Product Safety in a World of Services: Through-Life Accountability

Peter Fielder, Adrian Roper, Bill Walby, Joe Fuse, Andrew Neely and Chris Pearson

This paper was made available in hard copy, free of charge to delegates attending the 22nd Safety-Critical Systems Symposium. This took place at the Grand Hotel, Brighton UK on 4-6 February 2014.

Why this paper might be of interest to Alliance Partners:

Recent years have seen changes in the way that companies in a number of industries have responded to a changing market environment where the demand for intelligent service contracts and the requirements of corporate social responsibility continue to rise. Central to these changes is a modified approach to the theme of increasing services provision. Reductions in the delivery of new products and the extensions to life of existing products has forced companies to reconsider their existing product portfolios and how they can generate new business from the maintenance, through life upgrade and support of the products they previously supplied. BAE Systems like others in the defence arena has done this and in doing so has considered what changes it has had to make, and continues to make, to the way in which it now looks at and ensures the safety and performance integrity of its products in all aspects of its operations.

This paper draws together the journey that BAE Systems has been (and continues to be) travelling down as it moves to delivery of a more service oriented portfolio of products, and the research that Cambridge University has been pursuing to better understand how accountabilities are managed for service through-life (Fuse, 2013). It should be recognized that this paper represents initial thoughts and analysis on Through Life Accountability and recognizes the need to pursue further research and analysis before the Company has a more fully informed understanding of how it can best use this information to improve its service provision.

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The papers included in this series have been selected from a number of sources, in order to highlight the variety of service related research currently being undertaken within the Cambridge Service Alliance and more broadly within the University of Cambridge as a whole.

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Peter Fielder, Adrian Roper, Bill Walby,
BAE Systems plc, UK

Joe Fuse, Andrew Neely and Chris Pearson
University of Cambridge, Cambridge, UK

Product Safety Matters

Product safety is of central importance to many organizations and BAE Systems is no exception. The regular review of product safety, including sharing good practice has been part of ongoing learning across BAE Systems and its businesses for many years. Following a series of global events, and with an ever increasing external expectancy for higher levels of safety, in 2010 the company decided to conduct a holistic review of its approach to product safety. This included consultation in defence and other sectors all of whom work with complex products.

As a result of this review BAE Systems improved its approach to management of the safety of the products it provides for use on land, at sea and in the air. Central to this improved approach were four principles of product safety that have been applied across the whole company:

1.   Accountability
2.   Level of safety
3.   Conforming product
4.   Learning and sharing information.

These four principles form the basis of a deepening company-wide culture of safety and accountability, a culture which is based upon undertaking activities because they are 'the right thing to do'. Extensive testing of these principles has taken place, including external comparison with six other sectors (automotive, civil aviation, construction, health, offshore and rail) looking at how they each addressed their equivalent challenges through life.

The Company's Product Safety Principles are defined as follows:

   A.   <u>Accountability</u>.

   We shall work with our customers and others to ensure that there is, at all times through the life of every product, accountability for its unintended effects on the safety of people:

   •   We are and remain accountable for those aspects of our products that are under our control or for which we are legally responsible.

- We shall make reasonable efforts to maintain accountability when we no longer have control of, or responsibility for, our products.

The Company's accountability will be delegated to individuals.

B. Level of Safety.

We shall work with each customer to agree the level of safety that is to be achieved by each product through its life.

We shall seek the highest level of safety of those who might be unintentionally harmed by the product that is compatible with the product's required performance, cost and schedule and the way that it will be used.

C. Conforming Products.

We shall ensure that our products conform to their definition:

- With internal and, where necessary external, approvals for the organisation and product.
- By deploying suitably qualified and experienced people.
- By applying independent assurance.

D. Learning and Sharing Information.

We shall work with our customers and suppliers through the life of each product to:

- Provide topical information on safety so that each customer may determine how the product is used.
- Obtain information on the use and performance of the product to assess the consequences for safety.
- Understand the cause of significant accidents and incidents involving our products (where appropriate, with independent accident investigators), to reduce the probability of recurrence.

