Software Engineering Institute

What Price Agility?

Managing Through-Life Purchaser-Provider Relationships on the Basis of the Ability to Price Agility

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Table of Contents

List of Figures

List of Tables

Acknowledgments

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Foreword

By Nicholas Whittall

BACKGROUND

There have been various interactions between Thales and Philip Boxer (now a Senior Member of Technical Staff at the Software Engineering Institute of Carnegie-Mellon University):

- He was introduced by Graham Smart (now VP Strategy and Business Development for Thales North America) in 2000 to consult on organization at the time of Thomson's acquisition of Racal, following which he worked with Dr Llyr Jones (CEO NITEworks® at the time of this study) to advise on Prime Contract Management.
- In 2003, his research company conducted a study for the Defence Science and Technology Laboratory (Dstl) on the ability of the Capability Audit to be responsive to the demands of NEC.
- In 2005, he was brought in under Andy Low's sponsorship (an adviser to National Defence Industrial Council (NDIC) Research and Development Group at the time of this study), to advise on the direction of Network-Enabled Capability (NEC).
- The announcement of the Defence Industrial Strategy (DIS) by the Ministry of Defence (MoD) led to two studies sponsored by the Battlespace Transformation Centre (BTC) in 2006: the first to advise on the commercial challenges presented by capability-based acquisition, and the second to draw on Thales' experience of Smart Acquisition to advise on the commercial opportunities in Through-Life Capability Management (TLCM).
- Finally, convinced that there is something transformational about his ideas, I sponsored some work in 2007 to explore how the market for TLCM could be defined by examining the long term acquisition costs of Tactical Unmanned Aerial Vehicles (TUAVs) and how they related to its operational costs.

Thales' collective reaction to his work has been quite varied, ranging from the confused to, dare I say it, not-invented-here. But two things have niggled at me: the conviction that there is competitive advantage to be had in a transformation of Defence procurement, and that the key to this is in pricing agility. Our paper at the Royal United Services Institute (RUSI) C4ISTAR conference and its follow up in RUSI Defence Systems gave, I hope, an accessible peek into the work that Philip Boxer and, to a small extent, I have been doing [Whittall 2008a]. Also, I have been peddling some of Philip's thinking in the Team C4ISTAR argument which, again, has met with varied reaction in MoD - not dissimilar to our own range of reactions. However, recent events have seen a step change in reaction that demands some wider response from Thales.

A PRACTICAL DEMAND-SIDE APPROACH TO COSTING

The MoD has recently appointed a Key Systems Advisor (KSA) to bring CIO level help to the Enterprise Architecture challenge. NITEworks® was entrusted with developing the concept of such a KSA and Llyr Jones consulted Philip on the terms of reference. The briefing Philip gave to

the NITEworks® management on 30 May 2008 argued that the solution to the economic crisis in Defence is to take a demand-led rather than a supply-led perspective.

This has huge implications, demanding a new discipline in engineering for flexibility, and a demand-side approach to costing based on operational cohesion rather than relying solely on a supply-side approach, as at present. This leads to the notion of option-based pricing of agility and a whole new way of contracting that examines the impact of supply-side options on the demand-side costs of cohesion.

OPPORTUNITIES FOR NEXT STEPS

Whilst some of these arguments demand the introduction of new assumptions about the Defence Enterprise, and are thus not readily assimilated, they are supported by methods and associated tools to enable them to be tested. Projective analysis is the method (PAN being the corresponding tool developed by Philip's research company) that will be available open-source in about a year and is the reason why Philip is working at the SEI. This enables "a model of everything" to be developed from a demand-side perspective, and the various cohesion paths through the constellation of enterprises to be located and priced. Hence the means of establishing a demand-side view of what Defence really costs and why.

The NITEworks® team were so impressed that they urged Philip to present to General Figgures, and proposed their study into the more effective use of UAVs as an obvious place to start with the application of these ideas. Philip's work at SEI has included examining the interoperability issues presented by the US Army and the Federal Wildland Fire Service (demonstrating that these concepts are domain-agnostic and concern enterprises). Given the SEI's interests, the NITEworks® investigation into fielding a UK Brigade within a US force offers another avenue for investigation of the application of these concepts. It is thus likely that NITEworks® will sponsor SEI to participate in an investigation of the projective analysis methods surrounding PAN in application to one or both of the two areas mentioned (UAVs and the UK Brigade deployment).

IMPLICATIONS FOR THALES

In this report, Philip lays out the argument for an approach to pricing agility that can provide a commercial basis for the TLCM relationships identified by DIS, drawing on the work done to date with Thales.

Dr Nicholas J. Whittall
Strategy Director
Thales, Aerospace Division (UK)

Executive Summary[1]

In its 2005 Defence Industrial Strategy (DIS 1), the U. K. Ministry of Defence (MoD) invited Industry to join it on a journey from traditional equipment supply, through contracting for the availability of fielded equipment, towards contracting the through-life management of military capability.[2] Sectors which could identify capability with particular equipment or platforms such as helicopters —and which were dominated by major onshore suppliers—allowed the journey to be mediated through a Strategic Partnering Arrangement (SPA). An SPA sets targets for business transformation and the adjustment of contracts to the benefit of all parties (gainshare) while assuring offshore suppliers of competitions to come.

For sectors where no such identification was made and which were correspondingly inhabited by a multitude of companies with no dominant players (e.g., C4ISTAR), the TLCM journey was barely defined. Thus, industry has been encouraged to make its own proposals. Thales has responded by calling for appropriate collaboration to construct a framework within which appropriate competition may be held, with the notion of appropriateness being informed by an as-yet undefined measure of value for Defence (VfD). This circumstance invites several questions, including:

1. How is a change from a commercial arms-length relationship to be seen as in the interests of suppliers?
2. On what basis could different elements of military capability be packaged for supply by industry?
3. On what commercial basis would industry wish to supply different elements of military capability?

To address these questions, we should identify the impact of design decisions taken in the development of equipment or platforms on their integration across all Defence Lines of Development (DLoDs) to form military capabilities. Beyond that, we should identify their impact on the orchestration of capabilities to form composite capabilities that deliver effects to meet demands arising in operational contexts-of-use. Further, if we conceive of the Defence Enterprise as a single process, taking in equipment or platforms and delivering effect into its context-of-use, then between this input— where the MoD has traditionally met Industry—and the output— where the military meets its adversary—three levels of decision tempo govern the performance of the process.

One tempo is the *campaign tempo*, the rate at which *demand* arises within the operational theatre (i.e., within the context-of-use). The rate of change in the tempo of this demand may be driven by changes in technology (e.g., incorporating a new capability, say TUAVs) or by changes in doctrine —theirs or our own (e.g., their use of improvised explosive devices [IEDs] or our countering their new uses of improvised explosive devices). A second tempo, the *alignment tempo*, is the rate at which the military commander can orchestrate the available individual military capabilities to form those composite capabilities that will deliver the effect that meets the demand arising at the

[1] A version of this Executive Summary was published by RUSI in 2009 [Whittall 2009].

[2] We are referring to through-life availability management (TLAM) and through-life capability management (TCLM) respectively.

campaign tempo. This alignment tempo is governed largely by the ability of the force elements to form the geometry-of-use that delivers the composite capability. A gap arising in the range and flexibility of individual capabilities needing to be orchestrated to meet the demand may manifest itself as a user *need* that is registered with the procurement agency. The *acquisition tempo*, the third and final tempo, is then the rate at which the MoD meets this need through publishing a *requirement*—usually for equipment, where Industry is concerned, although it may be across any combination of DLoDs—and delivering to the military commander whatever is required to close the gap in the orchestration of capabilities.

The separation of these tempos is neither unique to Defence—it applies to all enterprises—nor to this age. However, reflection on these three tempos leads to the conclusion that meeting the campaign tempo at the lowest cost (and this need not be limited to mere monetary cost) is the defining characteristic of VfD. Meeting the campaign tempo depends on the alignment tempo possible, which in turn depends on the acquisition tempo at which gaps can be filled. Any slowness in acquisition tempo leads to increased bricolage[3] and process shortcuts to enable the alignment tempo to keep up with the campaign tempo. Thus, *agility* finds its richest expression in the ability of the alignment tempo to meet the required campaign tempo at the lowest cost.

This demand-side approach represents a change in perspective from that encouraged by the currently dominant approaches that encourage functional specialization and decomposition of enterprises into their contributing systems. This dominant paradigm within which today's systems engineers operate is one of working an engineering 'V' from a requirement through functional analysis and decomposition processes towards components that can be integrated to deliver a system that meets the requirement. Design decisions taken through this process seek the lowest project cost, with little regard to the ways in which systems are used in a range of contexts. This supply-side perspective may reach towards these contexts-of-use through contracts for the availability of fielded equipment—as in SKIOS[4] which refers to the platform alone—or aspire towards TLCM where the capability is identified with particular equipment or platforms. But capabilities tied to platforms or equipment are far from the contexts in which a military commander can face demands with an array of systems of systems at his disposal. This report suggests that the dominant paradigm needs a feedback loop—an inverted V or *alignment Λ*—to engineer how the resultant systems will be, or could be, used with other systems in varying contexts-of-use.

Adding an alignment Λ introduces a tension between the constraints of design decisions taken to acquire equipment or platforms for a *requirement* and the degrees of freedom envisaged as desirable in enabling them to be orchestrated in response to changes in *demand*. The traditional discontinuity between demand and requirement has created a divergence of tempos that has imposed unanticipated costs in Urgent Operational Requirements (UORs) beyond the contingency budgets, thereby creating readiness in MoD to change in procurement regime. One solution, making available an infinite variety of geometries of use, may be viewed as ideal, but is unlikely to offer the best VfD. Locating an optimum balance between UOR overuse and wasteful flexibility is required through examining the costs of meeting varieties of demand. *Cohesion-based costing*, in contrast to activity-based costing, is proposed as a means of assessing the impact of changes in agility on

[3] This term is used to mean a solution put together from a variety of things that happen to be available.

[4] SKIOS stands for Sea King Integrated Operational Support, an MoD program to promote partnerships with industry with the aim of assuring maintenance of its fleet of Sea King helicopters.

the costs of alignment. Real option pricing [Luehrman 1998b] can then be used to quantify how agility creates value and thus how VfD can be agreed between suppliers and acquirers.

Abstract

In its 2005 Defence Industrial Strategy, the U. K. Ministry of Defence invited Industry to join it in moving towards contracting for the through-life management of military capability. For Industry Sectors such as C4ISTAR which could not identify capability with particular equipment or platforms, the path to through-life capability management was barely defined. Thus, Industry has been encouraged to make its own proposals. The aim of this report is to examine the type of agility the MoD invitation implies, suggest a means to provide management of the through-life capability it requires, and provide the basis for identifying the nature of the competitive advantages open to Industry that will make it commercially viable to take up the different relationship with the Ministry of Defence.

1 Introduction

The aim of this report is to identify the potential basis for competitive advantage open to Industry in taking up a different relationship with the Ministry of Defence (MoD), based on the use of cohesion-based costing and attaching economic value to agility. The invitation to a changed relationship was put forward in the U. K. Government's 2005 Defence White Paper on Defence Industrial Strategy (DIS) [MoD 2005]. The DIS was clear that its reasons for pursuing this change were to secure greater value for Defence (VfD):

> *Defence acquisition must be able to adapt to the increasing uncertainty in our external environment and the future operational requirements; programmes that are increasingly complex, of higher value and higher risk; a greater drive for innovation and continuing cost improvement, and models of product and service delivery that are more through-life and long term in nature. Relationships between Department and industry that are purely transactional and conducted at arms-length will struggle to meet these challenges. Increasingly they demand the use of a different style of relationship* [MoD 2005, pp. 132-133].

This different style of relationship, when translated into a contractual basis, took two forms. It became Through-Life Availability Management (TLAM), if attention remained focused on sustaining the platform or equipment, or Through-Life Capability Management (TLCM), if its performance were defined in terms of military capability delivered across all the Defence Lines of Development (DLODs). We see these emerging from the more traditional approaches in Figure 1.

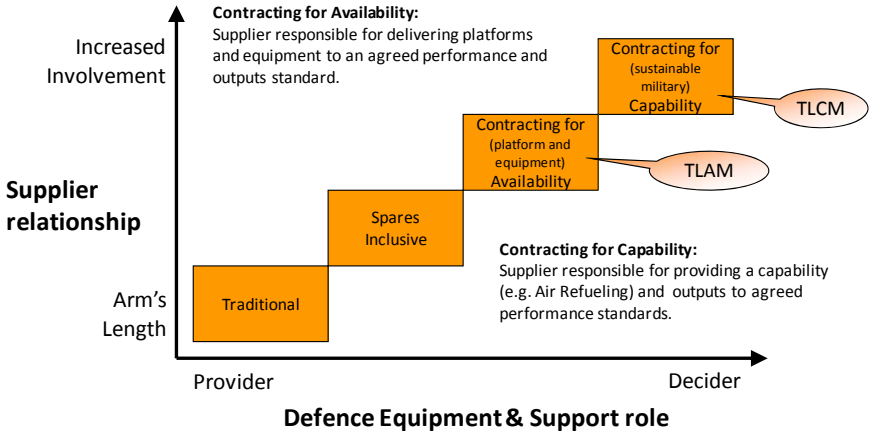


Figure 1: The Changing Relationship to Demand Proposed by the DIS [MoD 2005, Figure C1 (i), p. 135, revised]

This change in the approach towards capability programs demands that there be "culture change through setting the right values and behaviours, a programme approach to through-life capability management, effective integration across all the DLODs to deliver sustainable military capability, effective techniques for capability trade-off with early industry engagement in capability analysis, and defence/industry joint working to understand and address the dynamics of the supply chain and sources of innovation" [MoD 2005, p. 136].

So how could this change be made to be in the commercial interests of suppliers? The MoD's proposal was to make a much larger part of the defence budget accessible to industry. This became possible by placing the emphasis on effects-based operations (EBO) and the need to plan and manage the business of defence at the level of "military capability" as opposed to equipment and platforms. Military capability was defined as "integrated and agile combinations of people (appropriately trained and supported), equipments (appropriately updated and maintained), infrastructure and information, and structures and processes that can create military effect in a range of operational scenarios" [MoD 2005, p. 136]. But by what means would different elements of military capability be packaged for supply by industry and on what commercial basis?

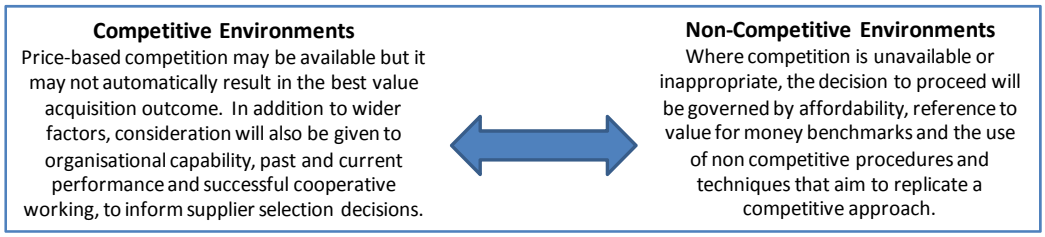


Figure 2: The Range of Possible Environments within which to Pursue VfD [MoD 2005, Adapted from Figure A7 (ii). P49]

The 2002 Defence Industrial Policy (DIP) had recognized that there were occasions "when *competition* might not be able to deliver the best long term value for money or sustain key UK defence industrial capabilities" [MoD 2005, p. 48]. As a result, procurement had to be able to include a range of possible environments in pursuing long-term VfD along the continuum described in Figure 2, in which a regulatory approach is taken in the non-competitive environment to compensate for the lack of market competition.[i] (Note: It is the convention in this report to denote endnotes with superscripted, lower case roman numerals and footnotes with superscripted numbers. Footnotes appear on the pages where they are cited; endnotes begin on page 46.)

DIS identified four possible procurement situations and outlined an approach in each case for assessing VfD. These are named and summarized in Table 1.

Table 1: Four Models of Procurement Situation[5]

Name	Procurement Situation
Single Source (Model I)	"One supplier has the capacity and [production] capability to deliver the requirement and is chosen because it is the sole source of supply, or it is chosen on the basis of consistently high performance compared to other suppliers, or it is the only suitable supplier to sustain sovereign capabilities in industrial base or other procurement grounds."
Collaborative (Model II)	"No single supplier has the capacity and capability to deliver the requirement and where an inclusive and willing group or groups of suppliers might be formed and sustained."
Through-Life (Model III)	"The through-life support of a capability that requires the engagement of the equipment Design Authority and/or other systems engineering capability."
Benchmarked (Model IV)	"[The potential for] competition exists but the procurement can readily be compared or benchmarked against similar technologies, supplies and services, or for [Urgent Operational Requirements] UORs where equipment is readily available."

[5] Model numbers and procurement situations taken from the DIS [MoD 2005, pp.50-51].

While the DIS laid out the MoD's approach towards Industry, it also raised questions that it did not fully answer:

- How was the change from a purely transactional and arms-length relationship to be in the commercial interests of suppliers?
- On what basis would different elements of military capability be packaged for supply by industry?
- On what commercial basis would industry wish to supply them?

