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UK Defence Innovation – Design and implementation of a system to realise value through exploitation of novelty

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UK Defence Innovation – Design and implementation of a system to realise value through exploitation of novelty

Mike Wilkinson and Simon Jewell

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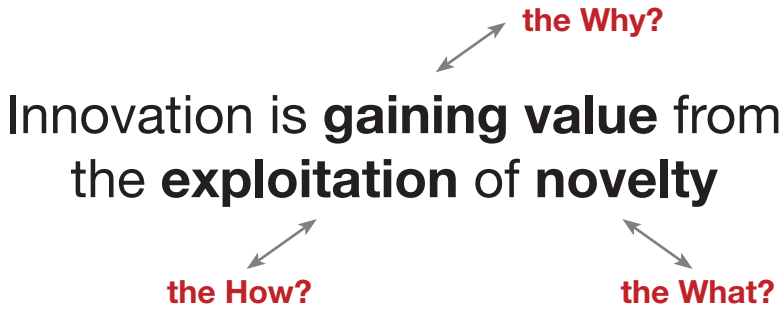
Executive Summary

Almost everyone has an opinion about innovation, yet its breadth as a concept makes it difficult to define and even harder to implement. With the launch of the Defence Innovation Initiative in 2016 the UK has taken steps to improve the delivery of innovation; however we observe, 12 months later, there remains a lack of systematic understanding of what innovation is and how it should be implemented. To address these shortcomings through this paper we seek to demystify the term 'innovation' by describing its key features. We go on to recommend how it might be implemented through the establishment of a Defence Innovation System that is mapped onto the existing capability development cycle.

The key recommendation of the paper is:

> **To enable successful Defence Innovation an Enterprise-level Defence Innovation System should be designed, developed and implemented (across MOD and its supply chain) to generate and deliver improvements over existing piecemeal approaches.**

For the purposes of this paper we define innovation as *gaining value from the exploitation of novelty*. Our definition of innovation is deliberately high level, as this helps reveal the *why, what* and *how* questions that need to be considered when designing a system of innovation.



The reason '*why'* we innovate is to gain value. Here we refer to value in the broadest sense of the word, which might be measured through reduced cost, time or risk, or through increases in performance, efficiency, resilience or agility, amongst others. Rigidly defining value at this stage is unhelpful, as value will vary dependent upon individual perspective and circumstance. What is important is the acceptance that innovation has only occurred once value has been realised.

The '*what'* concerns the generation of novel ideas or, more likely, the combination of existing ideas in novel circumstances. Ideas are not constrained to technology or products; essentially they should be unbounded and will apply equally to processes, organisation, management, market, business model or operations. Innovation should not therefore be confused with research and development or invention as these are only contributors to a much larger enterprise.

The '*how*' of innovation involves the exploitation of novelty requiring change. Despite the alarming simplicity of this statement, it is during this stage that most attempts to innovate fail. The reasons for this are generally well understood and are referred to in this paper as frictional issues, which include a lack of awareness, the unavailability of resources, incoherence of the system elements, or insufficient motivation/rewards. Approaches to reduce their impact are discussed in the paper and are incorporated in the proposed Defence Innovation System design.

The Defence Innovation System is a Human Activity System, which requires a focus on people, rather than technology. A human-centric innovation system requires a culture that values vision, creativity and transformational skills, along with the wherewithal to identify novel ideas/novel combinations, the planning and delivery of change, and the realisation of the value inherent in each innovation through transformation.

A successful Defence Innovation System must be sensitive to the temporal and dynamic issues affecting innovation, as each innovation requirement has its own timescale, as does each innovation response. Hence, time, or more precisely the time constant of change within an innovation cycle, is inevitably a driving factor in the selection of innovation approaches. The proposed system acknowledges this fact and responds by making the Operate Function within the Defence Operating Model the focus of innovation, whose needs are used to establish the innovation 'drumbeat' and the subsequent design of end-to-end innovation pathways.

We argue that innovation should be part of the day-to-day processes of Defence and believe that allowing innovation to be viewed as an 'initiative' that is separate to the mainstream activities of the Enterprise risks failure, as history has shown the difficulty associated with meshing new ideas with traditional ways of working. Put simply, making an enterprise innovative requires the enterprise to become systemically innovative; it is not enough to build a façade of innovation and leave the underlying establishment unchanged. We suggest that the required changes are predominantly behavioural, not structural; they are achievable but only if the will for change exists. To deliver this, cultural change is required across all of the Defence Operating Model (DOM) Functions, including industry, and therefore its implementation requires leadership at the highest levels of the Enterprise. The benefits of this should be measurable through more agile capability provision and increased productivity, prosperity and exports.

We are under no illusion that transformation of such scale will be easy or quick. Nonetheless, we believe the introduction of an Enterprise-level Defence Innovation System is pragmatic and achievable, as it is designed to seamlessly integrate with the existing capability management and acquisition approaches. We therefore regard it as a real world solution.

Within this document the proposed Defence Innovation System is more fully explained, though in summary it can be thought of as a system that:

- Is Enterprise-wide, is readily extensible and comprises public and private sector capabilities;
- Contains all of the elements required to deliver end-to-end innovation;
- Is open and makes no distinction between 'traditional' defence and non-defence competencies;
- Is pragmatic and tailorable through the use of bespoke innovation pathways designed specifically around a range of pre-identified innovation models and organisational constructs for each individual instantiation of innovation;
- Is designed to deliver and measure value from the perspective of the Operate Function;
- Embodies strong and vocal leadership that acts to establish a common direction, to create pressure for change and to make available the necessary resources.

Setting conditions that create a permissive innovation environment is a challenge for any organisation – doing so at the scale of an enterprise can only magnify the difficulty. For this reason, we argue that the Defence Innovation System should be centrally designed, owned and orchestrated, though the activities that flow through the system should be subject to localised control and pathway selection, such that they can be designed to meet specific local needs.

We view this methodology as aligned to the principles of Mission Command where high-level intent flows down through the organisation, whilst the methodology of how to implement is left to local discretion. As such, it is already familiar to the Defence community and readily adoptable; however, experience and good practice suggests a delegated approach works best when supported by *awareness* of the need for change, the *desire* to make it happen, the *knowledge* of how to change, an *ability* to implement new skills and behaviours, and *reinforcement* to retain the change once it has been made.

Throughout this paper, insights and recommendations are collated to define a set of high-level concepts and principles for the Defence Innovation System. An Innovation System Design Framework is also derived and defined, incorporating the concepts and principles, to enable a more detailed design of the Defence Innovation System.

These concepts and principles, and the analysis underpinning them, are commended to the Defence Enterprise as the foundation for the holistic design of its Innovation System. However, we see no reason to believe that similar principles and methods would not apply to other complex enterprises.

1 Introduction

Overview

Anyone who has spent time contemplating innovation will appreciate that it is a highly contested term, which means different things to different people. The very mention of the concept can stir strong emotions, making it difficult to achieve consensus and to agree strategies for its implementation.

For those with the time and inclination to look, there is no shortage of advice about innovation. However, because much of this advice has been written from the perspective of commercial and consumer markets, it is sometimes difficult to assess its applicability to the challenges of public sector innovation, let alone to the challenge of innovating within the specific constraints of UK Defence.

At a time when MOD is actively examining its approach to innovation, this paper seeks to demystify the basic concepts and, by using insights and evidence from Niteworks, academic research and experience from other sectors, to suggest how Defence might implement innovation more readily. The proposed approach is based on the design and implementation of a *Defence Innovation System*[1].

We define the purpose of the Defence Innovation System as being the delivery of *end-to-end innovation*, by which we mean that an idea leads to change, which in turn delivers value. Recognising that ideas can occur anywhere within the Enterprise, we believe that the end-to-end innovation lifecycle must be embedded within extant processes across the whole Enterprise and not considered separately or in a piecemeal way. In other words, innovation must be inseparable from routine activity.

A key design objective for the Defence Innovation System is to maximise the value delivered by innovation activity. Increasing value can happen in one of two ways: growing the number of ideas; or increasing the probability that ideas will be successfully exploited to deliver value. Whilst both measures are important, no idea will realise value if exploitation is not achieved, which is therefore the focus for this paper.

Purpose of the paper

In the paper we explain the multi-faceted nature of innovation and make the case for the introduction of an Enterprise-wide Innovation System to underpin the delivery of the nation's Defence innovation goals. We describe the key features of such a system and discuss how the existing innovation landscape might be transitioned towards the Enterprise-wide System that we term the Defence Innovation System.

1 Wilkinson, M. & Jewell, S.D. (2017) Defence requires Enterprise-Level Innovation: Using a Systems Approach to secure superior Value from Ideas, 27th International Symposium of the International Council on Systems Engineering, Adelaide.

Context

The catalyst and context for the paper is the debate within the UK Defence Enterprise on the use of innovation to accelerate the provision of operational capability, enabled by the democratisation of information and technology[2] and stimulated by the use of disruptive approaches by state and non-state actors in the development of their own military capabilities. This is set against the backdrop of the increased tempo of technology maturation, driving towards ever shorter timescales, and the countervailing rise in systems complexity that leads to an increase in the time taken to field military capability through the traditional acquisition system.

These challenges were clearly set out in the Strategic Defence and Security Review (SDSR) 2015, which regards innovation as essential to securing operational advantage, for controlling costs and to respond quickly to transformative ideas and technologies.