We shall seek to learn from other parts of the company, organizations and domains.

These four principles:

- describe the company's approach to the safety of products
- are a key part of the company's governance systems
- align with the company's values of being trusted, innovative and bold.

The 'acceptable level' (rather than the theorically highest level) of Product Safety is usually seen as a defined requirement. Designing a Product to comply involves trade

off's (e.g. Product performance, time and cost), analysis and thus engineering judgement (e.g. the use of formalised techniques and statistically relevant data), and ultimately Product qualification/certification.

In preparing a safety justification, it is often helpful to think of an additive layered model considering the level of safety in each of the layers of, 'as designed', 'as built', 'as maintained' and 'as operated'. Accountability for the end user operations will normally have the highest authority (and will or should have the authority to define the required 'acceptable level' of safety), but the design intent (i.e. to meet that level) and design data both influence and transcend the as built and as maintained layers into the 'as' operated layer where it is deemed to be acceptable. The BAE Systems portfolio of Products (defined as both Products and Services) includes Customer contracts at all four layers of the layered safety justification model.

Whilst the safe design & development of traditional non-service equipment has been progressing using the four Product Safety Principles, the world has also been changing. The defence industry is in the process of moving toward a services based environment, where customers contract for outcomes and capability.

This paper shares the detail of the company's approach and how this is changing in light of the shift to services. It starts with a brief discussion about the shift to services and explores the issues for product safety that this shift to services raises.

The Shift to Services

A commonly quoted statistic is that around 70% of GDP in most developed economies comes from services. However this figure underestimates the true importance of services, because it ignores "hidden services" – services provided by manufacturing firms that according to Government statistics are classified as production, rather than service. BAE Systems, for example, draws a significant amount of its revenues from providing maintenance and support services to the equipment it originally designed and manufactered. In 2012, over half of the Company's total revenue came from training, information and support services. Across its markets, sales of service products are rising steadily.

The concepts of a product and of product safety have to embrace the full range of the Company's products, from the intangible e.g. services, through the tangible-but-incomplete e.g. equipment or subsystems, to the more traditional platforms such as ships, armoured vehicles or aircraft. Its product range is therefore large and diverse and increasingly its customers procure both the goods it manufactures and the extensive range of associated services needed to maintain and use the equipment throughout its life.

Given that diversity, BAE Systems' adopts a broad definition of a product. The Company considers a product to be '*any goods or services, including intellectual property, developed or traded by BAE Systems*'.

Additionally the Company has made progress in implementing internal systems and decision making mechanisms that increase the awareness and control of products that BAE Systems no longer has either control over, or any contractual liability for, these are the so-called "Legacy Products". Some UK businesses have in place management arrangements for these Legacy Products that include registers of such Products, risk based assessment of each Legacy Product to determine what action to take with the current owner, and pro-active engagement with owners of Legacy Products. There are examples of design changes to Legacy Products being necessary and BAE Systems, in accordance with our Code of Conduct and Product Safety Policy, has worked with the owners to communicate the need and to help affect such design changes. There are also examples where we have facilitated access to archive design information for Legacy Product owners. Our approach to Legacy Products continues to be developed and refined as we engage the owners of our Legacy Products and understand how they operate their Products.

BAE Systems' customers, and indeed its suppliers, are also diverse: The Company has businesses in Australia, India, the Kingdom of Saudi Arabia, South Africa, Sweden, the UK and the USA with a supply chain which extends around the world. Accordingly, it provides these services under a number of regulatory and legislative environments, within its customers' established practices and within its own policies and code of conduct. Where the product being delivered is service and support, there are additional obligations to be considered over and above those necessary for goods. Wherever they take place, the services must also be provided in a safe, effective and cost-efficient manner, as they are offered within either competitive procurement processes or environments where affordability is the key issue of the prevailing economic environment.

