NITEWORKS

Issue 3

An update for defence decision makers

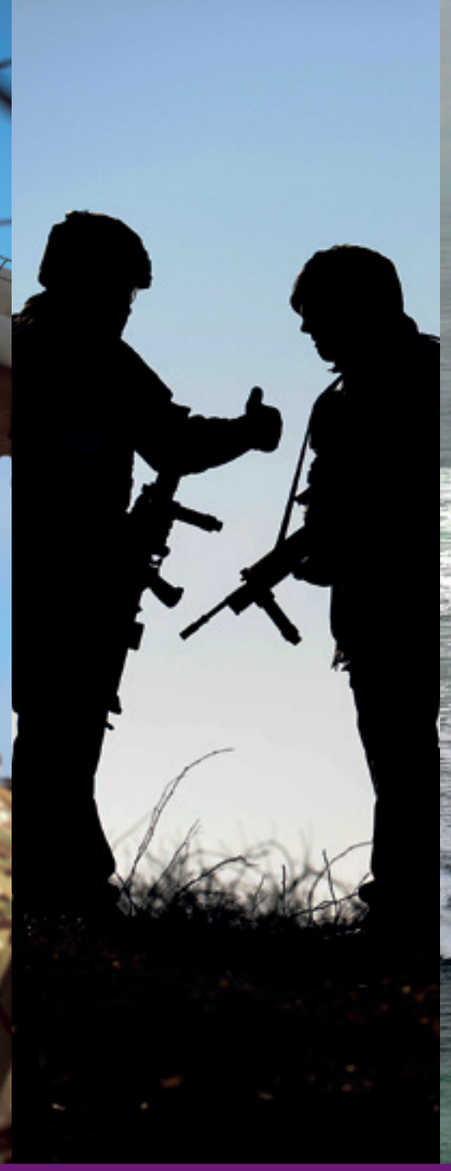
INFORM

August 2015

Experimentation in Defence

Inside this issue:

NITEWORKS is a part of the MOD



PROVIDING PRACTICAL, IMPARTIAL RESPONSES TO COMPLEX DEFENCE PROBLEMS

Niteworks provides a unique MOD/industry collaborative environment. MOD staff are encouraged to consider using Niteworks for military capability decision support, where complex problems exist which would benefit from wide-ranging, collaborative and impartial investigation.

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NITEWORKS

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Introduction

by Simon Jewell, Managing Director, Niteworks

Defence is routinely required to take decisions that have a deep and profound impact on future military capability. Generating evidence to inform such decisions is therefore an important undertaking that consumes resources and adds time to the project lifecycle. It follows that the quality of the evidence, and the quality of methods, should be of the highest order, particularly if evidence is to supplant advocacy. The recent publication of the Aqua Book speaks to this concern.

Providing robust evidence to inform good decisions builds on the ability to ask well-informed questions. This requires a good grasp of the past, present and future context and the engagement of a wide range of stakeholders across MOD, industry, other government departments and our allies. Inevitably this generates multiple perspectives and results in high levels of complexity, creating a significant challenge for the production of good (and timely) evidence, especially given the weight of evidence must always remain proportionate to the decision it underpins.

But when is enough evidence, enough? How can we be assured that the evidence produced from experimentation is representative of the ‘real-world’ in which we operate? How should evidence be gathered from settings that have high degrees of uncertainty? Is reductionism a solution or a problem? This issue of Inform seeks to spark the debate on such issues and aims to encourage fresh thinking into how we can best use experimentation to inform decision-making in a way that is fit for purpose for the evolving defence context.

Professor Vernon Gibson, MOD Chief Scientific Adviser

I am delighted to introduce this third edition of Inform, as it looks to the particular subject of experimentation. As the MOD’s Chief Scientific Adviser I am acutely aware of the breadth of activities that defence is either actively or prepared to be engaged upon, and for which it needs a strong evidence base to make its decisions.

The Niteworks partnership of MOD and industry, drawing a range of experts from across the MOD, Armed Forces, Dstl and our Industry members, is a clear tool helping defence make decisions on complex issues. I am committed to increasing the adoption of Evidence-Based Decision Making in the Department, and the Niteworks approach, by bringing scientists, military users together with industry colleagues, is setting a fine example to the rest of defence.

The 2015 Strategic Defence and Security Review, led by the Cabinet Office, is now under way involving departments across Whitehall as well as the MOD. It will review the full range of threats that we face; it will examine the capabilities we need to handle them; and help us judge how to resource those capabilities, aligned with the Spending Review. The Secretary of State has made it clear that it will be a hard-headed review of how we can deliver our national security strategy most effectively and efficiently. It will seek out the best of innovation from the private sector.

INFORM

Editors
Jessie-May Brown
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MOD photography

News in Brief

Niteworks contract extended to 2018

The MOD has reaffirmed the valuable contribution of the Niteworks partnership to generating military capability for the UK Armed Forces, with the announcement of a two-year extension to the current service. The contract which was due to run until 31 March 2016 will now be extended out to 31 March 2018.

Established by the MOD in 2003, the Niteworks partnership comprises more than 150 organisations including the MOD, Dstl, large defence primes, broader suppliers, research establishments and specialists.

Niteworks Managing Director Simon Jewell said: "In the face of the evolving security situation, the decision to extend the Niteworks partnership is timely given the need for MOD and industry to work as a whole force to de-risk and accelerate the provision of military capability. Niteworks offers a tried and tested construct through which MOD can mobilise industry and academia to gain impartial advice in support of its business and operational imperatives."

Focus on small businesses
as Defence Minister visits Farnborough

Philip Dunne MP has visited Niteworks to witness the partnership's work with Small and Medium Sized Enterprises (SMEs).

Mr Dunne, who is Minister of State for Defence Procurement, was in Farnborough to chair a regular meeting which brings together the MOD and other government departments with small business leaders. The SME Forum is the centrepiece of the MOD's interaction with Small and Medium Sized Enterprises and provides businesses with an opportunity to engage directly with senior MOD officials.

Mr Dunne met a number of small businesses who are playing an active role in Niteworks. This included Actica Consulting Ltd, a business and technical consultancy based in Guildford; Poole-based C3IA, a provider of secure ICT, technical programme management and information security services and solutions; SVGC Limited, a small company based near Salisbury providing decision support services in the defence and security sectors; and Drumgrange, an independent defence contractor with over 35 years of experience in the delivery of technological solutions to UK Armed Forces, NATO forces and overseas militaries. In total, around 40% of Niteworks' member organisations are SMEs.

In the afternoon, Mr Dunne visited Niteworks' headquarters to learn more about how the partnership is supporting the MOD to tackle some of its most challenging military issues. This included work to exploit open source information; activities to optimise the training of military aircrew through cutting-edge simulation; and support to large-scale, live military training exercises.

Philip Dunne MP chaired the SME Forum event in Farnborough.

INFORM | Experimentation in Defence

New associate members on board

Niteworks is pleased to confirm that nine new associate members have joined the partnership since the last issue of *Inform*.

Niteworks' membership now stands at 157 organisations, comprising the MOD (including Dstl), 12 Partners and 144 Associates. The announcement will ensure we continue to bring innovation and a fresh perspective into the partnership, in support of some of the MOD's most pressing issues.

Partnership briefing opportunity

The series of Niteworks coffee break briefings, which allow partner and associate members to provide an overview of their business to those working in the Niteworks office, continues to be popular. Most recently, presentations have been given by Lockheed Martin UK and Sigma and further briefings from Quintec and Engage Technical Solutions are in the pipeline.

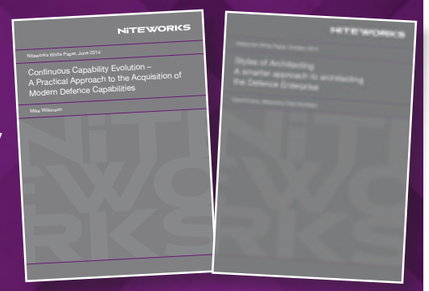
Speaking after his presentation, Russell Chesterman, Director of Sigma, said: "The presentation gave the opportunity to provide an overview of what our business does, and how it is relevant to Niteworks projects. It was attended by around 45 Niteworks members and people on task. There were many questions on the day, and good feedback from those who attended. Two more detailed conversations took place afterwards, which may lead to further business. It was a good way to promote our business in a relaxed environment."

If your organisation is interested in giving a future briefing, please send an e-mail to comms@niteworks.net.

New White Paper to be published

The latest Niteworks White Paper on *Holistic Complex Systems Interventions* is in the final stages of development. The draft paper was distributed to the partnership for comment in June and is due to be published shortly. You can find out more on page 24.

This is part of a series of White Papers drawing on best practice from a variety of Niteworks projects to address some of the root causes of major Defence issues. Published papers on *Continuous Capability Evolution* (which outlined a route to achieving a new, more agile approach to defence acquisition) and *Styles of Architecting*, are already informing MOD thinking. Other themes for future papers include *Capability Coherence* and *Innovation*.



Experimentation in Niteworks

Technical Director Mike Wilkinson explores the different approaches used for experimentation and considers how they are applied in Defence.

As a means of generating evidence, experimentation is nowadays entrenched in a diverse range of disciplines, such as science, engineering and medicine. Within Defence, experimentation is an established and valued approach, often providing a critical underpinning to robust (i.e. evidence-based) decision making.