In response to the SDSR, MOD launched the Defence Innovation Initiative (DII) sponsored by the Secretary of State for Defence, which has led to the formation of the Defence Innovation Advisory Panel (DIAP), the establishment of the Innovation and Research InSights (IRIS) unit, the Defence and Security Accelerator (DASA), and the creation of an £800m (over ten years) Defence Innovation Fund, supported by a number of early stage innovation calls. In parallel, the Commands, DE&S and Dstl have launched their own innovation strategies, to the point where a recent MOD study[3] identified over 200 people working on various innovation initiatives across the Department.

In 2017, the Future Force Concept[4] was published, which builds on the SDSR direction, setting out the requirement to enhance joint action by exploiting information better, being more integrated as a force, and being more adaptable to changing circumstances. It identified the importance of ideas to the Defence Enterprise in the context of a future force that is fully integrated across the Defence Lines of Development (DLOD). This statement highlights the importance of an Enterprise-wide Defence Innovation System.

Also in 2017, MOD commissioned a study[3] to review its approach to innovation and to make recommendations on the way forward. Whilst the report itself is not planned for general release, the key findings are understood to include:

- The distinction between *Innovation* and *Transformation* needs to be more clearly understood and managed;
- MOD needs a process of prioritisation, such that innovation should:
    - Be for a clearly identified Client;
    - Always lead to outcomes that are either cheaper, quicker or both;
    - Not ‘compete’ with existing global capabilities, but focus on UK expertise;
    - Have impact within five years;
    - Support prosperity;

2 Friedman, T.L. (1999) The Lexus and the Olive Tree: Understanding Globalization, New York: Random House.

3 Study undertaken by Kris Murrin CBE, member of the Defence Innovation Advisory Panel.

4 DCDC (2017) Joint Concept Note 1/17 Future Force Concept, UK MOD: Development, Concepts and Doctrine Centre.

- The process of Innovation needs coordination; it must penetrate the core programme and not be a peripheral activity;
- MOD should make its innovation community more coherent;
- There should be closer pan-government coordination and cooperation including innovation leadership.

This paper acknowledges and is aligned with the SDSR, the DII and the recommendations of the Murrin report[3]; we believe that the introduction of a Defence Innovation System will help realise the goals set out within these initiatives.

International experience

The UK is not alone in reviewing its approach to defence innovation. Despite the US spending an estimated $72 Billion each year on the DoD R&D ecosystem, Jeffrey Bialos in his exploration of US defence innovation[5] described the current DoD ecosystem as:

> …inherently change-resistant to the introduction of new and innovative capabilities. DoD employs antiquated, cumbersome and slow R&D and procurement processes, and has demonstrated, time and again, an unwillingness to employ legally available non-traditional contracting and business alternatives – despite numerous calls for change by DoD leadership, Congress, business, and think tanks.

Whilst such criticism is harsh, it is consistent with the US DoD's own Defense Innovation Initiative[6] and launch of the Third Offset Strategy (TOS) by the US Secretary of State in 2014, which identified the demand for innovation and the need to become more efficient in development and fielding. Although the change in US Administration may mean the TOS is not taken forward as an identifiable programme, the enduring nature of the challenge it addresses makes it likely that similar actions will be progressed under different labels. The US experience demonstrates that scale and money in isolation are not solutions in themselves.

The consequence to the UK of the US TOS is explored in a RUSI Occasional Paper[7], which recommends, in the light of US experience, that the MOD should establish a greater appetite for risk; manage innovation on a programme-by-programme basis; work more closely with the private sector; and ensure that innovation is a guiding principle for capital investment.

The Australian approach to innovation was set out in the 2016 Defence White Paper and supported by the 2016 Integrated Investment Program and the 2016 Defence Industry Policy Statement. A review conducted in 2016 of the Australian Innovation, Science and Research System[8] found that despite above average knowledge creation and world-class

5 Bialos, J.P., Fisher, C.E., & Koehl, S.L. (2017) Against the Odds Driving Defense Innovation in a Change-Resistant Ecosystem, Washington DC: The Paul H. Nitze School of Advanced International Studies. http://transatlanticrelations.org/wp-content/uploads/2017/05/Against-The-Odds-Driving-Defense-Innovation-in-a-Change-Resistant-Ecosystem-Final.pdf

6 Hagel, C. (2014) The Defense Innovation Initiative, Secretary of Defense Memorandum. http://archive.defense.gov/pubs/OSD013411-14.pdf

7 Louth, J., Taylor, T., & Tyler. A. (2017) Defence Innovation and the UK – Responding to the Risk Identified by the US Third Offset Strategy, RUSI: RUSI Occasional Paper. https://rusi.org/sites/default/files/defence-innovation-july2017.pdf

8 DST (2016) Performance Review of the Australian Innovation Science and Research System, 2016, Defence Science and Technology (Australia). https://industry.gov.au/Innovation-and-Science-Australia/Documents/ISA-system-review/Performance-Review-of-the-Australian-Innovation-Science-and-Research-System-ISA.pdf

research infrastructure, there was a need to improve collaboration between research organisations, business and government procurement in order to foster innovation. Few would argue that such findings do not equally apply to the UK. We again argue that the approach set out in this paper is consistent with the learning from the US and Australia.

Structure of the paper

After this brief introduction the paper divides into four further sections:

Section 2	Seeks to demystify innovation as a concept by understanding its various definitions and looking at key topics arising in delivering end-to-end innovation. The topics considered include timescales and dynamics, open innovation, the role of demand and entrepreneurism.
Section 3	Looks at innovation as a system and explores the features of the existing innovation landscape before identifying the types of innovation model found across the Defence Enterprise.
Section 4	Describes the working of a Defence Innovation System, drawing on experience to derive insights on its desirable features and principles of design.
Section 5	Sets out recommendations for the steps needed to implement the Defence Innovation System.

Why read this paper?

Innovation activities have impact across the whole Enterprise and the active participation of the Direct, Enable, Acquire and Generate & Develop Functions[9] (underpinned by industry and academia) will be required to deliver effective end-to-end innovation. Throughout, this White Paper has been written from the perspective of the Operate Function as we believe it is there that the value of innovation should be realised and assessed.

Change on this scale represents a significant transformation that will only be achieved through strong leadership and commitment at all levels and areas of the Defence Enterprise. We believe that the benefits of such a transformation far outweigh the effort needed for its introduction and that the long term advantage of a healthy Defence Innovation System will reap benefits through the generation of more agile capabilities, will enhance export potential, and will bring a vibrancy to Defence that will attract the best and most talented to serve and work within the Sector into the future.

Of course, we do not claim that this paper contains all of the answers to the challenge of innovating within the Defence Enterprise. We hope, however, that decision makers with the ability to deliver the necessary changes to the innovation landscape will find the paper's analysis of innovation and the proposed Defence Innovation System both compelling and motivating enough to take forward within existing plans.

9 Described in the Defence Operating Model, Section 3. Figure 2.

2 Demystifying Innovation

Introduction

This section provides an essential foundation for understanding the principal concepts of innovation and how they relate to the Defence Enterprise; these ideas underpin the developments described in later sections. The section begins by analysing various definitions of innovation found in the literature and proposes our own synthetic definition suitable for use in the context of the Defence Innovation System. The section moves on to consider several key topics that must be addressed in the design of the Innovation System, including timescales and dynamics, open innovation, the role of demand and entrepreneurism. Where relevant, insights from the literature and from Niteworks' experience are noted and are collected together under the Findings heading at the end of the section.

Historical Perspective

Girard[S1] noted that between the sixteenth and eighteenth centuries in theology, "innovation is practically synonymous with heresy", and "In politics, innovation is almost tantamount to rebellion and revolution".

Being called an innovator in Elizabethan England was not intended as a compliment, Francis Bacon observes in his 17th century essay, Of Innovation: "It were good, therefore, that men in their innovations would follow the example of time itself; which indeed innovateth greatly, but quietly, by degrees scarce to be perceived."

S1 Girard, R. (1990) Innovation and repetition. *Substance.* 19, No.2/3(62/63) pp.7.

Defining innovation

Innovation is undoubtedly a problematic term that defies simple definition. Dictionaries fail to do justice to the subject's breadth, and the fact that no dominant definition has emerged in the literature, despite centuries of attempts to create one, demonstrates the difficulty associated with capturing a universally accepted meaning (see Historical Perspective sidebar).

A few examples of available definitions illustrate this dilemma. The Organisation for Economic Co-operation and Development defines innovation from a *commercial* perspective as:

The implementation of a new or significantly improved product (good or service) or process, a new marketing method, or new organisational method inbusiness (sic) practices, workplace organisation or external relations[10].

Baregheh et al[11] propose a definition, itself an amalgam of over 60 prior definitions, which typifies the genre from a *process* perspective:

10 OECD (2005) Oslo Manual Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition. OECD and Eurostat joint publication. http://www.oecd-ilibrary.org/docserver/download/9205111e.pdf?expires=1506514283&id=id&accname=guest&checksum=95CD0BFB10AC79728DA1A569E2074978

11 Baregheh, A., Rowley, J. & Sambrook, S. (2009) Towards a multidisciplinary definition of innovation. Management Decision. 47(No. 8) pp.1323-1339.

> Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace.

MOD's definition of innovation contained within the Strategic Defence and Security Review[12] adopts a *problem solving* perspective:

> [Innovation is] generating ideas and putting them into practice to overcome challenges and exploit opportunities.

The difficulty with these and similar definitions is that they are only valid from a specific perspective, which narrows their utility. As a consequence, when innovation is discussed, the desire to reach consensus on a single definition typically proves divisive, and in our experience, tends to further divide and entrench opinions.