The expected follow-on document (DIS 2) will need to address these questions, if only for the MoD to establish the budgetary consequences of strategic, non-arms-length partnerships with prime contractors [Kirkpatrick 2008].

Part of the reason for publishing the DIS was to encourage Industry to propose its own answers to these questions. In order to identify the nature of the commercial advantages open to Industry by adopting the different relationship proposed by the MoD in DIS, this report proposes the following approach:

- To provide a framework that can account for the different contractual nature of the models associated with the four procurement situations (Section 2: The Agility Challenge)
- To use this framework to distinguish three different epochs in the development of the relationship between the MoD and its suppliers, the third of which corresponds to the full through-life relationship espoused by DIS (Section 3: Managing within Different Epochs).
- To draw on the work done with Thales to exemplify the commercial approaches characteristic of each epoch, and to identify the key obstacle to managing through-life relationships commercially (Section 4: Challenges and Obstacles by Epoch).
- To recommend a method for overcoming this obstacle based on the ability to price agility, which this report will also expound in outline (Section 5: Managing Through-Life Relationships on the Basis of the Ability to Price Agility).

1.1 THE DIFFERENCE BETWEEN THROUGH-LIFE AND THROUGH-LIFE CYCLE

Figure 3 shows two dimensions on which a supplier can meet its customer's demands: (1) in terms of the complexity of the capability required by the customer and (2) in terms of the way the customer wants that capability sustained through its life. The four quadrants of Figure 3 will be used to distinguish the four models in Table 1 and to argue that there is a missing model corresponding to the supply of complex systems of systems that cannot be identified with particular equipment or platforms.

Supply-side vs. demand-side approaches

The traditional relationship with suppliers (see Figure 1) assumes that demand for a capability can be anticipated and translated into an enduring requirement for equipment or platforms, whether or not the specified requirement includes the need to support the resulting equipment or platform with spares and maintenance through its life cycle of use. This relationship is represented in the

bottom and left quadrants of Figure 3,[6] the commercial nature of which is dominated by supply-side competition to meet the static requirement.

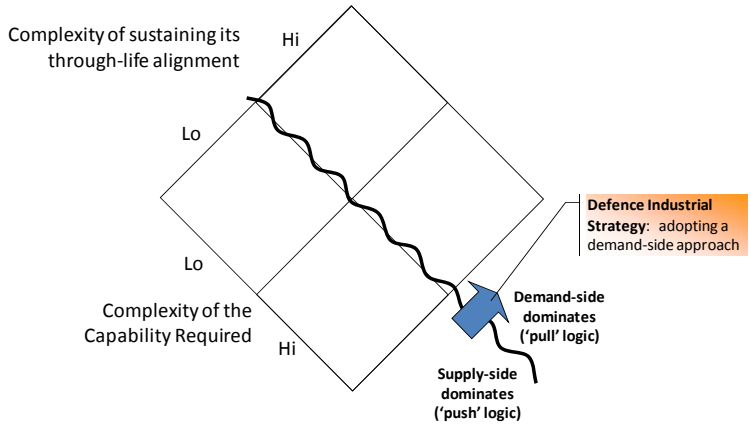


Figure 3: The Shift to a Demand-Side Approach

These supply-side relationships are shown in Figure 3 as presenting low levels of complexity to the supplier in sustaining the through-life alignment of the use of the capability with other capabilities, even when the inherent complexity of the capability required is itself high. They are contrasted with the DIS relationships which demand that the full set of DLoDs be included, associated with how the equipment or platforms are used.

This inclusion of the full set of DLoDs transforms the equipment or platform requirement into a military capability. This relationship is shown in Figure 3 as involving high complexity of sustainment, even though the definition of the capability may still be dominated by the nature of the equipment or platform itself. Thus

> *TLCM is an approach to the acquisition and in-service management of military capability in which every aspect of new and existing military capability is planned and managed coherently across all Defence Lines of Development (DLOD) from cradle to grave* [McKane 2006].

Sustaining what is produced by the supplier as a military capability through the life of the need for that capability significantly increases the complexity that must be contained by the supplier. It also changes the relationship from one dominated by supply-side competition to one dominated by demand-side considerations of how the capability will be used. In the quote which follows, this contrast is expressed as the difference between the through-life generation of desired effects and the managing of a project to deliver and sustain a required and affordable military capability through its whole life cycle:

> *Since capabilities endure, all capability management is in perpetuity, so the 'through life' is redundant. Thus there may be frequent step changes in the level at which capabilities (i.e. the ways to deliver effects) can be delivered, such as couriers being replaced by telegraph and then by radio, but it is rare that a genuinely new effect becomes possible. It is nevertheless still useful to retain it as it provides a reminder that decision making needs to take a long-term perspective. A more useful definition is 'Management of the long-term ability to generate desired effects through action across all Lines of Development'. [This contrasts with] the MoD's recommended approach to managing a project throughout its whole life*

[6] It is also the assumption represented in the bottom half of the double 'V' in Figure 5 on page 10.

cycle, which applies and integrates best practice management techniques to help deliver and sustain the required affordable military capability, in a coherent manner addressing all Lines of Development [MoD 2006].

Thus whereas *through-life cycle* remains focused on the equipment or platform, *through-life* focuses on the ability to generate desired effects.

1.2 THE MISSING MODEL

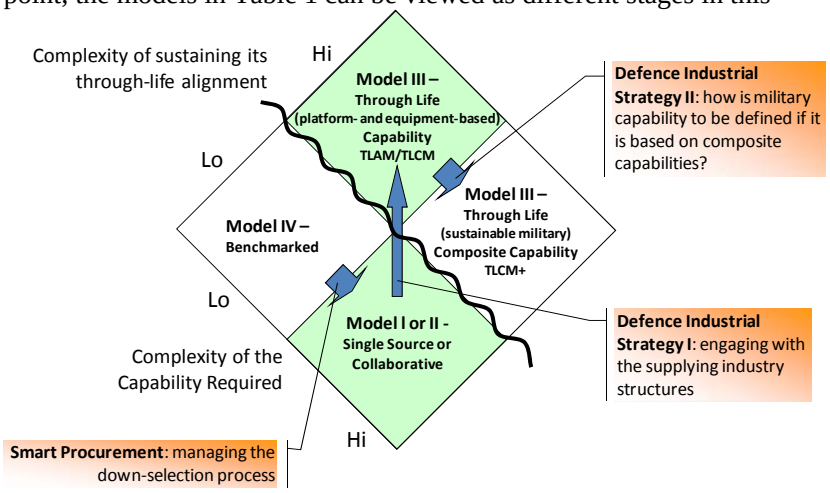
The DIS began the process of moving the role of Industry across the squiggly line in Figure 3 when it adopted an effects-based approach. Referring back to Table 1, Model III distinguishes between contracting for the availability of a particular form of military capability (TLAM, say Hercules Integrated Operational Support [HIOS] for the C130) and contracting for the management of the capability itself (say, theatre lift) through its life (TLCM).[7]

TLAM assumes that a single source of design control can be established for the given embodiment of military capability and that forms of contract can be established based on the anticipated use of the capability.[8] Two forms of TLCM need to be distinguished, however. One form assumes that the definition of the capability itself remains closely coupled to its underlying equipment or platforms (TLCM) and that any uplifts in capability—in this case closely identified with performance—will be contracted outside the original agreement. The other form assumes that the definition of the capability is not so tightly identified with or coupled to particular underlying equipment or platforms, and is referred to in this report as TLCM+.

[7] "The challenge for us and industry is to find mutually acceptable, robust commercial arrangements that incentivise delivery of the required support at minimum and continuously decreasing cost and improved long term value for money. In so doing, we would wish to transition from arrangements that reward volume and the cost associated with that volume, to one which rewards the active management of risk and the value it brings to defence - contracting for availability and /or other aspects of military capability" [MoD 2005, A7.35, p. 51].

[8] "We are procuring generally more reliable equipment and, consequently, there is a reduced requirement for moving spare parts and replacement equipment. Less broken equipment being sent back for repair also reduces pressure on the supply chain. It also means moving towards a system whereby we pay for availability not repairs. In the past equipment has been procured with two separate contracts, one for delivery and one for repair. This does not clearly incentivise the delivery of reliable equipment. We are moving to a single contract system, by which suppliers are paid for use of equipment" [MoD 2005, A7.35, p. 64].

From an historical viewpoint, the models in Table 1 can be viewed as different stages in this movement, shown in Figure 4 by the arrows.



- The sequence starts from the benchmarking approach of Model IV in the lo-lo quadrant, which assumed already-existent comparators for a requirement.
- Smart procurement ushered in the gated process whereby the MoD could de-risk the performance of a single source or collaborative supplier using Models I or II.
- The through-life Model III introduced by DIS involved crossing the squiggly line, to the TLAM/TLCM quadrant, where the capability is identified with particular equipment or platforms.
- Where the capability is not identified with particular equipment or platforms, it therefore remains for DIS II to more fully define the TLCM+ approach. This need is still the source of a major challenge for Industry since the economic models for TLCM+ have not yet been well defined.

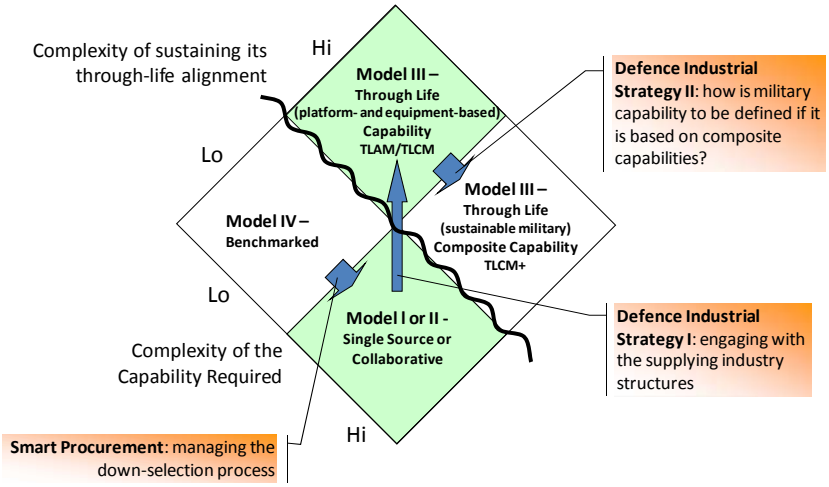


Figure 4: The Relationships between the Four Procurement Models from Table 1

This explanation of high capability and high sustainment complexity corresponds to the supplying and sustaining of composite capabilities, the definitions of which are not so tightly identified with underlying equipment or platforms.

To distinguish this through-life model from TLAM/TLCM, we call it TLCM+. Some examples help to establish this difference:

- Standardized sub-systems (for example power units) fit well into Model IV.
- Ships, aircraft, and unmanned aerial vehicles (UAVs) fit well into Models I or II. Thus the original smart acquisition of the Watchkeeper UAV fits here. (Although in order to mitigate the through-life sustainment risks of the Watchkeeper capability, more needed to be known about how it would be expected to interoperate with other capabilities.[9])
- Looking at Model III, the Sea King integrated operational support (SKIOS) contract is for TLAM, as is the contract for the provision of on-station UAV hours, while the contract for Armoured Vehicle Capability is for TLCM.[10] (What distinguishes the on-station contract for UAV from the *smart* contract is the explicit management of the capability's interoperability as part of the capability that is being made available.)
- The TLCM+ version of Model III involves a composite capability that is not so tightly identified with or coupled to underlying equipment or platforms. Here DABINETT[11] is a good example.

Examining the role of Watchkeeper within the larger context-of-use of Tactical Unmanned Aerial Vehicles (TUAVs) showed how the capability needed to be defined at the C4ISTAR[12] level in order to understand its interoperating role within the context of the system of systems associated with C4ISTAR [Rowe 2005]. Such a relationship would move the contract from being TLCM to TLCM+.[13]

What, then, are the characteristics of TLCM+? Another way of referring to a composite capability that is not so tightly identified with or coupled to underlying equipment or platforms will be as a network-enabled system of systems and therefore also a software-intensive system of systems. Thus TLCM+ also involves shifting from a system-centric acquisition viewpoint to a system-of-systems-centric acquisition viewpoint.

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9 This approach was taken in the evaluation of the sustainment risks facing the NATO AWACS capability. See *An Examination of a Structural Modeling Risk Probe Technique* [Anderson 2006a].

10 Although the role that AFVs play as nodes in the complex system of systems that will make up FRES will move it into the TLCM+ quadrant as well.

11 "DABINETT is a multi-faceted programme covering a broad range of Intelligence Surveillance Target Acquisition & Reconnaissance (ISTAR) issues including coherent Information Management, Tasking, Collection, Processing, Exploitation and Dissemination and provision of Deep & Persistent ISTAR. It represents a genuine departure from traditional programmes, requiring an effects-based focus and comprehensive consideration of all Lines of Development to assure delivery of improvements in operational ISTAR provision, and hence decision superiority in the future strategic environment" [QinetiQ 2005].

12 Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance

13 For an argument from the UK IT, telecoms and electronics Industries for this transition from a focus on the platform (UAV) to a focus on the systems in which it participates (UAS), see *Inquiry into ISTAR: the role of Unmanned Aerial Vehicles in ISTAR*: "As MoD develops its future UAS, improving the exploitation of the information they provide must be as much of a priority as improving the UAV itself. Industry has confidence that this is recognised within MoD, but once the current Planning Round is settled will be keen to see that future actions match the abundant statements of good intent" [Intellectuk 2008]

1.3 ACQUIRING SYSTEMS OF SYSTEMS

The DIS leaves unresolved this distinction between the challenges of the TLCM+ of complex systems of systems associated with supporting a composite military capability and the TLCM of a major system identified with particular equipment or platforms. It defines a system as follows:

> *a system [is] one which has a purpose and is viable in its own right. An example, from an equipment perspective, is a fast-jet combat aircraft. We will generally talk about platform systems – in the military sense, as the single viable equipment units, usually capable of independent movement – though examples include satellites, as well as vehicles, aircraft, ships and submarines. Network systems also exist, however; a Wide Area Network fits this definition of a system* [MoD 2005, p. 61].

By contrast, the DIS's definition of a system of systems makes the constituent systems independently viable. This is the distinction between individual and composite military capabilities (emphasis added):

> *a system of systems (SoS) contains systems which have purpose and are viable independent of the SOS,* ***but which can when acting together perform functions unachievable by the individual systems acting alone****. For instance, the future aircraft carrier, combining its aircraft carrier group with its own sensors, communications and command systems and weaponry and interacting with wider networks, represents a SoS* [MoD 2005, p. 61].

The difference between TLCM and TLCM+ thus remains unresolved because while it is clear how to acquire a major system on a TLCM basis, it is not clear how a system of systems might be acquired other than by treating it as another major system. This leaves unresolved the challenges **after** acquisition peculiar to sustaining the dynamic alignment of an evolving system of systems to its operational uses, and enabling these varying uses of its constituent systems to interoperate.[14] It also leaves unresolved the nature of the acquisition strategies supporting TLCM+. Thus, DIS goes on to qualify a system of systems as follows:

> *It is of course possible to see the carrier, from an operational perspective, as itself part of a wider system of systems, e.g. the carrier battlegroup, or indeed the complete set of defence resources that can be configured to a greater or lesser extent on demand to meet the changing needs of Government policy* [MoD 2005, p. 61].

What is being acquired becomes clear only when the viably independent systems are separated out from the interoperability and alignment issues associated with the generation of composite capabilities.[15] In order to overcome these difficulties, the processes surrounding the contracting for TLCM+ will need to be seen as belonging in a different epoch (see Section 4) in Industry's relationship with the MoD from those surrounding TLAM and TLCM. In the following four sections,

- the economic implications of the DIS call for a different relationship are explored, with its associated demand for agility (Section 2, The Agility Challenge)
- a framework is introduced within which to manage TLCM+, to distinguish different epochs in procurement and to provide the means to identify the incentives that will make it commercial-

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[14] Boxer, P.J. (2008) *SoS Navigator Principles for Sustaining Dynamic Alignment: The Example of U. S. Army Acquisition Strategies and Operational Realities*, CMU/SEI-2008-SR-027, September 2008, (in press)

[15] This and a number of other challenges associated with systems of systems are described in *SoS Navigator 2.0: A Context-Based Approach to System-of-Systems Challenges* [Boxer 2008a].

ly viable for Industry to join this new relationship (Section 3, Managing within Different Epochs)

- the particular economic characteristics of the epochs are examined to exemplify some of the value and profitability challenges within each epoch (Section 4, Challenges and Obstacles by Epoch)
- particular methods are put forward to manage the commercial consequences of supporting agility (Section 5, Managing Through-Life Relationships on the Basis of the Ability to Price Agility)

The report concludes that in order to sustain a different relationship with Industry, the MoD will also need to change the extent to which it makes its own processes transparent.

