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"The Evolution of C2"

Improving Capability Effectiveness in a Complex Environment

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Abstract

Within the complex world of command and control (C2), the critical need for shared situational awareness (SSA) demands effective integration of disparate data feeds. This can only be achieved by forethought in the requirements and design phase - to provide mechanisms for disparate data sets to be made available when and where needed - and active learning from experience in order to make sure new or evolving solutions reflect best practice. In contrast, the solutions currently deployed are weak in their exploitation of both current information (where exploitation includes effective management & visualisation techniques) and of the available human capital, and so deliver a sub-optimal ability to respond creatively to emerging situations and emergent properties.

The need for effective operational decision support to the warfighter (a key purpose of C2 applications) mirrors the need for effective decision support in the acquisition space to respond to the threat tempo of evolving operations and also to provide better value for money in Defence. Compelling visualisation of structured information and the application of experimentation techniques are important mechanisms for de-risking and developing better solutions which make more effective use of available budgets.

The paper will examine some of the techniques being used in the UK to achieve greater capability effectiveness through a systems approach: effective information exploitation methods deployed in a collaborative environment where skilled serving officers sit alongside analysts to form joint MOD / industry subject matter expertise. This powerful combination enables a highly interactive environment to be created where the problem and solution domains can be readily compared and tested, leading to robust requirements, solutions and pragmatic results.

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Introduction

There is currently acute pressure on Defence budgets, precipitated by the economic environment and fuelled by the long-running expeditionary warfare campaigns. The combination of these factors, together with inefficiencies in the use of existing budgets, are exacerbating a defence acquisition environment now asserted to be unaffordable [1].

Making better decisions about how money is spent has now become an imperative as defence departments try to balance growing demand with limited budget. As amply evidenced by the UK National Audit Office (NAO) Major Projects Report for 2009 [2] (and especially through the project references within the appendices [3]), this factor is a key driver within the complex world of command and control, where the critical requirement for shared situational awareness demands effective decision, design and planning activity to ensure the availability of capability for deployment. Current operations provide valuable opportunities to review and improve deployed capability. In doing so however, it is necessary to acknowledge that the current portfolio of products and solutions is the product of legacy investments, and the complexity and inter-connectivity of these with other solutions precludes the option of a green field approach; however, application of such experience from the field needs to influence the way future solutions evolve.

These considerations imply two fundamental problems:

1. Establishing and evolving deployed C2 solutions, covering coherently all Defence Lines of Development (DLoDs)[1]. For a definition and elaboration of UK DLoDs see [4]
2. Governing and acquiring the elements of these pan-DLoD solutions.

In addressing each of these problem domains, information is the critical element: decisions, either operational or acquisition, demand effective coherence and exploitation of relevant sources. Such effectiveness means that information needs to be presented visually in ways that are easy to assimilate and will intuitively lead to more effective decision making by military personnel. The techniques that we have used to support decisions in both of these domains have a common basis in powerful methods to provide evidenced option evaluation:

a. Experimentation – the means by which options are identified and evaluated
b. Visualisation – the generation and presentation of options and implications to aid decisions

The decision-making and planning approaches currently deployed in UK limit the ability to respond creatively to emerging situations and emergent properties, and this relates particularly to the need for better decision support, ever more important as the demand increases for better value for money in Defence[2].

At previous ICCRTS conferences [5, 6] we have shown how the careful management of data and the use of a fully linked set of intuitive visualisations can provide decision makers with an environment that helps them to make trades and reduce the amount of subjectivity in deciding between acquisition options. This environment - *TRAiDE*[3] – combines BAE Systems' experience of working with major defence acquisition, exploited through the decision support facilities of Salamander's MooD software. During the past year further work has extended TRAiDE's effectiveness in providing decision support visualisations and the use of these to support capability trading in diverse domains.

[1] UK MOD DLoDs cover Training, Equipment, Personnel, Information, Concepts & Doctrine, Organisation, Infrastructure, Logistics, and Interoperability (as an overarching theme)

[2] See p.9 of the UK NAO Report [2] "*The Department is introducing Through Life Capability Management … to ensure that new and existing military capability is planned and managed coherently across the DLoDs [to] generate more reliable and robust management information than is currently available*"

[3] ™ TRAiDE is a Trademark of BAE Systems in the UK and / or other Countries. The authors acknowledge BAE Systems' continuing investment in development and exploitation of this innovative and valuable programme.

As testimony to its thought leadership in the discipline of Through Life Capability Management[4] (TLCM) and its commitment to furthering best practice decision support across the Defence sector for the benefit of both the UK Ministry of Defence (MOD) and the wider defence industry, both the MOD and BAE Systems are keen to see broader exploitation of TRAiDE. This has led to the endorsement of TRAiDE by the UK National Defence Industries Council (NDIC) as the decision support framework of choice for the conduct of capability investigations for the MOD. Furthermore, in addition to the TRAiDE examples presented here based on work conducted by BAE Systems and Salamander, these techniques have been applied by MOD in Capability Investigations [7, 8] where it has been recommended as the best practice approach, and in the latter period through the vehicle of a unique partnership between UK Industry and the MOD called *Niteworks* to present options and demonstrate the art of the possible

Niteworks [9] was formed some six years ago to examine the challenges of experimenting with and implementing effective NEC, initially through warfighting experimentation. Since then it has evolved to become a highly flexible decision support capability for MOD. It now represents over 60 industry partners and associates as well as incorporating Dstl, the MOD's in-house advisor on solutions, science and applied technology. Front line service personnel and secondees from the MOD centre also provide a representative operational and acquisition community input as a direct part of the Niteworks team. Between 2003 & 2007, exploitation of Niteworks output delivered an estimated £240m in financial value to the MOD with an estimated £195m in potential benefits still to be realised[5].