This leaves a dilemma, one that has long troubled entrepreneurs (that enigmatic breed described by the economist Schumpeter[13] as agents of innovation delivery): how to communicate something that defies simple definition? We suggest the solution to this is to first choose to answer the strategic question *why* innovate, leaving the tactical *what* and *how* of innovation to specific instantiations, when detailed narratives can be appropriately tailored.

In our own search for a strategic rationale for innovation, analysis of multiple definitions of innovation in the literature led us to three commonly recurring themes, namely *novelty*, *change* and the delivery of *value*. Based on these themes, it follows that successful innovation is the introduction of novelty that results in change that delivers value (where value is a measure of usefulness and cost-effectiveness). At its most rarefied therefore *Innovation is gaining value from the exploitation of novelty* (Figure 1).

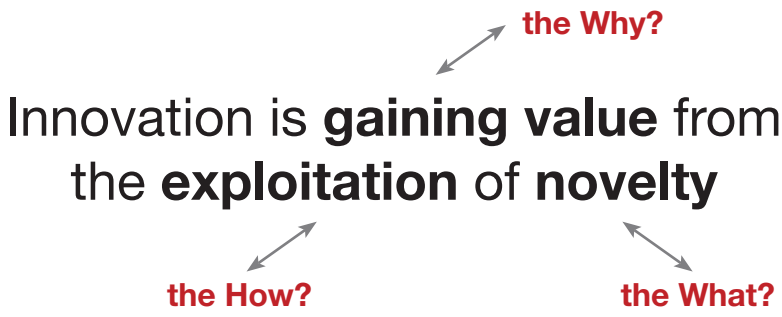


Figure 1: Definition of Innovation

This definition allows for innovation to arise from any kind of novelty, including product, process, market, organisation or operation. It also embraces the adoption of mature concepts, processes and technology from external sources into the Defence environment. Despite its limitations as a definition, it sets out our expectation for the Defence

12 HMG (2015) National Security Strategy and Strategic Defence and Security Review 2015. (CM9161) London: Her Majesty's Stationary Office.

13 Schumpeter, J.A. (2012 [1934]) The Theory of Economic Development, (Sixteenth printing) New Jersey: Transaction Publishers, p.89.

Innovation System and provides a point of reference against which a systems design can be tested.

In Section 3 and 4 we go on to discuss the features of such a system before turning in Section 5 to discuss how it might be operationalised. Before this, however, we consider in more detail why innovation is so often seen as challenging and why many ideas fail before they reach the stage when they could deliver value.

Why is innovating difficult?

Organisations and individuals within a cooperative enterprise like Defence are typically challenged by both the *novelty* and *change* associated with innovation. Analysis by Christensen[14] showed that it was not ignorance or a failure among practitioners to see potential in new ways of doing things that led to a lack of innovation, rather it was a wilful decision to forego the opportunity and stick to the current path, thereby exhibiting 'downward vision'[15]. As a result, companies and their customers often unwittingly conspire to maintain their existing trajectory.

To understand this fully it is necessary to differentiate between ideas that *sustain* and those that *disrupt*. Sustaining ideas incrementally improve what has gone before and make things better. Disruptive ideas may deliver worse performance, at least in the short-term, but offer a different value proposition and have greater potential for the long term (see Disruptive Ideas sidebar). Both approaches are therefore valid but it is often easier to implement a sustaining idea over a disruptive idea as sustainment follows the course of least resistance. Even so, at some point the ability to continue to make gains incrementally through sustainment reaches the end of its potential and there is a requirement to move to a new solution. The failure to do this in a timely manner can represent an existential threat to a market, organisation or business.

Disruptive Ideas

Kodak dominated the photographic film market for most of the 20th century. Despite inventing the digital camera in 1975 it exited the digital camera market in 2013, selling off many of its patents to its competitors in the process. Kodak was late to react to the threat posed by digital cameras to its film business. Early digital cameras did not offer the same quality or practicality as film and the virtual absence of mobile phones, home computers and printers meant that their usefulness was restricted and niche at that time.

So innovation is all about better ideas, right?

Well, no. As novelty closely links to the creative process and the generation of ideas, there is a temptation to think that the solution to innovation is simply to generate more or better ideas; however, as Keeley et al[16] point out, such approaches have a 95%

14 Christensen, C.M. (1997) The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston, Massachusetts: Harvard Business Review Press.

15 ibid p24

16 Keeley, L., Pikkel, R., Quinn, B. & Walters, H. (2013) Ten Types of Innovation, the Discipline of Building Breakthroughs. Hoboken: John Wiley & sons.

Parable of the Sower

The well-known 'Parable of the Sower' provides a good metaphor for innovation. In the Parable, seeds that fall on stony ground, fall among weeds or are eaten by birds do not develop. Only those that fall on fertile ground, are tended by the farmer, and have sunshine and water bear fruit. In the metaphor, the seeds are ideas, the water and sunshine are essential resources and the tending is everything else that must be done for the realisation of value (fruit).

failure rate. Drucker[17] similarly observes that no more than 1% of patents earn enough to pay back development costs and patent fees. Having good ideas is important but this should be thought of as the beginning of the innovation lifecycle, not its conclusion or even its main focus – the hard work is yet to come (see Parable of the Sower sidebar).

Most readers will recognise the fashion for organisations to respond to innovation needs by opening their own 'innovation centres', usually replete with Post-it® notes and brightly coloured bean bags. There is, of course, value in having purpose-built environments designed to inspire better ideas but unless they are part of a systemic approach that has appropriate mechanisms and behaviours to underpin the delivery of innovation, and the linkages to realise value as part of an end-to-end system, the evidence[16,17] suggests that such approaches are destined only to result in failure.

Combinations

Digital photography is a good example of where the combination of ideas has helped form new capabilities. Without the combination of home computers, desk-top printers and a digital camera, or the mobile phone with an embedded camera, it is doubtful that digital photography would have become so ubiquitous.

With hindsight such combinations are obvious; the innovator's challenge here was to have the vision to see how existing things combine in novel ways. This can be as demanding as thinking of a new idea itself and requires an extensive awareness of the external environment.

Closed and open innovation

So far we have only discussed the concept of individual ideas. To Schumpeter[18] however, innovation was less about single ideas and more about *combinations* that unite existing ideas/inventions in new forms that are themselves novel (see Combinations sidebar). This approach links strongly with the concept of the diffusion of innovation[19], where ideas from an external environment are adopted and brought into a target innovation system.

17 Drucker, P. F. (2011) Innovation and Entrepreneurship Practice and Principles, Abingdon: Routledge, p.118.

18 Schumpeter, J.A. (2012 [1934]) The Theory of Economic Development, (Sixteenth printing) New Jersey: Transaction Publishers, p.89.

19 Rogers, E.M. (2003) Diffusion of Innovations. (5th Edition) New York: Free Press.

Where this is the case, the focus of innovation naturally moves away from creating ideas towards creating novel combinations and their exploitation, placing at least equal emphasis onto *managing change* and delivering *value*.

In his seminal work, Chesbrough[20] explores the relative advantages between internally developed ideas (closed innovation) versus the infusion of ideas from outside (open innovation). Whilst he observed that both models are viable (or the combination thereof) he suggests that an entity faced by resource constraints and/or where more knowledge and talent exists outside rather than within the entity, an open innovation approach is more beneficial. In such cases, emphasis needs to be placed on accessing ideas rather than generating ideas. Whilst this is conceptually simple, creating an environment and culture that is capable of open innovation is elusive and requires considerable effort.

Open Innovation

Whilst much of the discussion on Open Innovation tends towards accessing external capabilities and leveraging external competences, the concept applies equally to external routes to exploitation. Such thinking requires the development of novel pathways through which capability can both be developed and exploited.

A frequently cited example of successful open innovation is the transformation achieved by the consumer goods conglomerate, Procter and Gamble (P&G). Huston and Sakkab[21]describe the challenge, set in 2000 by P&G's then CEO, to reinvent its business innovation model and to acquire 50% of its innovations from outside the company. Under the brand *Connect & Develop,* which replaced the traditional *research* terminology with *connect,* emphasising the requirement to source external ideas, P&G successfully shifted its approach from internal research and technology to a model that identified external ideas and innovations through collaboration (see Open Innovation sidebar).

The P&G example is not unique. Hall and Janman[22] describe how in 2000, Goldcorp, a Canadian mining company, released previously confidential company geological data to the external environment and challenged the global community through competition and the allure of a prize to identify the location of gold deposits in the company's Ontario mine. Frustrated that the in-house geologists appeared to be out of ideas, and after listening to an MIT lecture on Linux open source software, the then CEO drew inspiration from the belief that if an operating system could be developed through what we now know as crowd sourcing, then similar novel possibilities existed for Goldcorp. The response was overwhelming and the result turned around the company, yielding 110 sites, 50% of which were previously unknown, that in more than 80% of cases yielded significant gold reserves.

20 Chesbrough, H. (2003) Open Innovation the New Imperative for Creating and Profiting from Technology. Boston, Mass.: Harvard Business School Press.

21 Huston, L. & Sakkab, N. (2006) Connect and Develop: Inside Procter and Gamble's New Model for Innovation, March 2006 issue, Boston: Harvard Business Review.

22 Hall, T. & Janman, K. (2010) The Leadership Illusion – The Importance of Context and Connections, Basingstoke: Palgrave Macmillan.