The original purpose of Niteworks was to provide a mechanism for conducting 'man-in-the-loop' experiments to provide evidence for Network Enabled Capability (NEC) options across the Defence Lines of Development (DLODs). This sort of activity is still an important component of the Niteworks portfolio, although the cost and time needed to conduct such experiments has inevitably led to a broadening of approaches and project styles.

This article outlines some of the various approaches to experimentation routinely used in Niteworks, including typical projects they have been used on, and it also describes some of the challenges arising. Experimentation is a broad and deep topic – readers with a desire to dig into the details are encouraged to consult the Authoritative References (see details on page 8) and the Niteworks project archives.

Prerequisite: What is evidence?

In common-sense terms, *evidence* is anything that is persuasive in relation to a belief or proposition. So, in law, for example, evidence could be based on analysis of DNA traces, the opinion of an expert, or an eyewitness report. Not all evidence is equal, of course, and some will carry more weight than others because it is considered more accurate or reliable.

In the context of Defence, which has tended to borrow ideas and terminology from science, evidence is generally based on experimental observations and is often couched in support of (or against) a particular *hypothesis under test.*

A key consideration in experimental design is the *level of confidence* required in the evidence to support robust decision making, which can be subjective and context dependent. The various experimental approaches in use are each best suited to providing evidence at a specific level of confidence. In the important case of MOD investment decisions, the views of the scrutiny community on the level of evidence required and the most appropriate experimental approach are critical.

Manipulation experiments

The basic 'scientific' approach to experimentation is to establish a controlled situation that can be manipulated such that the effects of the manipulations can be observed. Typically, an *independent variable* will be changed and the effect on one or more *dependent variables* observed. It is important in such experiments that extraneous influences are removed in the design of the experiment with the aim of establishing cause-effect relationships.

In the hard sciences, where extraneous influences are generally controllable, identical experiments can be repeated many times and statistics applied to the results to obtain a confidence measure. Typically, very high levels of confidence are achievable, which are rarely if ever possible (or needed) in the Defence context.

Beyond the hard sciences, extraneous influences are typically more difficult to remove. This has led to experiments using a different statistical approach based on randomly selected 'samples', such that the extraneous influences ought to average out across the non-identical samples. This sort of methodology works well in medical experiments and similar situations (e.g. in randomized control trials) but may be impractical or unaffordable in some Defence experimentation.

Niteworks' experience is that the manipulation experiment works best when a small number (or small groups) of participants are working in a common battlespace. For example, in the Integrated Air Defence System (IADS) project – which considered what pan-DLOD changes would be most effective in mitigating capability gaps in the detection, tracking and identification of difficult air targets for air defence Command and Control and effectors – the enemy had limited options for attack and the operators had a limited choice of responses.

The approach tends to work less well when there are many participants within a rolling scenario – where it is difficult to compare one treatment with another – something of a challenge on the Medium Weight B experiment, for example. Similarly, Urban Warrior 5 – which considered what would be the most effective Armoured Infantry Company Group (AI Coy Gp) for Major Combat Operations in the Urban environment in 2020 – had over 200 participants and while attempts were made to constrain platoon and company behaviour to support comparisons, this was a significant challenge with such large numbers.

Empirical studies

When it is not possible or appropriate to establish a manipulation experiment, it may still be possible to observe a range of variables in an experiment without direct manipulation. This is a 'passive' form of experimentation which may be useful for establishing correlations between variables but is less useful for establishing cause-effect relationships. In some instances, observations of military training exercises can be considered as empirical studies.

Niteworks' experience is that the empirical study is a much more flexible construct than the manipulation experiment – as long as the various warfighting areas can be covered, data can be gathered to understand the relationships between factors and their associated correlations. The Light Forces Battlegroup project – undertaken as a strand within the CD Combat experimentation programme – conducted a series of table-top exercises culminating in a large wargame, which effectively provided the user population and the decision makers with an understanding of what would work in that particular context.

Exploratory investigations

In some circumstances it can be valuable to observe an experiment (e.g. which introduces a new organisation, process, manning level and so on into an existing situation) without any preconceptions or test hypotheses but just to 'see what happens'. This discovery process can give rise to insights, for example into emergent phenomena, which would be difficult to anticipate from a purely theoretical standpoint. Such insights might lead to testable hypotheses that could be subject to manipulation experiments or empirical studies.

In other cases, an exploratory investigation might provide evidence that something is achievable – i.e. to 'show by doing' – and simultaneously uncover a range of practical issues to be addressed. Although a demonstration of this type is only an approximation to an operational situation, it can provide good evidence of feasibility if it is sufficiently representative. In the military domain both Capability Concept Demonstrations (CCDs) and Technology Demonstrations (TDs) are in common use.

Experience within Niteworks is that the exploratory approach is very powerful. For example, the Brockworks series of demonstrations, using a "fail early fail fast" philosophy, have successfully demonstrated how existing commercial products can be integrated to solve a variety of difficult IT and telecoms problems,

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Experimentation in Niteworks

Continued from page 7

including secure information sharing, identity management, and secure gateways. Similarly, the Open Source Intelligence (OSINT) series of projects has successfully explored novel ways of delivering an Open Systems information and data analysis capability, including technical, process, training and acquisition aspects.

Challenges for Defence experimentation

It is clear from the above that, within Niteworks and Defence more widely, the use of experimental evidence to support decision making is alive and well. However, there are both practical and more fundamental issues impacting the ultimate value the approach can deliver.

At the most basic practical level, the constraints of cost, time, availability of personnel, or other factors, often limit the quality of evidence that can be generated. A key consideration is whether the cost of obtaining the desired level of evidence is commensurate with value of the decision it is intended to support.

Simulation modelling is often used in an attempt to address the practical difficulties. Different forms of simulation – Live, Virtual and Constructive – occupy a spectrum that, among other things, balances fidelity against speed/cost. In theory, the different forms can be used in combination (see for example the Land Handbook) in an attempt to obtain the required evidence in an optimal fashion. In practice, this approach can be difficult to make work because of the near impossibility of aligning complex experiments in such a way that their results can be merged coherently.

At a more fundamental level, some researchers have challenged the objectivity of evidence-based decision making (EBDM), wherever the evidence comes from, arguing that human cognitive biases, an unwarranted faith in numbers and other psychological/social factors undermine its rational basis. Some critics have used the phrase "Decision Based Evidence Making" to caricature such issues.

There are also relevant (but rarely considered) problems at a deep philosophical level, for example with the use of inductive logic (which underpins the process of generalising from specific experimental observations to a general conclusion) and probabilities (which have multiple interpretations) as part of the experimental approach. Although such worries might be considered abstruse and academic, one pervasive consequence is that experimentation is unable to deliver conclusive 'proof' (100% confidence) of a 'positive' proposition (e.g. "all swans are white").

There are situations within Niteworks experiments where practical and fundamental issues appear to intersect, for example when manipulation experimentation is applied to *complex systems* (e.g. Command and Control systems involving human beings). As many real military systems fall into the complex category, this is of more than passing interest. In this situation, the desire to control extraneous influences is liable to modify the experimental system so that it is no longer sufficiently representative (e.g. if its complexity is diminished or removed). This knotty problem is taken up in the Niteworks White Paper on Holistic Complex System Interventions discussed on page 24 in this issue.

Summary

Experimentation is a key method for generating evidence to support decision making in Defence and beyond. It can take several forms, each of which has utility in different situations. Nevertheless, designing effective and affordable experiments is invariably a challenge; worse, there may be practical and theoretical limitations to the utility of experimentation in numerous real-life situations of interest.

Authoritative references for Defence experimentation

"NATO Code of Best Practice for C2 Assessment", revised 2002.

"TTCP Guide for Understanding and Implementing Defense Experimentation (TTCP GUIDEx)", Version 1.0, 2005.

"Joint Experimentation Process", Defence Council Instruction Joint Service 13, 2005.

"Code of Best Practice for Warfighting Experimentation", Niteworks, V3.0, 30 September 2011.

"Land Handbook – Force Development Analysis and Experimentation", DG Cap.

Experimentation within the Commands

With the Commands taking on responsibility for planning future capabilities after the Levene report, senior military leaders are increasingly recognising the important role that experimentation provides in the generation of objective evidence with appropriate level of proof to support the decision-making processes. In spite of competition for resources, experimentation remains a valuable tool in the development of future capabilities for an increasingly complex Defence environment. In this section, we find out more about the approaches taken by the British Army and the Royal Navy.

A view from Capability Directorate (CD) Combat, Army Headquarters

Major Yann Searle has been a Troop Leader, Squadron second in command and Squadron Leader in a Challenger 2 Regiment. He has also worked with the TA, in Collective Training Group, and as a Divisional staff officer. He is currently SO2 Force Development and International within CD Combat at Army Headquarters. Here he describes CD Combat's approach to experimentation and its priorities going forward.

Why do you think experimentation is important?

Experimentation is absolutely vital for the Army, in simple terms, because it gives us a reliable body of evidence on which to base decisions on current and future capabilities. Examples would be: how we best maintain our capabilities within budgetary constraints, how we adapt and innovate or how we set ourselves up for success against the increasingly challenging operational environments we are faced with. All of this work is termed by the Army as Force Development or 'FD'.