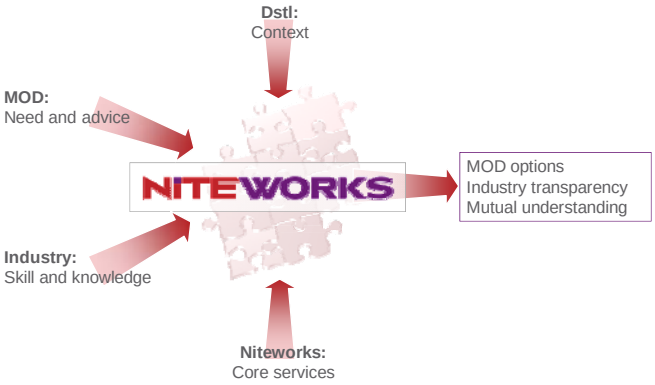


Figure 1. The Niteworks Partnership Perspective

The paper examines some of the techniques being used in the UK to bring together tools, a systems approach, effective information management and the right skills in a collaborative environment where serving officers sit alongside analysts to form joint MOD / industry subject matter expertise. This powerful combination enables a highly interactive environment to be created where problem and solution domains are compared and tested, leading to robust solutions and pragmatic results.

Supporting Capability Management Decisions: Needs & Challenges

Decision support in the context of capability acquisition and sustainment through-life applies at many levels, including:

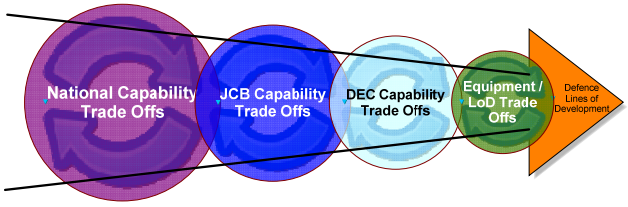


Figure 2. The Capability Value Chain

- Which capabilities are needed over future time horizons, to satisfy national ambitions and projected operational threats?
- Which solutions should be provided (by Joint Capabilities Board – JCB) to deliver those capabilities, including forces, platforms, alliances, systems, techniques?
- In developing the capability solutions, what is the optimal balance across DLoDs; i.e. training vs equipment vs personnel vs doctrine?
- In delivering affordable capability components, what set of detailed requirements and tolerances will yield the greatest effectiveness across all DLoDs?
- What learning can we capture through operational experience, and how do we exploit this to ensure we continually improve the effectiveness of the deployed capability?

[4] The term was introduced in 2006 by the McCane Report [10]
[5] Extract from Niteworks business case for 2008, approved by MOD scrutiny.

The breadth of this problem, together with the need to address such considerations coherently in a continually changing political climate poses very significant challenges in terms of how the requirements are expressed and how requirements, contextual and supporting information is managed, and how this is achieved in a timely and transparent manner across widely drawn stakeholder communities (which may be disparate geographically, culturally and philosophically).

Within these, we have identified two key and inter-related areas which, if addressed effectively, are capable of delivering step-change improvement in military effectiveness:

a. Experimentation – the means by which options are identified and evaluated using empirical data from deployed experience, or by construction and exploitation of analytical model. Without the use of such methods there is a high risk that complex interactions are not understood, with unpredictable consequences, and that learning is never incorporated, leading to repetition of common failings.

b. Information Management & Visualisation – the compelling presentation of options and implications to aid decision makers at any level, and from any discipline. Without this, there is a tendency for senior decision-makers to rely on their own, subjective judgement, in the face of apparently impenetrable objective inputs, which in turn detracts from an underlying evidence-basis for critical decisions.

We assert that these approaches can be introduced at any point in the Capability Value Chain, to improve common understanding and contribute to the objectivity of decision making. Wherever they are introduced opens the possibility of the resulting environment sustaining forward through the life of the capability. The examples given later in the paper provide supporting evidence of this breadth and sustainability of applicability.

Clearly there is a need for a range of other techniques in addition to these, including planning and configuration management; our focus here is on these approaches because we consider them to have specific relevance to addressing the MOD's pressing issues.

This section reviews some of the key challenges facing the introduction of those specific areas of need in further detail. The following sections address our contributions to addressing the challenges posed, including several recent examples to substantiate our assertions.

The experimentation challenge

There is a strong body of evidence (see the specific examples below), from the six years that Niteworks has been in existence, to show that experimentation – which can range from collaborative studies through to full blown interactive simulations – can significantly speed up the process of acquiring new capabilities and getting them into service.

