# Obsolescence Challenges for Product-Service Systems in Aerospace and Defence Industry

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**Abstract**

The aerospace and defence industries are moving towards new types of agreement such as availability contracts based on Product-Service System (PSS) business models. Obsolescence has become one of the main problems that will impact on many areas of the system during its life cycle. This paper presents the major challenges to managing obsolescence for availability contracts, identified by means of a comprehensive literature review and several interviews and forums with experts in obsolescence management. It is observed that there is a lack of understanding of the impact of obsolescence on whole life cost. Experts agree that the development of a framework to support estimation, management, and mitigation of these costs is desirable, but the difficulty in forecasting future obsolescence issues constrains industry to a reactive approach rather than proactive.

**Keywords**:

Obsolescence Management, Obsolescence Costing, Product Service Systems.

## 1 INTRODUCTION

Traditionally in the aerospace and defence industry, an initial contract for development and manufacture was followed by a separate contract for spares and repairs. More recently, there has been a trend towards availability contracts where industry delivers a complete product-service system (PSS). The typical PSS has progressively increased in scale and complexity (e.g. from the humble photo-copier) through to major infrastructure projects (e.g. private finance initiative hospitals) to large defence projects (e.g. complete sea, air or land platforms) [1]. The challenge for both the solution provider and the customer is that, at the point of signing a contract, they must be confident in their estimates of the whole life costs (WLC) over periods of contracts that stretch 20, 30 or even 40 years into the future.

This research is part of the PSS Whole-life Cost Project (PSS-Cost) which is carried out by Cranfield University in collaboration with UK industry in the defence and aerospace sector. The project aims to develop a framework for the estimation of WLC in availability contracts and affordability assessment at the bidding stage in the defence context. This could include the non-recurring costs of developing, prototyping, integrating, and testing the product, the ongoing costs of maintaining the product (including obsolescence management), delivering and operating services (including staff training, commodities, consumables), and the end-of-life disposal of the product and/or termination of services. The exact composition of a WLC estimate will depend on the category of PSS contracts.

The obsolescence problem has a huge impact on the WLC of PSS in the defence and aerospace industry due to the long periods that the system is required to be in service [2].

Obsolescence may affect many aspects of a system such as: (See Figure 1) [3]

- Availability of replacement electronic components needed to replace those that fail in service
- Failure of non-electronic components (e.g. typically mechanical or structural), frequently in unexpected ways [4] owing to wear, fatigue cracking, damage and corrosion as the PSS ages.
- Software within the PSS (i.e. operational software including operating systems) and the software development environment needed to maintain it (i.e. hardware platforms, editors, compilers, linkers, loaders, and test rigs).
- Documentation and data (e.g. in terms of content, data format, and ongoing availability of IT systems and toolsets needed to access and maintain it).
- Procedures and methodologies.
- Skills and knowledge.

