development and acquisition of "equipment capability" follows CADMID, similar in principle to ISO 15288, i.e. "Systems Engineering - System Life Cycle Processes" [10]. The MOD framework comprises 6 discrete stages (Figure 1).

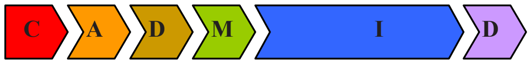

Figure 1. CADMID Lifecycle

The 6 stages are Concept, Assessment, Demonstration, Manufacture, In-Service and Disposal; thus a project / artefact should experience a linear progression through each stage of the lifecycle.

The In-Service phase of an RN vessel may be considerable, e.g. HMS Cornwall (Type 22 Frigate) was In-Service for more than 23 years. In order to sustain the capability of a naval vessel and extend its life, numerous Upkeep periods are undertaken which include capability upgrades, e.g. HMS Somerset experienced "enhancements to the ship's Seawolf missile system, installation of an advanced electronic communications system,..." [11].

Given the duration of the In-Service phase, the evolving operational threat and physical environment; timely effective maintenance together with prompt rectification of unexpected defects and system failure is essential to maintain the requisite level of capability and availability. Each Upkeep period will constitute a discrete CADMID lifecycle (Figure 2).

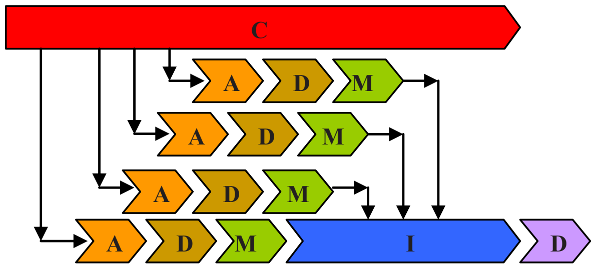

Figure 2. Capability Enhancement Lifecycle

The "Systems Engineering Handbook" [12] states a key benefit of systems engineering as "Ensuring stakeholder satisfaction on delivery". Indeed, failure to "effectively engage" with stakeholders is identified as a common cause for project failure [13]. Within the maritime defence environment engaging with and ensuring stakeholder satisfaction is the function of the "service provider" organisation, i.e. the COM, to the extent the customer (RN) is embedded within the structure.

The process model detailed in "A process view of maintenance and its stakeholders" [14] identifies 4 key stages, i.e. Maintenance Planning, Maintenance Execution, Functional Testing and Feedback. In addition to a definitive functional requirement, Soderholm asserts "Other inputs are maintenance documentation, such as maintenance objectives, strategies, and policies, which all should be based on stakeholder requirements" [14]. The "objectives, strategies,