The challenge comes in getting sufficient sponsorship to undertake what is usually seen as an 'extra' or costly task and for what is often viewed as 'insurance'. In practice this often comes down to an assessment of cost vs. value. The issue being that the case for investment for early de-risking and integration testing can be hard to justify in an environment where budgets are squeezed and tomorrow's problems are easier to bury than to deal with. However, the alternative is to tackle the risks late in the day and potentially bear the costs of "disintegration" – which has been experienced all too often when DLoD components come together for the first time at the point of use. Consequently, the application of experimentation tends to be localised, where those who have 'seen the light' – i.e. those who have previously witnessed the benefit of experimentation – need no convincing of the value of the investment, whereas the reluctance of others can be difficult to overcome.

A further question relates to who should pay for experimentation; who is the beneficiary? In practice such de-risking can benefit the sponsor and user of the capability and also its provider. This raises a further organisational challenge of bringing MOD and Industry together under one roof, and asking them to collaborate and work with the Science groups to produce objective evaluations and options.

Niteworks has considerable first hand experience of these problems, and the issue is seldom about demonstrating benefit: it is about ensuring that benefits are successfully accrued. This is because

there is no single budget holder. The Sponsor for implementation is rarely the same as the problem holder: the MOD is a complex cluster of stovepipes, each with its own local issues which can often appear to take precedence over the primary objective – the delivery of military capability. This is a problem for most MODs of any size - worldwide.

Making the case for experimentation needs a 'religious belief' in its importance and having the courage to do it when other pressures give plenty of excuse to avoid it and solve the problems later; encouraging a consensus of false optimism.

The information & decision visualisation challenge

In a complex arena such as the acquisition of command and control capability, it is normal for a significant number and range of data inputs to be used to inform decision making, including statements of requirement, cost models, plans, concepts of operation, system architectures, supply chains and technology roadmaps. It is also typically the case that these are managed through a multiplicity of localised tools and facilities, many of which offer little or no underlying structure and which together offer poor overall decision coherence. A consequence of this is the failure by capability planners to undertake effective investigation and comparison of tradable-options at an early stage in the lifecycle, which means that acquisition decisions are prone to high levels of subjectivity and parochialism. This is exacerbated by the fact that cost is very often baked in early in the process through undocumented or poorly-advised assumptions about the implications of specific requirements. Acknowledgement of these problems is one of the MOD's motivations for the introduction of TLCM (see footnote 2 on page 1).

The challenge therefore can be expressed as follows: given a complex, multi-dimensional information set, a decision community that comprises stakeholders from many disciplines must be supported in gaining a common understanding of the need, the current situation, the options and trades available, and the implications of adopting each of these, in terms of capability, cost, time and risk. And this is an enduring requirement, in that options change through time together with threats, budgets, priorities, technical opportunities and other key factors.

TRAiDE takes a systems engineering approach to addressing this challenge. This includes the definition and deployment of a repeatable methodology that addresses the key processes involved (for MOD this includes, for example, definition, audit, analysis and investigation [11]), and which emphasises the pervasive criticality of coherent information management and of supporting management decision making.

Consequently, through the application of TRAiDE, an information-centric focus underpins the capability management process to yield a live *Common Capability Picture* that supports decision making across the community of stakeholders who can identify and explore trading options at all levels of capability management – from capability priorities through specific project options – in a way that remains synchronised with authoritative information sources, and which enables automatic generation of the connected visualisations needed to inform understanding and decision making.

Responding to the Challenges: A Connected Perspective

These key challenges have a particular resonance in UK MOD at present due to the imminent Strategic Defence Review (SDR), which will respond to the funding challenges – see the Gray Report [1] – matched against the UK's current projections for future capability requirement. Without connected information and strong support for clear and confident decision making, the SDR and the response to Gray both face a high risk of compounding the current difficulties, giving rise to further poor decisions.

Consequently, the recent innovations in these areas are of significant interest at the present time. Figure 3 illustrates the inter-relationships between these aspects, and shows how, together, they form a comprehensive approach to effective capability management.

In essence, the approach assumes that capability evolves throughout its life by means of a well-ordered process, implemented through proven techniques and underpinned by a common information manager. Within this, there are three key components, as shown in the Figure:

- A collection of data capture & synchronisation mechanisms whereby data from diverse sources is collected and connected to form an architectural model that is amenable to flexible exploitation by a diverse community of users.
- A range of analytical and experimental techniques that exploit this information to identify, analyse and assess options.
- Visualisation and presentation forms that engage stakeholders and encourage objective application of available evidence to support decision processes throughout acquisition and into live deployment.

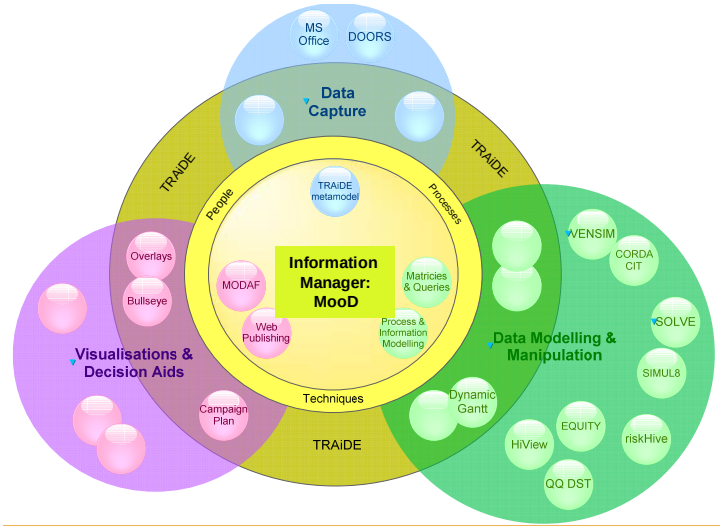


Figure3. Relationships between aspects of the approach

The following sections draw out some of the key thinking in these areas, and combine this into a set of clear conclusions that dictate an action plan.