A single approach to product safety would therefore be inappropriate for each combination of product and customer or supplier. However the set of product safety principles that have been developed are global – they apply equally wherever the Company works, and throughout the intended life of the product for the provision of both equipment and services. Each business within the BAE Systems Group is responsible for adopting and embedding the principles for its own products and markets and for ensuring and assuring that it has the capability to implement the policies and processes that give them effect.

The Service Delivery Environment.

As has been said previously, BAE Systems must ensure that its products are safe and effective. However in the complex environment of service delivery the Company may, but does not always directly control all the elements that drive effective and efficient support and service delivery.

An example from BAE Systems Maritime Services business illustrates the point. The Company has a contract to maintain warships at Portsmouth Naval Base. As part of this prime contract, the Company is required to run the Naval Base. It is contracted to maintain the Naval Base facilities – the harbour, the real estate, and the offices. It is also

contracted to provide services for sailors and their families – catering, accommodation, leisure and social facilities. The Company outsources parts of the contract to key partners – e.g. in areas of catering and facilities services. The contract has already run for over five years and negotiations are under way for a further five-year contract. The Company will only meet its service commitments to the Ministry of Defence (MoD) if our subcontractors maintain the facilities to the agreed standards. To meet its service commitments we also rely on the MoD to order and deliver on time the spare parts that are needed to maintain the warship. The MoD manages inventory, not BAE Systems.

The fact that BAE Systems, as the prime contractor, is so dependent on its partners, including the client, raises important issues. Understanding accountability in this context therefore becomes essential if we are to manage the associated risks and liabilities, as well as ensuring the safety of our people, our client's people, our partner's people and third parties.

The safety of these services depends on the concept of sustaining the as-designed level of safety of the product, intent through design of the equipment that the Company manufactures. It is also reliant on the service providers' ability to recognize and successfully manage key risks and hazards that the service delivery environment introduces.

Recent experience has shown that the following issues need to be considered and managed if safe service provision is to be maintained:

1. The ability of the Accountable Manager to resolve service delivery challenges could be significantly impaired without excellent *Customer & Supplier relationships and communications.*

2. *Unclear contractual (safety) requirement* flow could lead to misunderstanding of accountabilities and therefore poor hazard/risk management.

3. *Short term basic Fixed Price service delivery contracts* could drive short term decision making which can be contrary to long term holistic safety performance.

4. A lack of *available and effective data sets* could lead to poor decision making and increased risk of incident.

5. *Different cultures* could drive different perceived levels of safety tolerance (even within single contracting mechanisms).

6. A lack of *clarity around accountabilities* could drive poor hazard/risk management.

While this example draws on the defence sector and BAE Systems specifically, we would anticipate that similar examples could be found in other sectors wherever these outcome-based, multi-organisational contracts are becoming more commonplace. They raise an important question for product safety, namely how do we manage these service system risks and hazards and is there a model or framework that recognizes the Product Safety Principles and can support effective management and control of these risks?

The 'Accountability' principle.

The Company has recognized for some time that Accountability is a 'golden thread' that runs through the contractual, commercial and operational structures to ensure that in any organisation someone is always accountable (and accountability is personal) for every decision that affects safety. It allows everyone to know what he or she is accountable for and to whom. In principle accountability remains for the life of the product which may or may not be the life of the project, and it extends all the way from the most senior level to the lowest level in the supply chain. It is personal in that the person who is accountable for a decision or action remains accountable; it is not the current holder of that office but the person who was in office at the time the decision or action was taken. Of course, when subsequent accountable people carry out their duties as they arise, they may need to revisit the earlier decisions or actions of their predecessors.

In light of real life experiences and a traditional view of what Accountability meant for product safety (equipment) focussed provision, BAE Systems also recognized that more work was required before a better understanding of what the Shift to Services meant for product safety. The Company therefore approached Cambridge University via the Cambridge Service Alliance (CSA) to look into this further. Initial research has highlighted a number of findings which are discussed over the next few pages.