2 The Agility Challenge

The DIS makes planning and managing military capability central to creating military effect across a range of operational scenarios. The orchestration of military capability rests on the ability to create integrated and agile combinations of people, equipment, infrastructure and information, and structures and processes. Progress in developing this ability is evidenced by the creation of a MoD *unified customer* that merges equipment and support provision with the other DLoDs, and by the slow but steady progress being made in the realization of NEC [Butler 2008].

An earlier examination of the effectiveness of the Capability Audit (CA) process to identify the NEC issues associated with integration and agility found the following:

> *…CA has been a very positive force, increasing objectivity and identifying areas of capability shortfall/excess. It works well in domains where capability can be easily quantified in terms of either numbers or where the capability can be largely inferred from the equipment, but is more difficult to implement for supporting capabilities, where human factors influence the military capability and the decision processes examined affect the course of the scenario. This is of particular concern for assessing the C2 elements of a scenario . . .* [Iwar 2003].

This difficulty with failing to define capabilities in terms of equipment can be summarized in terms of the double 'V' diagram in Figure 5 [Ring 2001]. The bottom 'V' is the familiar system engineering process diagram, and the top inverted V (herein 'Λ') represents the alignment processes. This top alignment 'Λ' introduces the concept of the geometries-of-use needed to create particular military effects from multiple systems and teases from them the individual capability gaps that need to be filled by the bottom 'V' in a future development/enhancement cycle. The concept of *geometry-of-use* [Boxer 2008b] denotes the particular combinations of people, equipments, infrastructure and information, and of structures and processes that are needed to create a particular range of composite military effects. The squiggly line separates the bottom-half supply-side concerns of the engineering 'V' from the top-half demand-side concerns of the alignment 'Λ', which together form a cycle creating VfD.

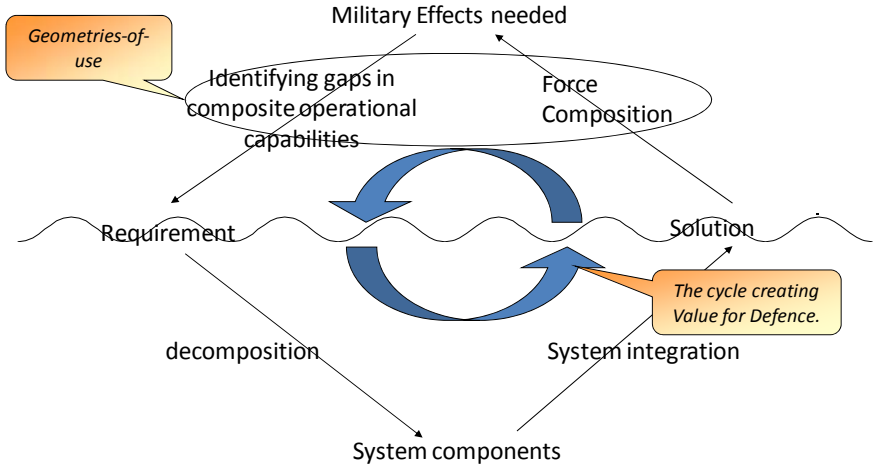

Figure 5: The Double 'V' Creating Value for Defence

Once the supplier has embarked on the systems engineering journey from requirements to validated delivery, the design decisions constrain the range of configurations (termed ***flexibility*** herein[16]) by which the resultant system may participate in multiple geometries.[17] The consequences of this constraining action may be quantified through traditional operational analysis. But that assumes the geometries-of-use forming the context for the isolation of the system requirements are adequate to define the military capabilities demanded in emerging or unforeseen operational contexts.

The problem facing the MoD under conditions demanding agility is to work the double 'V' as a whole cycle in an integrated fashion, and not just to outsource the bottom half to industry. This ***agility*** of a force structure is defined by the variety of geometries-of-use it can form.[18] The difficulty in working the whole cycle is in knowing how to focus on the agility of the force structure itself, from which these geometries-of-use are being formed.

The need for this agility is driven by changes in the nature of the defence role, associated with increasing asymmetries between forces, and forms of warfare that are increasingly irregular.[ii] This need for agility removes the previously relatively stable assumptions about the nature of warfare.[19] For example,

> *[One] bar to stability is the rapidly and dramatically changing nature of the threat... the growth of asymmetric and non-state threats has changed the capability requirement substantially. Indeed, the reason asymmetric threats have grown is precisely to shift future combat away from areas where the West has achieved a more or less unassailable superiority. Inevitably, therefore, countering such warfare requires a great deal of rapid innovation and agility* [Blackham 2006, p. 54].

Thus the more unstable the assumptions about how threats need to be met, the more important a range of responses (a manifestation of agility) becomes. It becomes prohibitively expensive to develop new capabilities for every situation, so that the wider the variety of situations that can be supported by a given force structure, the better. Hence the need for agile force structures:

> *The greatest [bar to stability] is the substantial unaffordability of the Equipment Program (EP)... There is no easy cure for this problem, other than some very hard decisions. It is difficult to see the budgetary situation easing in the foreseeable future, so there has to be a real effort to balance what the government wishes to do with its forces with what it is prepared to afford* [Blackham 2006, p. 53].

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16 As explained in Section 3.1, agility becomes a property of a force, while flexibility becomes a property of the independently viable systems from which a force is composed.

17 This distinction between a capability and the geometries-of-use in which it participates relates to the distinction made between a system of interest and the wider system of interest that forms its context-of-use. See"Understanding Complex Engineered Systems," [Stupples 2008]. The point made by the presentation is that contracts to provide a system of interest will only be successful if the wider system of interest is understood.

18 This structural definition of agility complements the timeliness definition, in which "doing right things right at the right time" is added to the ideas of effectiveness (doing right things) and efficiency (doing things right). The next section will explore this issue created by demand that arrives at a tempo that outpaces the enterprise's ability to respond with the adequacy required by the enterprise's stakeholders.

19 An example particular to the role of ISTAR is this: "The increasing incidence of asymmetric operations in difficult environments (including the urban) against irregular forces and individuals who are increasingly aware of our ISTAR capabilities is driving a requirement for increasingly detailed, unambiguous, persistent and timely information. At the same time, peace enforcement and peace keeping operations require persistent surveillance in a more benign environment" [MoD 2005, p. 106].

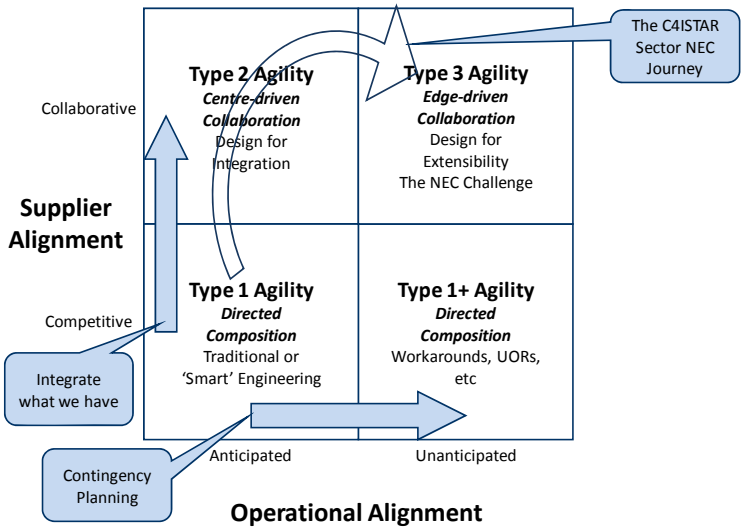

Figure 6: The Three Types of Agility[20]

This agility challenge can be understood better if placed within the larger context of Industry's ability to respond to the demands laid out in DIS. Figure 6[21] reveals two dimensions of contrast: (1) between competitive and collaborative approaches in the way suppliers respond to the MoD, and (2) between the anticipated operational demands arising from assumptions about conventional warfare and the unanticipated demands more characteristic of the way the current operational environment must respond to asymmetric and irregular demands. The resulting matrix accounts for three types of agility:

- Type 1, organizing the business model of a single competitive entity in relation to anticipated forms of demand (Type 1+ is combined with Type 1 because both involve traditional acquisition processes, which may or may not be competitive.)
- Type 2, organizing the business model of a collaboration between multiple competitive entities, still in relation to anticipated forms of demand
- Type 3, organizing the business model of a collaboration between multiple competitive entities, which is dynamically changing in response to unanticipated forms of demand

From these views, we can distinguish three kinds of transition expected of suppliers. Two of these transition modes spring from familiar challenges:

- UORs in response to contingency planning (Type 1 to Type 1+)
- Prime Contracting in response to the demand for integration (Type 1 to Type 2)

But the transition to Type 3 agility, driven directly by unanticipated operational demands, presents a different kind of economic challenge to suppliers because of the way the relationship to demand changes.

[20] The original analysis of Type 3 agility is in *Type III Agility* [Boxer 2006a]. Smart engineering refers to the practices associated with smart acquisition. See, for example, "The Revolution in Defence Acquisition Affairs: Why Smart Acquisition is Working" [Nixon 2007, pp. 66-67].

[21] Adapted from: "Appropriate Collaboration and Appropriate Competition in C4ISTAR Transformation" [Whittall 2007].

2.1 THE ECONOMIC CHALLENGE PRESENTED BY TYPE 3 AGILITY

In order to describe this economic challenge, it is useful to distinguish three tempos which impact the way suppliers ultimately support the delivery of military effect, shown in Figure 7[22]:

- *Campaign tempo* (meeting the demand) is the tempo at which Joint Command is able to generate military effects by tasking composite capabilities orchestrated from the military capabilities available to it to meet changing demands. The campaign tempo is driven by the demands emerging in the battlespace scenario and the campaign objectives being pursued.

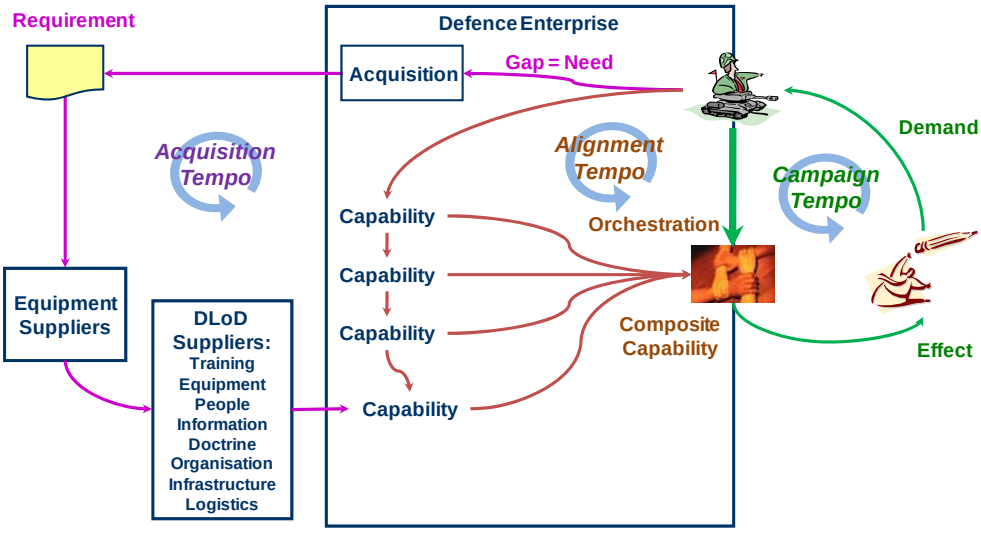

Figure 7: Distinguishing the Campaign, Alignment, and Acquisition Tempos

- *Alignment tempo (meeting the need)* is the tempo at which individual military capabilities (force elements) can be brought together within deployable force structures, and orchestrated to form composite military capabilities. It is these composite capabilities that can be described as geometries-of-use. The agility with which these composite capabilities can be generated is constrained by the variety of geometries-of-use that can be supported by the underlying individual capabilities and which are themselves constrained by the design decisions taken in the formation of their capabilities across the DLoDs. NEC is expected to have a major impact on this agility.[23]
- *Acquisition tempo (meeting the requirement)* is the tempo at which new military capabilities can be created in response to an identified capability gap. The extension of the equipment supply process to include the full range of DLoDs enables the acquisition process to deliver military capability rather than just fielded equipment, but the acquisition tempo will be driven

[22] Also adapted from: "Appropriate Collaboration and Appropriate Competition in C4ISTAR Transformation" [Whittall 2007]

[23] "Individual acquisitions are increasing in their complexity, as technology develops and as military effects increasingly are delivered through a combination of different platforms, forces and information systems. Realizing Network Enabled Capability (NEC) is all about making different capabilities work together in a coherent system, to deliver a step change in capability. As our own systems become more complex, achieving interoperability with our allies becomes an ever greater challenge. Open architectures can help manage this trend, but the underlying drivers remain. Our priorities for our forces include flexibility, precision, agility, and reach. Good systems engineering (particularly in pursuit of sustainability) can help design out unnecessary complexity, but in general, a flexible, precise, agile, and long-range capability, will be a complex one" [MoD 2005, p. 60].

by the nature and urgency of an originating capability gap. Thus it tends to be slow for platforms and infrastructure, moderate in support of tactical level integration, and rapid in support of force protection and ISTAR.

Military effectiveness depends on being able to operate at the required campaign tempo, but the faster—and more difficult to anticipate—this campaign tempo becomes, the greater the importance of the alignment tempo in being able to form the requisite composite capabilities. Thus military effectiveness will flow from the ability to span these three tempos.

Within the context of accelerating campaign and alignment tempos, any acceleration that DIS can achieve in acquisition tempo will help sustain the alignment tempo. This acceleration can be accomplished by developing types 1 and 2 agility in the MoD's suppliers. Even with improved type 1 and 2 agility, there will still be an inevitable divergence between the acquisition and alignment tempos as the latter increases to keep pace with accelerating campaign tempos responding to unanticipated demands. For example, even before Watchkeeper was delivered, new operational demands had emerged that had to be satisfied by UORs.

A consequence of this divergence between the tempos of acquisition and alignment may be an increase in the costs of alignment. Costs of alignment arise from their intensive use of manpower to overcome limitations in underlying capabilities and include the costs from both the purchaser and the provider. We see evidence of increasing costs in UORs (e.g., the H450 UAV), workarounds that are used as an alternative to UORs (e.g., adapting tanks for unanticipated desert conditions), and the adoption of alternative solutions less suited to pressing operational needs (e.g., the use of Nimrod as a tactical ISTAR asset).

This consequence becomes clearer if we add a third axis to Figure 6 to describe how the alignment tempo is managed in relation to the other two tempos. Figure 8 shows this third axis as an alignment of capabilities (to the alignment tempo), in relation to operational alignment (to the campaign tempo) and supplier alignment (to the acquisition tempo). Within this three-dimensional space there are now three different kinds of question to be addressed, corresponding to each of the three blue arrows.

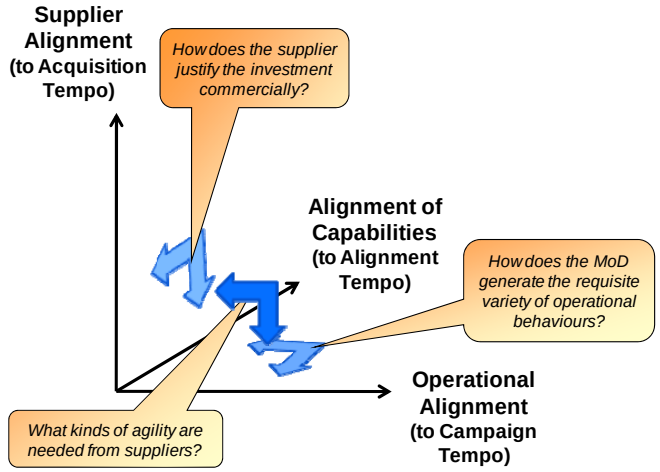

Figure 8: The Third Axis: Aligning Capabilities

The question of what kinds of agility are needed in the relation between suppliers and the ultimate operational alignment refers back to Figure 6. But the additional viewpoint allows us to think about two other kinds of issues faced by suppliers when they try to support the alignment processes that, in turn, support the accelerating campaign tempos:

1. How does the MoD generate the requisite variety of operational behaviors associated with Type 3 agility?
2. How does the supplier justify the investments needed to support Type 3 agility, and ensure that its behaviors remain consistent with this justification?

From this perspective, the importance attached to NEC follows from the need to meet the challenges of Type 3 agility. That is, the costs of the greater agility that NEC enables can be offset by generating economies in the costs of alignment.

> *At the heart of the force structure and capabilities modernising programme is Network Enabled Capability (NEC). NEC is about the coherent integration of sensors, decision-makers and weapon systems along with support capabilities…. This enhanced capability is about more than equipment; it includes exploiting the benefits to be obtained from transformed doctrine and training, and optimised command and control structures. The ability to respond more quickly and precisely will act as a force multiplier enabling our forces to achieve the desired effect through smaller numbers or more capable linked assets. In summary, the emphasis is no longer on quantity as a measure of capability* [MoD 2005, p. 20].

Within this view of the world, generating these economies of alignment becomes as important as securing the economies of scale and scope normally associated with the acquisition process.