Exploiting Experimentation and Results

Whilst it is possible to consider solution options in the abstract there can be no substitute for using good experimental analysis to demonstrate the practical and realistic options that emerge from moving effortlessly between the problem and solution domains: this is where Niteworks excels.

Niteworks brings together the key players from the defence community to form an organisation which is sponsored and directed by MOD and which has a unique commercial and IPR construct enabling Industry to play a full role. The unique combination of MOD, Scientific and Industrial staff make it possible to deliver an experimental base which is fully informed and suitably skilled. Moreover the whole process achieves a level of controlled transparency which at the early stages of acquisition replaces the less honest environment (the so-called 'Conspiracy of Optimism' referred to in [10]) which is often created by the poor use of competition. Naturally the onus is to stay well away from the specifics of any definitive single company solutions that would render later competition unfair. But, provided that good systems practices and effective industrial engagement (choice of players by the use of best athlete practices) are deployed at the early stages, the result is a well-informed combined problem - decision space. This approach encapsulates a more robust basis which can take an unbiased approach to understanding the real cost drivers and the difficult or unnecessary requirements which can force up cost. It also provides a well informed and practical check on the art of the possible and the readiness of certain technology solutions.

The application of these principles is illustrated through the following sample of recent experimentation themes.

Talon Strike CCD – trading near term with the future

The Talon Strike project (named after an operational exercise) is concerned with interoperability aspects of US and UK forces. It follows the prototype build of a command and control system for UK forces operating as part of a US military division. Last year a full experiment, involving representatives of both armies debugged and proved that the UK-US battle command interoperability prototype meets basic needs and now Niteworks has been asked to turn this into a 'concept capability demonstrator' – a step closer to implementing a fully deployable solution. The highlight will be a live military demonstration running as a combined exercise as part of Operation Talon Strike in Fort Leavenworth and at the UK Land Warfare Centre in Warminster in May 2010.

In any business environment, there is always a degree of tension between the near term and longer term solutions. When we are fighting a war, this tension is inevitably increased. The Niteworks Talon Strike CCD project was originally focussed on the medium term (2017) requirement, but naturally, the

pressures to increase current operational effectiveness have forced a need to address the priorities of the current campaigns. This situation has led to a difficult compromise, but the need for solutions to current problems has to be investigated. With experimentation funding again a critical parameter, Niteworks has had to develop an experimental route which achieves a mixture of architectures that will tackle the current solution and will then enable an iteration to deliver the 2017 solution. The advantages of the de-risked experimental approach over stove-piped and piecemeal acquisitions are clear to see, but as ever the case was difficult to make to achieve the necessary funds.

Operational Intelligence Support Group (OISG)

The OISG is an Urgent Operational Requirement (UOR) for current operations, designed to deliver improved intelligence co-operation. Within this, an experiment was established to identify options for savings and cost avoidance across non-equipment DLoDs in related intelligence systems programmes.

Applying the broad methodology illustrated in Figure 4, the experiment brought together the operational customer and the acquisition customer to develop Information Management structures that are now being exploited more widely as input to a generic J2 IM structure, to be deployed through UKINTELWEB(TS). It also identified a requirement for an additional tool to support intelligence management (subsequently incorporated into a further UOR).

In summary, the experiment was able to deliver:

- Options for savings and cost avoidance in intelligence systems programmes
- Early deployment of the OISG
- Improved tactics, training and procedures
- Requirement capture for management of intelligence
- Optimisation of the contribution of national strategic intelligence into theatre-derived operational and tactical intelligence

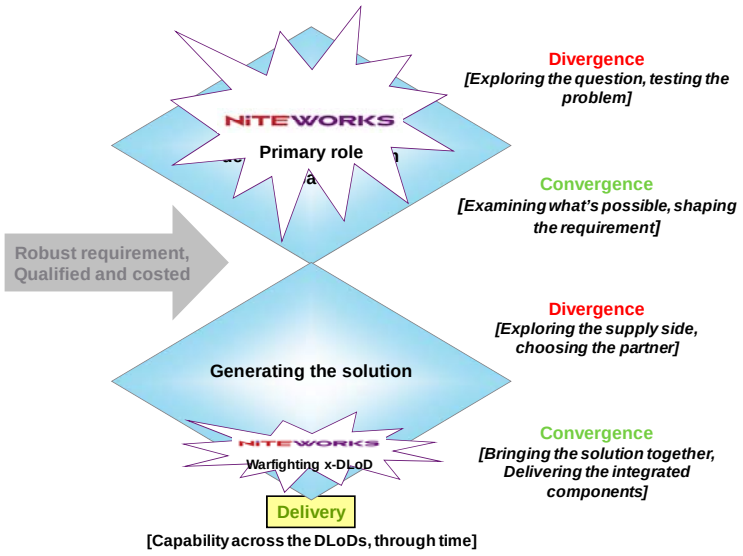


Figure 4. Niteworks Experimentation Approach

As a consequence of these outputs, the MOD estimated the value of the Niteworks OISG experiment at £5.2m.