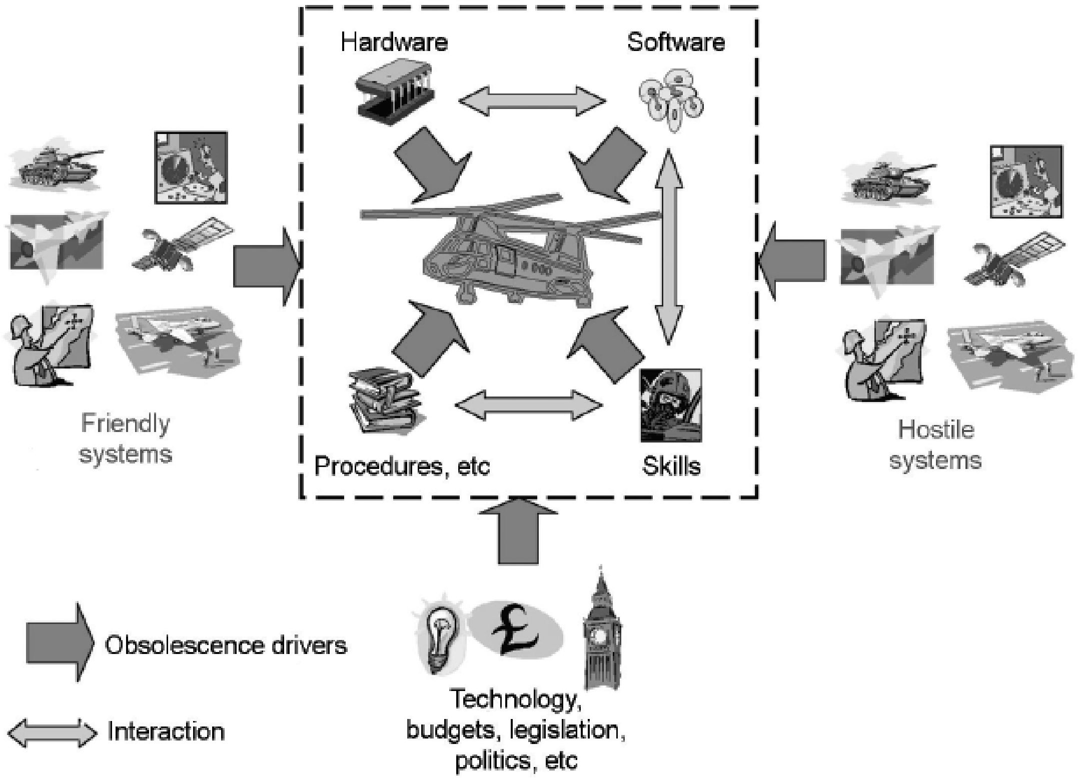


**Figure 1. The Holistic View of Obsolescence (at the System Level) (Adopted from [3])**

## 2 RELATED RESEARCH

In the literature it can be appreciated that many attempts have been made to manage obsolescence [2, 5, 6]. However, the challenge is still to develop a methodology that embraces obsolescence forecasting and the costing of all the possible alternatives to resolve it, delivering the optimal planning for managing the obsolescence problem [5, 7]. The first step is to minimise the impact of obsolescence at component level by development of a methodology able to determine the best dates for any design refresh and the optimum combination of actions required. For example, for electronic components, this has been addressed by Singh, Sandborn and Feldman [2, 8] at the University of Maryland by developing the Mitigation of Obsolescence Cost Analysis (MOCA) tool.

All the research described in the literature and carried out in order to minimise the impact of component obsolescence makes an attempt to determine: [9]

- How to anticipate occurrences of component obsolescence;
- How to react to occurrences of component obsolescence;
- How to reduce the risks of future component obsolescence;

Collaboration within the industry [10]; standardisation [11] of designs and modularisation [12] that may promote the interchangeability of components; and the implementation of proactive actions to determine accurately the cost and impact of obsolescence are the major means of minimising obsolescence risks [6].

Most of the research done so far in obsolescence has been focused on electronics components. Very few studies have considered a holistic approach taking into account the effects of obsolescence on mechanical components, software, skills of the personnel and processes. As Dowling [3] highlights, although there are tools and techniques developed for dealing with components obsolescence, “there is no defined process in MoD or elsewhere for managing system obsolescence”. Therefore, it is considered that a holistic study of the obsolescence topic will allow the overall impact on a PSS to be determined across the whole life cycle.

This research will focus on the development of a framework that allows forecasting and measuring the impact of obsolescence at the system level on cost. It will promote the use of proactive strategies in order to minimise the impact of obsolescence.

## 3 CONTRACTING FOR OBSOLESCENCE MANAGEMENT

### 3.1 Case Study

The continuous evolution of contracting in the defence procurement in the UK, which has been motivated by the MoD’s aim to deliver military capability at optimised cost of ownership, is bringing with it new challenges for ensuring both the affordability of military operations and the profitability of suppliers. Acquisition strategies now include a range of initiatives including spares inclusive, availability based contracting and ultimately, contracting for capability (Figure 2). These system-support contracting strategies can range from the provision of traditional fourth line repair and overhaul to usage based service level agreements. This range gives evidence of the recent expansion in the strategic degrees of freedom available to organisations operating in the defence sector.