But although the need for Type 3 agility is clearly identifiable, it is not clear why a commercial supplier should support it. The DIS offers the Defence Industry access to more of the MoD's expenditures as possible revenues, based on contracting for capability instead of equipment or platforms.[24] But how is this type of agility to be defined, and what would its costs be to suppliers?

2.2 TYPE 3 AGILITY CREATES ECONOMIES OF ALIGNMENT

Industrial structures have traditionally used the division of labor and specialization of function to create and sustain competitive advantage [Porter 1996].[25] This has led to the pursuit of *positional advantage* through which a supplier can dominate its chosen niche. The superior performance of the supplier comes from some combination of its ability to generate superior economies of scale[26] and/or of scope[27] for its customers. The pursuit of defensible intellectual property rights by suppliers is a characteristic of this positioning, which is represented in the bottom left of Figure 9. It is this approach that the DIS aims to correct for in pursuing TLCM.

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[24] "In the future, assuming this trend continues, an increasing amount of the defence budget would be made accessible to industry and the packaging up of different elements of military capability at the MOD/industry interface would continue. We would … become more explicitly dependent on key suppliers for delivery of defence outcomes" [MoD 2005, p. 28].

[25] The classic text on this is *Competitive Strategy: techniques for analysing industries and competitors* [Porter 1980].

[26] The supply cost advantage that a firm obtains relating to the volumes supplied.

[27] The cost advantages that a firm obtains relating to producing different products together.

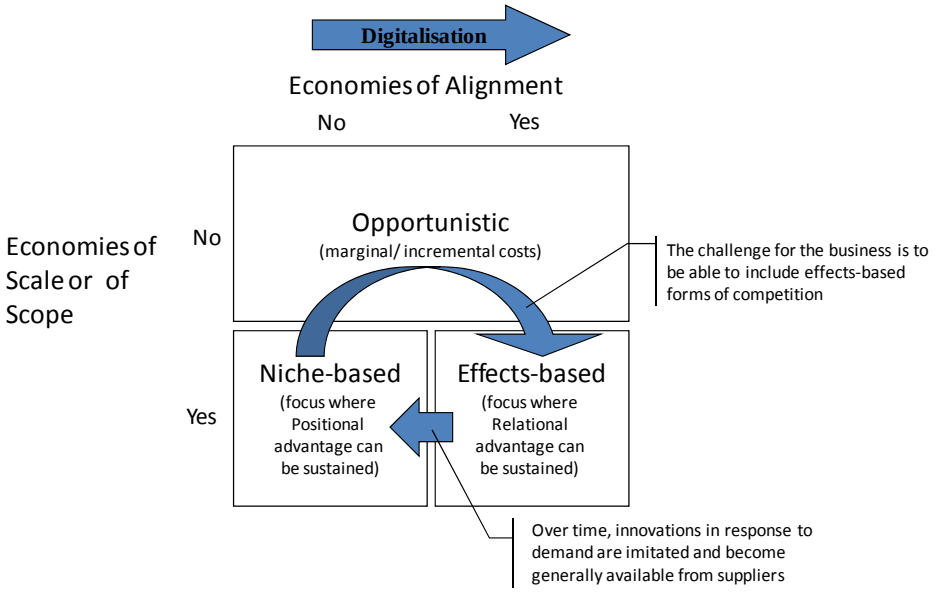


Figure 9: Niche-based vs. Effects-based

Two factors relating to *digitalization*[28] are tending to reduce the effectiveness of this positional approach. First, digitalization is reducing the potential benefits of scale and scope, making it economically viable to sell less of more different products or services. Thus the low costs of making and distributing product variants enable unique products to be supplied to single individuals, so that the virtues of "any color you want as long as it is black" have been replaced by the endless product variants generated by mass customization [Anderson 2006b]. Combined with globalization, this has led to an intensification of competition and a resultant commoditization of many products and services as they are priced at marginal or incremental cost. Competing on marginal or incremental costs in an ever more competitive market is represented as the *opportunistic* space in Figure 9.

The second factor is indirectly caused by digitalization as it reduces the costs of creating new forms of business. This views the niche-based approach as the pursuit of the operational effectiveness of a given business model, generating profitability for as long as its positional advantage remains competitively defensible. It contrasts this with an effects-based approach, which involves finding new positions that do different things in different ways to create effects that customers value (bottom-right of Figure 9).[29] Such approaches are *relational* because the new ways in which they create alignment of supply to demand emerge through relating to each customer's particular demand instead of trying to sell pre-packaged solutions. These are the form of partnership with Industry envisioned by the DIS.[30]

The effects-based approach is understandably disruptive of the existing ways in which market niches are organized [Christensen 1997]. It is easy to understand, therefore, why an existing in-

[28] Digitalization means that everything is becoming digital.

[29] Sixteen years after publishing *Competitive Strategy*, Porter he changed his own positioning in *On Competition* [Porter 1996].

[30] Such partnerships are not limited to the Defence Industry. See "The New Frontier of Experience Innovation " [Prahalad 2003] and *The Support Economy: why corporations are failing individuals and the next episode of capitalism* [Zuboff 2002].

dustry might resist such approaches because of their impact on existing competitive positions. Once new forms of value proposition are established by effects-based approaches, the opportunities they create ultimately define niches, so creating an innovation cycle from effects-based to niche to opportunistic and back again. Thus in adopting an effects-based approach, with the threat to existing positions also comes first-mover advantages.

This cycle can apply as much to the Defence Industry as to the MoD. So how is the supplier to think about this cycle commercially? And what are the commercial opportunities created for suppliers when their customers are pursuing an effects-based approach to alignment? Part of the answer can be seen in the different models proposed by the DIS in Table 1. These introduce the effects-based approach with the through-life concept. But they also leave an ambiguity in the definition of capability, so that while TLCM is defined as "management of the long-term ability to generate desired effects through action across all lines of development" [MoD 2006] it also remains largely identified with underlying equipment or platform (e.g., Armored Fighting Vehicle (AFV) capability) rather than by its desired effects. This leaves the particular challenges of Type 3 agility unresolved because of the unanticipated nature of the demands it must meet.

3 Managing within Different Epochs

One way to begin to address the unresolved challenges raised by the need for Type 3 agility is to separate all three agility types in time. We use the concept of epochs to represent this separation. Epochs as generally understood are periods of time that may overlap, are defined by start and end dates, and are marked by their distinctive character. The epochs described in this report are characterized by their corresponding form of agility in Figure 6. Thus the first epoch is identified with the period of time before the announcement of the DIS in December 2005, which included the introduction of Smart Acquisition. The second epoch, ushered in by DIS, introduced the effects-based approach to capability acquisition, and argued that all such acquisition had to address the full set of DLoDs.

This report argues that this second epoch needs to be distinguished from a third epoch which has not yet been distinguished formally, but which is characterized by the need to provide TLCM for capabilities which are not identified with particular equipment or platforms i.e. TLCM+.[31] The publication of a DIS II would be expected to make this distinction, but in the meantime this report aims to describe some of the challenges that DIS II might be expected to address.

3.1 THE DOUBLE 'V' AND ITS LAYERS

The relationship of the MoD pre-DIS to Industry was in terms of a *Customer 1* that established a requirement that Industry could supply. Figure 10 shows the Systems Engineering 'V' associated with meeting this requirement, and the particular place held by the Tier 1 Design Prime in meeting the requirement. It was left to the Design Prime to be the integrator of sub-systems sourced from Tier 2 and 3 Suppliers.

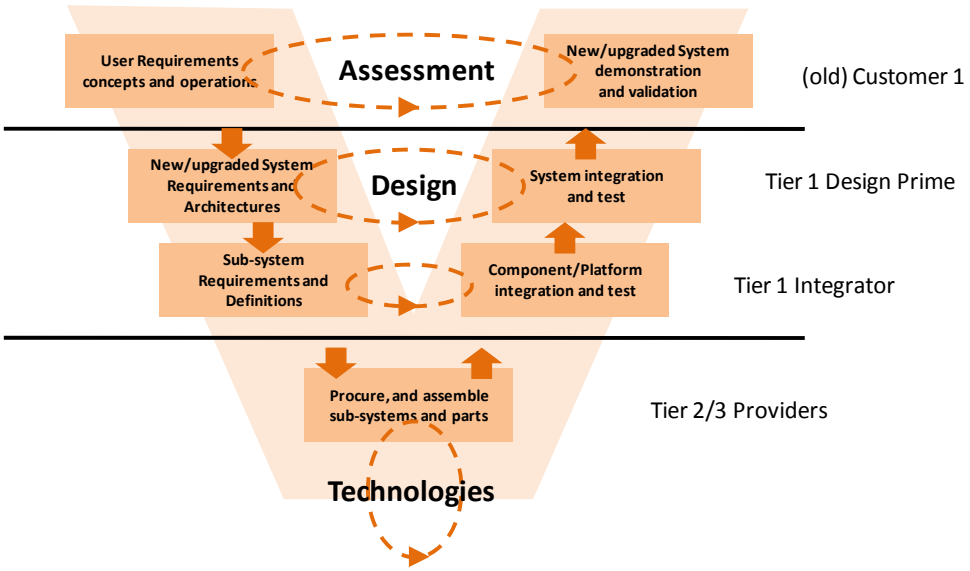


Figure 10: The Systems Engineering 'V' [MoD 2005, p. 60]

[31] These capabilities are to be found within the context of ultra-large-scale (ULS) systems [Northrop 2006].

Following the double 'V' of Figure 5, the top 'Λ' is shown in Figure 11 as an alignment 'Λ'.[32] This shows the *old* customer 1 in Figure 10 combining with the *old* customer 2 to form the unified customer introduced by the DIS. This unified customer includes the full set of DLoDs in the way the demand for capability is defined. The resultant military capability then becomes a constituent part of an agile force structure, which in turn comes under mission command. It is mission command that decides how to use the composite capabilities that can be generated by the forces to create the military effects associated with the decisive points in their campaign strategy.

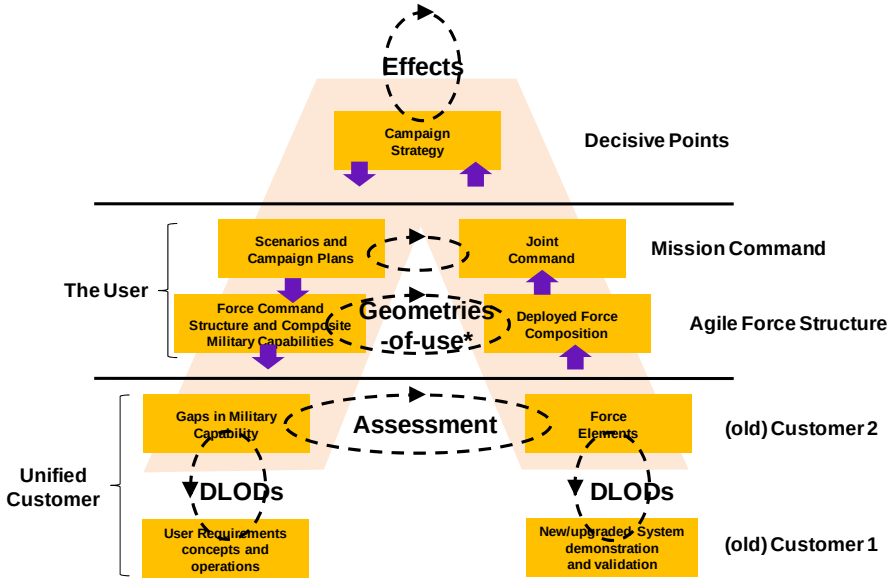


Figure 11: The Alignment 'Λ'

The relationships between individual and composite military capabilities are represented by the geometries-of-use. Going 'up' the alignment 'Λ' these geometries-of-use describe how composite military capabilities are generated, while going 'down' the 'Λ' they describe the context in which individual capability gaps can be identified. This is where NEC becomes important, since the more *flexibility* that is endowed in an individual capability by enabling it to interoperate with other capabilities, the more *agile* the force structure becomes. This is accomplished through the greater variety of geometries-of-use that the force structure can support. Agility therefore becomes a property of a force, while flexibility remains a property of the independently viable systems from which it is composed.

The full double 'V' can now be put together in Figure 12 and six different layers can be associated with its key elements.

[32] This top 'V' is adapted from a study in 2003 for Dstl on the ability of the Capability Audit to be responsive to the demands of NEC.Aspects of it are covered in "Systems-of-Systems Engineering and the Pragmatics of Demand" [Boxer 2008b].

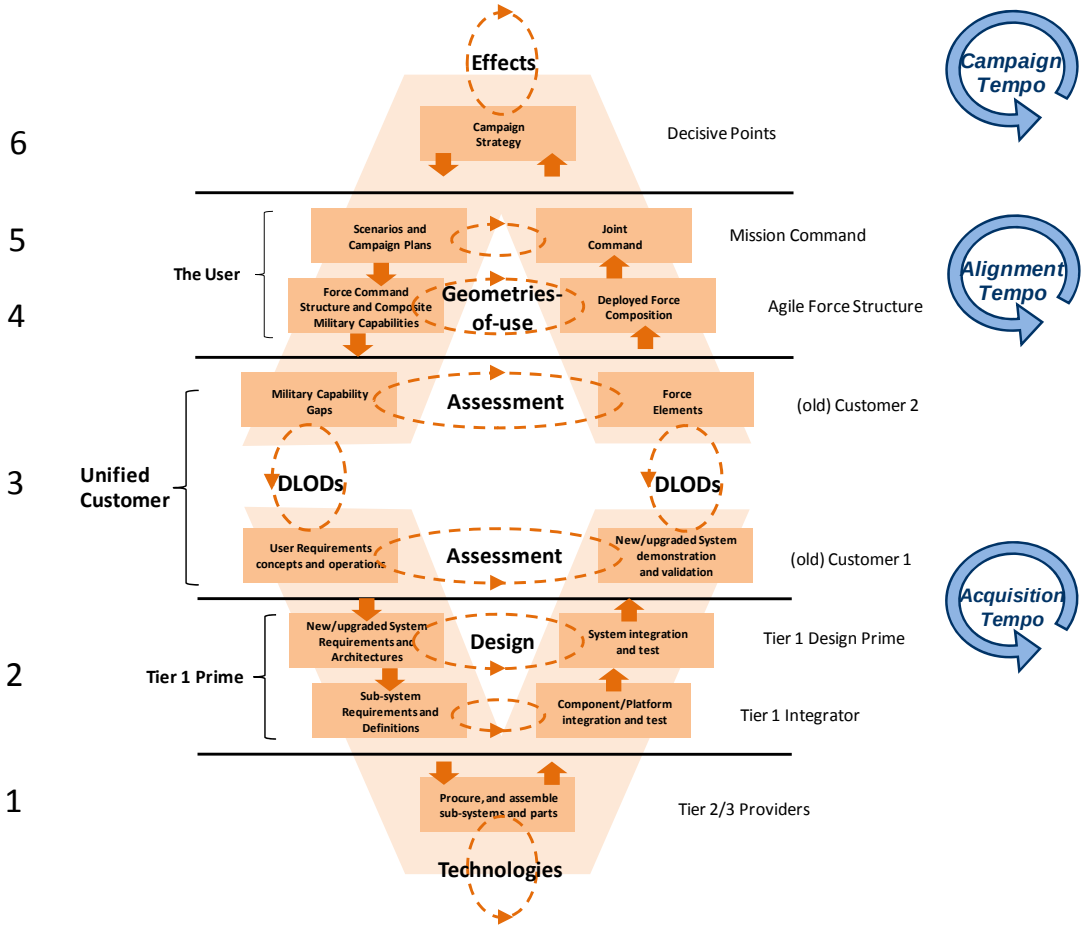


Figure 12: The Double 'V' Cycle and Its Layers

Describing the layers from the top to the bottom:

- At layer 6 (Decisive Points) is the relationship of the force to the campaign environment. This relationship is governed by the externally driven campaign tempo.
- At layers 5 and 4 (Mission Command and Agile Force Structure, respectively) is the DIS User made up of the forces (layer 4) and command (layer 5). The relationships between them are governed by their alignment tempo, so that the less agile the force structure, the slower the alignment tempo.
- At layer 3 (Force Element, not shown in the figure) is the unified customer; at layer 2 (Fielded Equipment, not shown) is the Tier 1 Prime. The relationships between them are governed by their acquisition tempo.
- At layer 1 (Equipment, not shown), then, are the Tier 2/3 providers with their relationships to the underlying technologies.

