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A conceptual framework to assess the impact of training on equipment cost and availability in the military context

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Abstract

Designing military support is challenging and current practices need to be reviewed and improved. This paper gives an overview of the Industry current practices in designing military support under Ministry of Defence/Industry agreements (in particular for Contracting for Availability (CfA)), and identifies challenges and opportunities for improvement. E.g. training delivery was identified as an important opportunity for improving the CfA in-service phase. Thus, an innovative conceptual framework is presented to assess the impact of training on the equipment availability and cost. Additionally, guidelines for improving the current training delivery strategies are presented, which can also be applied to other Industry contexts.

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Keywords: Availability Contracts, Support Design, Training, Equipment Availability, Cost;

1. Introduction

Over the last decades the collaboration between Industry and UK Ministry of Defence (MoD) has been increasing towards achieving more cost effective solutions to support military equipment. Currently, this collaboration is typically established by means of Performance Based Contracts (PBC) [1]. These contracts are agreed between MoD and an Industry Contractor and aim to reduce the cost of the assets ownership while ensuring the system performance [2]. They also include incentives for both parties to improve efficiency and effectiveness over the duration of the contract [3]. A typical example of these contracting approaches is Contracting for Availability (CfA). Under CfA agreements Industry is responsible to design and deploy support to the military equipment by maintaining it at an agreed level of readiness over a period of time [3]. However, designing support strategies for CfA is challenging and Industry recognizes that current processes and techniques need to be improved. On the other hand, there are important cost and performance contract drivers that are not fully understood either by MoD and Industry. In particular, the nine Defence Lines of Development (DLoD) stated by the UK MoD (Training, Equipment, Personnel, Information, Doctrine & Concepts, Organisation, Infrastructure, Logistics, and Interoperability [4]) are recognised by Industry and MoD experts as having an important impact on the contracts success, as they provide a pan-Defence taxonomy for development and management of the military capability [5]. There is a gap in understanding the benefits of the effort over each DLoD on the contracts outputs.

This paper is focused on the Training DLoD and aims to assess the benefits of Training on the equipment availability and cost. The objective is to demonstrate that investing more in Training delivery can significantly improve the Personnel efficiency on operating the Equipment so that less failure occur; consequently, the money saved with maintenance can be significantly higher than the money spent with extra training.

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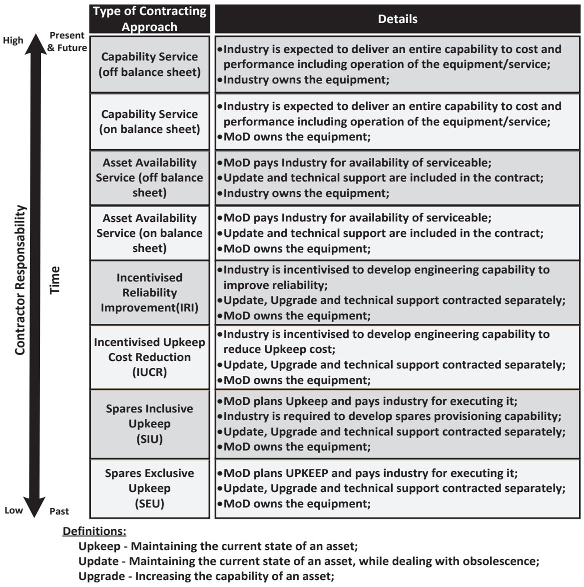
This document is structured in the following way: section 2 describes the current UK MoD acquisition processes and the agreements with Industry for provision of military support. Then in section 3 challenges and gaps are identified in the industry current practices of military support design and deployment, as well as the opportunities for improvement. A conceptual framework is then presented in section 4 to provide guidance in how to measure the impact of training on the personnel skills development and consequent impact on the equipment availability and projects cost. Finally in section 5 the key conclusions are presented and some future work suggestions are made.