Although it seems to have recently come to prominence, experimentation has been a key feature of military capability development for over a century. The best remembered example is probably the experimental mechanised force of the late 1920s, although a better example of successful capability development through experimentation was the adoption of oil-powered battleships by the Royal Navy prior to 1914, giving it a huge advantage in terms of reach and firepower over the German navy which remained entirely coal-powered.

However, the most important part of combat capability is our people; it follows that the most important part of our experimentation is understanding how to enhance those soldiers whether they operate mounted, dismounted or both, rather than just being about having a technological edge in equipment terms. Our experimentation must also involve all Defence lines of development (training, equipment, personnel, information, doctrine and concepts, organisation, infrastructure and logistics).

Major Yann Searle, SO2 Force Development and International within CD Combat at Army Headquarters

There has been a huge amount of change in the last few years in terms of combat capability. Some of this change is a result of optimising for success in Iraq and Afghanistan and the Army's subsequent re-setting for contingency operations; while some is the result of the significant re-organisation brought in by Army 2020. There is significant change still to come over the next ten years, much of it stemming from the very positive enhancements we will have to combat equipment, in particular our armoured fighting vehicles and communications.

Thankfully the Army has developed a very useful FD framework which splits us by time (or epochs) into four forces: the Current Force (what we have now); the Funded Force (what we will have in five years' time); the Future Force (what we need in ten years' time); and the Conceptual Force (focussed on what we will need in twenty years' time). There is a team responsible for the development of each of these forces, with whom we work extremely closely, under the Army's Director Capability.

What is CD Combat's approach to experimentation?

Probably the most important part of our approach is that experimentation does not happen in isolation. It won't come as a surprise to anyone that our experimentation budget is limited and we do have to compete for resources, however we are able to draw insights from a wide range of combat arms unit (as well as formation-level) training and conceptual development. It is the job of the combat directorate plans team (which I am part of) to take insights from all this activity, as well as our supporting Dstl research and operational analysis. We must then turn it into a coherent body of evidence focussed on where we need to adapt in order to mitigate current capability gaps and inform our development priorities for now and in the future.

Within this work, our experimentation tends to be focussed on areas of our current and funded forces which we know require adaptation and innovation, as well as on informing us as we develop requirements for future capabilities. In order to do this, we try to use a combination of live and virtual activity (including war-games) supported, where possible, by constructive simulation. However, we do not have the resources available to run bespoke live, virtual and constructive manipulation experiments in every area; and, in particular, our live activity tends to draw insight from already programmed collective training. Therefore we also use a variety of activity such as capability workshops and military judgement panels, involving as much of the combat community as possible, in order to develop our evidence and, crucially, to exploit what has been learnt.

Each experiment is run by a small team, including capability desk officers and contracted support (mostly from Niteworks). Oversight, governance and coherence with other research and development, across all experimentation activity, is provided by our FD team. This includes our Dstl Science Gateway, supported by our Dstl Capability Advisors, reporting to our Assistant Director Plans, by means of our Research and Experimentation Working Group.

What do you think are the challenges associated with this approach?

I think that, broadly, we have the right approach. The biggest challenge comes from the amount of activity we have to support with a very small core team, notwithstanding the fact that we draw on the whole of the combat arms (and beyond), which is still over twenty percent of the Army.

Please can you tell us about the five-year rolling plan?

In broad order, the five year experimentation plan is focussed on three main areas. Firstly, the development of our Mounted Close Combat capabilities which are enjoying significant investment; experimentation is now focussing on how to operate and fight these improved capabilities. The second area is dismounted lethality, situational awareness and sustainment; the strapline "Fight Light" informs much of this work – we have three experiments in this area this year. The third area is Command and Battlespace Management, which includes the integration of future communications and ISTAR capabilities.

What are your priorities for the next 1-2 years?

The absolute priority for combat over the next two years is the development of a coherent medium capability to complement our well-found heavy and light forces.

What role has Niteworks played in this area so far, and what value has it added?

Niteworks has been crucial to the success of combat experimentation over the last three years. During my last two years in this post, I have seen over a dozen members of the partnership work across the majority of our experiments. They all have relevant defence industry experience, usually with a military background, combined with technical expertise, enquiring and innovative minds and a focus on delivery within budget. Most important for the relationship, I think, has been to make integrated teams of military, Niteworks and Dstl as well as operational analysts such as Scientific Advisors (SCIADs). The bedrock of this approach has been to have a combat experimentation lead within Niteworks who has looked across all the experiments and worked directly with the combat FD and broader Plans team on a weekly, or sometimes daily basis.

The real value that has been added by Niteworks has been the ability to draw on subject matter experts from across the partnership, who have brought not only technical expertise, but a willingness to fully immerse themselves in the relevant areas, sometimes to our initial discomfort, but always to our benefit. Most importantly, they have helped us to present the evidence (on time) in a simple, but considered and contextualised form, with a focus on how it can best be exploited.

What do you see as the future for experimentation?

My personal view is that we will have to become more focussed on producing combined arms effects within a joint context. Therefore I would like to see an Army Force Development team consisting of combat, combat support, combat service support and command support SMEs, working closely with the Joint Warfare branch of Joint Forces Command; and the doctrine organisations such as DCDC and the Directorate of Land Warfare as well as the Field Army. This team should concentrate on bringing a coherent body of evidence from research, development, analysis and experimentation set against the epochs described above – and could do far worse than following the experimentation model developed by CD Combat with Niteworks.

British Army Experimentation – a look back in time

As a result of the introduction of armoured fighting vehicles during the First World War, the British military formed several "experimental" organisations. Once in service, the officers and men of the Tank Corps became the lead for experimentation but faced considerable challenges from the Army establishment.

In the 1920s, the British Army Council decided to conduct experimentation to explore the mechanisation of the cavalry. In 1928, the 3rd Carabiniers (Tidworth) were issued with their first motor vehicles as a means of "comparing the merits of the Morris six-wheeler light track vehicle with those of pack-horses as the best method of carrying the Vickers guns of a cavalry regiment" (Crow, *British Armoured Fighting Vehicles 1919-40;* p152).

Having started mechanisation at a relatively small scale, the British Army subsequently commenced the world's first large-scale experimentation on mechanisation. The Experimental Mechanised Force (EMF) was first created in 1926 but spent its first year conducting conceptual development (eg Wargames and Tactical Exercises Without Troops), before starting to train on a fleet of 280 vehicles (of some 15 different types). All this in the midst of economic austerity and Defence cuts!

Much has been written about the British Army's failure to adopt the most important lessons from the experiment (and how the German Army did adopt them, leading to their Blitzkrieg in May 1940). However, the EMF paved the way for further experimentation in the early 1930s, which led to the establishment of two experimental Mobile divisions and, ultimately, the British Army's first Armoured Divisions.

Major General Burdett-Stuart highlighted to the War Office that, whilst experimentation would be supported by the formations, units and personnel under his command, the Division would require external assistance. He remarked: "What help are you going to give me in organizing, launching and guiding this experiment? It is no use handing it over to an ordinary Divisional Commander like myself. You must connect with it as many enthusiastic experts and visionaries as you can; it doesn't matter how wild their views are if only they have a touch of divine fire" (Winton, *To Change an Army; General Sir John Burnett-Stuart and British Armored Doctrine* 1927-38; p76).

Major Mike Baxter,
Niteworks Military Advisor (Land)

Army experimentation in practice: Project BRITTANY

Over the last year, Niteworks has been supporting major Army experimentation to inform its requirements for the next generation of armoured fighting vehicles. Jessie-May Brown visited the Niteworks team in France to see how the partnership's skills and technologies have been brought to bear on this critical project.

On a warm, sunny day in the heart of France's Champagne region, it could be easy to forget that I'm here for work. In front of me, grassy plains and dense, green forest stretch as far as the eye can see.

Suddenly, however, the peace is shattered as an armoured vehicle appears over the near horizon. It hurtles towards me at great speed before pulling up next to a tall building just behind me. All of a sudden, the vehicle's rear door is flung open and soldiers in full combat gear storm into the building through a volley of gunshots and smoke. There is a constant, dull hum from an unmanned aerial vehicle circling overhead.

This was the scene in May, when more than 200 members of the British Army travelled to France for the capstone event of Project BRITTANY. The experiment seeks to develop the British Army's understanding of its requirement for a future medium weight capability, complementing its light and heavy weight capability currently fulfilled by Foxhound, Mastiff and Warrior vehicles.

Niteworks Project Lead Bob Wallace briefs senior British and French visitors at CENZUB, France.

Since 2008, the French Army has used the VBCI (Véhicule Blindé de Combat d'Infanterie, or *armoured vehicle for infantry combat*) as an 8x8 wheeled infantry fighting vehicle, however the British Army does not currently have an equivalent platform. Under Project BRITTANY, which would consider how a wheeled fighting vehicle might complement UK forces, the French Army agreed to loan 19 VBCI vehicles to the British Army, as well as more than 200 French military personnel and an urban training area in North East France where I found myself that day.

Troops storm a building supported by the VBCI.

For the Niteworks team, the journey to France began in June 2014 when it was tasked by the Army's Director Capability Combat to provide analysis and experimental support to Project BRITTANY. This would include the live experiment in France forming a Capability Concept Demonstration (CCD) phase, as well as a series of events leading up to it.