From these descriptions it is apparent that the DIS language of User, unified customer and Tier 1 Supplier can be adapted to TLCM as long as two conditions are met. First, the supplier must be able to take up some of the roles of the unified customer in providing capability to the *user* in lay-

ers 4 and 5, and the capability no longer continues to be identified with particular equipment or platforms. Second, the user must be able to take up the role of the customer. As soon as the role of the customer moves above layer 3, the unified customer can itself be described as a provider from the point of view of the user as purchaser (and budget holder)it becomes convenient to speak in terms of a purchaser-provider relationship (see Table 2).[33]

Table 2: The Purchaser-Provider Relationship across the Different Layers

Relationship	Layer 2 → Layer 3	Layer 3 → Layer 4	Layer 4 → Layer 5
Purchaser	Unified Customer (old customer 1)	User	Mission Command
Provider	(Tier 1) Supplier	Unified Customer (possibly in collaboration with suppliers)	Agile Force Structure

3.2 DISTINGUISHING THE EPOCHS

This need to distinguish the language of supplier and customer from the more complex purchaser-provider relationships brought about by DIS is the first reason to distinguish epochs. Thus we can distinguish Epochs 1 and 2 as pre- and post-DIS, corresponding to the change from a supply-side to demand-side orientation (as described in Figure 8 on page 14) in order to deal with diverging acquisition and alignment tempos.

These distinctions make more sense if the demands for military effect are expressed from the perspective of Joint Command. Thus in Figure 13, which uses the same layers as in Figure 12, the unified customer becomes a provider of Force Elements, and a supplier becomes a provider of Fielded Equipment. Referring back to different models of procurement in

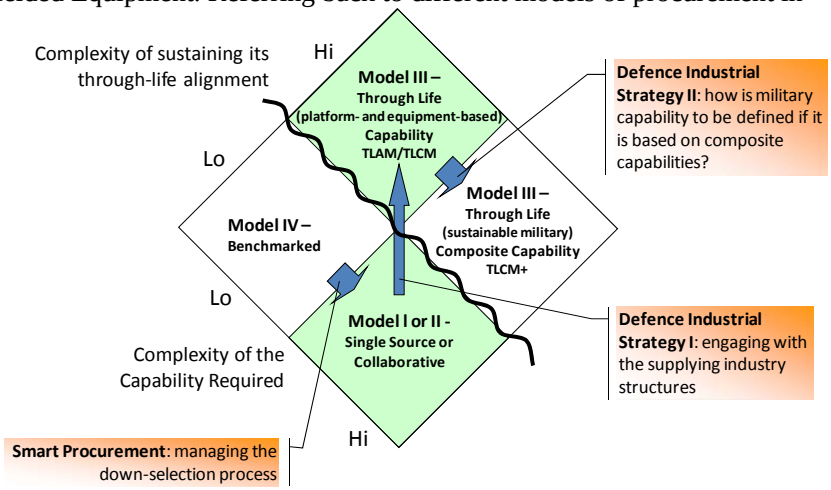


Figure 4 (on page 6):

- The *Benchmarked*, *Single Source* and *Collaborative* models of procurement belong to Epoch 1, driven by the acquisition tempo (i.e., by the rate at which new requirements are generated from capability gaps).

[33] This becomes even more apparent in the way NATO force deployments are funded independently of the assets used by such force deployments [RUSI 2005].

- The TLAM/TLCM versions of the *Through-Life* model of procurement belong to Epoch 2, driven by the alignment tempo (i.e., by the rate at which requirements for individual military capabilities are generated from capability gaps that emerge in geometries-of-use).
- This leaves Epoch 3 identified with the TLCM+ version of the *Through-Life* model of procurement, as exemplified by C4ISTAR and DABINETT. The demands for these composite capabilities are driven by the campaign tempo diverging from the alignment and acquisition tempos (i.e., by the rate at which requirements are generated for new geometries-of-use which, in an ideal world, the existing force structures are agile enough to meet with the existing set of individual capabilities).

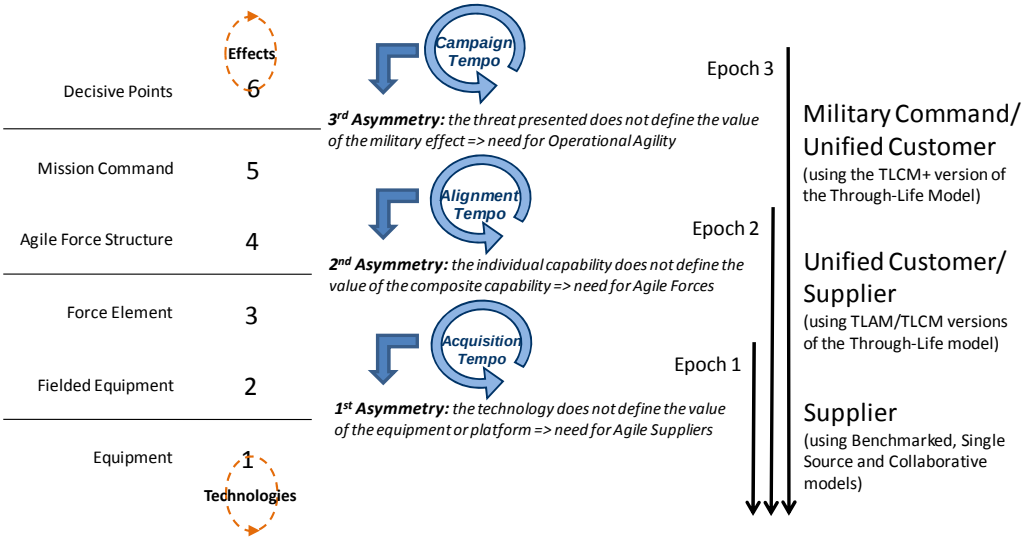


Figure 13: Distinguishing the Epochs

Defining the basis of the epochs

The epochs are driven by the need to align increasing numbers of tempos, in each case generating particular challenges that each epoch must overcome. These challenges share the common feature of competitive asymmetries; that is, that the value of the entity created (equipment, capability, effect) is determined by its relationship to its context, and not by the constituents that are united in the creation of the entity. Thus, equipment may be viewed as an arrangement of technology to meet a set of requirements frozen in time, but the value of the equipment is to be seen in its operation within its context-of-use. This may be extended to any military capability, which finds its value when orchestrated with others to form composite capabilities. Finally, an effect finds its value in the contexts in which the consequences of the missions generating it are experienced.

These challenges are described as particular competitive asymmetries that are cumulative in their effects on the epochs:

- 1st Competitive Asymmetry: In Epoch 1, the need is for an agile supplier, so that the Tier 1 supplier must manage the fact that the underlying technologies do not define the value of the equipment or platforms that will meet the requirement. Rather, the individual military capability needed (the force element in Figure 13) defines the equipment or platforms. Smart Acquisition was designed to improve Epoch 1 suppliers and worked well with small projects, but

the MoD had difficulty implementing its recommendations with respect to the larger and more complex acquisitions [Blackham 2006, pp. 52-54; Nixon 2007, pp. 66-67].

- 2nd Competitive Asymmetry: In Epoch 2, the need is for an agile unified customer supported by agile suppliers, so that the supplier and unified customer must jointly manage the fact that the individual military capability with its DLoDs does not define the value of the composite capability. Rather, mission command defines the composite capability, thus requiring flexibility in how the individual capabilities can be used. This leads to restrictions having to be placed by suppliers on the operational contexts in which capabilities provided by them under TLAM could be used, and continuing difficulties dealing with the system-of-systems characteristics of the larger and more complex composite capabilities.
- 3rd Competitive Asymmetry: In Epoch 3, the need is for an agile force structure, relying on an agile unified customer supported in turn by agile suppliers. Military command and the unified customer must jointly manage the fact that the threat against which composite capability was defined does not determine the value of the military effect. Rather, the decisive points of the campaign define the required military capability, thus requiring operational agility in how composite capabilities can be generated and their use synchronized. This is where gaps still exist in knowing how to generate operational agility and how to create a purchaser-provider relationship that supports it.

Note in Epoch 3 that Industry is only involved directly insofar as suppliers are jointly participating with the unified customer in the through-life management of *individual* capabilities. This becomes clearer if we examine these epochs in terms of the nature of their underlying contractual relationships with suppliers.

3.3 THE CONTRACTUAL BASIS OF THE EPOCHS

Epoch 1

The left-hand column in Figure 14 represents the *smart* contractual relationship to the stratification in Figure 13. (The column to the left of this smart column representing the *arms-length* contractual relationship has been omitted). The numbers in the boxes refer to the layers in the column (as shown in Figure 12 and Figure 13). The pre-contractual process (box numbered 3 in the column) defines the context in which the contract will be defined, expressed in terms of the individual military capabilities that the equipment or platform will support. The contract (box 2 in the column) is for defence equipment and support, and is expressed in terms of what will be fielded, and it is left to the supplier to manage the 1st asymmetry in how it acquires the needed technologies from its Tier 2/3 subcontractors (box 1 in the column). The layers above the pre-contractual process (boxes 4, 5 and 6 in the column) remain above the customer's strategy ceiling (i.e., the layers that do not have to be explicit in the pre-contractual process). An example of this type of contractual relationship is the acquisition of UAV equipment and platforms to be supplied to a regiment (i.e., Watchkeeper).

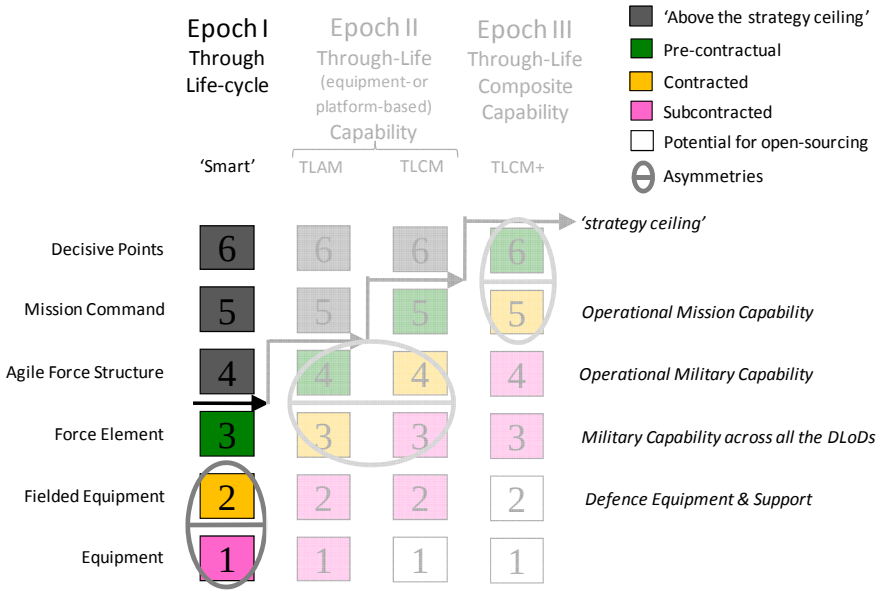


Figure 14: The Commercial Characteristics of Epoch 1

What distinguishes the Epoch 1 is that there is no need for the supplier to be involved with the way capabilities are to be used operationally, a fact that enables the competitive nature of the smart acquisition process to be maintained, keeping the supplier's focus on managing the product life cycle of the equipment or platforms that have been supplied.

Epoch 2

Epoch 2 is characterized in Figure 15. In the second column, the supplier now becomes a provider, since the unified customer is to some extent managing the 2nd asymmetry jointly with the provider, and the purchaser (the force) defines the operational military capability.

An example of a TLAM contract (second column in Figure 15) is UAV capability made available in theatre for operational use (i.e., the H450 provided as "ISTAR by the hour"). Here the pre-contractual process (box 4 in the column) defines the operational contexts in which the particular equipment and platform will be used, which in Epoch 1 was above the customer's strategy ceiling. Layers 5 and 6 in the column remain above the purchaser's strategy ceiling.

The contract (box 3 in the column) is to provide the operational military capability (or some part of it) across all the DLoDs ready-for-use by the purchaser (the force). This contractor as provider creates his own design authority and collaborates with the subcontractor as integrator (box 2 in the column) to bring together the relevant Tier 2/3 suppliers (although this subcontractor may be another part or the provider's organization). Savings accrue to the purchaser as a result of reorganizing the way the capability is made available from layer 3, including reorganizing the role of the

unified customer. The profitability for the provider comes from the savings generated for the purchaser, part of which savings become profit for the provider as proposed in the DIS.

An example of a TLCM contract (third column of Figure 15) would be a UAV capability made operationally available for mission tasking. Before the acquisition of Reaper, an example of this would be the provision by the USAF of Predator capability through the RAF's participation in a joint U. K./U. S. task force [Defence News 2007]. Here the contract (now at box 4 in the column) is for the operational availability of the composite capability that interoperates with other elements of an agile force structure. The pre-contractual process (now at box 5 in the column) is about defining the kinds of mission tasking for which it will be available (which in the example would be the terms of reference for the task force). Only one stratification layer is now above the purchaser's strategy ceiling (box 6 in the column), relating to the campaign strategy and its decisive points. The service provider (box 4 in the column), who is a supplier acting jointly with the force, is managing the 2nd asymmetry and determining the integrator role (boxes 3 and 2 in the column). Subject to the way this integrator role is defined, there is also scope for technology substitution at the bottom layer on an 'open source' basis (box 1 in the column).[34]

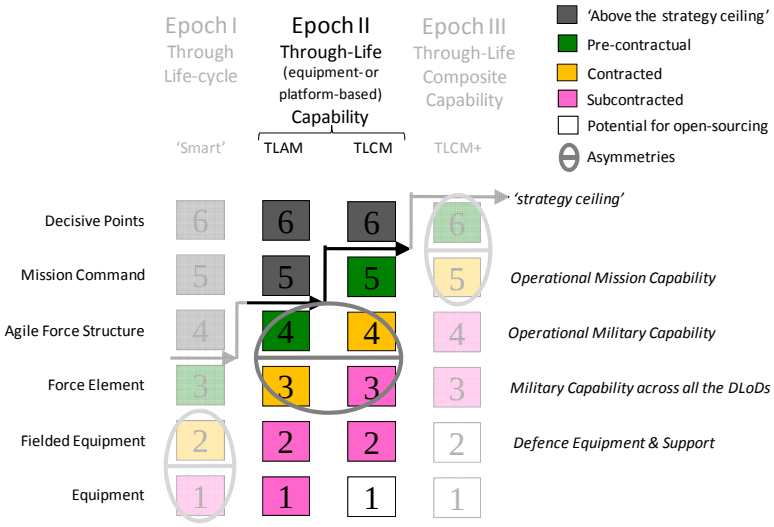


Figure 15: The Commercial Characteristics of Epochs 1 and 2

A key characteristic of Epoch 2 is the collaboration that is necessary between the unified customer and the role of the supplier as a joint provider in layers 3 and 4. This collaboration distinguishes the TLAM/TLCM contractual relationship from the arms-length relationship with the supplier in Epoch 1's smart acquisition. What further distinguishes Epoch 2 is that the provider does not need to have knowledge about the nature of the military effects that the capability they provide will be used to generate

Epoch 3

In Epoch 3, the 3rd asymmetry (that is, the threat does not define the value of the military effect that needs to be created) has to be managed explicitly. This situation is illustrated in the fourth

[34] The effect of defining the purchaser-provider relationship between the layers 4 and 5 means that its competitive identity is defined at the level of the 2nd Asymmetry. Provided that this identity is made explicit, then it becomes possible to substitute functional elements in the tier 2/3 layer. This is what defines the open-sourcing approach.

column of Figure 16 (TLCM+). In this column, the pre-contractual assumptions about the nature of the effects that need to be generated (box 6 in the column) inform the nature of the operational mission capability that needs to be provided contractually (box 5 in the column). Different mission capabilities will need different geometries-of-use, so that the variety of effects needed (defined in terms of the variety of decisive points) will determine the variety of geometries-of-use. It is this required *variety* of geometries-of-use that defines the requisite agility of the force structure. The contractual relationship between the purchaser (military command) and the provider (the supplier acting in collaboration with the unified customer as part of the force and embedded in the command process) is therefore different from that in Epoch 2. It is expressed directly in terms of the variety of operational mission capabilities that can be provided.

An example here is a coalition partner acting as a supplier, operating alongside Mission Command providing an operational capability to source responses to Commanders' Critical Information Requests (CCIRs), or the ability of DABINETT to provide a service of coherent information management, tasking, collection, processing, exploitation and dissemination in the context of providing deep and persistent intelligence surveillance target acquisition and reconnaissance (ISTAR).

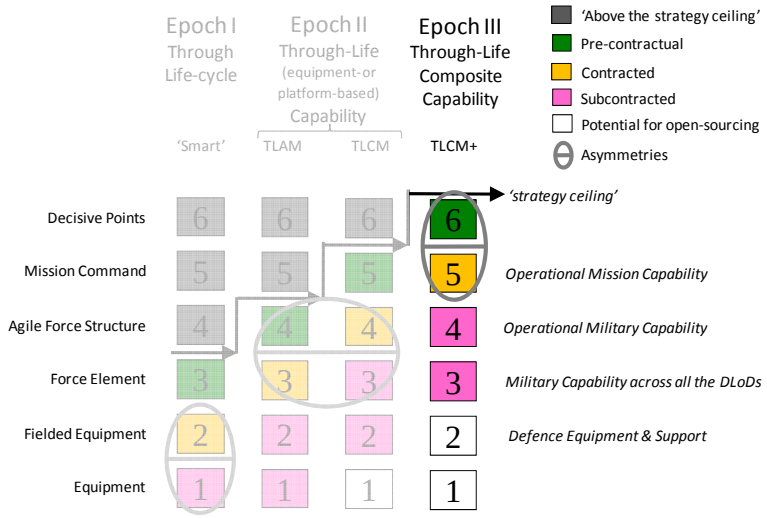


Figure 16: Distinguishing the Commercial Relationships of Epochs 1, 2, and 3

Figure 17 takes a different look at the top 'Λ' in Figure 11(on page 19) to understand the difference in the nature of the relationship in Epoch 3 by illustrating layers 4-6 of the stratification in a slightly different way. The Agile Force Structure (box 4 in the column headed Epoch 3) is enabling some combination of force elements to form multiple geometries-of-use that generate composite (military) capabilities. This creates a many-to-many relationship between force elements and composite capabilities.