2. Approaches for Support Contracts

The UK Defence Government recognises the important contribution that Defence Industry gives to the military capability support. Since the Defence Industrial Strategy (DIS) policy published on 15 December 2005 [6], the engagement of MoD with Industry has developed by creating new type of partnering arrangements towards more cost effective solutions to support the military equipment. Currently, MoD follows the Support Options Matrix (SOM) to distinguish the level of cooperation with Industry; developed for Project Teams by the Equipment Support Continuous Improvement Team (ESCIT), the SOM is used to identify support contracting options and indicates who is best placed to manage the equipment performance and cost drivers (Industry or MoD) [7]. The SOM is granular in terms of rising of responsibility for Industry for support delivery and has 8 different contracting options as shown in Figure 1.



Type of Contracting Approach	Details
Capability Service (off balance sheet)	•Industry is expected to deliver an entire capability to cost and performance including operation of the equipment/service; •Industry owns the equipment;
Capability Service (on balance sheet)	•Industry is expected to deliver an entire capability to cost and performance including operation of the equipment/service; •MoD owns the equipment;
Asset Availability Service (off balance sheet)	•MoD pays Industry for availability of serviceable; •Update and technical support are included in the contract; •Industry owns the equipment;
Asset Availability Service (on balance sheet)	•MoD pays Industry for availability of serviceable; •Update and technical support are included in the contract; •MoD owns the equipment;
Incentivised Reliability Improvement(IRI)	•Industry is incentivised to develop engineering capability to improve reliability; •Update, Upgrade and technical support contracted separately; •MoD owns the equipment;
Incentivised Upkeep Cost Reduction (IUCR)	•Industry is incentivised to develop engineering capability to reduce Upkeep cost; •Update, Upgrade and technical support contracted separately; •MoD owns the equipment;
Spares Inclusive Upkeep (SIU)	•MoD plans Upkeep and pays industry for executing it; •Industry is required to develop spares provisioning capability; •Update, Upgrade and technical support contracted separately; •MoD owns the equipment;
Spares Exclusive Upkeep (SEU)	•MoD plans UPKEEP and pays industry for executing it; •Update, Upgrade and technical support contracted separately; •MoD owns the equipment;

Definitions:

Upkeep - Maintaining the current state of an asset;
Update - Maintaining the current state of an asset, while dealing with obsolescence;
Upgrade - Increasing the capability of an asset;

Figure 1 - Support Options Matrix (adapted from [8]).

All the different contracting approaches differ in terms of applicability, level of support involvement/responsibility, and equipment ownership.

This work is focused on the Asset Availability Service Contracts or CfA. These are typically fixed price contracts but can also include mutual benefits to be gained from incentives and gainsharing of any profit and efficiencies [9]. Under these contracting arrangements the outcomes are defined in terms of availability and can be applied to: platforms, systems, sub-systems, equipment, spares, personnel, services, or facilities [3]. Availability is achieved as long as the equipment passes a working test, demonstrating that it is ready to be operating.

Design support to CfA requires a mature consideration over a wide range of factors such as: maintenance, operational safety, possible changes in the support requirements (i.e. equipment upgrades, change of mission scenario, etc.), obsolescence, gain share and training. The next sections present the current MoD contracting process and identify which are the challenges and gaps in the Defence Industry environment.

2.1. Methodology

The preparation for this paper started with performing several structured and semi-structured interviews and workshops with experts from Industry and UK MoD, aiming to understand the current practices in the Defence acquisition and support design, and to identify which are the gaps and challenges faced by the several stakeholders involved in the process. The amount of interaction with Industry included: 9 interviews and 1 workshop with Industry project managers, modelling engineers and engineering managers, and 1 interview with a project manager from MoD (DE&S); all of the interviewees had an average of 15 years of experience in-house. Each interview had an average duration of 1.5 hours whereas the workshop lasted 4 hours in duration. At these sessions the following type of questions were performed: "what kind of CfA does the company runs with MoD?'', "what challenges does the company faces to design these contracts", or "which resources are more critical to meet availability?". After each interview all the findings were registered and posteriorly validated by all the participants.

A literature research was also implemented in parallel, aiming to investigate techniques that could be applied to provide support and solutions for the challenges and gaps identified. As a result, a conceptual idea was developed to assess the impact of training on equipment cost and availability. The process was monitored and validated by bid managers from an UK military contractor company, based on their experience of previous contracts.

