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INDUSTRY SURVEY REVIEW OF OBSOLESCENCE MANAGEMENT STRATEGIES IN PERFORMANCE BASED CONTRACTS

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ABSTRACT

This research study has been developed through a cross sectorial benchmarking survey and represents the development of a descriptive framework from a management strategy perspective. The survey is based on face to face interviews and a questionnaire about obsolescence and availability in defence and non defence sectors. The high research elements reported are related to the set of obsolescence factors and unavailability drivers identified, the availability modelling methodologies studied, and the categorization of obsolescence management strategies from suppliers to customer perspective reported. The main results presented in this research are the evolution of the state of the art of the availability modelling techniques, the justification of the lack of availability predictive tools based on a list of typical commercial tools applied in the industry today and the positive and negative outcomes of using commercial of the shelf (COTS) as design criteria in long life systems.

Keywords: Obsolescence Management Strategies, COTS, System Availability Modelling Techniques.

1 INTRODUCTION

The trend of the UK manufacturing Industry is currently moving from capability contracts to availability contracts based on service performance between the contractors and the final customer. The availability metrics as key indicators are the measurements of the performance of the product, service and systems contracted by the customers. One of the main challenges in the supportability of complex systems which consists of hundreds and thousands of components interconnected with different serial and parallel configurations is related to the predictability of the system performance. These high availability systems are impacted by the obsolescence issues delivering a critical behaviour. This makes the risk associated to the lack of fulfilment of the commercial agreement result in penalties and loss of benefits to the customer. Some of these risks are shared across the supply chain from the original equipment manufacturers (OEM), suppliers and the distributors to the first contractors. Today the customer's benefits from an industry business strategy perspective come from the management and optimisation of the sustainment processes and associated services more than the acquisition and management of the spares. The maintenance policies will be optimised based on the prediction of the failure rates and the control of the obsolescence management processes. It implies a better information collection and management control.

Obsolescence management is a key requirement in design, production, and maintenance during system operation and support stages. The obsolescence issues impact mainly on the system supportability in terms of cost and the selection of the appropriate maintenance strategies. Due to the different Technology Maturity Levels and in order to avoid the consequences of the component/module obsolescence a mix of reactive and proactive mitigation strategies is taking place. Industry is focussing on the schedule and component availability optimisation to reduce the impact of the obsolescence event occurrences during the sequence of operation and support phases. Some of the related critical aspects are the availability optimisation of the spare parts in the inventory, the implementation of logistic strategies to decrease component lead times and the schedule of technology updates and upgrades at several points. It is also relevant the proactive mitigation strategies to avoid component degradation and capability reduction and the design strategies for obsolescence which could include system functionality improvements. The planning of active obsolescence management strategies rests in the fast technology evolution of electronic components, the lack of guarantee of suppliers and the continuous changes in environmental policies such as the "waste electrical and electronic equipment" WEEE or the restriction of Hazardous substance (ROHs). Therefor the obsolescence mitigation strategies will be focused on the impact reduction of the obsolescence issues on the availability of complex systems during the support and operational phases.

One of the benefits of this research paper is to help the managers of complex systems with the decision making process drafting a framework with the problems and potential solutions for the impact of the obsolescence on high availability systems. This study represents an insight review of critical operational research areas such as the reliability, availability, maintainability or logistics that is impacting on the systems performance in the industry today.

2 RESEARCH METHODOLOGY

This survey methodology is based on the sequence of activities shown in Figure 1.

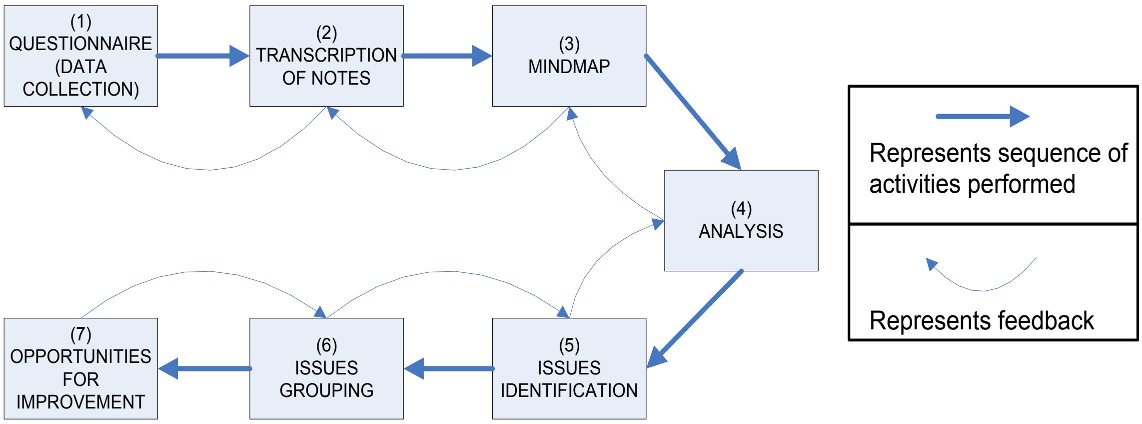

Figure 1: Research methodology of the cross sectorial benchmarking survey (Romero 2011).

