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THROUGH LIFE CAPABILITY MANAGEMENT: BENEFITS AND BEHAVIOURS

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Many commercial and social endeavours require a multitude of socio-technical systems to work together effectively in what has come to be known as systems of systems. The Through Life Capability Management (TLCM) construct, currently being embraced by defence departments across the globe, is one such endeavour. TLCM demands changes in the organisation and culture of the defence supply chain in ways that fly in the face of traditional commercial wisdom. This paper reports on two workshops held with TLCM stakeholders in which they identified, and then prioritised, the benefits that they sought from TLCM. From an agreed set of priority benefits, the groups identified the behaviours needed to realise them; the results point to significant challenges in terms of culture and knowledge management. Ergonomists and systems engineers will need to support development of intervention strategies to effect these required changes.

Introduction

Recent years have seen a trend towards manufacturers and suppliers integrating products and services into capabilities to which customers can subscribe. This gives suppliers the advantage of better predictability of demand, while customers get the capability they need without the overheads associated with ownership. In defence, governments are integrating industry into overall management of military capability (especially in the UK), so that industry now takes responsibility for many roles that were previously the provenance only of Government owned entities (MoD, 2005). The aims are to make systems more cost effective, affordable through life, and responsive to the rapidly changing threat. It is believed that only by taking a whole system approach to managing capability, both in terms of large scale integration and over the long term that the benefits can be realised. Through Life Capability Management (TLCM) is an approach being developed to manage military capability (MoD, 2007; Stein, 2009). It considers not only the delivery of systems and equipment into service, but also the servicing, upgrade and support of those systems throughout their entire lifecycle. It is generally expected that TLCM will need new customer-supplier relationships; but how best to realise

these and what are the steps to be taken?

This paper describes a workshop (held twice with different stakeholders) in which the benefits of TLCM to both customers and suppliers were identified and used to initiate a consideration of the behaviours needed to achieve them. These point towards the need for substantial changes in culture within the defence supply chain and advances in knowledge management. The results of this work provide a platform from which research will develop into how these changes may be achieved.

Systems of Systems and the TLCM Challenge

The interoperation of discrete systems within a wider environment has always been a feature of commercial, social, political, and technological endeavour. But as the interdependencies between systems increase, so does the risk of unexpected, or emergent, behaviours. Systems of systems (SoS) engineering (Delaurentis, *et. al.*, 2007) is a discipline that seeks to understand and predict the behaviours of interacting monolithic systems, and so design those systems for participation in SoS. Interoperability is fundamental to SoS and this poses significant technical and commercial challenges for the defence supply chain. TLCM is a SoS problem. Systems of Systems are distinguished from monolithic systems by the following properties, identified by Maier (1998):   - Geographical distribution of elements
     - Operational independence of elements - Managerial independence of elements
     - Evolutionary development   - Emergent behaviour

The systems through which they are constituted generally have managerial and operational independence; the SoS undergoes evolutionary development (i.e. no clean sheet), the individual systems are spatially and/or temporarily distributed (i.e. it is information that travels between the individual systems); and, very importantly, they exhibit emergent behaviours that are not present in any of the individual systems, but only from the interoperation of the constituent systems. Emergent behaviours may be beneficial or detrimental and even – in some circumstances – catastrophic. We emphasise that the SoS include humans and organisations and it is very often the interoperation between these (or rather lack of it) that can lead to undesirable emergence. This is a problem of central importance to the ergonomics community.

TLCM is an evolving concept and in the UK organisational changes are occurring very rapidly as the understanding of TLCM develops. Daw & Sillitto (2009) suggest it is made up of three components: Capability (the ability to achieve desired military outcomes), Force Elements at Readiness (FE@R are the various components of military force that are ready for deployment at a particular time and may be combined to provide the required force), and the Defence Lines of Development (DLOD). The latter are Training, Equipment, Personnel, Information, Doctrine and Concepts, Organisation, Infrastructure, and Logistics. All of these aspects must be developed appropriately to realise capability. The formal definitions of all these terms for the UK MoD are provided in the Acquisition Operating Framework (MoD, 2009).