3. Current Design Practices – Industrial Interaction

From the identification of the military needs until the award of the contract with the Industry there is a detailed process involving several governmental and non-governmental entities. This process may vary depending on who identifies the gap and what type of gap is identified. There are two types of military gaps: capability gap and optimization gap. When a military contractor is in a contract with the MoD it may identify some opportunities of improving the current support strategy or a need for making an equipment upgrade; it can also be the case that Industry identifies external factors that are harming its current deployment plan; in both cases it is said that an optimisation gap was identified. The contractor may then report it to MoD and propose a collaboration plan and/or changes on the Defence Doctrines/Logistics. In some other cases MoD identifies these gaps itself and then asks to Industry for collaboration.

The capability gaps are those when MoD identifies that the current systems are not effectively fulfilling the military needs. For example, if a gun system is currently designed to engage with air targets and the threat changes and the focus shifts to land targets that the current system cannot achieve, MoD recognizes that this is a capability gap. The capability gaps are identified by the Naval Command Headquarters (NCHQ). They then report it to the Defence Science and Technology Laboratory (DSTL) as well as make some prospection among the Industry "offerings". DSTL design plans where they apply innovative science and technology for a through-life support of the military capability needs, using external suppliers where possible so they need to assess all the DLoDs. They consult Defence Equipment and Support (DE&S) to decide about the equipment whereas Training is mostly controlled and delivered by the Industry.

The list of final solutions is then presented to the NCHQ, which control the money and give the final approval. The NCHQ can also decide about the ownership of the assets used for support, which can vary across the DLoDs. After NCHQ have selected the preferable solution, they explain the problem and requirements to the DE&S, which evaluates the need in equipment reliability, availability and safety level, and presents possible collaboration agreements to Industry (e.g. in a form of CfA), to take lead on the equipment DLoD. Figure 2 summarizes the MoD acquisition process; it shows the MoD NCHQ which control the acquisition process by identifying military needs and approving possible support solutions, whereas the manufacture and delivery of those support solutions results from a cooperation between Industry and the two MoD acquisition support organizations: DE&S and DSTL.

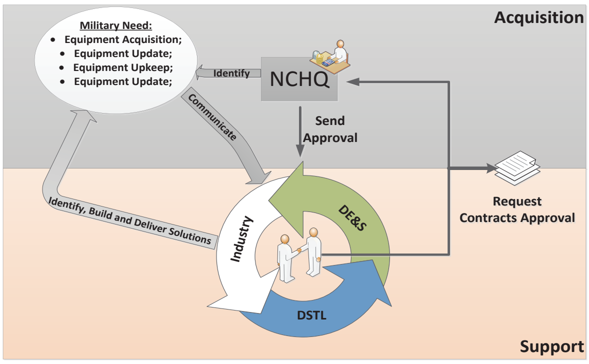


Figure 2 - MoD Acquisition Process.

In this process MoD works as an "intelligent customer" by developing and applying decision-making tools and mechanisms to find guidance in all of its decisions and planning.

When MoD manifests a need for support, Industry contractors design their strategies to bid for a contract. The bid design process differs from company to company but there are some common procedures: normally, each company includes a number of individual functions (e.g. Engineering, Commercial, Procurement, Project Management, and Finance), which work collaboratively to develop and deliver product/service offerings that are aligned to customer requirements. The Commercial, Project Management and Business functions are the ones with more responsibility and they collaborate to lead new business activities such as bid preparation. They are the functions that interact with the customer and suppliers. Project Management and Commercial functions work collaboratively to develop detailed cost estimates and Statements of Requirement (SoR). A SoR is a document that defines the scope of a specific work package that is required for the customer. During the bid preparation stage of the project lifecycle, the SoR is distributed to all functional departments each of which are then required to select the tasks that are from its responsibility and send back to the Project Managers an estimate of man-hours and resources necessary to accomplish those tasks; this also includes the identification of any known risk and opportunities. Project Managers working within the Commercial function are responsible for collating the estimates in order to create an overarching project estimate and plan. They will review and challenge each individual department estimate as part of the bid preparation process in order to ensure that the final estimate is as accurate as possible. The bid design and build of cost estimates are mainly conducted based on the opinion of experts. Historical data from legacy projects (if available) is used for comparison purposes.