Our own experience within Niteworks, particularly through the Brockworks programme[23], has shown that innovation within Defence is far more easily and rapidly achieved when it is based on open innovation principles using new combinations from existing, external sources, rather than relying on the generation of novelty from research. This is not to denigrate or negate the value of research as this remains a key source of invention. It simply recognises the differences between the two approaches and the importance of agile solutions, a subject to which we now turn.

Temporal and dynamic effects across the capability and innovation lifecycles

Whilst ideas and the sources of ideas are important, our experience in Niteworks is that so too are the temporal and dynamic issues affecting innovation, as each innovation requirement has its own timescale, as does each innovation response. So time or, more precisely, the *time constant for change within an innovation cycle*, is inevitably a driving factor in the suitability of an innovation approach for a specific problem, in the context of a specific capability. Furthermore, the various potential innovation approaches must be correlated with the particular needs of the stages of the capability lifecycle. In particular, for the designer of an innovation system it is both a blessing and an inconvenient truth that the formation of ideas or concepts is 'non-linear', that is to say ideas can (and should) appear at any point in the end-to-end capability lifecycle. It is therefore important to avoid conflating research & development (R&D) with innovation as if they were one and the same. Whilst R&D can lead to innovation, and R&D processes can be conducted innovatively, it is unproductive for an organisation to see innovation solely through this optic. (See Temporal Demands sidebar.)

Temporal Demands

An innovation system must be capable of delivering disruptive and sustaining innovation, whilst satisfying the temporal demands of long, medium and fast spin technologies and capabilities. This requires the adoption of the correct innovation models, constructs and connectivity to ensure ideas realise their value within the innovation target.

The innovation system itself must therefore accommodate the fact that some capabilities are focused on future needs that require basic research to be undertaken, whilst other capabilities, such as those addressing a current operational capability shortfall, are much more pressing, demanding a more rapid response. Inevitably, in such cases, there is little opportunity to undertake meaningful research, and innovation must be focused on working with what already exists or can be quickly modified. As a result we should not be surprised that an innovation system requires multiple pathways exhibiting different qualities in order to support different requirements. Another way of making this point is to note that Defence is an enterprise executing enterprise-level processes; it therefore requires an enterprise-level innovation system accommodating multiple pathways that are themselves sensitive to the different timescale requirements.

23 Brockworks is a rapid prototyping concept and environment developed to support ISS demonstrate agile solutions to systemic problems (see http://www.niteworks.net/case-studies/brockworks-mar-17)

Innovation lifecycles are strongly dependent on the types of technologies and/or processes involved – with information technologies and telecommunications being notorious for near-continuous change, giving rise to a need for near-continuous innovation. It seems fairly clear that a Science & Technology (S&T) focused innovation approach (with a commensurately long duration end-to-end innovation journey) is not well matched to a pseudo-continuous drumbeat-driven operations/innovation lifecycle, where agile approaches such as DevOps[24] might be deployed. In such instances the logical location for the innovation system is to be fully integrated with the operational capability (as described in the Niteworks Continuous Capability Evolution White Paper[25]); typically in such cases a focused innovation hub or similar construct would be established as part of the operational capability.

Conversely, long-cycle research is also needed, and innovative ways of delivering this, such that long, medium and short-spin lifecycles can be meshed and delivered coherently, is another valid approach that must be accommodated within the system. (There is a risk that the current preponderance of digital technologies and their fast-spin properties distracts attention from the need for innovation in other, more traditional, disciplines where the timescales are often longer.)

When Drucker[26] observed, ”don’t try to innovate for the future, innovate for the present”, he highlighted the clear distinction between research and innovation. One advantage of identifying existing ideas that form new combinations, over developing new ideas internally, is the reduced time and cost compared with developing from new. Whilst in most cases this will not eliminate the need for development altogether, the relative maturity of the underpinning elements allows development to be focused on integration. Our experience of the Brockworks programme within Niteworks has shown repeatedly the advantage of combining the ideas of multiple companies with MOD’s own ideas, and it has allowed the rapid integration of new capability using spiral developments that take months rather than years.

It follows that to manage differing requirements effectively, the innovation system needs to use a range of innovation models each optimised for a specific purpose, which itself generates the need to ensure coherence between the models to enable the system to achieve end-to-end innovation. Our research identifies twelve such innovation models being used in the generation of Defence capability. These models and how they should be linked together as part of the Defence Innovation System are discussed in greater detail in Section 3.

The importance of supply and demand to innovation

Rothwell[27] identified five generations of innovation within Western and Japanese economies through which companies sought to vertically and horizontally integrate

24 DevOps = the conflation of Software Development & Information Technology Operations

25 Wilkinson, M. (2014) Continuous Capability Evolution – A Practical Approach to the Acquisition of Modern Defence Capabilities, Niteworks White Paper June 2014. http://www.niteworks.net/~/media/Files/N/Niteworks/documents/content/White-papers/NWP%20-%20Continuous%20Capability%20Evolution.pdf

26 Drucker, P. F. (2011) Innovation and Entrepreneurship Practice and Principles, Abingdon: Routledge, p.124.

27 Rothwell, R., (1994) “Towards the Fifth generation Innovation Process”, International Marketing Review, Vol. 11 Issue: 1, pp.7-31, https://doi.org/10.1108/02651339410057491

in-house activities with those of their suppliers and customers and link *supply* with *demand*. Although each model was introduced consecutively in the period following World War 2, each generation is distinctive, rather than hierarchical, being tailored to specific market circumstances. Rothwell's five generations are *Technology Push, Market Pull, Coupling, Integrated* and *System Integration, and Networking*.

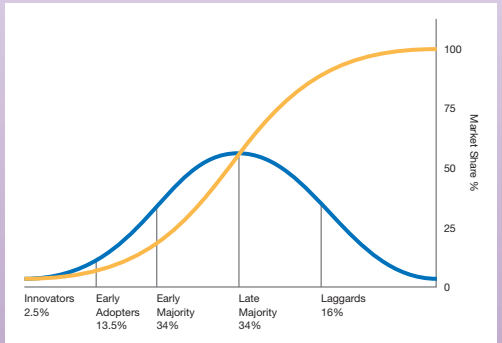
Ultimately the choice of model needs to match the nature of demand. For example, *Technology Push* works when customers are willing and able to pay to adopt new capabilities, whereas *Market Pull* requires the developer to correctly interpret the market's demand signals and to hit a price point that the consumer is willing to pay. *Coupling*, *Integrated* and *System Integration and Networking* all assume an increasingly complex and intimate relationship between supply and demand. Whilst Rothwell's generations specifically refer to product innovation (distinct from process, business or market innovation), understanding his work is important to understanding the challenge of Defence innovation.

Whilst it is not possible to characterise the whole of Defence into one generational model, the language of the SDSR and DII suggest it is closer to third generation *Coupling* than any other. Coupling blends the new needs of society with the state-of-the-art in technology and production and from this an understanding of the way forward is developed. This model first emerged during the early 1970s when supply in the UK economy generally outstripped demand, inflation was high and demand stagnant. During this period the focus turned to cost control and cost reduction during an era of consolidation and rationalisation. Rothwell noted that the success of the model relied heavily upon key individuals with strong personal commitment to innovation.

Coupling requires both the supply-side and demand-side to fulfil their respective roles. For industry, this means a preparedness to invest, for MOD, the willingness to adopt the outcomes of the investment. In the language of Rogers[28] this means MOD being prepared to act as an innovator or early adopter (see Diffusion of Innovations sidebar).

Diffusion of Innovations

Rogers'[S2] work on the diffusion of innovations provides a framework that shows the importance of different categories of adopters ranging from innovators, early adopters, early majority, late majority and laggards.



S2 Rogers, E.M. (2003) *Diffusion of Innovations.* (5th Edition) New York: Free Press.

28 Rogers, E.M. (2003) Diffusion of Innovations. (5th Edition) New York: Free Press.

In both cases, confidence and trust are required. Here, however, it is an uncomfortable truth that investment confidence has fallen in recent decades as R&D has halved since 2002, with research falling by 27% and development by 56%[29]. Today's research system lacks the incentive to stimulate speculative investment at scale.

Attempts over the years to shift the responsibility for investment back to industry have, in the view of the authors, been largely unsuccessful due to failure to properly link research outcomes with the acquisition process. Simply put, it has been too difficult to make a return on investment and to make a compelling business case as a result.

This dilemma, which is at the heart of the innovation conundrum, can therefore be summarised as 1) downward vision, 2) lack of demand, 3) lack of capacity (beyond the committed plan), 4) lack of trust and entrepreneurial spirit, and 5) the absence of an innovation system with coherent innovation pathways. Such issues are examined further in Sections 3 and 4.

Whilst this appears to provide a bleak assessment, we remain optimistic that the underlying competences of a Defence Innovation System already exist within the UK. We do not believe that the solution lies in new money or radical reorganisation, but, as described in later sections, it can be achieved through the application of systemic effort to understand, educate, link and align the elements of the system, and by the freeing of the entrepreneurial spirit that continues to exist and that we witness throughout Defence on a daily basis.

Becoming an entrepreneurial organisation

For the reasons outlined so far in this paper, being serious about innovation requires making it part of everyone's day job. We observe within MOD and industry the temptation for organisations to hide behind a façade of activity, quick to announce the generation of new ideas and ventures, which become a shield allowing the rest of the organisation to carry on with business as usual (see Language of Innovation sidebar). Keeley et al[30] go further, describing the practice of separating out innovation into specialist units in the belief that this will lead to better ideas as "a thin effort to quarantine the crazies".

Language of Innovation

Machiavelli[S3] observed "… as new things disturb the minds of men, you ought to endeavour that these changes retain as much as possible of the ancient (forms)".