The team's efforts centred on helping to formulate and then answer 52 questions specified by the Combat Directorate, for which insights are required in order to make future decisions on a possible medium weight capability. The team then began to design an experiment which would take full advantage of existing opportunities to capture relevant data and to work up new events when required.

When I join the team in France they are embedded in the Exercise Control

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British soldiers in action on the live experiment in France.

or 'EXCON' building which forms part of the 'CENZUB' urban training area, the largest of its type in Europe. The facility comprises a modern zone including high rise buildings and an underground car park, an industrial zone and two residential zones. Each presents a different urban challenge for the soldiers operating within them.

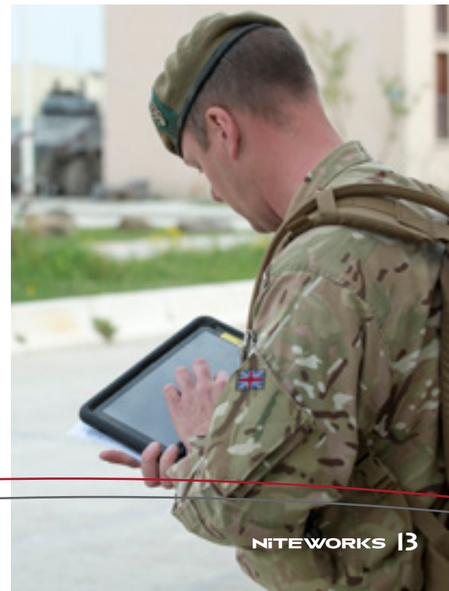
I'm shown around by Bob Wallace, who has led the project on behalf of Niteworks since it stood up in 2014. The Niteworks team is five strong for the CCD work package, with Bob assisted by a Technical Lead, CCD Manager and CCD Analyst drawn from the partnership, alongside the uniformed Niteworks Military Advisor (Land). The team is augmented by four Scientific Advisors from the Land Warfare Centre who provide analytical support and specialist equipment, and a team of uniformed military subject matter expert (SME) observers who have been trained by Niteworks to collect data on the ground during the CCD. It is immediately obvious that this blend of military personnel, industry experts and MOD civil servants allows the Niteworks team to effectively integrate within the experimental environment, whilst bringing innovation and deep technical knowledge to bear.

Arriving at the training area at around 7.30am each morning, the team's role is to collect data in support of the Army's experimental question set and then to collate and synchronise it in a way that allows recurring threads and their potential causes to be identified.

A key data source is a series of 75 sensors which have been attached to warfighters, vehicles and observers by the Niteworks team. Using the 'Force Watch' positional tracking system supplied by Niteworks associate Ultra Electronics, which relies on low cost mobile phone technology, the Niteworks team generates and records a picture of the unfolding battle. Snapshots can be taken and a set of slides created for each mission. The data will be replayed at a later date in the virtual domain for movie clip editing using VBS software and a service supplied by Niteworks partner, QinetiQ.

Other data sources include video footage from a series of fish eye camera lenses installed by the Niteworks team on the VBCI vehicles. These capture battle action outside of the vehicle as well as crew interaction inside it, which is then recorded onto SD cards and downloaded by the Niteworks team each day. Tactical Engagement Simulation (TES) vests provided by the French and worn by the soldiers simulate battlefield injuries, whilst the Niteworks team also intercept and record voice traffic from personal role and combat-net radios.

Niteworks Military Adviser (Land) Major Mike Baxter makes observations on a tablet.



A key component of Niteworks' data gathering role is the team of uniformed SME observers. Trained and rehearsed by Niteworks, they are positioned in the thick of the simulated battle armed with android tablets. These are used to collect observations, imagery, video footage and other data from the experiment as it plays out and to conduct interviews with warfighters immediately after each scenario. 'AKKA' software supplied by Niteworks associate SAAB allows subjective and contextual data to be easily captured by the busy observers, encrypted and then synchronised on a server at EXCON.

Niteworks' Paul Addenbrooke monitors the Force Watch tracking system.

Although the demonstration has finished and soldiers are emerging from buildings and vehicles, the Niteworks team is now busy collating the data that has been gathered using 'MADCAT'- a multimedia tool that is capable of synchronising audio and video files. This allows the team to go back to specific points within the experiment and to identify trends and threads in support of the experimental question set.

Although the Army continues to digest the results of the experiment, it is clear that it is already helping to inform decisions around a potential medium weight capability for the British Army and the training associated with it. Early findings were briefed in June to the Army's Mechanised Infantry Vehicle Requirements Working Group and other key stakeholders, so that they now have a common level of understanding of the Army's needs going forwards. A separate Training Exploitation Symposium discussed lessons from R Company 4 Rifle's training on the VBCI, using data gathered by the Niteworks team, which will now inform future training. An interim report produced by the project team is due to be published shortly.

However work does not stop there; Niteworks has recently been asked to extend its support and will go to Texas later this year to collect data from C Company, 1st Battalion the Scots Guards using the Stryker 8x8 vehicle and undertake further analysis of the different usage expected to be observed. The final Niteworks report will be delivered to Army HQ in early 2016 and will facilitate decision making focusing on the procurement of the UK Mechanised Infantry Vehicle and their subsequent employment within the emerging Land Joint Strike Force concept.

It is also hoped that Niteworks' recent activities should deliver benefits above and beyond the immediate challenges set by Project BRITTANY. All evidence, including the final Niteworks report and data pack will be uploaded on to Director Combat's experimentation server for future exploitation across the Army.

With the British Army resetting for contingency operations under Army 2020, Project BRITTANY will allow it to revisit the concept of a modern medium weight capability and in so doing help to ensure that it is a balanced force with a range of capabilities to meet the widest variety of challenges in uncertain times. Niteworks is grateful to all those in the partnership who have lent their support.

VBCI on the move.

Troops prepare for an assault at the CENZUB training area.

A British soldier equipped with French weapon and TES kit.

The role of experimentation in the design of the Type 26 Flexible Mission Bay

The Royal Navy is in the advanced stages of designing the Type 26 Global Combat Ship – a new warship for use in complex combat operations, counter piracy, and humanitarian and disaster relief. Due to replace the Type 23 frigate from 2020 onwards, 13 ships are planned for delivery in both the Anti-Submarine Warfare (ASW) and general purpose variants.

Adaptability is a key feature of the Type 26. Designed to allow for upgrades as new technology becomes available, it will meet the demands of the maritime environment throughout its life (until 2059). Central to this concept is the flexible mission bay – an area forward of the helicopter hangar and below the main weather deck, which can accommodate up to ten standard 20-ft ISO containers or other equipment such as a Merlin helicopter, embarked military force Inshore and Offshore Raiding Crafts (IRCs and ORCs), two Wildcats, unmanned vehicles and ship's Sea Boat behind a side loading door.

It is the first time in this class of ship that the Royal Navy has deliberately built in 'modularity' – changeable modules which alter the role of the ship – within a dedicated 'mission bay'. The main advantage will be that it offers an unprecedented level of operational flexibility, with the ability to change deployment at short notice by offloading and loading relevant mission modules at any port in the world (the bay will have its own crane system with the ability to lift up to 15 tonnes). In addition, the UK is leading the project that aims to set international standards for the module interfaces, which means that the ships will be compatible for use with other NATO allies.

Yet with this adaptability come a few challenges, some of which have used experimentation in order to test for potential problems or solutions.

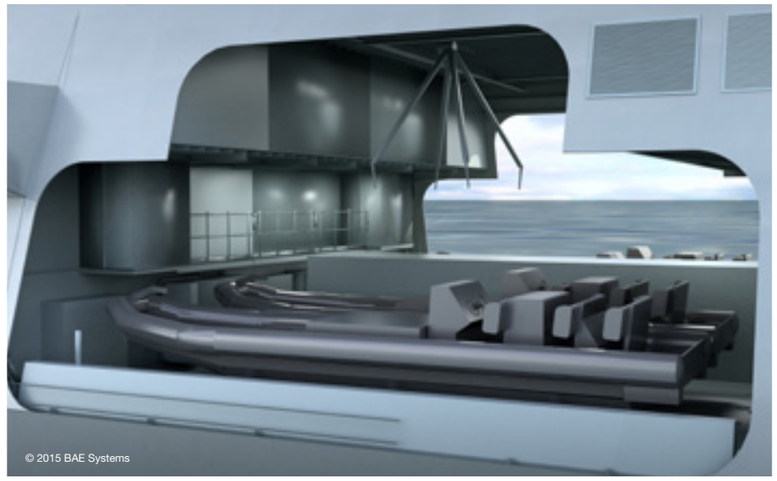
The mission bay

When trying to use a large but compact space for so many different tasks, there will inevitably need to be some compromise. During the current development phase of the programme, a lot of effort is focused on determining the concept of use, identifying the issues involved and finding a way to make it all work.

To test some of the specific issues relating to this area, a mock-up of the mission bay and adjoining compartments was constructed at RNAS Yeovilton in March 2015 in order to go through the practicalities of moving modules and equipment from point A to point B. This experimentation activity highlighted several key issues, which has led to redesign work that is currently underway. For example, the location of a door within the mission bay has been moved in order to improve access in various configurations and operating procedures have been adapted in order to meet the requirements of the space. Once the redesign is finished, the testing exercise is likely to take place again at the same location to refine this – a classic cycle of experimentation.