3.1. Recognised Gaps and Challenges in the Military Industry

MoD wants to reduce the costs associated with the military acquisition and support [10] whereas it expects more readiness and effectiveness from Industry to answer to its requirements: "We recognize that Industry will have to reshape itself, to improve productivity and to adjust to lower production levels once current major equipment projects have been completed, while at the same time retaining the specialist skills and systems engineering capabilities required to manage military capability on a through-life basis"[6]. In turn, Industry recognizes difficulties in design cost effective support solutions that answer to the MoD requirements. Several challenges are currently faced by the Defence Industry, as well as gaps of knowledge that require attention from the research community. The interaction with MoD and expert people from two Industry Contractors (process described at the methodology section) enabled the identification of the following problems:

- The average length of the contracts between the MoD and Industry is relatively short in comparison to the product/service lifecycles involved; it does not enable the development of strategic through-life product-support systems (PSS);
- The risk of counterfeit parts entering the supply chain is increasing due to the impact of obsolescence, i.e., contractors are forced to use non-preferred suppliers in order to satisfy the demand for obsolete components;

- There is a need for increasing Industry’s control over the military logistics and in particular for the control of the transportation system;
- Missions durations also represent a problem; longer missions imply higher crew rotation which in turn implies need for more training for the new elements as the skilled individuals are leaving;
- The data provided by the MoD is limited and typically not complete or appropriate;
- The personnel culture is not well driven; personnel are not sensitized to report/register relevant equipment failure details;
- The process of managing data inside the companies is also not good and could be significantly improved. Data managing and information sharing has a big impact on Logistics; if this could be improved, the logistics could move from a pull type logistics to a push type logistics and Industry could be more pro-active;

3.2. Opportunities for Improvement

Both MoD and Industry recognize that more investment across the DLoDs would have a strong impact towards the success of the support contracts. In particular, Training is emphasized by several bid managers as being an important driver for the personnel performance. This line of development is defined by the MoD as “the provision of the means to practice, develop and validate, within constraints, the practical application of a common military doctrine to deliver a military capability” [11]. Training is believed by Industry to have a big impact on the personnel ability to perform the tasks which consequently impacts the equipment availability by reducing the need for maintenance actions or executing it more effectively. They believe that increasing the quantity/quality of training delivered to the personnel, mitigates a lot of the problems identified above. For example, there are equipment upgrades that are not accompanied by personnel training update or upgrade and therefore, they do not know how to use the equipment properly. Training is also important to convince the operators about the importance of register equipment failures and the correspondent root-cause, and to provide them guidance about how they should register that information; this training should be elaborated aligned with the techniques used by the project modelers that will need that data to build their estimates. In addition, a big amount of the knowledge acquired from each operational comes from the experience and daily mentoring given by older generations; when these older individuals leave the company, it creates a threat for the future of these skills and there is a need to perpetuate this knowledge and delivery it as a regular training basis. Finally, the amount of time that an operator stays at the ‘holding state’ (waiting to be called for mission), may incur in a natural skill fade; increase the frequency of training delivered may be a good mitigation for this problem.

Nonetheless, assessing and measuring the benefits of Training is also a recognized gap of knowledge for the contracts designers; MoD Doctrines dictates how training should be delivered although it does not say how training helps to reduce through-life cost; There is need to learn how to assess the benefits of Training on the contracts performance indicators.

4. A Conceptual Framework to measure the Training impact

This paper presents a conceptual framework that aims to provide a solution for how to assess the benefits of Training. Although Industry recognizes training as an opportunity for improvement in the in-service support phase of the CfA, there is a recurrent question that remains without an answer: how to measure the impact of training on the equipment availability and cost? An iterative conceptual framework has been developed aiming to answer this question. The amount of training delivered to the operators and maintainers is recognized by Industry experts as an important driver to the equipment failure rate and to the efficiency of the maintenance actions. Therefore, there is an inherent link between training, personnel, and equipment that need to be well understood in order to be measured and assessed.