Some relevant characteristics of TLCM, for the results of the workshops reported herein, are that a systems approach is necessary for its realisation; systems engineering is a crucial skill

for both customer and supplier (Tibbitt, 2009). Whole life costs (development, procurement, in-service operation, and disposal) must be considered. There has also emerged a concept of incremental delivery of systems, based on the notion that a working but under-mature system delivered early and subsequently enhanced is of greater utility than a fully mature system delivered much later. Interoperability between systems is a critical feature. This poses significant challenges associated with the integration of legacy and new systems so that they work effectively, and safely, together. There is a strong implication of the need for open architectures and open systems implied in this characteristic (Tibbitt, 2009), which in turn implies that the supply chain must adopt more open working practices and be, itself, more interoperable. There are both commercial and cultural challenges to be overcome in this regard. Finally, it also demands systems to be designed for flexibility, so that they can be changed in an agile fashion to meet the demands of a rapidly changing threat. The need for a more agile supply chain implies the need for new cultural behaviours within it and changes in the range of, and relationships between, the stakeholders (Yue & Henshaw, 2009). New systems engineering approaches have also been recommended (Neaga, et. al., 2009).

Case Study: Stakeholder Perceptions of Through Life Capability Management

A case study has been constructed by running two workshops with TLCM stakeholders. The workshop format enabled the collection of opinions and experiences concerning changing working practices and attitudes to TLCM from stakeholders immersed in those changes. Both workshops followed the same structure so as to enable consistent analysis of any information captured. The first of these involved members of the TLCM research & development community (industry and academic). Attendees were selected from a group of systems engineering practitioners and researchers from Loughborough University, BAE Systems and the Defence Science and Technology Laboratory (dstl), by way of interest and field of expertise. The second workshop was conducted as a part of an international conference on through life support and costing, attended by operational staff (industry and military) from the Integrated Logistics Support (ILS) community. The latter group was international in nature and participants in this workshop were practitioners currently trying to adjust their practices to the demands of TLCM. The workshops were both small groups (9 and 5, respectively) but provided useful data about stakeholder perceptions and form a foundation upon which further research will be based. The workshops included discussions about the following key points:
−   Why TLCM needs new approaches to systems engineering.
−   What is the impact of systems of systems engineering on the commercial environment in defence?
−   The significance of information and knowledge management in a TLCM environment.
The stated objectives for the workshop were that attendees would:
−   Appreciate a range of perspectives on the approaches and priorities for Systems of Systems Engineering.
−   Be able to contribute positively to the transformation of the defence supply chain to deal with the challenges of TLCM in the future.

Method
The workshops used the mini-Delphi technique (Dalkey and Helmer, 1963; Cuhls; Rowe &

Wright, 2001) to solicit and then prioritise stakeholder views on TLCM benefits. Such an approach is perfect for face-to-face discussion of future trends, decision making and forecasting, because it allows discussion, assessment, and reflection. In addition, the Single Transferable Vote (STV, www.electoral-reform.org.uk) method was chosen. It is a form of preferential voting for multiple criteria and has the advantage of providing a more representative ranking of candidates because it takes account of voters' ordered priorities instead of just their first choice. Preferential voting means that instead of casting a single vote for a single criterion, a voter provides a rank ordered list; every vote has equal value and the number of 'wasted' votes is extremely small. Attendees were encouraged to identify their own individual choice of TLCM benefits and behaviours through open questions. Discussions between the attendees enabled a consensus to be reached when identifying and selecting the top five TLCM benefits. TLCM behaviours were elicited by asking the attendees their opinions concerning future issues to be addressed. Data was collected by way of note taking and the STV software.

Procedure
The workshop was set out into three main sections, these being:

Section 1: an initial overview of TLCM was presented. This provided the background to the problem domain (with a focus on the UK instantiation of TLCM) and touched on future issues and potential problems. This presentation was very interactive and served to establish an agreed characterisation of TLCM among the workshop members.

Section 2: TLCM Benefits: working individually, workshop attendees wrote a list of their top three, perceived, TLCM benefits. The full list from all attendees was then collated and presented back to the group for discussion and reflection. This ensured that the intended meaning of the benefit descriptions was clear to all and some rationalisation of the full list took place to remove duplication (i.e. where two attendees had individually identified a benefit that was the same). The attendees chose and ranked their top five benefits from the full list and this generated the overall ranked list of benefits.

Section 3: TLCM Behaviours: focusing on the top five benefits overall, the final session examined the behaviours that would be needed to realise those benefits. The behaviours and the discussion that took place during their identification was recorded using a flipchart to capture the main points from the group discussion and note taking to record the detailed information.

Results
Workshop 1 consisted of six academics and three industrial participants all working in R&D and with some level of understanding of TLCM. The rationalised list of benefits is presented in Table 1, with those from the academics and industry identified separately. Table 2 shows the top five TLCM benefits resulting from the STV ranking from workshop 1. Workshop 2 consisted of two industrial practitioners and three military personnel working in logistics with a very good understanding of TLCM. The results for workshop 2 are presented in Table 3 and Table 4.