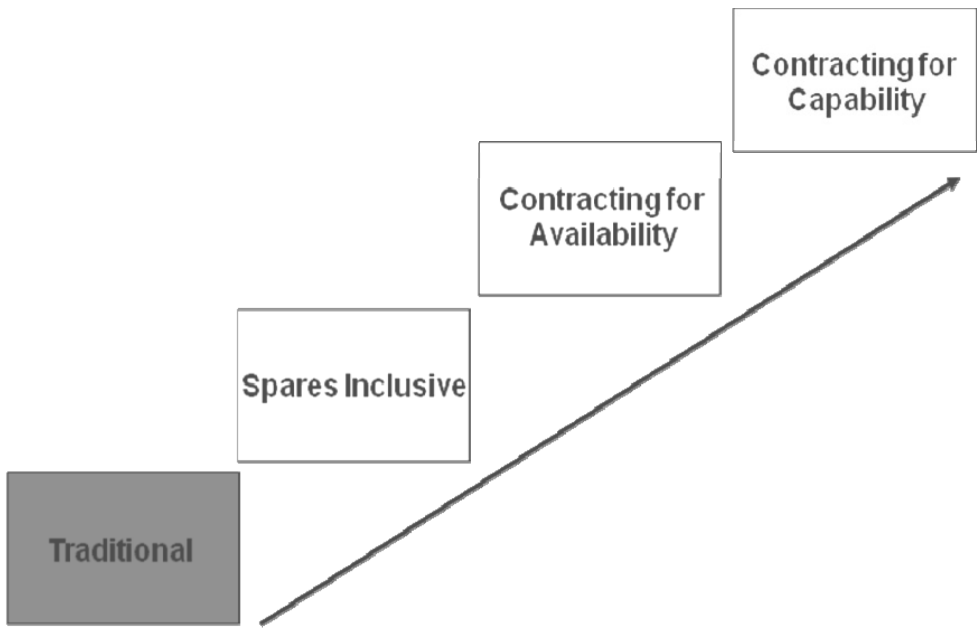


**Figure 2. The Evolution of Contracting in the Defence Sector**

However this business evolution brings with it the potential of increased operational risks for military customers, and issues arising from the commitment to future expenditure over long period of time.

There will be increasing trend towards contracting for availability. Nowadays it is regarded as a challenge to be able to cost availability as it is radically different from costing a solution, as it has been done so far. The current trend of contracting is moving in that direction and contracting for availability is the latest stage reached. The essence of availability contracts is that the suppliers are paid for achieving an availability target for the PSS (typically expressed as a percentage, e.g. "available 99.95% of the time") and not just for the delivery of the product and spares/repairs. This helps to ensure value for money for the customer.

The process currently adopted for acquiring equipment, systems or services for the UK armed forces is known as the CADMID cycle (Figure 3). This has six phases: concept; assessment; demonstration; manufacture; in-service, and disposal – all of different lengths, of course, with formal approvals at Initial Gate and Main Gate.

One of the biggest challenges of contracting for availability is costing obsolescence. It can affect not only the in-service phase of the CADMID cycle but any other phase because of the long duration of each stage. At the bid stage there is little information that can form the basis of the obsolescence forecast and the cost estimation related to it. This becomes a big risk for both the customer and the supplier.

It is critical to agree in the contract the allocation of responsibilities for managing obsolescence, resolving obsolescence issues and defraying the cost of them. The resolution strategy for each obsolescence issue is decided by the supplier's project manager. The strategy may also have to be agreed with the customer but this depends on the contract; the allocation of responsibilities between the supplier and the customer varies. The most common strategies are described as follows:

(1) The customer is responsible for the cost of resolving any obsolescence issue while the contractor is in charge of managing and resolving it. This has been the traditional way of contracting in the military sector. Customers would like to move away from this contracting style because, from their point of view,