The methodology proposed consists of a sequence of steps that aim to evaluate the possible benefits of increasing the amount of training delivered along the individuals’ career. The process is as follows:

A. <u>Identify the current training delivery methodology and milestones;</u>

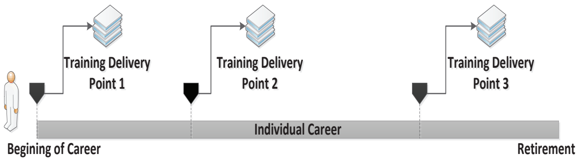


Figure 3 - Training delivery milestones.

Normally, (and particularly in the military context) there is a pre-defined training delivery structure that identifies milestones where training should be provided to the individuals from when start their career until they retire. Figure 3 illustrates three possible training delivery points along an individual career (starting from the beginning of the career until the retirement).

B. <u>Identify the points where training delivery can be increased/improved;</u>

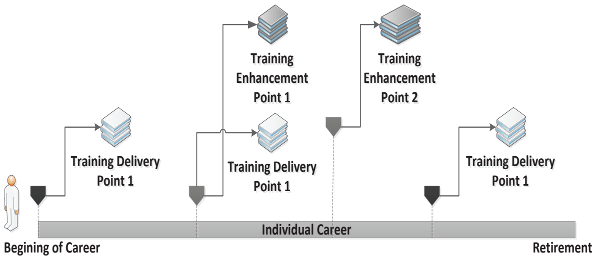


Figure 4 - Training delivery milestones with identification of possible extra training delivery points.

The proposed conceptual idea aims to prove that enhancing the current training courses or identifying points where extra training can possibly be delivered to an individual along his career can have a dramatic positive impact in the individual's ability to perform the tasks, reducing the number of equipment failures caused by human faults. Figure 4 illustrates one possible training enhancement point and one extra training delivery point along an individual' career.

C. Identify the training drivers;

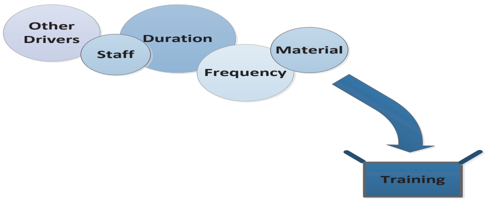


Figure 5 - Training drivers.

The main drivers (i.e. contributing factors) for effectively delivery training must be identified. Figure 5 gives four examples of important training drivers; each driver has a different impact on training.

D. Assess the impact of each training driver on the training delivery effectiveness;

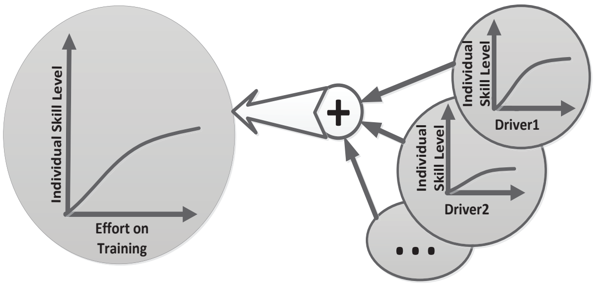


Figure 6 - Training impact on the individuals' skill level.

The impact of each training driver on the skill level of each person must be individually assessed in order to evaluate the overall impact of training in the ability of an individual to operate the equipment (individual skill level), as shown in Figure 6.

E. Estimate the relationship between individuals' skill level and equipment failure rate;

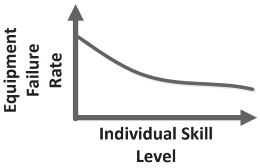


Figure 7 - Relationship between individuals' skill level and equipment failure rate.

This step consists of assessing the impact of individuals' skill level on the equipment failure rate (considering equipment failures caused by bad equipment usage or inefficient maintenance actions). Figure 7 shows a curve that describes one possible relationship between these two variables.

F. Calculate the cost of each training unit;

Figure 8 - Training cost.

The cost with training must also be correctly evaluated considering the effort invested across the different training drivers. Those individual costs need to be sum to calculate the cost of each training unit. In Figure 8 is presented a curve that represents the possible cost associated to an increasing of effort on training.