Machiavelli's advice is pertinent as the language of innovation can quickly become shrouded in obscure terminology of hackathons, ideation and co-creation, limiting its appeal and generating resistance.

The language of innovation should not be allowed to get in the way of its implementation.

S3 Machiavelli, N. (1517) *Discourses upon the First Ten (Books) of Titus Livy and Zanobi Buondelmonti and to Cosimo Recellai.* (Translated), p.47.

29 Louth, L., Taylor, T. & Tyler, A., (2017) Defence Innovation and the UK – Responding to the Risks Identified by the US Third Offset Strategy, Whitehall: RUSI.

30 Keeley, L., Pikkel, R., Quinn, B. & Walters, H. (2013) Ten Types of Innovation, the Discipline of Building Breakthroughs. Hoboken: John Wiley & sons, p. 2.

We have already said that creating ideas is not innovation and should not be celebrated as such – ideas should only be classed as contributing to innovation when they have released their value within a target system. It is important therefore that innovation is seen as more than a public relations exercise, as its absence risks fatally wounding a commercial organisation, or undermining the ability of a government department to discharge its responsibilities.

Drucker points out that successful entrepreneurial organisations are that way because "[t]hey are disciplined about it … they work at it … they practise it"[31]. We would say that such organisations go beyond having a *culture of innovation* to having a *system of innovation* that is entrepreneurial by design and is capable of delivering the organisation's to-be culture. Keeley et al define innovation capability as "an institutional ability to innovate reliably and repeatedly over time"[32] and they identify the four components of innovation capability as approach, organisation, resources and competences, placing emphasis on the need for the whole enterprise to commit to multi-functional engagement and leadership to overcome inertia and the fear of change. This is one of the main reasons that in this paper we choose to view innovation through the optic of the Operate Function, as this best represents the coming together of the components of innovation and is from where value should be realised and measured.

To achieve this at an enterprise level, innovation needs to be viewed as something that is inseparable from normal business and pervasive to the whole enterprise, on an enduring basis. In the case of Defence, this means understanding innovation across both public and private sectors; we call this the Defence Innovation System and go on to describe its elements and formation in the remainder of the paper.

Establishing a coherent system, in which innovation is conducted as normal business, requires that policies having influence over one or other part of the system must be conceived and implemented with as complete as possible an understanding of their consequences on the other parts of the system. Furthermore, policies require ongoing review and measurement such that they can dynamically change over time. It is suggested that historic efforts to do this have failed to address the needs of the whole system and, as a result, neither the systemic thinking nor the essential underpinning culture exists. It is critical to Defence that steps are taken to address these shortfalls.

31 Drucker, P. F. (2011) Innovation and Entrepreneurship Practice and Principles, Abingdon: Routledge, p.138.

32 Keeley, L., Pikkel, R., Quinn, B. & Walters, H. (2013) Ten Types of Innovation, the Discipline of Building Breakthroughs. Hoboken: John Wiley & sons, p. 200.

Findings

Based upon the high-level thinking set out in this section, some early key findings can now be collated:

- Innovation can arise from any kind of novelty, including product, process, market, organisation or operation.
- Innovation is not exclusively about novelty, it also requires exploitation via change to realise value (from the perspective of the Operate Function) – we call this 'end-to-end innovation'.
- Both sustaining (incremental) and disruptive innovation are important – and they typically require different approaches.
- Innovation is achieved more rapidly and easily when it is based on open innovation principles using novel combinations rather than relying solely on research. However, research-driven innovation is also required to meet specific needs.
- Different stages of the capability lifecycle require different innovation approaches matched to their characteristics, including timescales for change.
- As Defence is a complex enterprise, it requires a matching Enterprise-level innovation system.
- Fast-spin (continuous) capability development can be delivered best by integrating the innovation system fully with the operational capability.
- Innovation within Defence currently approximates to Rothwell's *Coupling* model. We believe this has been frustrated as a result of downward vision, lack of demand, lack of capacity, lack of trust and entrepreneurial spirit and the absence of coherent innovation pathways.
- For the Defence Enterprise to become entrepreneurial it needs to regard innovation as part of everyone's responsibility and inseparable from business-as-usual.
- Policies on innovation must take into account the whole Enterprise.

Coming next

We turn now in Section 3 to describe how a systems perspective can be applied to gain greater understanding of the extant Defence innovation landscape before turning in Section 4 to discuss how the same perspective can be applied to the design and implementation of the Defence Innovation System.

3 Features of the Defence Innovation Landscape

Introduction

Having sought to demystify the concept of innovation and introduced the need for a Defence Innovation System in Section 2, in this section we adopt a systems perspective to understand the elements and features within the extant Defence innovation landscape. We start by setting out the general principles of innovation that inform the system perspective before characterising the landscape in greater detail and then in Section 4 going on to discuss its design and implementation.

Adopting a systems perspective

Anyone familiar with the Defence sector will know that it is a dynamic environment, consisting of many interlocking parts. Some of these parts are loosely coupled, some are tightly coupled – some interlock to good effect, and some seem to pull in opposite directions. To an external observer the whirring of the Enterprise can be impenetrable, even seemingly chaotic, yet from this complexity emerges a well-equipped, well-trained and highly regarded warfighting capability.

Hence, what we are describing here is a *system*, namely an organised set of parts with emergent properties that are more than merely the 'sum of the parts'. In fact, the Defence Enterprise is what is usually termed a system of systems, in which each of the parts is itself a system. If we focus just on the aspects of the Defence Enterprise that play a role in innovation, we can think of this as the Defence Innovation System (see Systems Perspective sidebar).

Systems Perspective

Whilst interest in innovation has increased in recent times, investigation of the relationship between innovation and Systems Engineering goes back several decades. Early thinking considered Traditional Systems Engineering (TSE) processes and how they related to simple innovation models. Walden[S4], for example, concludes that Systems Engineering and innovation are addressing the same basic process but from different perspectives. They can in principle be made harmonious, particularly in the context of incremental innovation/engineering. Other researchers[S5] recognise that innovation can occur at different levels, eg societal, and promote the use of Soft Systems Methodology to develop innovation strategies.

S4 Walden, D.D. (1998) *Innovation in the Context of Systems Engineerin*g, Proceedings of 8th Annual International Symposium of the International Council on Systems Engineering, Vancouver, BC.

S5 Stajnko, F. & Doukas, L. (2001) *Innovation and Soft Systems Engineering*, 11th Annual International Symposium of the International Council on Systems Engineering, Rochecouste, H.(ed.), INCOSE, Seattle.

Systems have several key features, which are fundamental to understanding how they work:

- Systems have an external boundary, which separates what is outside of the system (the environment) from what is inside. The 'external structure' of the system can be understood in terms of the cross-boundary relationships between the system and its environment (eg inputs/stimuli and outputs/responses). This is sometimes known as the 'black box' or 'emergent' view of the system.
- Systems also have 'internal structure', which defines relationships (including interactions) between the various parts of the system and how these contribute to the external (black box) view of the system. This is sometimes known as the 'white box' or 'glass box' view.
- The emergent properties of a system are generally not reducible to properties of the parts but depend on the parts, their relationships with each other and with the environment. Often a 'new language' is required to describe the emergent properties[33].

The idea of a specific 'Innovation System' is presaged in early work by Simpson[34] who considered innovation and technology management from a Systems Engineering perspective (see Innovation System sidebar). Although not using modern language, he identifies elements corresponding to the Target (System) of Innovation, the Target (System) Environment and the Innovation System itself. (Precise definitions are provided for these concepts below.) These ideas were developed further by Schindel[35] and co-workers in their definition of a System of Innovation. Schindel[36] also argues that system evolution and agility in innovation are related. He points out that detailed system configurations can be settled at different times – traditionally during design time, but increasingly in modern systems at later stages, including during operation. This multi-temporal nature of modern systems requires a commensurate time-diverse innovation system. In this paper we fully acknowledge the importance of timescales to understanding how innovation systems work. (See also the general considerations on dynamics introduced in Section 2.)

Inevitably, the scale and levels of connectivity complexity within the Defence Enterprise qualify it as a complex enterprise-level system[37]. As such it can

Innovation System

The term *innovation system* should not be interpreted as the imposition of a rigid innovation approach. The purpose of the system is not to constrain, rather it is to act as an enabler. Fundamentally, it establishes coherence between the elements of the Defence Enterprise such that ideas can traverse the elements and their value can be realised.

33 An example would be 'stopping distance' for a car. This is a complex property related to various static properties of the car, like its mass and design of the braking system, as well as dynamic factors such as how hard the brake was pressed and environmental issues like the condition of the road surface. 'Stopping distance' as a concept only makes sense when considering the whole car in its context.

34 Simpson, J.J. (2002) Innovation and Technology Management, INCOSE International Symposium, Volume 11, Issue 1.

35 Schindel, W.D. (2013) Systems of Innovation II: The Emergence of Purpose, 22nd Annual INCOSE International Symposium (IS2013)

36 Schindel, W.D. (2015) System Life Cycle Trajectories: Tracking Innovation Paths Using System DNA. INCOSE Vol.25, Issue 1 Oct 2015.

37 Holland, J.H. (2014) Complexity: A Very Short Introduction. Oxford: Oxford University Press.

be hard to say where the system boundary lies, because it can seem that everything connects to everything else. It is also not uncommon for the parts within a system to have multiple roles and/or connections with other parts, both inside and outside of the system. In practice, the Defence Innovation System will reach well beyond the UK and well beyond what we would normally think of as the Defence sector. As a result, not all parts of the system can necessarily be directly managed or controlled, but this is not to say that they cannot be harnessed for benefit.