Shock protection

One of the problems with using standard ISO containers is that they need to be adapted for military use. It quickly became clear to the mission bay team that these containers would need additional protection in order for them to be 'shock captive' i.e. to remain intact in the event of an impact from a mine or torpedo. This has been a concern for other NATO countries in the past, but DE&S and Dstl have been working with weapon effect specialists from Weidlinger Associates to develop a new shock mounted system, which was recently tested by underwater shock trials in Scotland. The official results are yet to be released, but early indications show that this is likely to provide a low-risk, low cost solution for the UK and its allies.



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Crane system

The crane system on the Type 26 is based on the commercial model used in the North Sea for handling container cargoes between oil rigs and support ships, but it has to be adapted for naval use. For example, the crane system must operate mainly inside the mission bay, under the deck head, and it will plumb over the side with the ship possibly heeling at different angles or moving in a seaway, rather than from a solid oil rig platform. Experimental work is taking place in Canada to address these practicalities to find out how it can be made to work close to the deck head and how it will fit in with the compact nature of a warship. In addition, there will be a significant learning role for the Royal Navy in terms of how to routinely hoist and stow the containers into a mission bay in the heart of a warship, connect them up to the ship's systems and then integrate the modules and their crews to quickly change to the new operational capability. In addition to loading and unloading of ISO containers, the crane is also capable of launching boats up to 12m in length whilst the ship is underway.

It is clear that experimentation has already played a valuable role within the development phase of the Type 26. As the design matures, there is no doubt that it will continue to provide the evidence required to support key decisions on this adaptable capability.

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Uncharted waters – Niteworks in support

Sponsored by Navy Command Maritime Capability, Niteworks was tasked to take a look at the impact of modularity across all Defence Lines of Development. As part of this, a Niteworks industry workshop held in January 2015 identified a wide range of non-technical issues, which would affect the capability of a modern modular warship. For example, experienced shipping and logistic operators pointed out several administrative and practical requirements for consideration when handling a large volume of containers. Others with personnel expertise raised the issue – faced by the Americans aboard their modular Littoral Combat Ships – of the much higher level of sea skills being required by ships' crews, leading to longer, more costly and retention-vulnerable training pipelines. Integration and training issues were also identified due to the changing nature of crew members attached to various modules. Niteworks also took a detailed look at the Danish, German and American experiences of modularity, the former arguably being the most successful. When sailing in uncharted waters it is important to have someone looking out for the coastline ahead.

The role of experimentation within Defence Equipment & Support's Technology Office

Within Defence Equipment & Support (DE&S), experimentation activity across all domains (Air, Land, Maritime) and cross-cutting areas (C4ISR, Enablers) is supported by the Technology Directorate's Technology Office – previously known as *Technology Delivery.*

The Technology Office, which includes the management of the Niteworks service for Defence, has two main roles that focus on experimentation:

1. Supporting the Front Line Commands (FLCs) in the early stages of decision-making (primarily pre-CADMID) by helping to define their User or System requirements, which will then transition into mainstream Equipment Programmes and support decisions;

2. Supporting the project Delivery Teams within DE&S in exploiting novel technology and innovation that might enhance their projects, by increasing their level of technical maturity and reducing risk.

A relatively small but experienced team of circa 60, the Technology Office has a mixture of specialist Project Managers and Engineers with a high level of domain and technology subject matter expertise, as well as military Requirements Managers embedded from the FLCs.

The Technology Office focuses on the areas where they can add the most value:

1. Cross-cutting technology issues that span all the domains and have similar challenges (e.g. Unmanned Systems Autonomy, Open Systems Architectures, C2&NEC, Force Protection & Survivability, etc);

2. Novel Technologies: Ensuring technology and innovation de-risking in order to enable Delivery Teams to integrate within their equipment projects.

Black Hornet

It is widely known and accepted that new technology can give operational advantage or a battle-winning edge, but the ability to transition ideas out of the research environment across the 'valley of death' and into a tangible product or system is a challenge for those in both the military and commercial worlds. Decision-makers need viable options backed up by reliable evidence in order to support the decision-making process.

Experimentation plays a vital role in supporting decision-makers in Defence capability. It is used to provide evidence to validate the potential integration of novel and existing technology into various defence projects by developing the Technology / System Readiness Levels (or maturity) of new technology, and by testing and evaluating the impact of new and existing technology on the relevant system / platform. The Technology Office delivers a portfolio of circa 50 concurrent projects via:

1. Technology Demonstrator Programmes (TDPs): To develop specific technology options and de-risk platform systems integration;

2. Capability Concept Demonstrators (CCDs): Experimentation with relatively mature Commercial Off-the-Shelf (COTS) or Military Off-the-Shelf (MOTS) equipment. Work will focus on how the technology might be used in a novel way and what impact it will have on wider Defence Lines of Development (DLoDs).

The Technology Office provides a unique stakeholder role within MOD for experimentation activity. As part of DE&S, it understands the Delivery Team requirements and with a focus on pre-CADMID activity, it is also closely aligned to the Dstl research programme and the FLC customer. In addition, it has links to suppliers of innovative technology – from the large defence primes through to Small Medium Enterprises and academia.

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Technology Office Land Experimentation: URBEX

Technology Office Land section is the Project Management Authority for the URBEX (Urban Exercise) experimentation programme focussed on Dismounted Close Combat capability. URBEX is a major User-led test, trials and evaluation programme of COTS/MOTS technology sponsored by Director Capability in Army HQ.

Key to the success of the URBEX model is the involvement of the right team of people:

- Dstl provides the deep, technical specialists who understand the subject matter area;

- Army Trials and Development Units (TDUs) provide the critical User input and detailed trials planning and execution;

- MOD Customer Friend (QinetiQ) supports detailed requirements definition, data capture, analysis and reporting;

- Technology Office provides domain / technology specialists, co-ordinates all activity and is responsible for overall project delivery.

For URBEX, a thorough structured assessment process takes place in order to determine which systems are down-selected for testing and trials:

Level A: System Performance

Initial assessment is via a Dragon's Den-style expert panel which clarifies capability gaps to be addressed by the system and verifies that the system 'does what it says on the tin'. Systems are assessed to gain confidence that they are suitably robust and reliable, usable by the soldier within the military environment and integrate with other soldier equipment. Approximately 80 initial system options are typically down-selected at this stage by 50%.

I Sense

Level B: Fightability

At this point, the systems are subjected to field tests with soldiers to ensure performance of the system in a realistic environment and conditions.

Level C: Soldier Performance / System Effectiveness

A higher level (vignette based) capability assessment / force-on-force evaluation within a Platoon-scale exercise takes place to test system effectiveness. Approximately 15-20 systems are typically assessed over a one month period.

Depending on the results from Level C, follow up activity will be supported by Technology Office to exploit URBEX outputs within the Equipment Programme. Examples of the equipment tested during previous URBEX include Small Arms / Support Weapons and sighting systems ; Munitions ; STA equipment ; Counter-IED equipment ; Unmanned Ground / Air Vehicles and load carriage / body armour. The Black Hornet Nano Unmanned Air Vehicle, which was used by soldiers operating in Afghanistan from early 2013 onwards, was initially trialled under the URBEX programme.

Technology Office C4ISR Experimentation: ENTERPRISE CHALLENGE

The Technology Office's C4ISR section is tasked by Joint Forces Command, under their Command Acquisition Support Plan, to support a number of activities relating to C4ISR Concept Development and Technical Maturation. As part of this, the team manages the UK's contribution to ENTERPRISE CHALLENGE (EC) which is an annual US-sponsored C4ISR experimentation activity.

EC2015 marks the fourth in a series of events, started in 2012, and offers the opportunity for the Five Eyes partners to explore improved interoperability. In particular it allows exploitation, where operationally desirable and technically feasible, of:

- Defence Intelligence Information Enterprise (DI2E)/Defence Common Ground Station (DCGS) Enterprise Assessment;

- Interoperability between emerging sensors;

- Interoperability between international partners (Five Eyes Partners);

- Progressing the US Department of Defense's Cloud Computing strategy

Niteworks is tasked by the Technology Office to provide key services critical to the success of the EC event. Specifically, the partnership provides the opportunity for pan-industry engagement in conducting complex and impartial decision support. Additionally, Subject Matter Experts provided through Niteworks have supported development of the supporting experimentation network, which is the most complex and comprehensive capability of its sort in the UK.

Informing decisions through experimentation

Dstl – a key member of the Niteworks partnership – plays a major role in the strategy and delivery of analysis and experimentation work within MOD. We spoke to Rob Solly, Head of the newly-created Defence and Security Analysis Division at Dstl, about his views on experimentation within Defence.

Rob Solly, Head of Defence and Security Analysis Division at Dstl

What do you see as the role of experimentation in operational analysis?

Experimentation (in the broadest sense of the word) is a vital part of the learning process, helping us to build understanding by learning from our successes and failures. As part of our commitment to Evidence-Based Decision Making, MOD makes considerable use of experimentation through trials and operational analysis (the discipline of applying advanced analytical methods to help make better decisions) to test ideas, concepts and capabilities in a safe-to-fail environment.