Understanding Humans within the System

In large integration projects, most failures can be traced back to human perception or communication issues rather than technical system faults. Yet the formal diagramming methods that architects use in large projects tend to focus almost exclusively on technical or system representations.

Niteworks does a significant amount of military experimentation using serving officers immersed in a virtual reality model of a mission to de-risk the specification and acquisition of military equipment. This type of experimentation can be expensive to conduct but provides the richest source of evidence about how commanders plan, control and execute a mission and what technical support they require.

Niteworks has been a pioneer in capturing the key findings of this type of experiment through the eyes of the commanding officer by exploiting Human Views[12] (an extension to MODAF), providing a set of diagram types to capture the subtleties of human relationship in a command chain environment. As an example, this approach was used in a Maritime ISTAR project where we were looking at how reducing the radar performance of an airborne command and control platform changed the command style and relationship dynamics of the forces involved. Effectively, reduced radar performance resulted in later identification of threats which needed urgent handling, and the commander went from a calm and consultative command style under conditions of wide radar performance, to a more

directive style when performance was reduced. Human Views provided the means by which these effects could be formalised and reasoned.

Land End-to-End – making the right decisions

Balancing the choices for Surveillance, Armoured and Support Vehicles decisions in coming years begins with understanding the legacy fleet and then examining the degrees of freedom in future acquisitions. It is compounded by the urgency to supplement availability to meet the needs of current campaigns. The Army had a complex array of platforms before the recently publicised purchase of high protection vehicles for the forces in Afghanistan. With significant budget challenge, and with such a complex inventory, the MOD must ensure it makes the right choices. To do this, they need to understand the configuration variants of all their platforms, their capability, how they are being used, their strengths, weaknesses and maintenance demands – and balance this with a budget through time. No mean feat.

The Land End-to-End Project is undertaking an experiment in how to trade and develop the options, and in doing so it is undertaking a practical exemplar of Through Life Capability Management (TLCM). This rapid Niteworks (4-month) project uses a number of techniques applying a series of proven tools, combined with military judgement panels and documenting the process to ensure it can be repeated as the widely publicised Strategic Defence Review (SDR) begins. This will also feed practical guidance to the TLCM team to support the evolution of these processes.

Delivering Coherent Visualisation of Problems and Options

Introducing TRAiDE

The need to address the key challenges of timely, evidenced decision support and to recognise the importance of information management and compelling visualisation as key enablers has motivated significant investment from BAE Systems and Salamander in the UK. Specifically: in a situation where data is distributed and incoherent, how can we support strong visualisation of the wider picture, in a form amenable to a range of stakeholders, enabling identification and analysis of trading options across the capability management arena?

The outcome of this investment is a decision support environment called TRAiDE – Through Life Capability Management (TLCM) Robust Acquisition inclusive Decision Environment, to emphasise its intended focus on addressing capability management decisions. See reference [13] for details of background and initial motivation.

Developed to address a range of MOD's decision support problems, TRAiDE provides an effective environment for providing the necessary control over and interlinking of data and analysis.

TRAiDE is customisable and incorporates intuitive interfaces, and because it is based on a number of key principles we are able to ensure that specific solutions will retain the inherent flexibility necessary for a dynamic but robust working environment. The underlying principles can be summarised as follows:

- Open approach – enabling utilisation of disparate sources of data.
- Information flows through a single information manager, regardless of its source/destination
- Inclusivity – designed to utilise new and extant mechanisms, tools and their providers
- Intuitive visualisations – enabling simpler interpretation of results
- Evolutionary – incremental and pragmatic development based on user feedback
- Scalable – enabling aggregation of information at all levels
- Timeliness and quality – appropriate outputs, matched to customer need and decisions

The environment is underpinned by MODAF [14] and provides a robust methodology that draws together a proven collection of models, processes, tools and techniques.

In short, TRAiDE is an environment that enables tools and techniques to be applied within a managed, consistent decision-making process. It provides a single point of access for visualising well structured, coherent, static and dynamic data sets, making use of a wide range of visualisation styles and

metaphors including targets, graphs, dials, and charts of various kinds. At the heart of TRAiDE is an information connection, management and visualisation capability provided by Salamander's MooD® software [15]. MooD has been chosen for this central role as it offers the best available match to the principles above; moreover it has the following additional attributes:

- It is MODAF compatible
- It is widely available and used within the MOD.

A key aspect of TRAiDE's inclusiveness is achieved through basing the core information management on MODAF. This enables standardised interoperability with information structures provided or generated from a range of other systems, including design tools.

The application of these principles is illustrated through the following recent example of TRAiDE.

TRAiDE application to Programme Board decision making

The delivery of military capability depends on the bringing together of a number of projects, each of which comprises specific DLoD elements. The MOD has now embarked on the roll-out of TLCM to bring together of a number of these projects under a "programme board" construct.