Ecosystem

One useful way to think about complex systems is to draw on the understanding of biological systems, where the term *ecosystem* is used to define the system of interlocking communities of biological entities and their non-biological environment. Typically, an ecosystem will constitute a harmonious and dynamically stable whole, which is sustained over time. An important point is that perturbations to the dynamic stability are self-corrected by the non-linear feedback relationships between entities (parts) and their environment. A commonly cited model of such a situation is provided by the Lotka-Volterra[S6] equations, commonly known as the predator-prey model, where numbers of predator and prey oscillate to keep the overall system within dynamic limits.

Although natural ecosystems are robust to many changes, they are not invulnerable. For example the introduction of so-called invasive species can have disastrous consequences if there is no mechanism to counteract the effect of the species. Similar considerations apply to external influences, such as the impact of a large meteorite on planet earth, like the one thought to be responsible for the 'extinction event' that wiped out the dinosaurs.

S6 Sternberg, S. (2009) Lecture 15 Lotka-Volterra @ http://www.math.harvard.edu/library/sternberg/slides/11809LV.pdf

The insight about control can be taken further. We pointed out earlier that Defence is a type of system known as a system of systems. Each system within a system of systems typically has a degree of autonomy, such that the resultant whole is too complex for a single 'controlling mind' to govern or manage it. This paper is therefore concerned with how to establish the conditions for an innovation system to develop and flourish with limited centralised control, so that it operates in a manner reminiscent of an ecosystem (see Ecosystem sidebar).

Although we can think of the Defence Enterprise as a system (system of systems) it is important to reflect in more detail on the nature of the system. In particular, we note that it is in essence a 'people system', sometimes known as a Human Activity System. This is extremely important as a design driver because humans are the embodiment of complexity. Thus, recognising the role of humans as non-deterministic intelligent agents within the innovation system encourages us to think about 'soft issues' such as culture, behaviour and beliefs. These factors can drive large scale, often unpredictable, *system behaviours*, like self-adaptation, and small

scale behaviours, such as resistance ('not invented here'), which can either promote or frustrate innovation.

Re-interpreting ecosystem considerations in the context of a complex Enterprise system like the Defence Innovation System suggests that we should:

- Not try to enforce a single *controlling mind* to govern or manage the ecosystem but rather be concerned with establishing the conditions for an Innovation System to develop and flourish with only basic tending;
- Look for dynamic stability via defined feedback mechanisms that adjust to accommodate external and internal changes or fluctuations;
- Exploit a value chain in which entities with different roles inherently cooperate to achieve holistic goals or purpose (ie end-to-end innovation);
- Recognise that the Innovation System contains intelligent agents (ie people) and elements of the system will therefore adapt and evolve over time to improve fitness for purpose.

Features visible within the extant Defence innovation landscape

Based on our research, analysis and synthesis of the literature, project experience and lessons learned, we have been able to identify a set of system elements that might be crafted into an overall Defence Innovation System. Before discussing the way in which the various elements could work together, it is necessary to establish a common language to describe the elements. What follows is a brief introduction to the key terms used in the paper:

Innovation System: A system whose purpose is end-to-end innovation. As with any other system, an innovation system could be characterised in terms of its external structure, internal structure and emergent properties. At the enterprise level, this would include elements such as organisations, resources, processes, governance, infrastructure, etc.

Innovation Model: A distinct type or class of innovation sub-system[38], with a well-defined purpose. An example would be the Innovation Broker model, whose purpose is to connect problem owners with potential solution owners. From a conceptual perspective, we consider an innovation system to be described by interlinked innovation models and routine activity.

Innovation Construct: An organisational entity involved in innovation and employing one or more *innovation models*. An innovation construct may participate in more than one *holistic innovation pathways*.

Innovation Hub: A type of innovation construct acting as a nexus linking together other innovation constructs (via 'spokes'). Typically serves to close-couple demand and supply to serve (multiple) specific innovations.

38 Also likely to be a system in its own right.

Target System: A system that at least one *holistic innovation pathway* acts upon and from where the value of innovation is measured.

Holistic Innovation Pathway: A recognisable end-to-end pathway through the Innovation System formed of *Innovation Constructs* and *Innovation Models* to bring focus to a specific outcome or series of outcomes within a *Target System*.

Defence Operating Model (DOM): The DOM provides a conceptual view of the Defence Enterprise functions and organisation. It identifies six core functional areas: Direct, Enable, Acquire, Generate & Develop, Operate and Account, and maps at a high level of abstraction constructs (organisations) involved in delivering the desired functionality (see Figure 2).

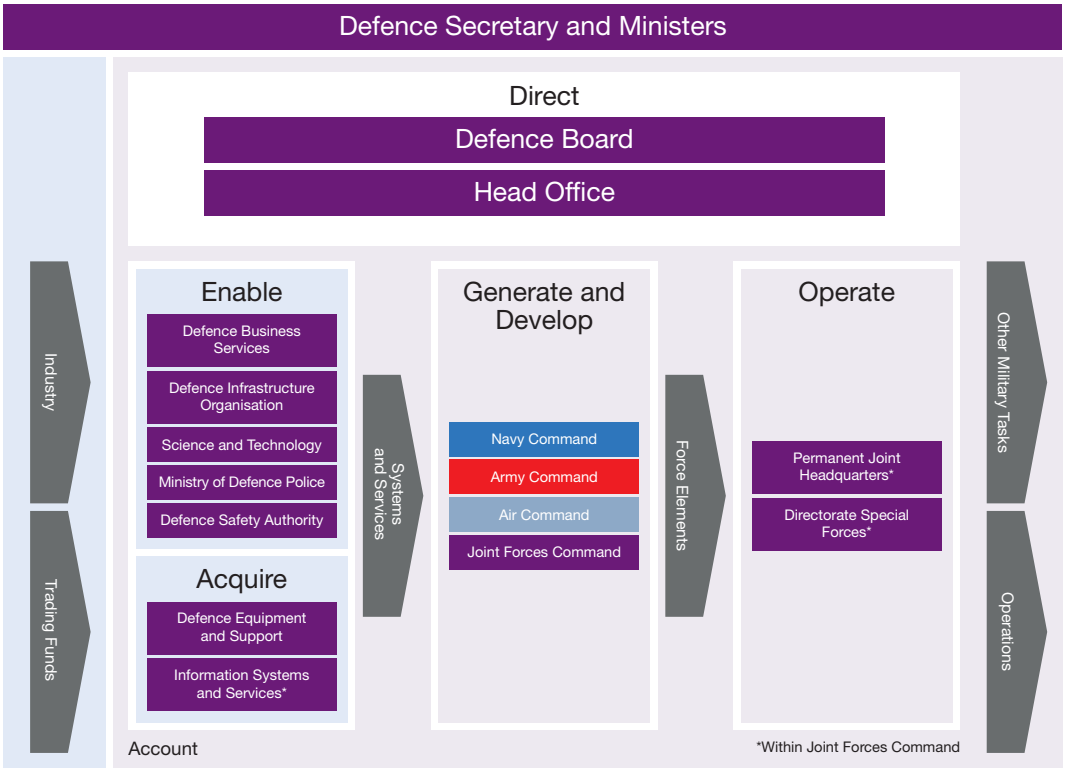


Figure 2: Levene Defence Operating Model (DOM)[39]

Though not formally stated, the DOM implies a left-to-right process flow where the outputs of the Enable and Acquire Functions become inputs for the Generate & Develop Function whose output in turn becomes input to the Operate Function, whose output is military operations. There is also an implied feedback loop from Operate back to Enable and Acquire. Although this is not a perfect mapping, it suggests that a series of interlocked, classical system models, based on inputs, outputs, transformation, control and actuation should be observable. However, once the models and constructs are

39 MOD (2015) How Defence Works, HOCS DRU (MOD), p.4.

observed closely at lower levels of abstraction, the complexity of the dynamics is such that the linear nature of the model is no longer readily observable, and what is left is a complex 'ecosystem', where understanding the detailed relationships between elements is essential (not to impose rigidity but to facilitate coherent interactions).

Despite the inherent complexity, we are encouraged that our analysis suggests that nearly all of the elements necessary to create the Defence Innovation System already exist within the extant Defence Innovation Landscape and that the DOM continues to provide a useful framework upon which to base its design. The challenge therefore is not in the creation of new elements, but rather to successfully align and synchronise the existing elements to form a coherent system, along with the necessary permissions, motivation and means to drive change and deliver value through the system.

Underpinning the Defence Innovation System are the Innovation Models that drive the innovation processes. We turn now to describe these in more detail before turning to consider their deployment as part of a wider system.

Identifying Generic Innovation Models

Through extensive research, analysis and synthesis[40] across the extant Defence innovation landscape we identified 12 systemic innovation models in use within the Defence Enterprise. Familiar terminology has been used for the innovation models where possible, although there is no consensus on model names within the literature, nor would all of the models necessarily be recognised by individual researchers or other stakeholders. Each model, including its key strengths/weaknesses and the innovation needs it can satisfy, is briefly described below:

M1. Fundamental and Applied Research Model: Provides fundamental and applied research. Outputs are generally low maturity. Good for generating radical ideas though may provide weak link to value. Seen as high risk – but potentially high gain.