For many cases, classical operational analysis techniques such as constructive simulation are sufficient for this purpose, but many of the problems that MOD is wrestling with today are highly complex, often involving human-centred issues, which cannot yet be modelled and predicted. In these cases, an experimental approach, using trials or virtual simulation, can help us develop understanding through an iterative learning process. As a result, I see experimentation as an essential weapon in our analytical armoury for developing policies and capabilities in such a complex space.

What are your views on current experimentation practices within Defence?

I have been extremely impressed by the professionalism and quality of experimentation across Defence, but in particular in the area of C4ISR research. I am really keen that we expand the application of experimentation to a broader range of MOD's problems. This will require us to avoid the temptation of the one-off, high fidelity, large scale experiment with tens or even hundreds of people involved, but instead to employ a more iterative approach using multiple smaller-scale experiments, each focusing on specific issues, with their results integrated afterwards.

What are the main challenges associated with experimentation?

The fidelity with which a scenario can be replicated in an experiment can make the results highly believable to those participating in it. This means that experimentation can be a great way of helping decision makers to experience the results of the analysis rather than being briefed on it afterwards. However, because experimentation often takes place in real time or near real time, only a limited number of replications can be completed. It is vital that we learn the right lessons from this small number of replications rather than the wrong lessons, which could have occurred by a chance, unusual result. This is one of the reasons why I would like to diversify and run an increased number of smaller experiments in future.

What do you see as the future for experimentation within Defence?

Defence faces a major challenge at present with budgets under pressure and an ever increasing array of threats and issues to deal with. In this highly challenging environment, I am convinced that MOD needs a much better understanding of the alternative ways of operating and the capability options available to us. We also need a mechanism for rapidly assessing new ideas and testing them out if we are to adapt rapidly enough to meet the demands of a quickly changing world. Within this context, I firmly believe that experimentation – in particular, the simpler, more numerous methods I referred to earlier – has a central role to play in helping MOD develop a more innovative, adaptable culture, where decisions are tried out in a safe-to-fail environment and the development of our capabilities is better informed.

How can Niteworks support you?

The role of Niteworks is to bring a pan-industry perspective to bear on MOD's challenges. The expertise that members of the Niteworks partnership have developed in areas such as experimentation will be vital in taking forward our vision for the future.

What is the Evidence-Based Decision-Making (EBDM) initiative and why is it important?

The EBDM initiative was instigated in 2011 by Ursula Brennan, the MOD Permanent Under Secretary at the time, and it aims to ensure that decisions across MOD are well-informed by evidence and analysis. This is a central tenet of government policy and it is an area in which MOD has led the way in the past, but it was felt that our expertise in analysis could be applied far more broadly across other areas of MOD such as policy, personnel and finance. Ensuring that our decisions are well-informed is not only required by government policy, but it will help to deliver more cost effective policies and enable us to be more confident in the decisions we make.

The initiative has three major strands: working to raise awareness and support senior decision makers; developing training for the staff members who support them; and building a community of analytical professionals within MOD. It is championed by Professor Vernon Gibson, the Chief Scientific Adviser, and Peter Watkins, Director General Security Policy.

NITEWORKS PROFILE

Caoimhe McManus, Commercial and Procurement Manager

Role and responsibilities

My role is varied, primarily focusing on the provision of commercial and procurement support to projects. This includes working with the project teams to build estimates and proposals prior to contract, support with regards to intellectual property management, compliance with export controls and management of Expressions of Interest/Request for Proposals.

I am responsible for keeping the Niteworks commercial processes up to date and also act as the commercial lead for organisations joining the Niteworks partnership. As a qualified Data Protection practitioner I also aim to ensure we are managing our data appropriately.

Career background

Following school, my ambition was to study law and pursue a legal career in the commercial sector. However during my law degree I undertook a work placement and quickly realised that I didn't want to be constrained by specialising in one area of law.

I have always had a keen interest in aviation and successfully applied for a job working in one of the simulators at West Drayton supporting the training of new Air Traffic Controllers. Whilst working there, I was offered an opportunity to transfer from the operational side of the organisation and was promoted to the role of Commercial Officer. I subsequently moved to BAE Systems to work as a Commercial Officer for Strategic Capability Solutions – part of the company which focused on developing transformational capabilities, technologies and processes. This role gave me an opportunity to take the Information Systems Examinations Board (ISEB) Data Protection qualification and to participate as a business lead in the pan-company change programme for records management.

Joining Niteworks

I joined Niteworks in January 2012 as Senior Commercial and Procurement Officer before moving to my current role in April 2015. Niteworks offered an opportunity to work face-to-face with a variety of industry and military stakeholders in a collaborative environment that is fast-paced and full of variety – I like that every day offers a different challenge.

Priorities for the rest of the year

Following the recent successful extension to the current Niteworks contract, my main focus is now on supporting the required revisions to the contract agreements across the 150+ partnership and ensuring continued support to the Niteworks projects.

Interesting fact

Caoimhe is pronounced as 'Kee-vuh'. My parents wanted to give me an unusual first name and as my mum is from Belfast, they chose an Irish name – although even there I don't always get the correct pronunciation!

We asked our Partner and Associate members to tell us about their views of experimentation and how it might evolve in the future.

Experimentation through open innovation

GENERAL DYNAMICS
United Kingdom Limited

General Dynamics UK works innovatively with small-and-medium-sized enterprises (SMEs) and academia through EDGE UK, its innovation hub based in South Wales. EDGE UK is a unique model in which General Dynamics UK, SMEs and academia come together as partners with government organisations and the user community in an open environment to rapidly deliver new technologies and innovative capabilities to defence customers around the world.

We need to identify in short order whether new innovations are worth pursuing without expending disproportionate time or effort, especially on the part of the SMEs whose resources are very limited. EDGE UK provides the perfect environment for this to be done.

The first step is to discuss how an innovative idea or technology could provide military benefit. When identified, the project hypothesis is tested by a practical experiment. The objective is limited to a proof–of-concept in the first instance, so that the experiment may be conducted as quickly, simply and economically as possible. If something does not work, we do not deem it a failure if we gain insight into why this is the case.

Success, though, brings its own challenges. Analysis is essential to addressing whether a promising result actually will bring real benefit: is the capability useful in a wide range of scenarios; will it work reliably in a demanding combat environment; will it make life easier for its users; will it work at scale, etc?

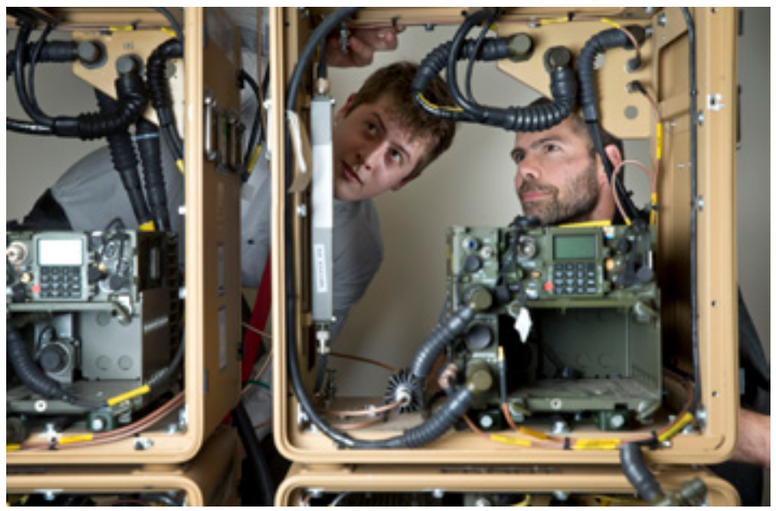
Technology maturity is also a key issue, with many promising ideas failing to make it across the 'valley of death' for want of funding to develop a deliverable product. Where appropriate, the EDGE UK supports SMEs in finding ways to take their good ideas further. Sometimes this is through Dstl's Centre for Defence Enterprise, so that the work becomes a three-way collaborative effort. In any event, success hinges on showing the end-user the art of the possible, so that they take ownership of the idea and reflect it in their capability development plans.

Nicholas Beswick
Head of Concepts Development

Experimentation remains a key activity for taking good ideas forward. We seek out opportunities to join planned military exercises and activities, in order to place experiments in the hands of users in a representative context in the most cost-effective manner.

To capitalise on the potential that exists in the wider supply network, 'light touch' experimentation needs to be better recognised and adopted throughout the Ministry of Defence acquisition community.

Nicholas Beswick
Head of Concepts Development,
General Dynamics UK



General Dynamics UK – EDGE UK

Bohemia Interactive SIMULATIONS

As a supplier of the Virtual Battlespace (VBS) software used by Niteworks and a number of other organisations for experimentation purposes, our approach is to work with our customers to make sure they fully understand the capabilities of the product in order to maximise the benefit of their experimentation activity. We also work with our customers to adapt our software in support of specific experiments if required – experimentation is part of our day-to-day business.

I am a great advocate of experimentation and we are proud to be able to bring so much of the battlespace to the experimentation environment. Experimentation is fundamental to the development of defence capability, whether it relates to equipment, training or any other defence line of development. With it, you can explore the boundaries of any future system that might be used.