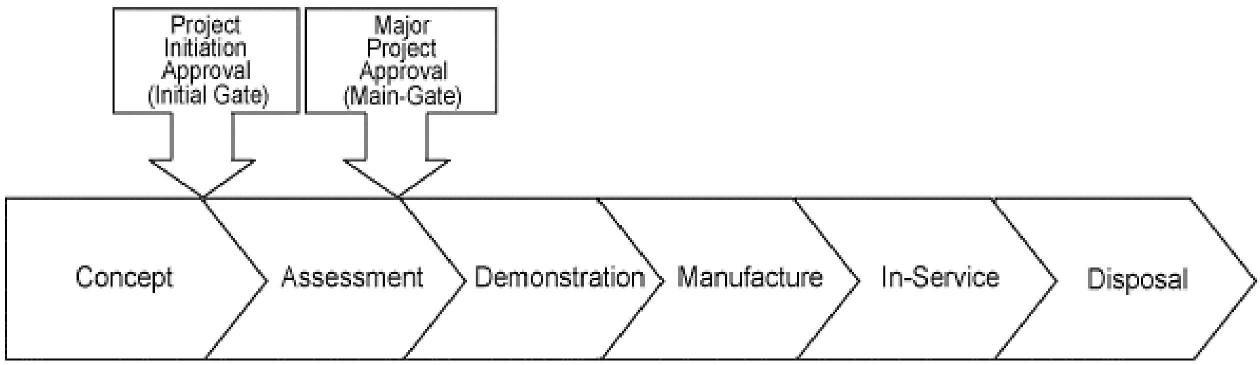


**Figure 3. The CADMID Cycle**

the supplier is not encouraged to find the most cost-effective resolution strategy.

(2) The supplier is responsible for the management and cost of resolving any obsolescence issue. Some availability contracts are implementing this strategy in order to agree a fix price. In principle the solution will be cheaper than option (1) because the supplier is better placed to manage the issues. However, the risk has transferred from customer to supplier and the supplier price will be driven up to cover the risk budget.

(3) Contractor pays for any form fit and function (FFF) replacement while the customer pays for any other obsolescence resolution.

(4) Financial threshold. A cost limit is set and the contractor will cover the costs related to solving obsolescence issues up to that limit. From that point onwards, the customer will be in charge of covering the costs.

(5) Target cost incentive fee. A target cost is set and if the final cost is lower than it, the contractor will receive a percentage of the cost avoided. This encourages the contractor to manage obsolescence in the most cost effective way.

(6) The supplier is responsible for the management and resolution of any obsolescence issue and the cost related to it is shared between the supplier and the customer. All resolution costs are split by a percentage factor between the customer and the contractor (e.g. 70/30, 50/50, 60/40). This is regarded as the best solution as it provides incentives to the supplier to search for the most cost-effective resolution strategy. It aligns the interests of both parties. The resolution strategies are defined by the supplier and approved by the customer.

The development of fair clauses for both parties is necessary, taking into account that experts spoken to as part of this research say that it is difficult to estimate the cost of obsolescence for more than eight years ahead. This figure is corroborated in the literature [13] and is based on the huge number of factors that may influence the forecasting of an obsolescence occurrence.

### 3.2 Approach Adopted

The current practice in the aerospace and defence sector has been captured across the Ministry of Defence in UK and the defence aerospace industry. A total of 27 interviewees from the above organisation have participated in workshops or one-to-one interviews. They are mainly Project Managers, Project Engineers and experts in Obsolescence Management, with experience in the area ranging from 3 to 20 years.

Another source of information is the documentation provided by these organisations, such as logistics and support plans, obsolescence management plans and examples of cost models.

Once the data gathering and analysis were completed, a cross case synthesis was performed by means of an internal workshop involving the members of the research team and compared with the observations from the literature review. The results were validated by Rolls Royce and approved by the other collaborators.

## 4 OBSOLESCENCE MANAGEMENT

The obsolescence problem cannot be avoided [14, 15]. The only way to minimise the impact of obsolescence and mitigate the risk is by planning and managing our response. Most of the organisations covered by the Case Study are using an Obsolescence Management Plan (OMP) that defines the policy to deal with obsolescence for each specific project. The OMP is developed by the department/expert in obsolescence management in each organisation. The OMP typically calls for a two-stage response: first, to identify obsolescence risks where economically viable; second, to mitigate the impact of residual risks should they arise.

### 4.1 Risk Assessment

This risk assessment is generally based on experience and expert opinion and some organisations have developed formulae on this basis (e.g. extrapolation of experience on past spares-and-repairs contracts to future availability contracts). Based on the results of this assessment it is decided which components (the critical ones) will be monitored in order to proactively tackle any possible obsolescence issue and which components (non-critical ones) can be managed in a reactive way.