M2. Technology Incubation Model: Searches for low maturity ideas and funds them to a higher level of maturity. This is typically focused on technology ideas and might operate in the Technology Readiness Level (TRL) space 1-4. Good match to product development. May not always be matched to operational requirements – there is a danger that technical solutions cannot be operationalised without considerable further resource (ie addressing System Readiness Levels). There is a risk to suppliers of losing control of Intellectual Property (IP).

40 This activity included assessment of existing constructs using a variety of innovation classification schemes described in the literature, including Rothwell's generations as described earlier, the dimension of innovation (Pisano, G.P. (2015) Creating Organizational Capabilities to Innovate, R&D Management Conference 2015, Pisa, Italy. Boston: Harvard Business School; Rothwell, R. (2002) Towards a Fifth-generation Innovation process, In: Henry, J. & Mayle, D. (eds) Managing Innovation and Change (2nd edition), The Open University Press; Keeley, L., Pikkel, R., Quinn, B. & Walters, H. (2013) Ten Types of Innovation, the discipline of building breakthroughs. Hobken: John Wiley Online), as well as a new style of analysis we developed based on Enterprise Architecture elements. Details are not reproduced here because of the volume of analysis – the results of the analysis are captured in the identified Innovation Models.

M3. **Spin-Out Model:** Provides a mechanism for generating new companies whose purpose is to exploit IP created in a different context. Often associated with academic and research institutions. Good for extracting potential value when not mainstream for the organisation. There is a risk of distraction. Requires a broader set of competencies beyond simply having a 'good idea'.

M4. **Innovation Brokering Model:** Acts as a clearing house between problem owners and potential solution providers. Often described as a 'marketplace' and operated in a particular sector. May make use of challenge/response mechanisms. Good match to product development. There is a risk to IP protection. Needs the right behaviours and approach to work well.

M5. **Product/Service/Business Development Model:** Provides a mechanism for industry-led development of new products/services/business for offer into the market. Product/service/business requirements are defined by perceived market demand often in contrast with competing products/services/business approaches. Good for development of off-the-shelf (OTS) elements and new ways of addressing familiar problems that can be exploited in capability focused systems.

M6. **Bespoke Development Model:** Provides a mechanism for delivering a specialised capability or subset of capability but is often equipment-focused. The problem-owner will typically seek to define a requirement that is believed to have viable solutions. Usually focuses on an acquisition process providing opportunities for innovation as part of a development. In UK Defence, the well-known CADMID[41] cycle is used, as well as the Urgent Operational Requirement (UOR)/Urgent Capability Requirement (UCR) procurement approaches when time is of the essence. Well-matched to acquisition focused innovation.

M7. **Problem Solving Model:** Provides an environment that brings together a problem owner with a solution provider(s) to jointly address a solution to problems. Encourages though does not require innovation. Problems addressed can be varied though typically they will address identified DLODs.

M8. **Collaborative Problem Solving Model:** Provides a collaborative environment bringing together problem owners and potential solution providers within an impartial framework for the collaborative solution of problems. Encourages though does not require innovation. Problems addressed can be varied and solutions can be pan-DLOD. Problem focus generally stimulates exploitation of high maturity technologies and other elements. Good match to capability and system of systems level problems.

M9. **Manufacturing Innovation Model**: Focuses on the introduction of novel manufacturing methods and processes. This is generally the preserve of industrial concerns and is a critical factor for productivity and competitiveness.

41 CADMID = Concept, Assessment, Development, Manufacture, In-Service and Disposal.

M10. Capability Integration Innovation Model: Focuses on novel ways of integrating the separate elements of capability in order to achieve overall effectiveness or other gains. Typically the responsibility of Front Line Commands – may be frustrated by delivery, resource or other pressures. Capability Integration might not be considered by some stakeholders from an innovation perspective or as an innovation opportunity.

M11. Continuous Innovation Model: Incorporates innovation directly in day-to-day operations, linking users, acquisition and system/service integration, typically via an innovation hub. Often makes use of demonstrations to accelerate innovation. Can be linked with a pursuit of 'marginal gains' and 'agile' mechanisms. Good match to in-service innovation though may focus too much on the existing system solution and is potentially vulnerable to vendor lock-in. Cultural change is often needed to deliver this model.

M12. Operational Innovation Model: Involves the provision of novel ways of conducting operational activities. Often not considered alongside other innovation models or regarded in innovation terms.

Overlaying the DOM with innovation models and constructs

In our terminology, innovation models are put into effect through innovation constructs, which employ one or more models to deliver their mission. In order to understand this further we performed an evaluation of the key Defence constructs to assess which types of innovation models are being utilised in the extant Defence innovation landscape. Figure 3 below provides such a mapping, between innovation models and innovation constructs, and then relates them to relevant functional areas of the DOM. Note that for simplicity of visualisation, only the *primary* relationships are shown – most of the Constructs play important *secondary* or *tertiary* roles in other Models or in other locations across the DOM. (We recognise that any attempt to develop such an abstracted and simplified mapping will be incorrect at the detailed level and therefore open to challenge, nevertheless we believe that it remains a valuable diagnostic tool, even at a high level of abstraction.)

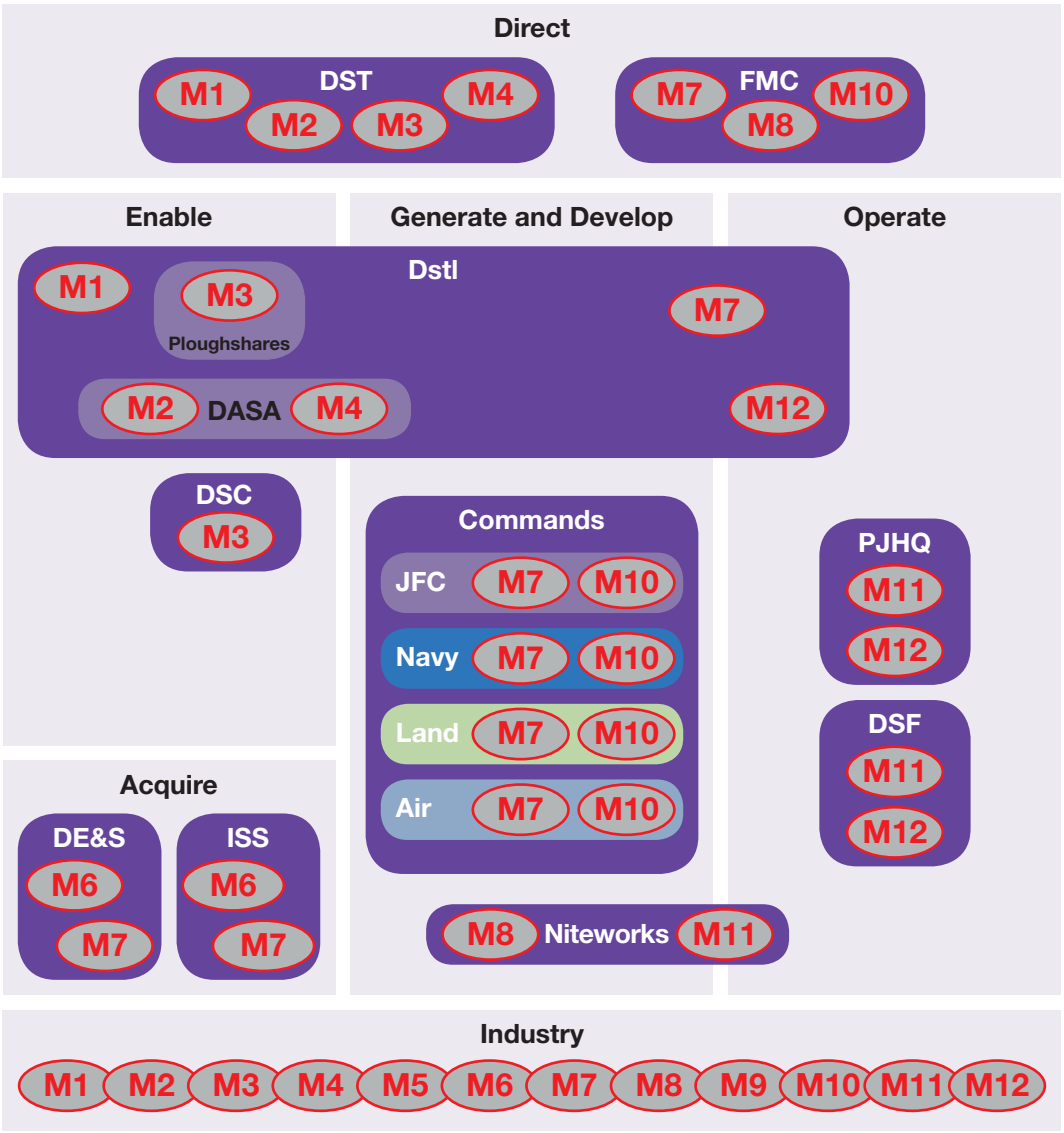


Figure 3: Primary Relationship Mapping of Models and Constructs onto the DOM

Even with a coarse Centre of Gravity mapping like this, from inspection of Figure 3 above, some key points emerge:

- Most of the constructs are found to embody more than one innovation model;
- Similarly, many of the innovation models are found in more than one construct;
- The requirement to build Holistic Innovation Pathways that extend beyond the boundary of a construct indicates the need for an inter-construct handover and orchestration in order to derive additional value;
- The current landscape fails to adequately integrate and value the combined potential of the public and private sectors.