This survey groups companies of Defence and non Defence sectors such as Railway, Aerospace, Marine or Power Generation. It develops more than 30 hours of face to face interview sessions and includes the participation of a total of 20 companies. Two main questionnaires about obsolescence issues and availability challenges have been answered by the industry. The results have been elaborated alongside with a literature review of the start of the art, which includes more than one hundred papers and reported to the companies participated.

3 OBSOLESCENCE MANAGEMENT STRATEGIES APPROACH

The obsolescence management activities can be classified into two different perspectives: the product life cycle approach based on the suppliers performance and the mix of proactive and reactive managerial approaches based on the resources and capability of the organisations which deliver the services contracted by the customer.

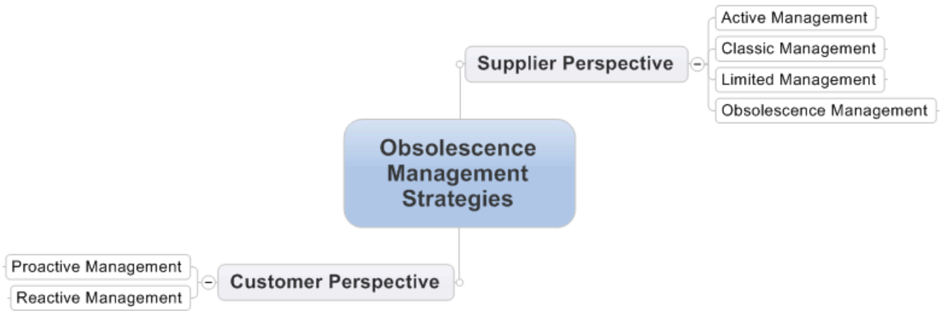

Figure 2: Obsolescence management strategies classification

The approaches showed in Figure 2 are described as follow:

1. Product Life Cycle Approach

It consists on four types of management strategies from supplier's perspective:

   a. Active management strategy: It is implemented when the items are fully sold and fully supported.
   b. Classic management strategy: It is implemented when the items are supported with spares and services.
   c. Limited management strategy: It is implemented when the spares and the supporting services are potentially available but are not guaranteed.
   d. Obsolescence management strategy: It is implemented when the spares, services and knowledge are not available and are not guaranteed.

2. Mix of Proactive/Reactive Management Approach:

It consists on two types of management strategies from operator's perspective:

   a. Proactive management strategy. Include several management activities such as:
      - Scheduling the updating and upgrading of systems.
      - Incentivising the supplier's chain to share the obsolescence risks.
      - Proactive Identification of obsolescence risk areas and components.
      - Periodic design reviews are in place.
   b. Reactive management strategy: Include several management activities such as:
      - Manual notifications.
      - Day to day obsolescence management tactics.
      - Obsolescence management plans based on suppliers' perspectives.
      - Component monitoring and marketing research.

Obsolescence events can be thought of as occurring at component and or system level. At component level the obsolescence of electronic components means the management strategies are focused on the logistics and management of inventory and how to improve component lead times under the constraint of the budget restrictions. Specific strategies include:

1. The periodic identification of the critical factors that contribute extending the lead time in supporting a specific component.
2. The obsolescence management planning and task scheduling for market research, component monitoring and acquisition processes.
3. The daily review tasks which include testing and integration of components in the equipment.
4. The process of identifying a list of critical obsolescence components for risk evaluations to reduce the number of potential obsolescence events.
5. Justification and prioritisation of the mitigation actions for each obsolete component based on cost-benefit comparison.

At subsystem/system level the obsolescence and availability management processes are focussed on the scheduling of technology insertions and different engineering aspects.

4 DESIGN FOR OBSOLESCENCE: COTS APPLICATION STUDY

Design for obsolescence in the actual system represents one of the main challenges in obsolescence management and implies the use of commercial off the shelf COTs solutions. Some of the relevant characteristics of these products are availability in the commercial market such as the high number of suppliers available for component replacement, the accomplishment of the specifications of the most popular buses and standard interfaces and the quality level requirements which are accepted by industry.

The managers of high complex systems prefer adapt COTs solutions than other kind of solutions such as the proprietary products because of they are cheaper and present better performance. They present clear advantages such as the standard protocols adapted by the industry for Hardware and software components based on commercial solutions. The COTs product flexibility for design based on standard protocols and well stabilised HW and SW interfaces allow find solutions for real system engineer problems. It also allows establish system open architecture that is one of the more power obsolescence mitigation strategies in design. Some of the advantages for control or computing systems in Defence, Nuclear or Railway when they adapt open system architectures are listed:

a. Facilitate the certification process of the products which allow accomplish the non-functional requirements such as the system availability, reliability or quality.
b. The whole lifecycle cost such the procurement or development cost are reduced through the whole life cycle.
c. The integration processes of components into subassemblies and assemblies and/or the integration of equipment into networks is less time consuming.
d. Reduce the maintenance time and facilitates the technology insertions reducing potential risks.