Cambridge Research – Through Life Accountability.

BAE Systems is a founder member of the Cambridge Service Alliance (CSA), a business-university consortium involving Cambridge University, BAE Systems, IBM, Caterpillar, and Pearson. The consortium is working together to explore questions around service and support contracting within different service contexts.

Whilst members of the CSA focussed on a number of Service related issues, BAE Systems worked with Cambridge to explore accountability in the service delivery environment and to better understand how accountability should be treated and considered as a through-life concept.

Building on the early work of the CSA, the Cambridge team began by reviewing existing literature on through-life accountability. Interestingly the first thing they found was that the concept of "through-life accountability" appears not to have been the subject of significant previous academic research papers.

Searches of the standard online databases for the phrase "Through-Life Accountability" returned zero hits. While searches for the phrases "through-life" and "accountability" separately returned just under 16,000 and over 400,000 hits in the ABI/Inform database. A single search with two key phrases "through-life" and "accountability" returned 167 results, but a detailed review of the abstracts for these papers shows that none of them deal directly with the concept of "Through-Life Accountability". Even a more liberal search on Google only returns 3,500 hits for "Through-Life Accountability", many of

which relate to one's personal accountability for their own life. The limited discussion about the concept of "Through-Life Accountability" is, in itself, an interesting finding. Clearly it raises questions about why there is such limited discussion in the academic literature of a concept that appears to be becoming increasingly important in the industrial world.

Given the lack of prior research on "Through-Life Accountability" itself, the Cambridge team then decided to expand their search for related literature by looking separately at the concepts of "accountability" and "through-life". Three particular streams of literature were seen as important in this regard. First, much of the work on outcome-based contracting is covered in the product-service systems/servitization literature, so the team explored this literature to see what it said about "Through-Life Accountability" (Baines, Lightfoot, Benedettini, & Kay, 2009). Secondly, there is an interesting and relevant stream of work on High Reliability Organizations – organizations that cannot afford to fail (Weick and Sutcliffe, 2007). Given that outcome-based contracts are often applied in safety critical environments, the team decided to explore the High Reliability Organizations literature. Finally, the team focused on the emerging service supply literature given the Company's interest in complex supply services. These specific streams of literature were supplemented by a review of the literature that focussed explicitly on accountability. Key themes to emerge from the literature include:

First, perspectives on accountability have broadened over the years. Organizations are now seen as being accountable to a wide set of stakeholders, against a broad range of performance variables. No longer, for example, can private sector organizations focus on shareholders alone. They have to account for their performance and their actions to a broader group of stakeholders (Gray, Owen, & Adams, 1996).

Second, accountability is seen not just as an external factor, but also of value to organizations internally. Being accountable forces organizations to reflect upon themselves, providing opportunities to learn from past mistakes and successes (Schillemans, Van Twist, & Vanhommerig, 2013).

Third, accountability can be thought of in terms of "an obligation to inform". Schedler defines accountability as "A is accountable to B when A is obliged to inform B about A's (past or future) actions and decisions, to justify them, and to suffer punishment in the case of eventual misconduct" (Schedler, 1999). Underlying this definition are three key concepts: (i) informing others about actions, decisions and the consequences of these; (ii) justifying actions, decisions and consequences to others; and (iii) bearing the consequences for poor performance.

Understanding this nested nature of accountability – accountability for decisions, for actions and for the consequences of these decisions and actions – is important in the context of Through-Life Accountability, where decisions may be taken by one party, but actions carried out by another.

An alternative perspective on accountability is provided by the concept of "responsibility for results". Tseng et al (1998), for example, defines accountability as "the ownership of

the responsibility to deliver results to meet the requirement of a process" (Tseng et al, 1998). While Williams (2006) defines accountability as "the acknowledgment and assumption of responsibility for actions, products, decisions, and policies including the administration, governance, and implementation within the scope of the role or employment position and encompassing the obligation to report, explain and be answerable for resulting consequences" (Williams, 2006).