G. Establish a relationship between equipment failure rate and cost;

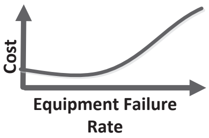


Figure 9 - Equipment failure cost

The number of times that an equipment fails has a direct impact on its availability; the relationship between equipment failure rate and cost must be well assessed (it must consider, between other things, the cost and effectiveness of the maintenance actions). Figure 9 shows a possible cost-estimation curve which describes cost as a function of the equipment failure rate.

H. Simulate several training delivery scenarios to assess the trade-off between training effort, equipment availability and total cost;

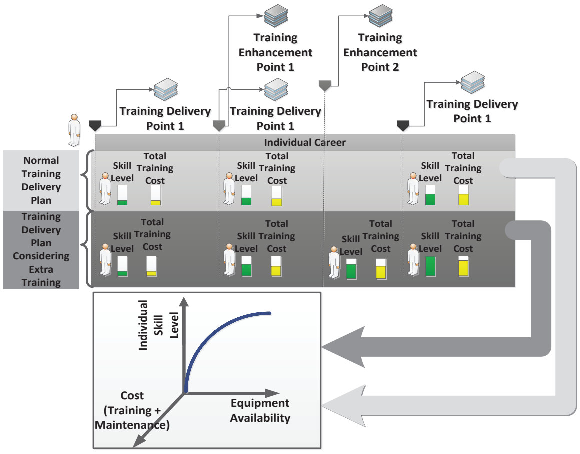


Figure 10 - Training assessment framework

The last step is to consider various training delivery scenarios (considering different efforts across the different training drivers, and perhaps extra training delivery milestones) and assess each configuration in terms of the final outputs expected: total cost and total equipment availability (this last one may need to be assessed at specific time frames according to each contract conditions).

The curves in all graphs are merely illustrative as their shape may vary depending on the context. They can be built based on several techniques such as: regression analysis based on any historical data available [12]; mathematical equations [13; 14]; probabilistic relationship [15]; breakdown each variable in a number of simple attributes in order to establish easier relationships and then merge results to build up the main relationship; intelligent data analysis tools [16]; build the curve based on expert opinion or comparison with similar variables relationship [17].

5. Conclusions and Future Work

There are several gaps and challenges currently faced in the Defence acquisition and support business. The interaction with the Industry experts showed that there is a need for expert guidance in areas such as: data collection, data processing, information management, personnel management, quality management, stock management, risks and uncertainty assessment and modelling. Although project managers have a lot of practical experience in the military environment, there is a visible gap in understanding how to develop and apply innovative techniques to model the practical knowledge and the historical data available to design cost effective through-life support plans. Some of the potential projects success drivers are identified but their impact on the projects outputs may not be fully understood. In particular, the effort across the DLoDs is recognized by Defence experts as an important driver towards contracts' success, as they provide a summary of the different aspects of capability that need to be brought together to create real military capability [18]. However, understanding the impact of the DLoDs on the effectiveness of the support strategies is one of the current challenges for the project designers. In particular, Training DLoD is highlighted by several project managers from Industry contractors as having an important impact on the equipment availability and cost, although it is not understood how the impact curve evolves with the increase of training delivery. This papers aims to present a solution for this particular problem. The proposed conceptual framework provides guidance on how to assess the possible benefits of increasing the amount of training delivered to the personnel during the projects in-service phase. It can also be applied to a more generic context such as other Industry sectors.

As future work, an application of this framework to a real case study would be interesting to test its maturity, applicability and value. Moreover, although this conceptual idea provides guidance in how to improve the training delivery strategies, there is a need for establishing processes and techniques to build the relationships between the variables, e.g., individual skill level Vs equipment failure rate, training effort Vs cost, etc. It requires an assessment of literature to find modelling techniques to support in the process. Besides that, an extension of this work to include the other six DLoDs would be a logical approach.

In addition, this paper enumerates several other challenges and gaps currently experienced by military contractors during the CfA life-cycle that are not covered in this framework; develop new ideas to solve this problems also represents an opportunity for future research.

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