The main challenge we often face is how to bind the experiment to ensure that it focuses solely on the specific areas that interest the customer. From a technical point of view, we need to work out how to implement the technology requirements so that it is genuinely representative of the future system. In other words, when you are trying to experiment with something that does not exist, you have to create a credible representation of it with a certain degree of uncertainty. This requires a strong relationship between us, the experimentation team and the user community to make sure that what is produced is genuinely credible so that the results of the experiment are viable. In the future, as experimentation becomes a mature capability, we will see the demand for it increase. One of the pitfalls is the proliferation of technology – it is everywhere and everyone has an opinion on which one is good. I believe that thought leadership is required from an organisation such as Niteworks on the technologies that should be used for experimentation. Otherwise every experiment starts from scratch and requires additional time and money to put it together.

Jonathan Read, Head of Sales and Operations, Bohemia Interactive Simulations UK

I would also like to see a structured programme of experimentation across Defence, working closely with the Front Line Commands and technology providers, so that there is greater co-ordination of the experimentation programme and supporting technology.

helyx

Experimentation is most important for testing and verifying evidence-based assumptions for MOD in an environment that is both cost effective and operationally low risk. Through such experimentation the UK MOD has maintained its position as the leader of one of the most cutting edge and capable forces in the world.

Our approach to experimentation and evidence based decision support

The Helyx Research and Development Team analyses emerging technologies and business practices, producing technical strategy advice and concepts for information management and related technologies.

By staying at the leading edge, we help our clients achieve fit-for purpose capabilities that fully exploit the latest technology, underpinned by a clear understanding of risks and potential benefits.

We design, develop and produce Information Management and Exploitation prototypes and concept demonstrators in order to prove a concept or new process. We offer horizon scanning, experimentation and testing, comparison and assessment of evolving technologies and options analysis with a particular focus on Geospatial Information.

The challenges of this approach

The key is to not work in isolation and to make it easy for the outputs to be exploited. By setting measurable goals from the outset a broad array of pros and cons can be considered, from implementation aspects, to consideration of factors that may affect cooperation with our allies, right through to training implications.

Karl West, Head of Business Development, Helyx Secure Information Systems Ltd

Research can only realise benefits if the outputs are shared in a way that is accessible to the people to whom it may make a difference. The use of experimental demonstrations of new concepts or principles is an effective way for stakeholders to assimilate key outcomes and findings, and for the research to realise the most benefit for the end user.

TECHNICAL PAPER

Holistic Complex System Interventions:

A pragmatic approach to evidence generation for complex Defence systems

Chris Jordan, Niteworks Chief Analyst

The Niteworks White Paper on Interventions in Complex Systems has been released for comment to the Niteworks partnership and is due to be published soon. The White Paper was written against the backdrop of increasingly complex problems and a paucity of tools to address them. This short article summarises the key points in the White Paper, highlighting the challenge facing both MOD and Industry in trying to evaluate interventions in the complex system and proposing an alternative approach for consideration.

Defence and Complex Systems

The current and Future Operating Environment (FOE) for UK Defence forces, based on the Future Character of Conflict (FCoC), is rapidly becoming "Congested, Cluttered, Contested, Connected and Constrained", with state-on-state and insurgency operations taking place alongside peace enforcement and defence engagement activities. Recent events in Europe and the Middle East have highlighted the unpredictability of the future environment and the challenge facing any form of analysis or evaluation of future capability.

The FOE represents a complex socio-technical system containing human actors interacting with local populations, with uncertain outcomes, and emergent behaviours arising in a wide range of contexts including individual, group, command and political.

The characteristics of complexity include:

- Large ***numbers*** of and high degrees of ***variability*** in the elements, particularly if those elements include people;
- Large ***numbers*** of and high degrees of ***variability*** in relationships between elements, such that the system cannot easily be reduced to a number of distinct subsystems;
- Emergent properties/behaviours[1] that are novel or unpredicted; i.e. where "the whole is greater than the sum of its parts[2]";
- Elements within the complex system change themselves and their relationships in response to their environment – known as ***adaptation***;
- There is considerable ***uncertainty*** in relation to outcomes, such that cause and effect relationships within the system are difficult to establish;
- Non-additive effects or ***non-linearities*** exist, such that the combined effect of two or more factors does not equal the sum of the two individual effects;
- There is ***sensitivity to initial conditions***, where the same system can exhibit significantly different behaviours from near identical starting conditions.

Apart from the operating environment, complexity is endemic within the Defence enterprise, which includes military operations, capability management and acquisition.

> ***"In looking at how the organisation currently works, we found that it was complex and difficult to understand, partly by necessity, but also partly by design. We believe this complexity is both a symptom and a cause of the current problems"***
>
> Defence Reform, Lord Levene

1. The defining feature of a system is that a group of elements, when interacting with each other and their environment, can generate emergent behaviours and properties. For example, the minimum stopping distance of a car on a wet road is an emergent property of the car and its elements (including the type of tyres and their air pressure, the type of brakes and their condition, the mass of the car, etc), and the car's environment (properties of the road surface, surface contaminants, depth of water, etc).
2. Attributed to Aristotle.

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What is an intervention?

An intervention is a managed change, which transforms the system from its 'current state' to the 'desired state'. In Capability Development and Acquisition, the problem situations we are interested in generally involve a desire to 'improve' (according to one measure or another) the behaviour or other properties of a complex system by means of one or more interventions.

Challenges of current methods for evaluating interventions in complex systems

A key technique for evaluating interventions in complex systems has been Warfighting Experimentation – specifically the manipulation experiment. Warfighting Experimentation provides an opportunity to pair real and competent military operators with real or surrogate technology in a real or simulated environment to understand the contribution of a change in procedure or technology (an intervention). In comparison to other forms of analysis, the key advantage is the presence and participation of the military operator and the application of his or her cognitive abilities.

Table 1 highlights the advantages and disadvantages of using a manipulation experiment.

A key disadvantage is the ability to apply the findings beyond that particular instance, which is referred to in the scientific world as 'generalizability' or, according to the TTCP Guide for Experimentation (2005), the *'ability to relate results to actual operations'*.

Manipulation or comparison experiments require cause and effect relationships to be demonstrated. However the control required to adequately demonstrate a cause and effect relationship can overly constrain the complex system. The experimental controls can also modify the intrinsic properties of the system. In extremis, the experimental system may fail to represent the real system. The evidence may be 'rigorously derived' but is inapplicable as it relates to the 'wrong' system. So not only did the experiment look at the wrong problem, but there is no valid generalisation of the problem to actual operations.

ADVANTAGES	DISADVANTAGES
Good for complicated systems or where cause and effect can be determined	Limited applicability to complex systems
Good exposure and engagement with participants and customers	One big event – one narrow focus opportunity
Many people can participate in the experiment gaining first hand exposure to relevant issues	Requires multiple participant groups to ensure one is used as a control in comparison to another or if using the same group, learning is a real challenge
Large number of assumptions are agreed in order to define the experiment activity	Large number of factors controlled or treated as random when they could impact the outcome considerably
With the right participants, right equipment and appropriate measures data can be collected with the intention to inform decision making	The ability to understand what has actually occurred during the event can be difficult due to many factors playing a part
Good for understanding the effect of a particular factor if highly controlled	It is difficult to apply the findings beyond a particular instance

Table 1: The advantages and disadvantages of using a manipulation experiment

Acknowledging the characteristics of complexity, it can be seen that the Warfighting Experimentation technique to demonstrate controlled cause and effect works well for complicated systems that have predictable behaviour, such as an individual soldier firing weapons with different ammunition, or using different weapons, however it is inappropriate for evaluating the effect of interventions on a complex system. While the discussion is focussed on the manipulation experiment, the conclusion is not solely constrained to Warfighting Experimentation. Recent studies are emerging that raise concerns about existing approaches to evidence generation for operations assessment, suggesting a more explorative, less constrained approach than has traditionally been conducted[3].

A new approach to evaluating the impact of interventions on complex system – HCSI

A change in mindset is required to adequately address the challenges of complexity. Moving away from the constraints imposed by traditional forms of Warfighting Experimentation (the manipulation experiment) and some forms of operations analysis, a more exploratory approach is required. The holistic complex systems intervention (HCSI) approach is offered as a strawman for such explorative thinking.

The aim of the HCSI approach is to explore holistically (focussing on the whole rather than the individual parts) how innovations/interventions may deliver benefits. The HCSI approach provides a high-level perspective on the factors that exist within the complex system so that the total effect of any interventions can be understood and evaluated.

3. A recent NATO study identifies that analysis should involve exploration and self-critical analysis whilst making sense of the complex system and developing an awareness of the potential for change within the system.

There are five key ideas behind the approach:

1. Focus on exploration/sense-making – the HCSI approach is about understanding enough of the system to explore what-ifs. This is likely to support loosely defined relationships rather than a requirement for them to be hard-wired;
2. Accept uncertainty – with relationships loosely defined within the complex system there comes some uncertainty;
3. Iterate with small steps – take small steps in the examination of an intervention on a complex system, perhaps by breaking interventions down into smaller chunks;
4. Be innovative – seek innovation opportunities wherever possible;
5. Evaluate – ensure you evaluate the whole system, not just component parts.