Koppel introduces an additional dimension – liability, as one of five dimensions of accountability in the public sector; the other four being - transparency, controllability, responsibility and responsiveness. Transparency asks whether the organization "revealed the facts of its performance". Liability explores whether the organization "faced the consequences for its performance". Controllability asks whether the organization did "what the principal desired". Responsibility looks at whether the organization "followed the rules" and responsiveness asks whether the organization "fulfilled the substantive expectations" (Koppell, 2005).

Even this cursory summary of the literature on accountability highlights a challenge. Namely that accountability itself, let alone Through-Life Accountability, is a nested and complex concept. However, as an initial approach one can ask the following questions of anyone in enterprise "accountability for what?" and "accountability to whom?"

Accountable for what and to whom

As the literature suggests one can be held accountable – i.e. have the duty to account – for different things, most notably (i) **decisions**: choices that one makes; (ii) **actions**: courses that one takes; and (iii) **consequences**: results that occur. This separation between accountability for decisions, actions and consequences, is particularly important in the context of Through-Life Services for two reasons. First, because of the extended life of the contract one has to consider who is accountable to whom for which decisions, actions and consequences, at which point in time. Second, one has to recognize that often the prime contractor might be accountable to the customer, but in turn cedes control over specific decisions and actions to third parties (sub-contractors). Hence while the prime contractor may remain ultimately accountable for consequences, he/she may not have control over all decisions and actions taken across the life of the contract. Understanding and managing these is the focus of the Cambridge University work and the sub-classification suggested by Koppel may prove to be useful in mapping complex accountabilities.

This issue highlights the importance of a second distinction raised in the literature – namely the separation of responsibility, controllability and liability.

Exploring the Current State of the Art

Having reviewed the literature, the next phase of the research sought to triangulate the initial findings through a series of semi-structured interviews. The team deliberately selected a diverse group of people (fulfilling different roles) in a wide variety of organizations (covering a range of different sectors). This sampling strategy was deliberate in that the research team wanted to maximise the diversity of the sample. As a

result the Cambridge team conducted interviews with 18 people from six different organizations, covering defence, safety, consultancy, transportation, energy and IT. The interviews were semi-structured and designed to explore concepts of Through-Life Accountability, as well as the distinction between responsibility, controllability and liability. Two significant themes emerged.

First, and regarding Accountability, while the distinction between responsibility, controllability and liability was seen as useful, rarely was it explicit in the organizations involved in the study. Beyond the issue of distinguishing between responsibility, controllability and liability there was also a distinction between areas of accountability. Partly a function of the interviewees and partly a function of the sector within which they worked, it became clear that interviewees identify accountability differently when considering product safety, service safety and/or service delivery.

The second major theme to emerge from the interviews was mechanisms used to manage and mitigate risks associated with the three different foci for Through-Life Accountability. In the literature review phase the Cambridge team identified five categories of mechanisms for managing and mitigating risk. These include:

1. Governance - internal systems and decision-making mechanisms that increase the awareness or control of accountability within multi-organizational service contracts.

2. Incentives - systems put in place in order to align goals between organizations to directly fit the effective outcome of the service provided.

3. Technology - systems that allow clearer transparency, helping to determine an objective decision on accountability.

4. Corporate culture – Organizational environments that shape internal or external (supply chain) activities, and influence constituents' personal decision outcomes to fit corporate objectives in the long term.

5. Organization - the design of organizational structure that influences understanding, such as transparency, of accountability and its related issues, especially the shaping of externally facing departments.