Table 1. TLCM benefits as identified in workshop 1 (academic and industry)

Academic Generated	Industry Generated
Through life costing for existence in the market	Rapidly changing organisation to compete in global market places
Ensuring interoperability through better management	Reduction of military manpower becomes okay
Geared towards customer & Organisation Satisfaction (relationship)	More flexibility to address more scenarios as required by politicians
Increase number of stakeholders - hence customers	Allows more opportunity to work more closely with private military organisations
Extend lifecycle of product	Availability at lower cost
Enhance competiveness of product	Continuous product development
Greater flexibility of use of resources (hence availability)	More opportunities for business (market opportunities)
Better requirement documents (involvement of users)	
Clearer drive to long-term strategic thinking in defence acquisition	
Less waste	
Risk reduction by working with customer	
A structured approach to management of capabilities	
Ensure consistent processes and means during development	

Table 2. Ranked list of benefits (top 5) from workshop 1

Rank	Benefit	Origin
1	More opportunities for business (market opportunities)	Industry
2	Availability at lower cost	Industry
3	Continuous product development	Industry
4	Rapidly changing organisation to compete in global market places	Industry
5	Geared towards customer & organisation satisfaction (relationship)	Academic

Table 3. TLCM benefits as identified in workshop 2 (military and industry)

Military Generated	Industry Generated
Definition of goals	Managing capability development
Modelling for scenario effects	Cost savings
Enhanced operational effectiveness	Effective contracting
Enhanced theatre of operation (flexibility)	Reduced time to market of systems
Increased systems availability	Better risk management
Better life cycle management	Effective total cost of ownership
Manpower capacity increased	Better integration of logistics support

Better understanding of risk and uncertainty
Better understanding of constraints and limitations of systems

Table 4. Ranked list of benefits (top 5) from workshop 2

Rank	Benefit	Origin
1	Managing capability development	Industry
2	Increased systems availability	Military
2(3)	Better integration of logistics support	Industry
2(4)	Effective contracting	Industry
5	Modelling for scenario effects	Military

Behaviours needed to realise and support TLCM benefits

The attendees were asked about their views on what behaviours should be exhibited by members of the defence supply chain (suppliers and customers) to realise and enable the aforementioned TLCM benefits. To some extent this discussion was structured around the behaviours that the customer community would wish to see from suppliers and vice versa. The five areas that were identified by workshop 2 (that included suppliers and customers) are reported here, these were (in no particular order): - Availability

- Retain knowledge better
- Openness of long term planning
- Cooperation at all levels (commercial)
- Integration (lifecycle)

Discussion of Workshop results

Breaking the list of benefits into industrial and military generated (Table 3) reveals, unsurprisingly, the focus of military on the functionality and the service to provide the end effect, i.e. the sustainment and facilitation of military forces within theatre (be it peacekeeping, war-fighting, etc.). The benefits identified by the academic participants (Table 1) mostly have process and tool characteristics, which is unsurprising as the group was broadly drawn from the systems engineering and ergonomics communities. The top five benefits from both workshops reflect some operational aspects, but are mostly focused on benefits that require industry and Government to work effectively together. This indicates that TLCM offers benefits to industry as well as the customer, although we note that in these and similar workshops the industry representatives have tended to identify benefits to their customer and, ultimately, ranked those customer focused benefits most highly. Given the mutual benefit that is anticipated by the stakeholders, the final part of the workshop, in which the behaviours needed to realise the benefits were considered, was likely to focus on the enterprise aspects of the TLCM problem.

Retain knowledge better – it was recognised that TLCM required the whole supply chain to take a long term view, not just government, and that the length of some programmes (decades) meant that knowledge retention was a major challenge. From industry's point of view, investment in training and skills retention requires clear long term commitment from the government side. On the Government side, though, this reduces the ability to gain value through competition. Overall, the behaviours needed to support this challenge are collaborative planning of skills and knowledge needs, managed through enterprise-wide long term partnership contracting. Through such an approach, industry can have the confidence to invest significantly in training and skills retention.

Openness of long term planning – in general, the military plan future acquisition using scenarios that are not shared with industry. From this a set of requirements follows and industry is contracted against these. The group (workshop 2) felt that this led to dissatisfaction on both sides, because industry does not fully appreciate the way that the systems will be used. Overall, this was manifested as a strong request from industry members of the workshop to be given earlier involvement in the planning process in order to better prepare for capability development, by way of maintenance of skill sets and better understanding of the real requirements.