These composite capabilities are themselves synchronized with an alignment tempo by Joint Command (box 5 in the column), again through a many-to-many relationship, to generate decisive points in the campaign strategy. And the organization of Joint Command's campaign strategy (box 6 in the column) is itself changing, reflecting a many-to-many relationship between decisive points and effects. The nature of this relationship changes, driven by the campaign tempo. Overall, Epoch 3 is concerned with managing the alignment between the available supply of flexible

individual capabilities—themselves embodied in systems of systems—and the variety of scenarios in which they must be able to be used to create effects.

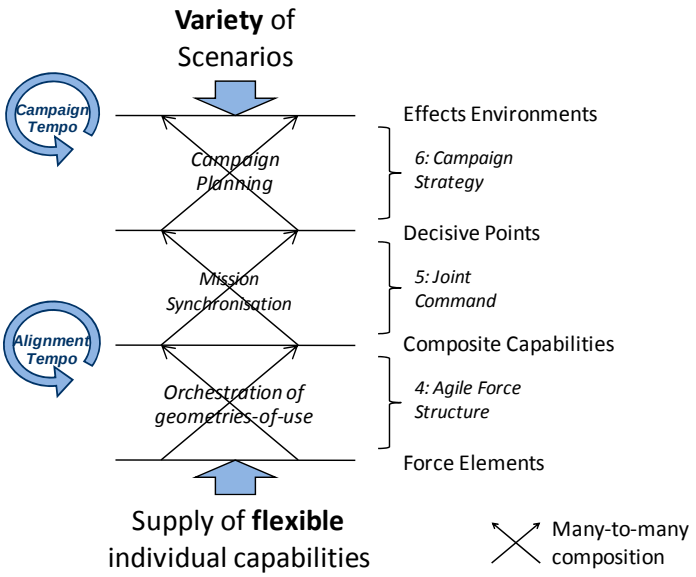


Figure 17: A Closer Look at the Top 'Λ'

Figure 18 provides a second example of key characteristics of Epoch 3. It uses layers 3-5 of the stratification to define purchaser-provider relationships. In this example, a C4ISTAR system of systems is a software-intensive platform made up of a number of independently viable interoperating systems (**3** in Figure 18), each one of which has been delivered by a Tier 1 Prime, but none of which defines the platform itself (recall the 1st and 2nd asymmetries). To distinguish this form of software-intensive platform from one that is identified with particular equipment, we refer to it as a platform+, consistent with the definition of TLCM+. The Agile Force Structure (**4** in Figure 18) is then defined by its ability to form a variety of geometries-of-use, the character of which depends on the demands for composite capabilities being generated by Joint Command (**5** in Figure 18). A C4ISTAR platform+ therefore becomes the ability to support this variety of geometries-of-use that enables operationally tasked composite capabilities to be synchronized by Joint Command.

In Figure 18, this C4ISTAR platform+ is illustrated as having horizontal scope in the range of individual behaviors it can offer and vertical scope in the way its systems are themselves built from subsystems. Its provider at layer 3 is now providing a software platform+ with a system-of-systems capability at layers 4 and 5. Individual Tier 1 Primes may be continuing to provide individual systems that participate at layer 3, and the definition of the platform+ as a whole by the unified customer may mean that potential exists for open sourcing its elements at layers 1 and 2.[35]

The important difference in the nature of this platform+ from a traditional platform is that it is supporting multiple and simultaneous geometries-of-use of its individual systems, determined by how the exigencies of Joint Command create operational tasking for multiple and parallel compo-

[35] Defining the contractual relationship in terms of a purchaser-provider relationship between the layers 5 and 6 means that the competitive identity is defined in terms of the 3rd Asymmetry. This creates "room" for open-sourcing in the Tier 1 layer as well as in the Tier 2/3 layer.

site military capabilities. From the point of view of the platform+ provider, the *market* for these uses of the platform+ arise from the interactions between the multiple missions it is supporting and the way these interactions vary over time within the larger context of Joint Command. The nature of this multi-sided market is another distinguishing characteristic of Epoch 3 and TLCM+, since in Epoch 2 the provider only has a one-sided TLCM relationship with the purchaser defined by the particular nature of the equipment or platform.[36]

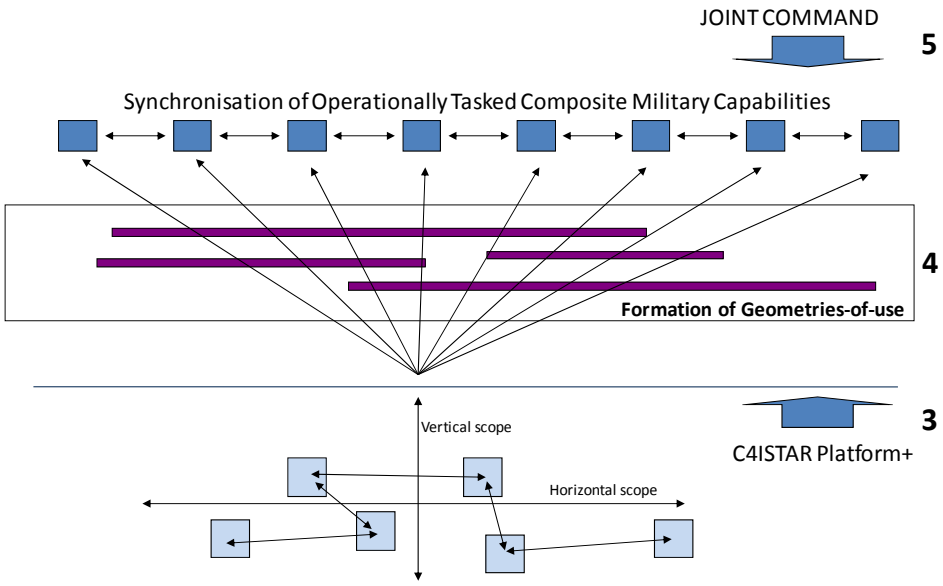


Figure 18: The C4ISTAR Platform+ Supporting Composite Capabilities

So what is the purchaser paying for in Epoch 3? And what is the basis of profitability for a supplier acting as the provider? The answer to both questions is the *agility* of the system-of-systems platform, meaning the variety of geometries-of-use supported by the system of systems that are deemed by the purchaser (military command) to offer utility. If a value for providing this agility cannot be established with suppliers who are needed to participate in this TLCM+ relationship, then Epoch 3 cannot come to fruition.

Some clues as to how to do such pricing come from considering the consequences of a lack of agility in the platform+ for its military users. Lack of agility is a symptom of the divergence between the acquisition and alignment tempos. Its consequences will be increased costs of alignment that the military users incur in order to meet the demands of Joint Command despite the divergence of tempos. In order to attach value to agility, it is therefore necessary to

- define the demand for different varieties of effect across the range of effects environments faced by the military
- establish the current costs of cohesion and alignment associated with this variety

[36] It is this characteristic that makes this a multi-sided market from the point of view of the platform+ [Hagiu 2007, Evans 2006].

4 Challenges and Obstacles by Epoch

In this section, we look at the particular economic characteristics of the epochs in terms of current experience and exemplify some of the value and profitability challenges within each epoch.

At the time of the original work on Tier 1 prime contracting in 2000, it was apparent that the approach adopted by Prime Contractor I to creating profitability by reducing the margins of the Tier 2/3 subcontractors was not working (columns 1 and 2 in Figure 19). Instead, the approach of Prime Contractor II was adopted (column 3 in Figure 19), corresponding to a Lead Systems Integrator (LSI) role, which treated the Tier 1 Prime role (see Figure 12) as a different kind of business that could create value through design.

The difference between the two approaches is shown in Figure 19, in which subcontract value is reduced through changing the design. The question remained, however, as to the potential returns on investment (ROI) achievable from Prime Contractors as distinct from subcontractors. The way this question is answered depends on the epoch.

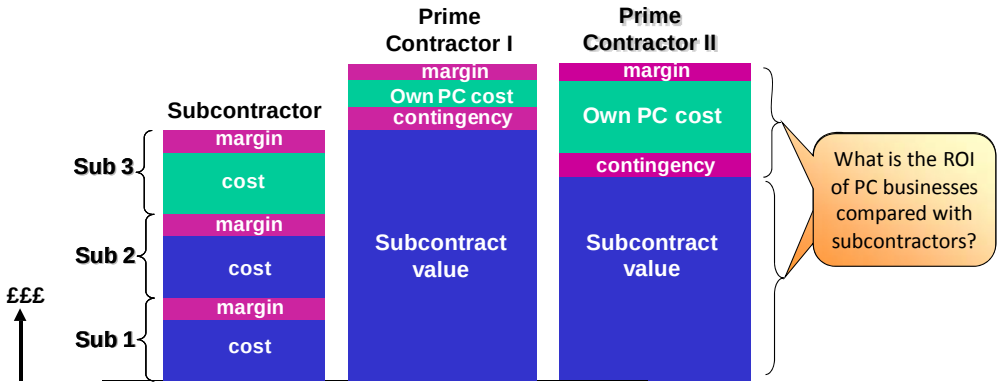


Figure 19: Two Models of Prime Contracting

The next three subsections outline the obstacles and remedies associated with each epoch as the MoD's relationship to defence expenditure changed.

4.1 NOW (EPOCH I: FIELDING EQUIPMENT)

In Epoch 1, the contractual relationship between the supplier and the customer is arms-length or *smart* and revolves around a requirement on the customer's part for acquiring fielded equipment and platforms (or systems treated as such). The difficulty for the supplier is that no value can be associated with their mitigating risks to the sustainability of the equipment or platforms or to their removing limitations on flexibility, other than those defined in the requirement. Watchkeeper[iii] was one of the first smart acquisitions. Although the contract was to supply and support the UAV through its life cycle, the budgetary constraints imposed by the Main Gate (the key decision point) in 2005 limited the scope of this sustainability and flexibility. Due to constraints on the funding profile and on non-recurring expenditure, the small costs that would have been incurred for reducing sustainability and flexibility risks were excluded, even though those expenditures would have had a large positive impact on total performance. Referred to in the 2006 report as *latent value*,

these costs represented options, the value of which did not count in the smart acquisition process, even though they had the potential to save significant costs later in the life of the military capability (see costs of excluding flexibility below) [Boxer 2006b].

A close examination of the costs associated with acquiring and sustaining the (independently viable) capability showed that nearly 60% of its costs were generated by Thales (see

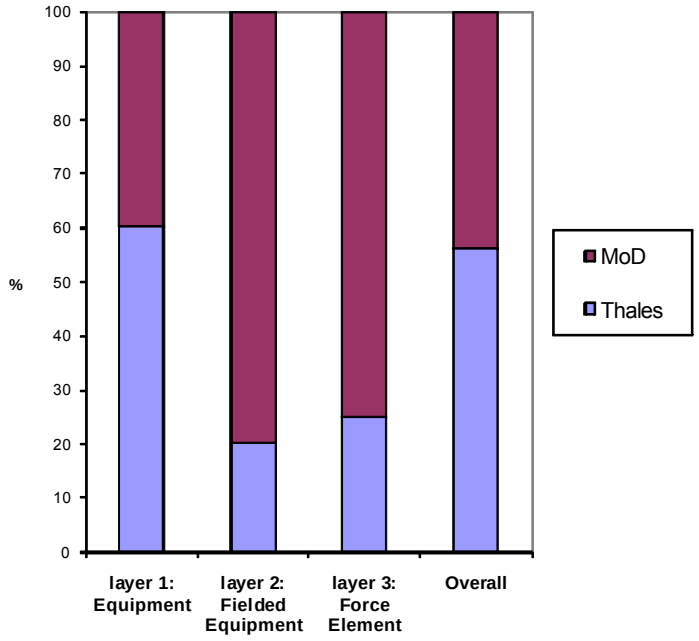


Figure 20), the great majority of which fell in the first 'equipment' layer in Figure 16 on page 26. But only 20% of the costs of fielding the equipment (layer 2) fell to Thales, along with only 25% of the costs of command of the operational capability (layer 3).[37]

[37] BTC UK – TLCM Briefing with supporting notes, Terry Newman – 24th November 2006.

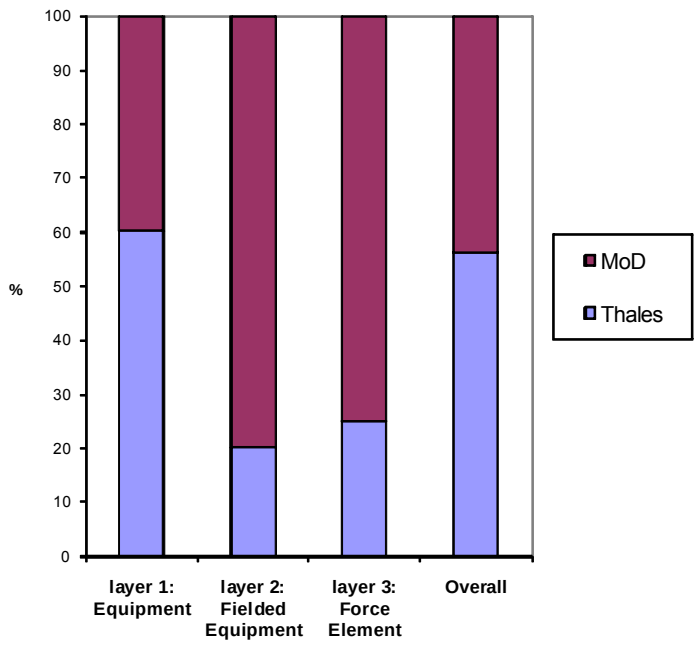


Figure 20: Summary UAV Costs

The costs of excluding flexibility

A later analysis of these equipment, fielding and operational support costs within the context of the through-life costs of the TUAV capability (Figure 21) showed how the subsequent in-service costs of meeting the evolving demands on the capability far exceeded any savings made early in the life of the capability (i.e. prior to the initial delivery of the equipment) [Whittall 2008b]. Not all these costs could have been saved by exercising the earlier option to create latent value, but a significant proportion of them would have been, based on the analysis performed in the study.

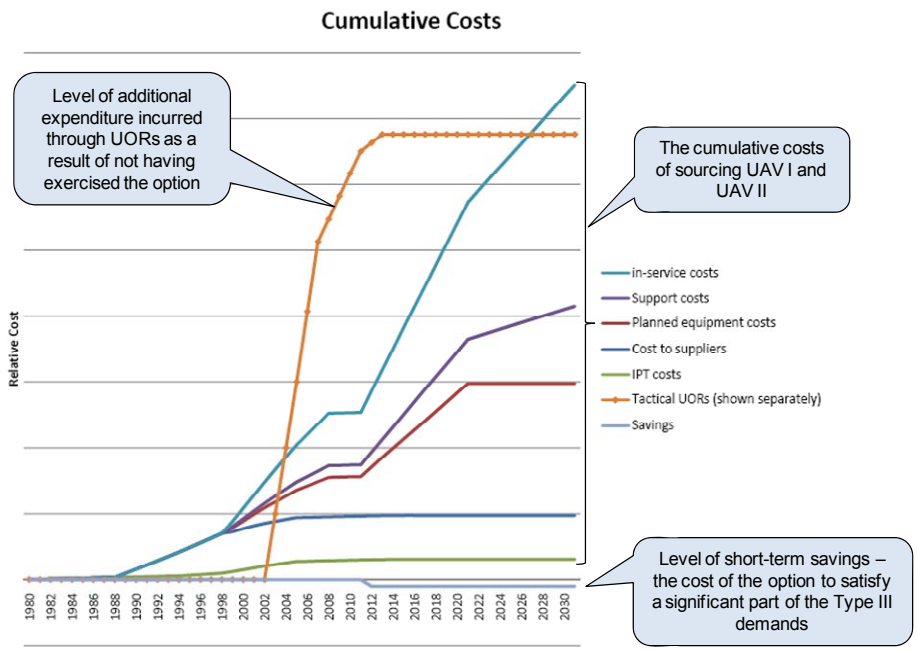


Figure 21: TLCM costs of TUAV in Epoch 2[38]

Part of the obstacle to considering these costs was removed when the DIS introduced the through-life focus in Epoch 2, a key element of which is to include consideration of the full set of DLODs in acquisition projects.