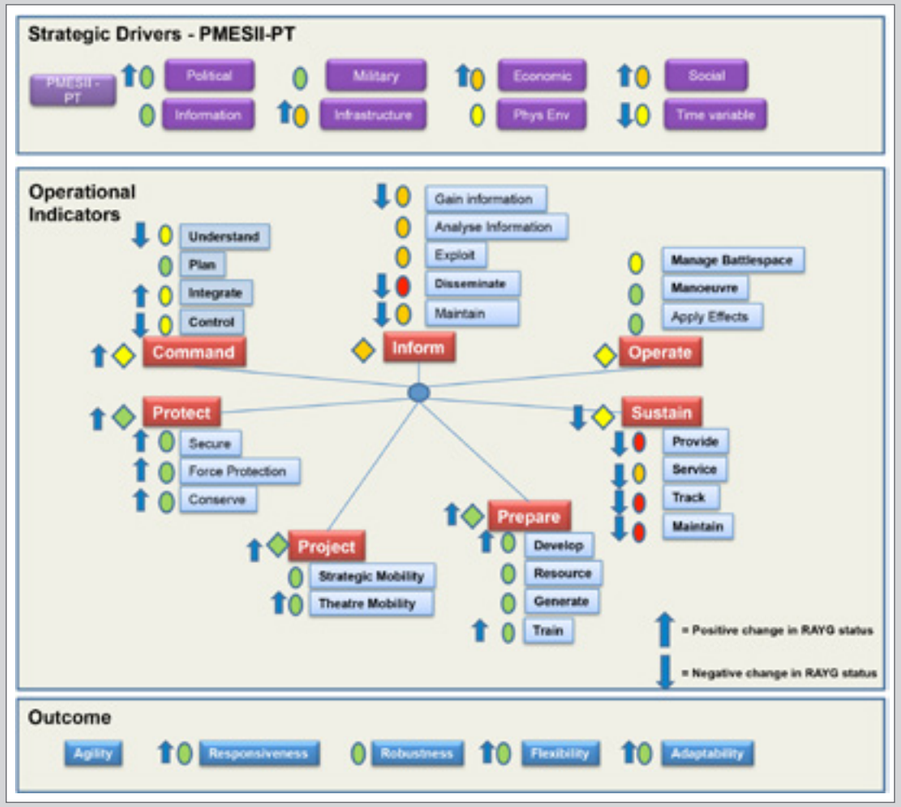
The loosely coupled system could be drawn from the Defence Capability Framework (Command, Inform, Operate etc), Functions in Combat (Firepower, Mobility, Protection), business units (acquisition, commercial) within an enterprise or even some combination. This is set within the context of strategic drivers such as political, military, economic factors and so on (see the example below to illustrate what it might show).

The advantages of the HCSI approach can be summarised as follows:

- Good for complex systems, particularly where elements are loosely coupled;
- Good consideration of a wide range of factors that might be affected by an intervention;
- Exploration with agreed assumptions as participants are skilled and task familiar;
- With the right participants, right equipment and appropriate measures, data can be collected with the intention to inform decision making;
- The findings should be generalizable and cover many different situations.

The disadvantages associated with using this approach are:

- Less useful for complicated or simple systems;
- The relationship between factors may not be fully understood;
- Small number of factors controlled. They are thought of as 'what-if' issues or in terms of sensitivity;
- Making sense of the impact of an intervention requires expert judgement;
- The output is qualitative rather than quantitative.



INFORM | Experimentation in Defence

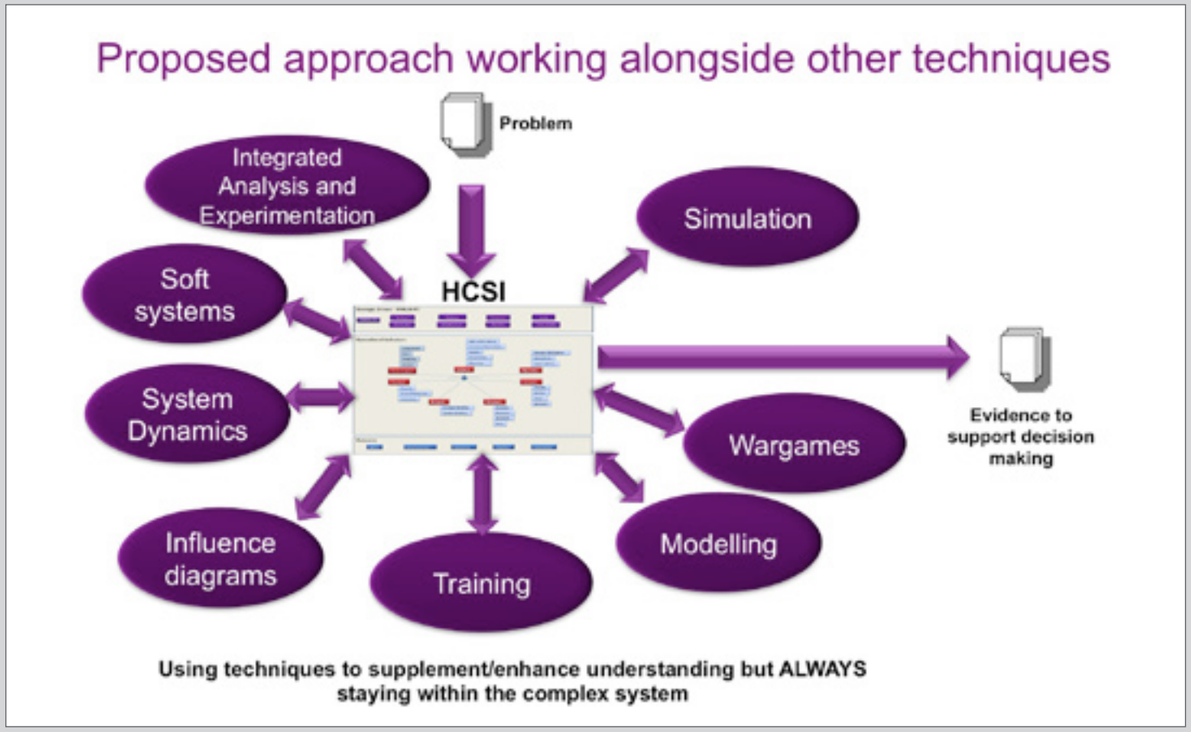
What next for HCSI?

Niteworks believes the HCSI approach, focusing on exploration and innovation, provides a pragmatic approach to evaluating the effect of interventions (whether equipment, doctrine, or other Defence Lines of Development) on complex systems. Where it sits in relation to other analytical approaches and techniques has yet to be fully addressed, however it is intended that this approach would assist in the management of the factors associated with a complex system and help the user or decision maker understand the contribution that different interventions could make to a particular capability decision. The other techniques, such as system dynamics, simulation and training exploitation could be used to explore particular interactions between elements of the complex system.

An illustration of how it could be used is shown below. The idea is to maintain a dashboard of the complex system throughout any analysis activities.

Exploitation

The principles of the approach were presented as part of the 'Ways' Module for the Advanced Command and Staff Course at the Defence Academy and the HCSI White Paper has been circulated within the Niteworks partnership for comment. Engagement with the Scrutiny community is being sought to see how this approach can be adopted within the wider analysis context to improve our approach to evaluating complex system interventions. We are also looking at opportunities for implementation across the partnership.



An Associate's View of Niteworks

There are currently more than 150 members within the Niteworks partnership, many of which are small to medium enterprises. For this issue, we spoke to Karl West, Head of Business Development at Helyx Secure Information Systems Ltd, about his company's involvement in Niteworks.

Tell us about your company.

Helyx was established in 2002 to provide applied research and project support for the UK MOD. More recently we have developed a reputation as a company that excels in information management and exploitation with specialist expertise in geospatial (location-based) information systems and intelligence to aid decision making.

We work predominantly within the Defence and National Security sectors and translate our skills into a variety of commercial sectors. We enable our clients to store, manage, disseminate and analyse their information and turn it into intelligence. This provides them with a common understanding of their operational environment which enables them to reduce uncertainty and make quicker, more accurate and more intelligent operational decisions.

How did you find out about Niteworks?

Helyx became aware of Niteworks several years ago when we worked on a research and development project for MOD called the Common Geospatial Tool Set (CGTS), supporting the Network Enabled Capability initiative. We decided to join Niteworks soon after (March 2012) and have been an active member ever since.

How have you been involved in the partnership so far?

Helyx has been directly involved with leading and supporting a range of projects including geospatial (location-based) intelligence (GEOINT) coherence across the MOD enterprise, Ground Based Air Defence, Maritime and the Brockworks project.

We have actively supported many industry and stakeholder workshops with specialist knowledge of information management and information exploitation (IM/IX), including GEOINT systems, processes, data standards and training.

What value do you think Niteworks provides to you and your company?

Niteworks provides a great collaborative platform where a specialist SME company like Helyx can work together with large companies to bring the best advice and evidence together to inform and support MOD with key decisions. It has enabled us to exploit our first hand user experience and expert knowledge in our field and combine this with experts in other fields as part of multidisciplinary teams, which not only benefits MOD but opens up new opportunities and fosters business partnerships for us.

Karl West, Head of Business Development, Helyx Secure Information Systems Ltd

Image courtesy of Getac

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