Availability – this feature was probably motivated, at least in part, by the current move towards availability contracting (e.g. Availability Transformation: Tornado Aircraft Contract - ATTAC), which could be regarded as a first step in TLCM. But importantly, this reflects a shift towards a service based environment, consistent with through-life concepts. Availability means that a particular service is available for use an agreed percentage of the time, where that agreement takes account of the type of use (e.g. for training, etc.). Participants noted the difficulty of contracting appropriately for availability and in particular the fact that so far availability has been platform specific, whereas the provision of an available service could be platform independent. Availability is improved by being able to achieve the service through a variety of means. The delivery of services is generally dependent on multiple organisations and relies, particularly, on the co-creation of value by customers and suppliers (Ng & Yip, 2009). This implies the need for a highly partnered environment.

Co-operation at all levels – although obvious, it was specifically identified by the participants in relation to commercial matters. Both workshops' participants were drawn from the technical community who felt that technical co-operation is frequently hindered by very drawn out contracting processes and even restrictive commercial arrangements. The TLCM environment implies the need to manage long-term commercial arrangements and participants identified the need for those arrangements to be sufficiently flexible that they could develop without the need for fundamental renegotiation and the delays and interruptions that might entail.

Integration – the context of this need, as expressed by participants, was the integration of the various organisations involved in TLCM. Such an approach would need better cooperation and better understanding of one another's policies, procedures and modus operandi so as to harmonise planning and operations. In effect an holistic approach (common procedures perhaps) would be a distinct advantage and allow for a smoother approach to TLCM, and possibly remove obstacles to easier and effective co-working and system and service support.

Discussion

The two workshops described above were conducted with a small number of stakeholders located largely in the middle management and ranks of the defence supply chain. It was also restricted to the technical community; the stakeholders could be regarded as largely taken from the developers and implementers of TLCM (now or in the future), rather than those charged with its strategic direction. This provides an interesting view of the challenges associated with operating within a TLCM business environment and of the benefits sought.

TLCM is a high priority for the UK MoD (Tibbett, 2009), the workshop revealed that similar strategies are being pursued internationally. The degree to which individual nations integrate the defence supply chain (i.e. to what extent industry assumes functions traditionally carried out by armed services personnel) varies, but the implications for all are that TLCM will rely on significant cultural and organisational changes.

Although we have identified the benefits as being industry-, or government-centric, in fact the prioritisation exercises and subsequent discussions identified the most important benefits as being those which were mutually beneficial. They all centre on greater levels of collaboration and, in particular, the need to share more information within the supply chain and for the earlier engagement of industry in the capability planning process. Areas of especial importance were the management of skills and knowledge and the risks associated with those. The risks within a commercial endeavour are different for different organisations: the industry participants were concerned with the risks associated with committing to retain, or create skills that might not be effectively utilised (and supported financially) in the longer term. The government participants were concerned with the implied reduction in competitiveness that long term contracting might bring about and possible lack of flexibility going forward in the systems that are long-term contracted. Both sides were concerned to have better knowledge of systems management for the future and better confidence in the costs associated with long term capability management. This suggests that the TLCM commercial environment must be one in which – as nearly as practical – risks are shared within the supply chain. Inevitably, this can only really apply to commercial risks. It was implied that greater sharing of information, especially earlier sharing of information, between customer and supplier (both ways) would be a vital ingredient in managing risk and achieving the overall objectives of TLCM. It was recognised by participants that this would require changes in contracting arrangements and changes in culture. It is certain that to achieve these changes, specific interventions will be required, although the nature of those interventions is not yet defined.

We have used the workshop format described above for a number of events involving industry and government stakeholders. The mini-Delphi technique and the use of STV for prioritisation appears to be an effective approach for gaining agreement of the benefits in a particular situation and for helping the stakeholders to understand the role they must play (i.e. changes they must make) in order to realise those mutual benefits. As such, this is not so much a research approach, but an activity that may be used to support transformation within the supply chain.

Conclusion

The work reported herein should be considered as 'work in progress' but, working with a limited number of TLCM stakeholders, we have established agreement around some key mutual benefits that those stakeholders seek. TLCM is already a fact – not an ambition – in many nations' defence departments, but significant further development will be required to achieve the benefits that are sought. Much of that future development will focus on a change in the commercial context, and in culture, towards a more collaborative environment in which customer and supplier share information more readily and the suppliers are engaged earlier in the activity of capability planning. The ergonomics community will have a crucial role in supporting these changes.

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