4.2 THE NEAR TERM (EPOCH 2: CREATING MILITARY CAPABILITIES)

An early success in Epoch 2 was the establishment of a TLAM contract for a large proportion of the avionics on Sea King aircraft.[iv] To achieve this, the customer relationship was defined by a unified customer at layer 3 (see Figure 12) so that operational costs previously incurred by the MoD in layers 3 and 2 became part of the TLAM contract. This meant that avionics were guaranteed to be operationally available on the aircraft for a range of operational uses. In practice, it took a number of years to analyze the existing costs across multiple parts of MoD's organization before it was possible to establish a baseline and propose cost savings. This analysis aimed to establish the existing costs of aligning the layers in the stratification to the operational uses of the capability, referred to herein as the *cohesion costs* of the operational uses.

The resulting organization had the potential to manage through-life support for mission systems, and was organized as in Figure 22 to span all of the first three layers. The flight-line in layer 3 marked the boundary between the provider's role and the role of the unified customer.

38 These figures approximate the cumulative through-life costs of acquiring, supporting and operating the TUAV capability (i.e. the Phoenix UAV I and the Watchkeeper UAV II) from its inception in 1980 through to 2030, the costs beyond 2007 being an estimate. The separate line then approximates the cumulative costs of the additional platforms needed to enhance the TUAV capability for military operations since 2002, including Nimrod, Reaper, Desert Hawk and the H450. See section 5.1 for more detail on the (Cohesion-based Costing) approach adopted to establishing these costs.

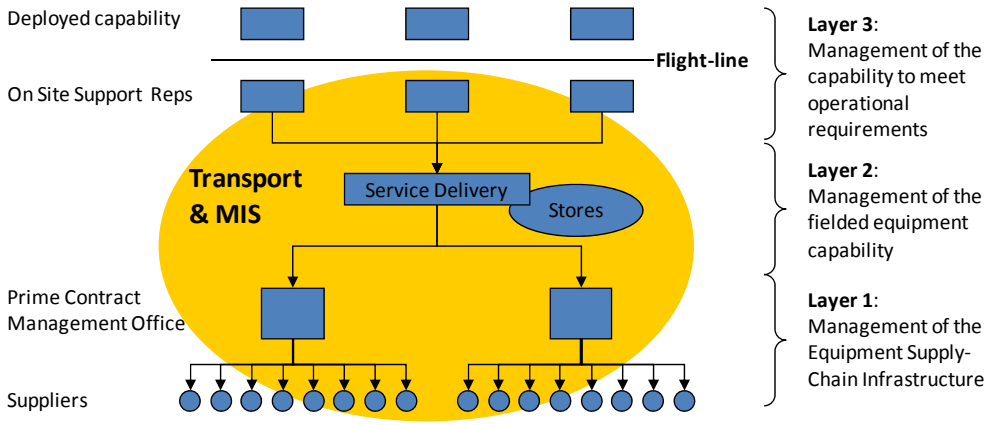


Figure 22: The Organization of the SKIOS Contract

The approach worked well insofar as baseline costs could be established from an equipment- and platform-centric definition of capability. However, attempts to extend the approach by widening the definition of the capability and changing the technologies being supplied met with much greater difficulties, with the overall tendency to lock-in a particular way of using the capability, thereby reinforcing an equipment- or platform-centric view of capability and running counter to the objectives of TLCM. The barriers to meeting the objectives included the following:

- The existing suppliers had a vested interest in excluding technologies that they could not supply themselves, because it would dilute their workshare in the overall contract.
- The equipment- and platform-centric definition of the capability made it difficult to consider alternative (and, for the suppliers, potentially even more disruptive) approaches to providing the capability.
- There was also a danger that the pricing mechanism built in early on would also become obsolete with subsequent changes, putting the business model itself in question.

The difficulties associated with how the capabilities themselves are defined cannot be overcome in epoch 2 because of its dependence on supply against a fixed capability requirement, even though that requirement addresses all DLoDs. Overcoming this obstacle will depend on being able to attach a value to enabling flexibility in the capability beyond what is justified by its immediate requirement.

The starting point for the SKIOS project within Epoch 2 was analyzing the costs of alignment—the cohesion costs relevant to through-life management. This exercise was slow, laborious, and complex, making performance of the analysis an obstacle to extending it as part of the more systematic approach to through-life management recommended in the report on Agility in TUAVs [Whittall 2008b] This approach, referred to as cohesion-based costing (CBC), is described in more detail later in relation to both epochs 2 and 3.

4.3 THE LONGER TERM (EPOCH 3: TRANSFORMING COMPOSITE CAPABILITIES)

Figure 23 shows the tasking organization for an exercise in anticipation of Afghanistan 2011. It shows a number of different military assets interoperating in support of a number of situations,

not including the order of battle (ORBAT) itself. These situations including mission planning, high and medium tempo effects, peacekeeping, and peace support.

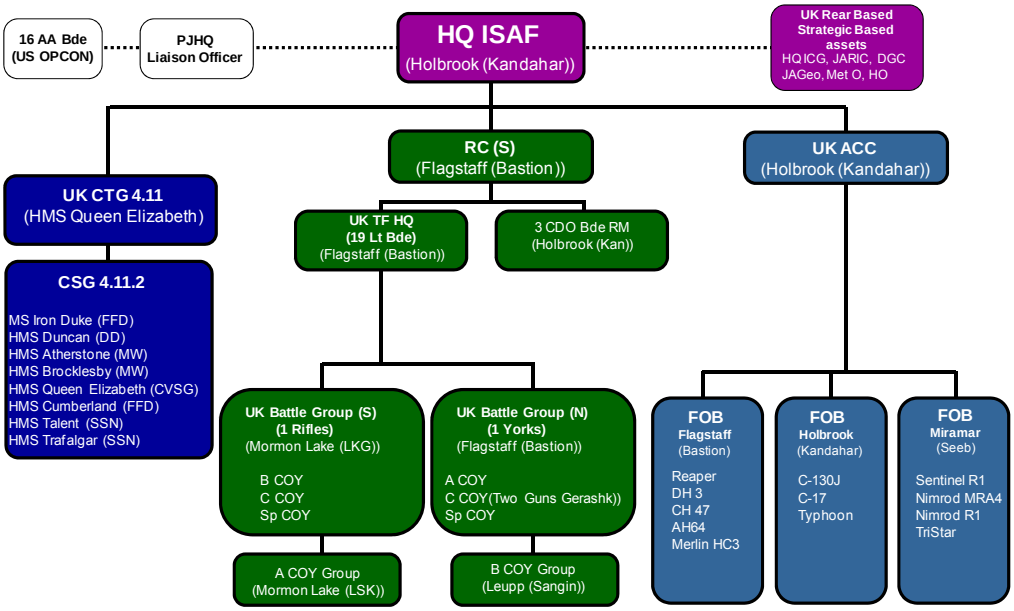


Figure 23: Coalition Warrior Interoperability Demonstration (CWID) 2008

Although the Coalition Warrior Interoperability Demonstration (CWID) was invaluable in establishing the viability of planned geometries-of-use, it was not used to evaluate how individual capabilities constrained the agility of the force structure. Nor was it used to inform choices concerning the form of these composite capabilities. How, then, are suppliers to determine the value of any contribution they might be able to make to the agility of the force structures from which these composite capabilities are being formed?

First, the cohesion costs of alignment need to be determined for the composite capabilities involved with any given Decisive Point (DP) in the exercise. Second, there has to be a way of attaching a value to any changes (positive or negative) in the flexibility of the individual capabilities involved. The absence of a solution to establishing these two types of cost is a major obstacle to taking up the contractual relationships associated with Epoch 3.

The solution emerging from the work on TUAV Agility lies in being able to quantify the impact of the change on the cohesion costs, using an approach that makes use of Real Option Theory [Luehrman 1998a, Luehrman 1998b, Amram 1999]. Where an investment is being made in relation to a number of different possible future scenarios, Real Option Theory makes it possible to attach a present value to the alternative futures on the basis of their probabilities with respect to the costs of the Real Option. For the TUAV, such options would be defined as the costs of mitigating risks to the sustainment and effectiveness of the force structure.[39]

Given a practical approach to implementing this solution, the transformation that it makes possible in the CWID case is to be able to define the relationship between the value of opportunities to

[39] This identification of these risks was the basis of the study of the NATO AWACS capability. See "An Examination of a Structural Modeling Risk Probe Technique" [Anderson 2006a].

invest in capabilities and the cohesion costs associated with supporting particular kinds of DPs. In terms of a multi-sided market perspective, the systemic impact of an extension to the scope of an individual capability can be evaluated in terms of its impact on the way DPs generate expenditure on the use of composite capabilities.

Expressing the ranges of probability of incurring these costs then provides a basis for pricing agility: the value of agility is the net present value of the real option to save later costs of cohesion/alignment. To provide value to both purchaser and provider, some equitable sharing of these saved later costs is appropriate.

Arguably, suppliers have an interest in not building in flexibility, or at least not making it available to the customer. Instead, they can wait until the customer is forced to make a purchase at a later date, in effect creating a *de facto* monopoly over later adaptations in the use of particular equipment or platforms already supplied. Although possibly attractive to an equipment-centric supplier, what this leaves out is the potential growth in turnover and profitability available through participating in the multi-sided markets in the upper layers of the stratification [Whittall 2007]. To be an attractive market, however, the MoD has to be able to attach a value to a supplier's ability to reduce its costs of alignment, an approach to which is described in the next section. Attaching value to the creation of economies of alignment in turn requires the MoD to change the way it addresses through-life trade-offs between equipment and operational budgets within the context of changing strategic demands.

5 Managing Through-Life Relationships on the Basis of the Ability to Price Agility

Real Option pricing provides the means of relating the cost of adding new flexibility for individual capabilities to the overall cohesion costs of the composite capabilities that make use of it. In this way a supplier can attach a value to such changes (e.g., the 'latent value' in Watchkeeper). In Epoch 2, the supplier joins with the unified customer to deliver given capabilities more effectively at lower cost. In Epoch 3, however, some degree of transparency is needed in the way the Military User derives the need for composite capabilities from campaign plans if the supplier is to anticipate the forms of agility needed and thus to propose new flexibilities in individual capabilities that will more effectively support that agility. These conditions of transparency are anticipated by the DIS as being necessary for TLCM [MoD 2005, pp. 52-54].

The transparency required in epoch 3 relates not only to the ability to classify DPs in terms of the mix of composite capabilities needed to create them[v], but also to identify the cohesion costs associated with the interoperability characteristics of the force structure from which those composite capabilities are formed. This involves viewing the force structure itself as a system of systems, supported by the software platforms+ that enable it to function as such.

5.1 COHESION-BASED COSTING

Activity-based costing (ABC) is a method of costing complex activities that starts from the output of a value chain (such as the one that delivered Watchkeeper) and defines the activity chains supplying that output.[40] ABC then identifies the ways in which that activity chain drives costs, so that all the costs that are associated with the output can be directly related to it.

In the case of SKIOS, there were 6 different types of Sea King, 22 Integrated Project Teams (IPTs) controlling other "bits" on these different types, and 40% of the budget associated with operational expenditure on deployed assets across hundreds of budgets in 22 locations and deployments. In practice, the consortium could only earn credit for costs that had been identified, and it took two years to nail down the costs enough to create a target cost 22% lower than the existing costs. This analysis was done as an industry team with thousands of things to think about, such as operational budgets, performance, transferring personnel, and risk.

What was being analyzed here was the way the MoD organization took the outputs of a number of different value chains and made them *cohere* around sustaining the operational capability. Cohesion-based costing (CBC) therefore examines the cohesion of a given operational performance, identifying all the processes of alignment through which its constituent value chains are made to cohere. Thus CBC starts from the outputs of the value chains used by the identified alignment processes, analyzing the costs of the alignment processes.

In the case of TUAVs, three different types of operational performance were analyzed and used to generate the cost summary in Figure 21 [Whittall 2008b]. These three types of performance were chosen to correspond to different epochs in TUAV development. The first of these used a small

[40] See for example "Profit Priorities from Activity-Based Costing" [Cooper 1991].

UAV (Phoenix) with a Multiple Launch Rocket System (MLRS) deployed with the Artillery (UAV I). With a limited range, its role was to provide target information, and the cohesion analysis showed how the fielded equipment formed an organic part of the MLRS capability, so that the cohesion cost was associated with the use of the MLRS capability and not the UAV, placing it in Epoch 1.

In the second operational performance situation, the role of the TUAV (UAV II—Watchkeeper) was to provide support at the Divisional level in response to CCIRs, with the ability to feed the resultant intelligence down to battalion level and below. Unlike UAV I, the TUAV here is part of an independently viable system contributing to ISTAR capability, with the TUAV participating in the alignment of composite capabilities at the Divisional level. The cohesion costs here are associated with this Divisional level of capability across all of the DLoDs, placing it in Epoch 2.

In the third operational performance situation, the TUAV capability takes the form of a number of assets (UAV III). This level of performance provides CCIR support ranging from Desert Hawk at Battalion level through the H450 to Reaper and Nimrod at Corps level, supporting the alignment of a whole range of composite capabilities extending all the way down to the direct support of engagements at the lowest level of fighting unit. Here, the capability is no longer identified with individual platforms, but rather with a system of systems that can fuse data from multiple sensors and deliver the resultant intelligence to a range of possible situations depending on the nature of the threat situations being addressed. The cohesion costs here are directly associated with these situations, and what is at issue is the agility of systems of systems to be aligned differently depending on the situation.

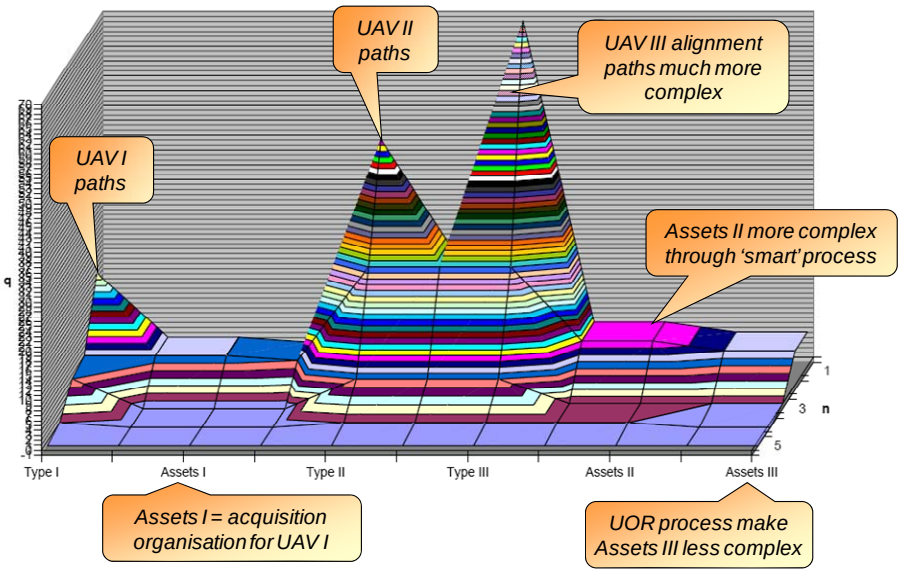


Figure 24: The Analysis of Cohesion

The forms of cohesion were analyzed in each case as paths of interoperability, making it possible to separate out the different forms of cost being brought into alignment and to define the extent of interoperation needed in each case. Figure 24 illustrates the results of a matrix-based stratification analysis that highlights particular relationships (or lack thereof). The ordering along the x-axis places composite capabilities next to each other that use individual capabilities and processes that interoperate in the same ways (i.e., they have geometries-of-use in common). Thus the UAV II

and UAV III alignment paths have much in common. The y-axis (q) shows how many capabilities and processes are interoperating, and the z-axis (n) shows how many other composite capabilities are interoperating with the same number of interoperating capabilities and processes. The figure shows the different nature of UAV I and its acquisition organization (Assets I) from the other two operational performance situations and the different level of complexity being managed by the UAV III when compared with UAV II.

The result of these analyses of cohesion cost is that the full cross-DLoD costs can be identified for the provision of particular individual (Epoch 2) or composite (Epoch 3) capabilities. In Epoch 2 this use of cohesion costing provides a basis for the kinds of improvement in alignment shown by the SKIOS contract, but only in relation to a defined capability. In Epoch 3, cohesion-based costing provides the starting point for pricing the flexibility of individual changes in terms of their impact on the overall cohesion costs associated with a given DP.

5.2 REAL OPTION PRICING

How is a supplier to determine the incremental value of an individual capability that has the flexibility to support a variety of composite capabilities? It is necessary to start from the gaps that emerge in a force structure as it tries to form new geometries-of-use, in order to mitigate the risks associated with these gaps, investment options have to be created for increasing the flexibility of individual capabilities in such a way as to reduce these gaps. The steps in this process are shown in Figure 25, which revisits Figure 17 but adds to the many-to-many compositions in each layer of the alignment 'Λ' (Figure 11):

(i) Support for layer 6: the way different scenarios generate different mixes of decisive points (DPs), depending on the ways the campaign strategies are organized. The approach here is to select a variety of scenarios that will generate different kinds of DP.