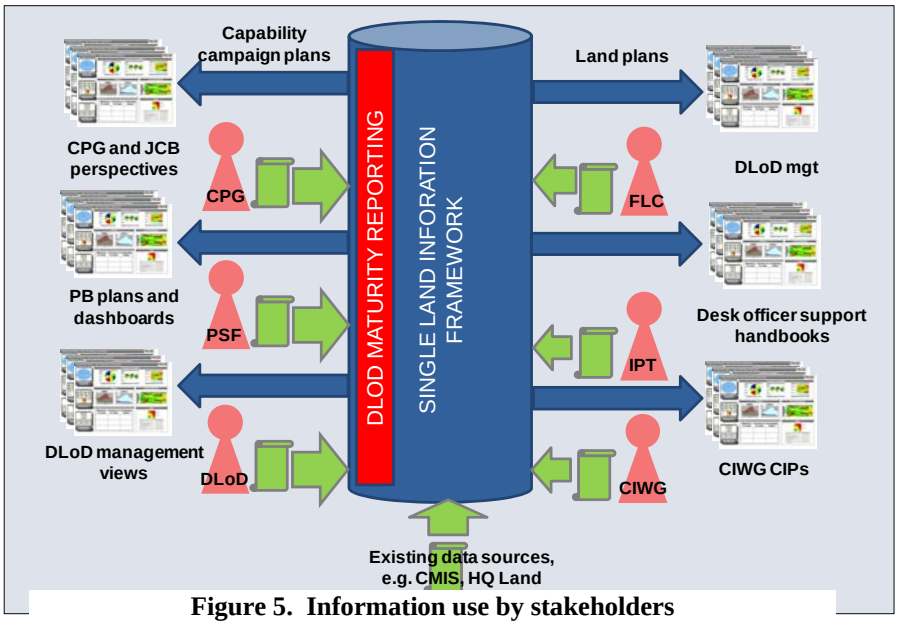


Figure 5. Information use by stakeholders

To achieve the full benefit from this initiative, significant work is needed to improve the availability, coherence and connectivity of data, so as to provide a basis for confident and effective decision making. The vision is illustrated by Figure 5, which relates to the MOD's Land Environment but which is readily generalised.

The essence of this vision is a single common, managed information model across which are provided a range of views appropriate to the diverse stakeholder groups, operating at differing levels and making decisions in differing situations.

Achieving this vision will require Programme Boards to address a range of key questions about data, required visualisations, and the analysis needed to support decision making (see Figure 6).

Programme Boards constitute the primary body by which trades will be undertaken. In particular they will trade DLoDs at the level above individual projects. In working with Programme

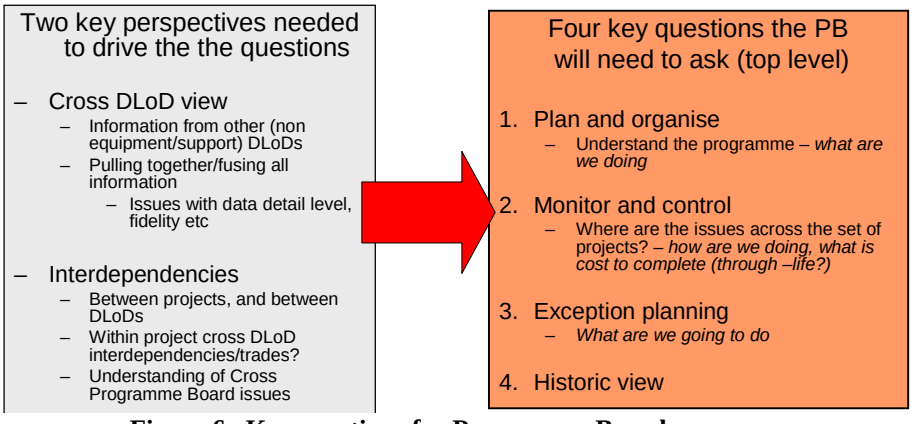
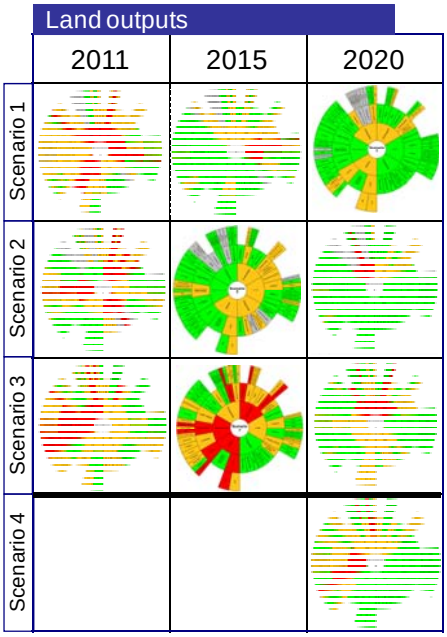


Figure 6. Key questions for Programme Boards

Boards in the early stages of their development it has been possible to examine the types of trade, the way the information is presented for decision purposes and the measurements associated.



Visualisations deployed across Programme Boards

The **Capability Bullseye** is a widely-applicable visualisation that can be used to provide a dashboard representation of capability effectiveness at a particular point in time, subject to a set of investment assumptions. The projected Bullseyes for a series of future epochs makes a powerful decision aid in relation to investment options and implications.

Its attraction is the rapid visual effect, with effectiveness cascading from outer rings towards the centre, according to configurable threshold definitions. Variations of usage have been applied, including DLoD readiness reporting, capability decomposition (i.e. aggregate components, and abstraction hierarchy (i.e. relative effectiveness of sub-types of a common capability).