- At hardware component level many organisations tend to combine the use of commercial monitoring tools, such as Q-Star$^{TM}$ [17] or the IHS products [18], with manual monitoring or in-house developed tools. This supports the determination of which components are most critical (e.g. on the Pareto principle).
- At higher levels of integration including both hardware and software, technology roadmapping is widely used to inform expert opinion. This particularly applies to commercial-off-the-shelf (COTS) product lines, e.g. where a supplier may have a three to five year plan for future development.

### 4.2 Impact Mitigation

In principle, proactive mitigations seek to sustain the FFF replacement of failed system elements over the planned lifetime of the system in the most economic way. The approaches to proactive mitigation identified in case studies include: -

- Life-time buys for components which are single-sourced, for materials whose continued supply is at risk, or where commercial factors may come in to play (e.g. a key supplier is at risk of being bought-out by the supplier’s competitor). An understanding of the rate of consumption is necessary in order to establish the quantity of the life-time buy.
- Multiple sourcing, e.g. the design of a system should make the best possible use of “industry standard” or “commodity” components, materials, and COTS so that FFF replacements are readily available.
- Partnering agreements with suppliers to assure continued availability for single source components, materials or COTS (e.g. subsidies for maintaining production capabilities even if used intermittently).

In the limit, the overall budget for proactive mitigations is established as a system-level trade-off between the level of assured availability desired by the customer and the price the customer is prepared to pay.

Reactive mitigations are used where the likelihood of obsolescence is believed to be low and / or the cost of proactive mitigation is not economically viable. The benefit of this approach is that costs are only incurred if obsolescence problems materialise. The disadvantages are that it is not possible to achieve an assured level of availability, and the customer and supplier must agree how the mitigation costs are covered if obsolescence does materialise.

Reactive mitigation generally involves a degree of re-design at component, assembly, sub-system, or system level. Costs include: -

- Development engineering costs including re-design, prototypes, integration, verification and validation, safety cases analysis, and re-certification against regulatory requirements.
- Production engineering, (re)manufacture, production and fitting of modification kits in the field, updates to documentation and training.

## 5 CONCLUSIONS

### 5.1 Key Findings

Several challenges in costing obsolescence have been identified in this paper. The challenge of predicting obsolescence more than eight years ahead has been covered in Section (3).

Secondly, there is a general lack of standard procedures in the defence industry for the cost estimation of obsolescence. Most of the organisations in the defence sector are estimating this cost at the bidding stage based on experience and expert judgement. This rough estimate is in general inadequate to set the basis for the negotiation of the contract.

Thirdly, at the bidding stage it is difficult to predict what obsolescence issues will arise, at what rate, and which resolution strategies will be viable in the future. All of these issues constitute risks and uncertainties in estimating the cost of obsolescence.

Finally, the organisations studied in this research used a range of techniques for assessing the risk of obsolescence including prior experience, commercial tools, technology roadmapping but they struggle to combine this information with the understanding of the "health" of their suppliers (supplier assessment carried out by the procurement, commercial and engineering functions), regulation changes (in UK, EC, USA) and market trends (carried out by the sales & marketing and commercial functions) in order to forecast obsolescence events accurately. This is necessary to plan ahead the mitigation strategies that should be put in place.

### 5.2 Future Research Opportunities

The decision between a proactive vs. reactive approach to managing a given obsolescence risk depends on two main factors: -

- *The customers' attitude to risk*. Do they consider it essential to be assured of a given level of system availability (e.g. in safety critical situations), or are they prepared to accept a certain level of unplanned outages? How can trade-offs between availability and affordability (for the customer), or between availability and profitability (for the supplier), best be modelled and visualised over the whole life of a PSS?
- *The cost of proactive vs. reactive mitigations*. Is it possible to devise some generic guidance, e.g. this was studied by the MoD in 2004 [16] and is being pursued in collaboration with Cranfield University?

Further study on each of these factors is necessary to improve obsolescence managing decisions.

Furthermore, a need for a framework for the cost estimation of system obsolescence at the bidding stage has been identified. It will allow the use of a flexible process for cost estimation of obsolescence and further integration with the rest of life-cycle costs, taking into account the influence of factors such as the maintenance strategy.


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