(ii) Support for layer 5: the way this variety of DPs demand expenditures on composite capabilities. The approach here is to identify distinctive kinds of DP and identify the best possible mix of composite capabilities needed to support them. A further development of this would be to develop alternative mixes of composite capabilities reflecting possible force substitutions.

(iii) Support for layer 4: the way the cohesion costs of these composite capabilities are themselves based on the orchestration of underlying force elements.

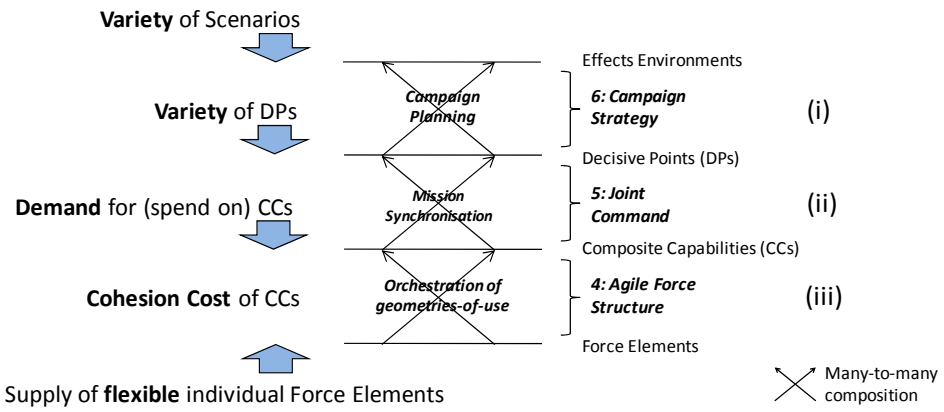


Figure 25: Relating the Costs of Alignment to the Variety of Scenarios

The value of any new flexibility lies in the impact it has on the cost of the composite capability, established by cohesion-based costing. Real Option Pricing is used to provide a way of valuing this impact, summarized in Figure 26 and Figure 27.[41]

- The analysis above establishes the variety of scenarios and the variety of DPs that they generate, based on campaign strategies.

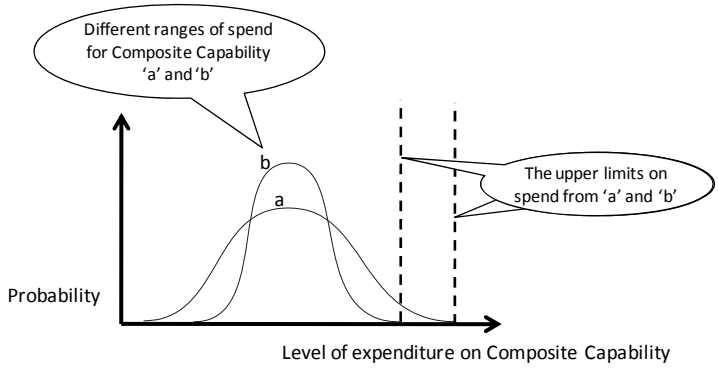


Figure 26: Ranges of Expenditure on Composite Capabilities

- This variety of DPs generates a range of levels of expenditure on a variety of composite capabilities, based on the approaches adopted by mission command. This creates a range of possible expenditures on composite capabilities with varying levels of probability, depending on how the composite capabilities are used. This is represented by the different ranges 'a' and 'b' in Figure 26 with their respective upper limits. These ranges will be tight for capabilities used everywhere and spread out where there is a high degree of variability in how the capabilities are used. (Alternatively, changes to the agility of a force structure will alter the ranges and absolute levels of expenditure.)

[41] A fully worked example of this analysis is the subject of a subsequent report.

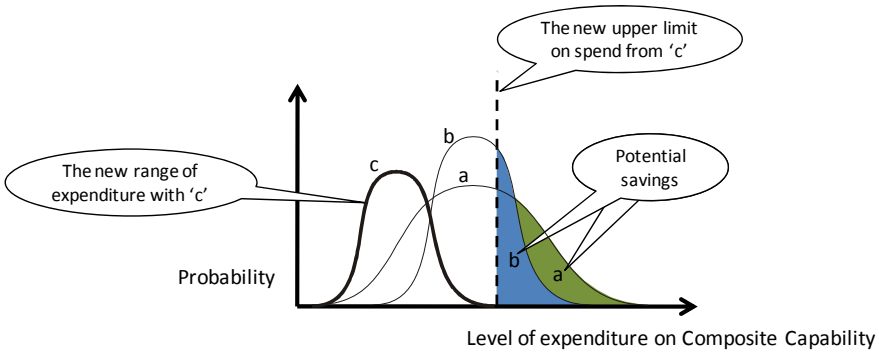


Figure 27: Real Option Pricing

- A real option is then some change in the capability or flexibility in one or more of the individual capabilities supporting the composite capabilities. The impact of this change is to reduce the range of expenditure by changing how the composite capability is formed, shown in Figure 27 as range 'c'. The ability of this option to change the upper limit of the range of expenditure on the composite capability to less than the vertical dotted line in Figure 27 is what makes it valuable. The colored areas 'a' and 'b' then represent the potential savings generated. The value of the option is therefore based on its reducing both the range and upper limits of future levels of expenditure.[42]

Defining options in this way enables a value to be attached to how changes in the flexibility of individual capabilities contribute to the agility of the force structure. The answer to how a supplier is to price the value of a capability that has the flexibility to support a variety of composite capabilities therefore lies in defining the impact of changes in flexibility on the cohesion costs of composite capabilities.

Evaluating real options introduces the transformation that involves (1) analyzing the existing agility of the force structure (the variety of geometries-of-use it can support) and (2) incrementally deriving the need for new capabilities from the gaps in composite capability. This is the left-hand side of the alignment 'Λ' in Figure 11 on page 19.

[42] A parallel here would be in the value of multi-role, variable geometry aircraft. By increasing the agility of an aircraft, its costs can be spread over a greater number of roles and its flexibility means that the future uncertainty in costs associated with having to develop new aircraft is reduced.

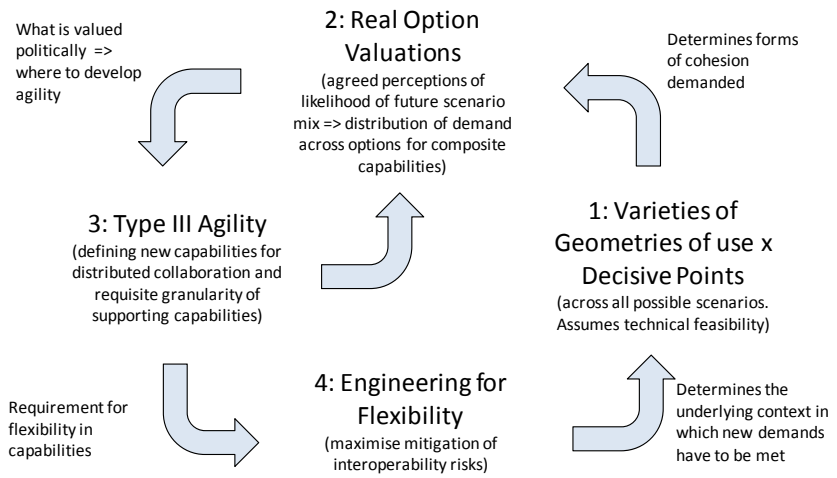


Figure 28: An Approach to Agility Based on Real Options

This approach to pricing agility based on the use of real options results in the cycle in Figure 28, which is associated with TLCM. The cycle begins with an analysis of the variety of DPs and their supporting varieties of geometries-of-use and associated costs of alignment (1). This analysis expresses the demand environment in which the value of new forms of cohesion supported by new flexibilities in capabilities can be established (2). These valuations interact with the ways the type 3 agility of the force structure is defined (3), which will modify the way the options are defined and valued (2). Once settled, choices can then be made on the basis of the valuations to engineer flexibility (4) into elements of the force structure that give it the agility that is needed. At that point, a new cycle begins with the definition of the varieties of geometries-of-use that can be supported by that level of agility.

6 Conclusion

The report described the particular difficulties associated with implementing TLCM with respect to systems of systems and proposed that solving those difficulties requires a third epoch in the way VfD is created. Competitive advantage in Epoch 3 will be based on creating value in the multi-sided market environments associated with the demand on the part of Defence for composite capabilities rather than on individual capabilities identified with particular forms of fielded equipment and platforms.

Real Option valuation provides a promising way of quantifying the value of competing propositions in these environments, because the valuation is derived from the agility the propositions create in the underlying force structures. To be effective, such valuations require

- a transparency from Defence on the ways in which it chooses to generate composite capabilities within the context of campaigns
- establishing the cohesion costs associated with the way Defence aligns individual capabilities to those composite capabilities

While the focus throughout this report has been on Defence, the approach applies much more generally. Thus for example in healthcare, TLCM becomes the through-life management of the patient's condition within the context of the patient's way-of-life. And in jet-engine aftercare, TLCM becomes the through-life management of the performance of the jet-engine within the context of its operating and (changing) regulatory environment.

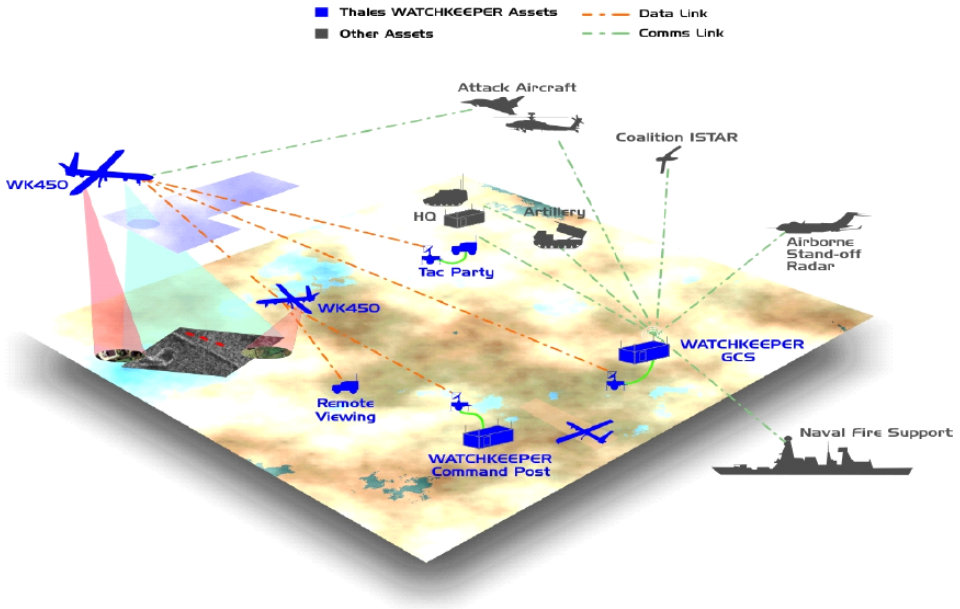
Glossary

Endnotes

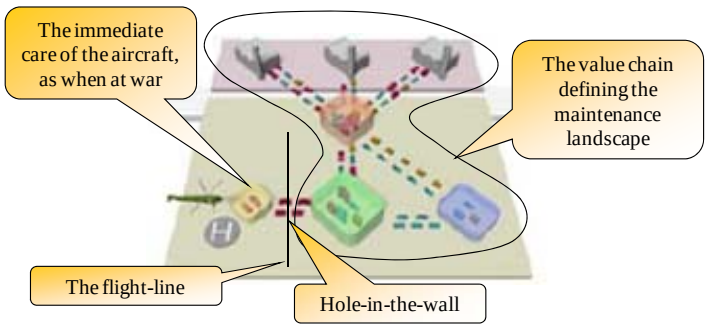
[i] This dichotomy between markets and hierarchies as organizing principles worked well up to the late 70s, when extended to include the hybrid forms proposed by the models in Table 1. Since that time, a third form has emerged, based on collaborative or network alliances resting on a different approach to governance that adds a crucial relational dimension. It is the recognition of this third form of approach which leads to a need for a third epoch and to the distinguishing of collaborations that can be identified with particular equipment or platforms from those that cannot [Dunning 1995, Dunning 2001].

[ii] The term *asymmetric warfare* originally referred to war between two or more actors or groups whose relative military power differs significantly. Contemporary military thinkers tend to broaden this to include asymmetry of strategy or tactics; today asymmetric warfare can describe a conflict in which the resources of two belligerents differ in essence and, in the struggle, interact and attempt to exploit each other's weaknesses. Such struggles often involve strategies and tactics of unconventional warfare, the "weaker" combatants attempting to use strategy to offset deficiencies in quantity or quality [Wikimedia 2008].

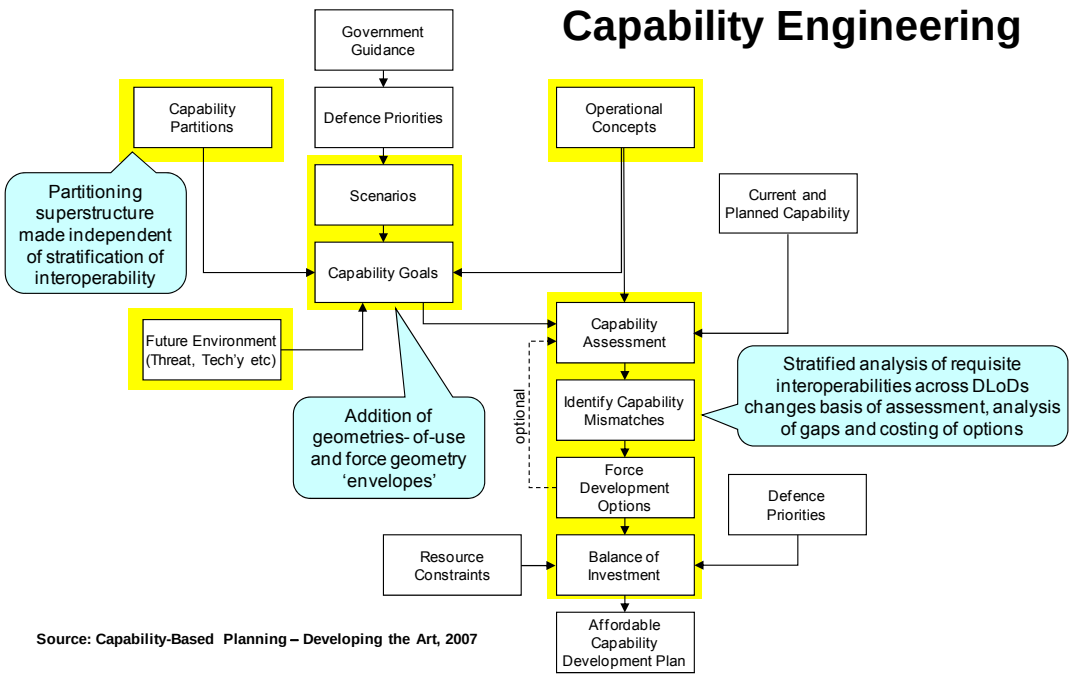
[iii] The Watchkeeper capability had 60% of its equipment on the ground, a primary capability being to survey an area of XxY, in order to find and identify so many targetable entities in such-and-such a time across a number of different types of terrain within any force package from a Battlegroup through to a Division. The main element of the capability is the TAC party at HQ, separated from the Ground Control Station so that maintaining the operation of the capability on station could be uncoupled from its tasking.



[iv]The innovation was twofold. Firstly, there was a fundamental change in the way that aircraft engineering management was conducted, including the assurance of airworthiness. Engineering management was now delivered through a combined Engineering/Design Authority team (i.e., an Industry/MoD team working together to manage issues as they arose. Secondly, the supply chain was re-engineered so that, even though every program had its own teaming, the management of the different subcontractors' share of the work within the overall contract (workshare) in each case was aligned to the interests of the customer. Thus, although the levels of use and repair flow were assumed to be unchanged, by DLO managing the outputs at the flight-line and by optimizing the maintenance landscape behind that, everything could be made to work better. This resulted in (on the order of) a 25% saving in cash costs to the MoD and substantial growth in turnover for partners (~70%), in which the partners' workshares followed from the way the maintenance landscape was defined and efficiencies introduced (although how to compete for upgrades was left outside the agreement *pro tem*).



[v] This has implications for the approach to capability engineering, which can be summarized in terms of the following diagram. The most important change here is in separating the definition of the capability partitions from the way the geometries of use are defined in relation to DPs.



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In its 2005 Defence Industrial Strategy, the U. K. Ministry of Defence invited Industry to join it in moving towards contracting for the through-life management of military capability. For Industry Sectors such as C4ISTAR which could not identify capability with particular equipment or platforms, the path to through-life capability management was barely defined. Thus, Industry has been encouraged to make its own proposals. The aim of this report is to examine the type of agility the MoD invitation implies, suggest a means to provide management of the through-life capability it requires, and provide the basis for identifying the nature of the competitive advantages open to Industry that will make it commercially viable to take up the different relationship with the Ministry of Defence.

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