Other visualisations used to inform decision making

Figures 8 and 9 below illustrate the application of the Capability Bullseye along-side a range of other visualisations, all generated dynamically from the same common, integrated information model.

Figure 7. Illustrating the use of Capability Bullseyes by Option over Time

Figure 8. A sample TRAiDE High-Level Dashboard

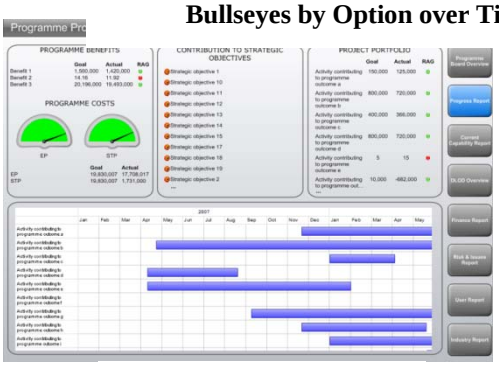


Figure 9. A more detailed TRAiDE Dashboard view

Many of these visualisations will be familiar from other contexts. The originality comes from the use of such approaches as alternative windows into common information to support a diverse and ever-changing range of decision requirements.

The visualisations needed have been derived from analysis of user communities' requirements, which differ in respect of information types /connections and also level of abstraction. As an example of the latter, the risks of interest to a project decision maker are not necessary applicable to a programme role, and additional programme risks may exist beyond those applicable to specific projects.

The TRAiDE approach to Programme Board decision support acknowledges and addresses this need with a mechanism for selective escalation of information.

Army Equipment Development Plan (AEDP)

This Niteworks project is responsible for examining the contribution of key equipment availability to the overall projection of capability. The approach applied by the project involved identifying and visualising the effectiveness of a set of options, each defined in terms of organisational mix and equipment portfolio, against a set of policy outputs, as shown in Figure 10. This analysis provides decision makers with a meaningful blend of objective data sources against which to apply military judgement.

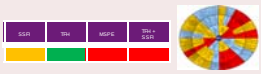
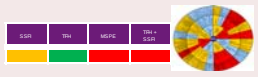
Options	The 'what'		The 'how good'	The 'how much'
	ORGANISATION	EQUIPMENT	OUTPUT	
Option 1				
Option 2				
Option 3				
Option 4				
Option 5				

Figure 10. AEDP: Methodology Applied

More specifically, the methodology adopted was as follows:

a. Define taxonomies of organisation, equipment, required capability to structure the TRAiDE environment
b. Identify options (in terms of organisation, equipment, scenario and timeframes), and build these into the environment
c. Integrate existing data sources into relevant parts of the model, to populate the structures
d. For each option, conduct an MOD-led Military Judgement Panel (MJP) to validate the model and assess the implications
e. Red team review the output

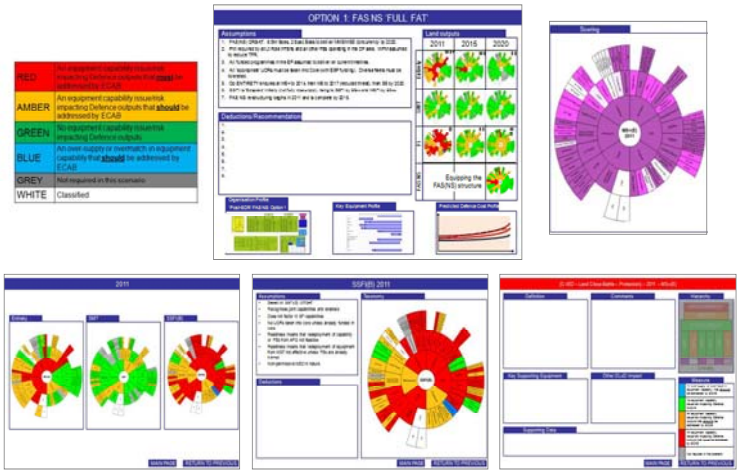


Figure 11. AEDP: Sample Screenshots

The output generated is a live environment of visual perspectives that objectively project for each option how well the equipment capability meets the requirements placed by Defence policy, highlighting areas where the board should be focussing attention or resources to solve issues. The sustained value of the environment is the flexibility it offers for users to re-configure taxonomies and / or options, or to change assumptions to reflect changed circumstances.

Counter Indirect-Fire: using visualisations to inform trading options

Achieving a common understanding across stakeholders within a complex environment clearly delivers significant benefits. A further aspect of TRAiDE is its application to the identification and analysis of trading options. A recent application within MOD can be used to summarise this, but see also references [7, 8].

An experiment was conducted recently in the area of Counter Indirect Fire (IDF) to pull together the constituent parts and present these in a way that will both capture the capability evolution and enable stakeholders to decide where problems lie and decisions need to be taken. Figure 9 shows a (redacted) Bullseye for the capability area, showing a decomposition of components and projected status of each component by DLoD.