Unfortunately the use of COTS product in complex systems presents some disadvantages:

a. The complexity of large software applications make very difficult to run exhaustive testing activities.
b. The commercial availability is becoming shorter due to the rapid technology changes in the market.
c. The interdependence between hardware and software modules makes difficult to upgrade the software application which is running over a legacy hardware decreasing the system capability.
d. The number of supplier to support application during long periods of time is reduced.
e. It is difficult to manage the quantity of the spares in the inventory due to the rapid changes in the stock levels as the components become obsolete quickly.

5 SYSTEM AVAILABILITY MODELLING TECHNIQUES

The prediction of high availability systems mainly depends on the reliability, maintainability and supportability parameters as stochastic factors that influence the system's behaviour. The real systems such as ships, defence equipment and nuclear plants consists of hundreds and thousands of components interconnected, with different serial and parallel configurations, multiple state levels, different maintenance policies and failure and repair dependencies. Analytical methods such as Coloured Petri Nets or Renewal Markov chains (Cekyay and Ozekici, 2010) and simulation techniques such as Monte Carlo (Zion et all, 2005) or Discrete Event Simulation (Schryver, 2012) are the most appropriate set of methodologies to model the availability of these real and dependent systems. Some of the methodologies applied to predict the availability and reliability behaviour can be evaluated as follows:

a. Simulation methods. This methodology is a time consuming technique but present the advantage of being an easy computing technique. This can be appropriate with the introduction of clear restrictions such as the description of the main reliability parameters with exponential distribution functions or the assumption of independence behaviour of the failure and repair times. The reliability theory describes the operational availability in terms of down time and uptime which are mainly represented by the mean time between failures MTBF the main time to repair MTTR and the mean logistic delay Times MLDT parameters and is applied in the renewal alternating process (Yañez et all, 2005) or the design for availability approaches (Jazouli and Sandborn, 2012) which are both examples of the last availability modelling methodologies.

b. Optimisation methodologies are based on heuristics and analytical methodologies. There is in the literature review four main techniques to find an optimal solution of the availability parameters at component level: "dynamic programming"," integer programming", "non integer programming" and "heuristic or metaheuristic algorithm implementation" which also require the introduction of some assumptions. The availability optimization problem of series- parallel configuration in repairable systems which represent a real problem description in the industry today can be modelled using the metaheuristic approach of genetic algorithms (Juang et all, 2008). It can give a solution near to the optimum saving computing time in comparison with Monte Carlo Simulation techniques.

6 COMMERCIAL TOOL APPLICATION REVIEW

The final objective of the management of long life systems is to implement a decision making processes based on risk assessment and predictive tools which imply the optimization of the obsolescence strategies to reduce the system impact in terms of cost, safety and performance. The industry today is aware of the lack of predictive tools to mitigate the impact of the obsolescence events in the performance based contracts (PBC). A general view of the commercial tools for the management of complex systems is listed:

- Operational Field: Failures Modes Effects Analysis (FMCA), Failures Modes Effects and Criticality Analysis (FMECA), Prognostic /Diagnostics techniques and modelling and simulation tools.
- Design Analysis: The High Reliability design tools, Design Failures Modes and Effect Analysis (DFMEA) and Computer Aided Design CAD tools.
- Logistic and Support areas: The logistic Support Analysis (LSA) tools, the Supply Chain Modelling Tools, the component Risk Assessment or the monitoring and forecasting tool.

7 DISCUSSION AND CONCLUSION

This research identifies the relevant aspects of the obsolescence issues and the main solution approaches to plan the management strategies of repairable and complex systems. The decision processes are described as a set of procedures focused on the development of optimal support, design and repair policies which mitigate the impact of the obsolescence events on high availability systems in the context of performance based contracts (PBC). This set of solutions can be supported and informed by a mix of tools aimed to quantify and estimate the behaviour of availability parameters based on stochastic simulation and an optimisation methodology and conducted to mitigate the support problems. The critical factors of the framework described are focused on the technology upgrades planning, the improvements of engineering processes in the testing, qualification and integration steps of subassemblies, assemblies and equipment, the identification and adaption of the appropriate obsolescence resolution approaches based on the companies capability , the inventory management and the long partnerships with the providers

The obsolescence management strategies review in performance based contracts presented in this research allow some open questions to further discussion:

1. How to measure the availability at system level in different sectors to estimate the impact of the obsolescence events on the operational availability and determine the optimal maintenance strategy?
2. What is the relevant set of design criteria, such as open architectures, to facilitate the logistics and support programs and mitigate the obsolescence problems?

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