In the interviews the team explored the extent to which each of these mechanisms was used by industry. Figure 1 shows the average ranking for each of these five mechanisms. In essence culture was seen across the board as the most important mechanism for managing Through-Life Accountability, followed by Governance and Organisation. Interestingly Technology was ranked as the least important mechanism, despite the growing prevalence of software for example in sensing and monitoring solutions, especially those that can be used to monitor remotely how products are deployed. In the car insurance market companies, such as Progressive Insurance, are now using telemetry and GPS systems to manage risk premiums for young drivers. The technology is used to monitor driver behaviour, ensuring that the risk that Progressive takes in insuring a

particular driver reflects the style and safety of their driving habits. It does not appear that similar technological solutions are widely deployed to manage Through-Life Accountability yet. Of course, even if they were, this would not mean that the other dimensions no longer mattered. Creating a basis of accountability will still be important, even if technological solutions can be used to support this.
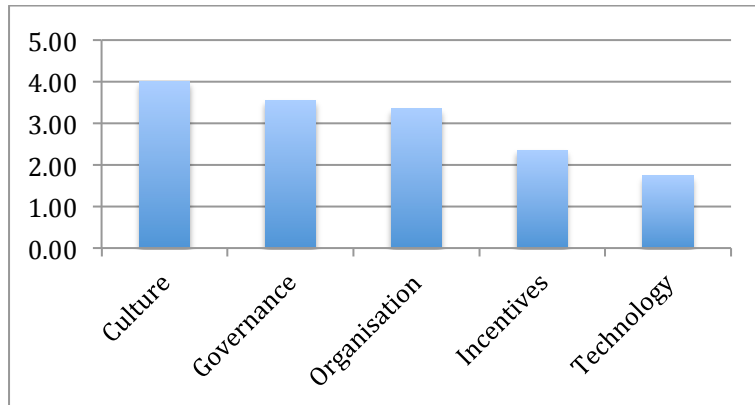

Figure 1: Average Ranking for Five Mechanisms for Managing Through-Life Accountability

It is also now possible to see how well the BAE Systems risks and hazards identified in section 2, map onto the derived mechanisms for managing Through-Life Accountability.

	Customer & Supplier relationships & comms.	Unclear contractual Safety requirements	Intelligent Service Delivery Contracts	Available and effective data sets	Different Cultures	Clarity around accountabilities
Culture	*		*		*	
Governance		*	*	*		*
Organisation	*	*			*	*
Incentives	*		*		*	
Technology	*	*		*		

Figure 2: Initial mapping to show correlation between BAE Systems identified Through-Life Accountability Risks and Cambridge derived Through-Life Accountability management mechanisms

It can be seen from Figure 2 above that initial mapping shows that correlation between the real world risks and the derived management mechanisms is close. Further understanding of these mechanisms and their effect on through-life accountability will be a focus of our further work.

Looking to the Future

The research carried out so far has highlighted two key themes:

1. The fact that there has been little research to date in the academic community on "through-life accountability". The need to distinguish between different dimensions of accountability when thinking about through-life accountability: (i) accountability

for decisions, actions and consequences; (ii) the separation between responsibility, controllability and liability; and (iii) the need to distinguish between accountability for product safety, service safety and service delivery.

2. The five broad mechanisms for managing through-life accountability: (i) culture; (ii) governance; (iii) organisation; (iv) incentives; and (v) technology.

Intuitively the five broad mechanisms map well with BAE Systems' experiences in managing complex service delivery contracts and this close mapping provides confidence that the concepts, survey techniques and research methodology are aligned accurately with the service delivery industrial environment. The findings also align with existing thought from within the Company that a better understanding of its organisational culture in all sectors of its diverse businesses will be fundamental to driving improvements in safety performance.

Therefore based upon this research the next steps for the Company will be to not only seek to better understand the differences in its organisational culture but also to look closer at accountability and therefore how it might better optimise its businesses for improved service delivery performance. BAE Systems is keen to continue to seek learning and external input and advice in this area, to share our experience with others and to learn from others when appropriate. We will continue to support additional research in this area.

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