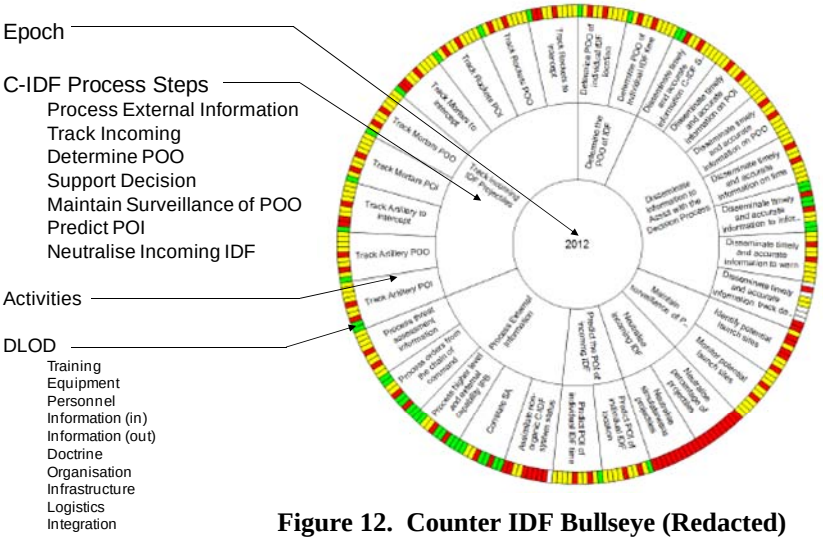


Figure 12. Counter IDF Bullseye (Redacted)

The visualisation indicates areas of capability gap, allowing more detailed exploration of attendant risk.

Building upon this structure, the method enables analysis of the projected implications of options, as illustrated in Figure 13: the current projection is aligned with two future options (with and without UOR support), clearly showing the projected implications under current programmatic assumptions. By experimenting with such assumptions, the projected Bullseyes will automatically reveal changed future projections, hence informing the difficult but potentially critical investment decisions.

Operational Activity /DLOD	T	E	P	I (In)	I (Out)	D	O	I	L	I
Maintain surveillance of potential IDF launch sites										
Predict the POI of incoming IDF										
Track incoming IDF projectiles										
Disseminate information to assist with the decision process										
Determine the POO of hostile IDF										
Neutralise incoming IDF										
Process external information										

Current (with UOR)

Planned (without UOR)

Planned (with UOR)

Figure 13. Counter IDF capability evolution

Summary & Conclusions

Feedback from users at all levels has been consistently encouraging of these kinds of activity:

- "Niteworks applies intelligence at the front end of the process"
  – Ursula Brennan, 2nd Permanent Undersecretary of State, UK MOD

- "Niteworks is the only thing which saves me money"
  - Lt Gen Andrew Figgures, formerly DCDS(EC), UK MOD

- "… experimentation is critical to ensure we deliver what the front line needs. Niteworks provides a unique ability to link from 'current to concept' and ensure we deliver practical, affordable increments …"
  - Vice Adm Paul Lambert DCDS(Cap), UK MOD

- "At some time during a tenure in acquisition, almost every Director, HoC and IPT Leader will find a point, where the need for impartial testing of the options and engagement with industry becomes necessary. They often hesitate to do so because of commercial worries; had I known what I know now when I was last sitting in Abbey Wood, I would have certainly used the Niteworks construct. The chance for an open and frank industrial discussion where MOD owns the output is a particular benefit and I commend it to you"
  - Rear Adm Amjad Hussain Director Precision Attack, UK MOD

Decision making in complex environments needs to be supported cohesively, intuitively and with robust evidence. Within the complex arenas characterised by 'command and control' and 'acquisition management', it is clear that there is a need for common practices which have a basis in the effective use of information and its presentation. Both problem spaces demand the development of shared understanding, shared situational awareness and the application of effective forethought, drawing upon integration of disparate information and active learning from experience. We have argued that:

- the problem needs to be approached holistically, through-life; e.g.. throughout acquisition and into sustained evolution of a capability;
- it needs to be addressed from a capability and joint perspective; e.g. addressing all DLoDs coherently, with industry to inform the decison space
- and it needs to be addressed early in the life cycle of option and solution development through collaborative experimentation
- and that the positive consequences of undertaking the above practices effectively are better, evidenced decisions which lead to a more coherent deployed capability, which in turn leads to improved predictability of both cost and military consequences.

We have also argued that the key aspects to be addressed are in relation to:

- Experimentation, coupled with
- Information management and visualisation to support decision making

And we have shown the intimate relationship between these aspects.

By pursuing innovative approaches to address each of these we are helping to bring about a transformation in the way that capability is managed, the benefits of which are demonstrable by some of the examples which have been reported here. Above all we have tried to show that there are some clear enablers to delivering solutions in a sector which has been plagued by piecemeal approaches, in particular:

1. Making experimentation the default condition, properly funded and collaboratively delivered
2. Understanding the importance of good evidence, well presented and supported by quality data which is singly sourced
3. Providing an effective capability focus which solves real needs and stimulates joined up solutions

The action plan for progressing this activity – which is timely in the UK due to the economic and political climate – is to:

1. Expand the use and capability of the experimental environment and Niteworks' role as a joint facilitator
2. Use specific pilots and pathfinders to demonstrate the practical advantages
3. Concentrate on the delivery of single source, effectively linked information management approaches that structure and exploit information in ways that are compelling to military decision makers
4. Manage the stakeholder community to understand and appreciate the significant benefits of a proactive approach to 1-3 above.

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