In an attempt to bring some clarity to the nature of the innovation landscape, no attempt is made in the above diagram to show the relationship between the constructs – indeed these can be quite complicated because, we believe, the relationships have developed organically over time in the absence of an overall system design. For example, the role of the DE&S construct and its M6 (bespoke development) model is reliant upon the M6 model within the Industry constructs because DE&S is a facilitator for M6, which is undertaken by Industry. Other such 'hidden' relationships exist between other constructs – for example Dstl makes use of industry and academia to deliver M1 (fundamental and applied research), Niteworks is a partnership between MOD, industry and academia, etc.

Identifying sources of system friction in the extant landscape

Having identified a rich set of innovation models and shown how they map (at high level) to Constructs and the DOM, we now consider how this landscape currently operates to deliver innovation. As previously described, we adopt a systems perspective and build on experience of numerous stakeholders across Defence to derive insights on where 'friction' within the system acts to inhibit its smooth running.

From the research conducted during the development of this White Paper, including Niteworks partnership workshops and review of the Dstl[42] report on barriers to innovation, we find that the frictional elements that frustrate innovation effectiveness are most prominent in the following areas:

- Lack of awareness;
- Unavailability of resources;
- Incoherence of system elements;
- Insufficient motivation/rewards.

Lack of awareness

One of the surprises arising from our engagement with the Niteworks partnership (including MOD, industry and academia) was the lack of consensus on even the basic concepts of innovation. This ranged from the definition of innovation to the ways in which it should be delivered within the Enterprise. Evidently, the 'specialisation' of innovation within each organisation or situation has led to a tailoring of understanding, and sometimes a lack of appreciation of the broader perspective.

This lack of awareness is compounded by the lack of high-level guidance on how to conduct innovation – there is high-level encouragement to pursue innovation but little practical support. These two factors have led to an upwelling of localised innovation constructs sometimes without the benefit of learning from previous experience, potentially further contributing to the absence of effective communications between stakeholders identified by Dstl as one of the barriers to innovation.

42 Gale, S., Starkey, J. Youngs, I., Wright, S., Stacey, J, Seedhouse, A. & Maltby, J. (2015) Catalysing Defence Innovation through Science and Technology: Open working with a connected system, Portsdown West: Defence Science and Technical Laboratory.

Lack of broader awareness can also result in misperceptions and misdirected effort. For example, there is a widespread focus on 'disruptive' technologies[43], which are seen as offering critical advantage to UK Defence forces. Whilst such efforts are to be applauded, they should not be considered, in themselves, as constituting an innovation strategy, as this must also deliver 'sustaining' technologies, which by dint of their characteristics, are more likely to occur frequently and have a greater likelihood of delivering value.

Lack of resources

Any system requires 'fuel' to sustain it. In the case of Enterprise-level systems like the Defence Innovation System, the 'fuel' includes a variety of Enterprise resources like people, facilities, processes and commercial arrangements. Underpinning all of these resources is the ability to pay for them – in other words there is a general issue about where the costs of innovation should fall. We observe that the Defence Enterprise, with subdivisions within and between MOD and industry, is not optimised to bring the critical mass of resources together to enable innovation.

Of course, there is now 'new' money available for innovation via the DII. It should be noted, however, that this funding is dwarfed by the need just to sustain business as usual: the DII has £800M over 10 years[44], over the same period spend across Defence is planned to be in excess of £178Bn[45]. This argues strongly for absorbing innovation within business as usual activities. Nor should it be assumed that additional funding will easily resolve any and all resource limitations – one of the innovation barriers identified by Dstl[42] is access to end-users, which is more of a cultural barrier than one of funding. More generally, as evidenced by the US experience described in Section 1, 'throwing money' at innovation in the absence of commensurate cultural and systemic change will not deliver the desired effect.

Incoherence of system elements

It is intuitively obvious that with a system as complex as Defence and with so little shared understanding of innovation there is a risk of incoherence in the system. This is exacerbated by the proliferation of 'initiatives' across Defence that create a sense that innovation is already being addressed at a local and/or organisational level, even perhaps suggesting that it is 'someone else's problem'. In its study of innovation barriers, Dstl[42] identifies the lack of senior leadership as a barrier to coherence and longevity. This might be restated as lack of Enterprise-level leadership, exacerbating incoherence at the local level.

Reflecting the lack of Enterprise-level leadership, and although there is some articulation of R&D priorities, there is no Enterprise-level articulation of innovation priorities or communication of those priorities across the Enterprise. As far as we are aware, there

43 MOD (2016) Advantage through Innovation – The Defence Innovation Initiative, Whitehall: MOD.

44 ibid p13.

45 NAO (2017) The Equipment Plan 2016 to 2026, Report by the Comptroller and Auditor General, HC914, Session 2016-17 27 January 2017, London: House of Commons.

is no overall Defence Enterprise innovation plan, or innovation system design, or even framework that could be used to analyse the overall system. It is obvious that if there is a lack of an overall design, it is likely to give rise to uneven innovation focus across the Enterprise and a potentially inefficient use of resources. This overall situation has been characterised as fragmentation across the innovation ecosystem[42].

Whilst there are many good innovation elements within Defence, described by Dstl[42] as 'islands of brilliance', the lack of any known mechanisms to achieve *end-to-end innovation coherence* between the innovation models and constructs, makes it difficult to obtain value from MOD's investment in innovation. Indeed, the launch by MOD of the DII can be regarded as an acknowledgement of its concerns relating to this issue.

If there is no overall design for an innovation system, the associated system design rationale will almost certainly also be lacking. One key aspect of this is that it inhibits understanding of the innovation value chain, which would be used to inform decisions about how much effort should be invested in the 12 different innovation models and associated constructs operating across Defence.

Implicit in understanding the innovation value chain is understanding the relationships between the different innovation models applied in the Enterprise, which, again is, as far as we aware, not understood. A simple illustration of the types of question arising from this issue: what are the different innovation pathways that could be traversed over models to link constructs in the landscape; how are the handoffs between models organised; and what kind of commercial agreements/obligations are in place between the models? Put another way, although the constructs embody different innovation models, we have found no evidence of inter-construct understanding or agreement on the roles that each play and therefore the nature of the required interactions. These observations are supported by the Dstl analysis, which identifies that academic and industry players find it hard to engage with MOD and that current business models discourage pan-Enterprise collaboration[42].

As a result, it is today difficult for stakeholders to articulate or understand specific Holistic Innovation Pathways, making the system hard to navigate. This also means it is difficult for the system to react to changing circumstances and sustain the delivery of innovation, given that the individual models within the system are not adequately informed by, or inform, the other models within the system. This situation is also

Overcoming Barriers

It is well-understood that there is no 'innovation magic wand' that can be waved to remove friction within the current capability and acquisition pathways. That said, the introduction of an innovation system that is recognised as a human-activity system, provides the opportunity to introduce a culture to overcome the barriers that currently inhibit innovation across the Enterprise.

responsible for the manifestation of the 'Valley of Death', where there is no mechanism for the outputs of research to be transitioned to higher states of maturity and ultimately into service. Clearly, investing in research that has no prospect of ever being exploited is not an efficient use of resources (see Overcoming Barriers sidebar).

We return to discuss later in more detail a further factor, namely the unintentional overlapping implementation of models by separate Innovation Constructs, compounded by the plethora of budget holders currently sponsoring innovation activities and the competition for resources that might occur. Whilst an ecosystem of competing innovation constructs can be an entirely valid approach to the design of the system – it becomes problematic when it leads to unintended consequences or is an accidental by-product of the lack of overall design and management.

Insufficient motivation/rewards

There is strong downward financial pressure within UK Government generally, and within UK Defence in particular, which drives a culture of risk aversion and inertia. MOD project managers are highly motivated to deliver projects on time and within budget – and it would appear culturally to be preferable to 'say no' to prevent an activity starting than it is to 'say yes' to an activity that subsequently fails to deliver. This means it is difficult to inject innovation throughout the capability lifecycle, which is perhaps one reason why there is undue focus on research-led innovation (because risk is understood as inherent in research). In the phrase used by Dstl[42], within UK Defence there is a widespread perception that 'taking risks is too risky'.

The complementary factor to risk is reward – risks may be worth taking if the reward is sufficiently great. It is well established that UK Government competition policy is to seek solutions to Defence requirements via the international marketplace – indeed the whole acquisition system is based on this approach. The approach works well when there is an effectively functioning marketplace – but works less well when the market is distorted. A variety of factors can distort market operation in Defence, such as the need for freedom of action, which typically requires assured supply from domestic suppliers, or sovereign restrictions on the export of those technologies that provide operational advantage. These factors impact market operation, both from the perspective of importing to the UK and exporting from the UK, resulting in a fragmented and frictional market. The fact that the UK's policy of international competition is often not reciprocated is a further distorting factor in the marketplace.

Industry decisions about return on investment in a well-functioning market, such as a decision to invest in a consumer product, can be informed by good market intelligence and by the predictable statistics of large numbers. Within a distorted market, like the UK Defence market, industry decisions will be coloured by perceptions of the likelihood of the single customer (MOD) making a purchase, probably in the context of a competition that might be influenced by other factors, and by the likelihood of the company being allowed to access the export market to offset the investment made.

The market is also fragmented in relation to the different stages in the capability lifecycle and across the Defence/non-Defence divide. Firstly, for example, research is often funded from the public purse as an enabling activity, potentially curbing motivation to exploit the outputs of research. Secondly, the scale of MOD investment in innovation is dwarfed by the scale of investment by providers of commercial products and services, such that Defence can no longer guarantee to have the technological upper hand. This strengthens the case for continued innovation to redress the investment imbalance. As discussed in the Niteworks Continuous Capability Evolution White Paper, this implies that Defence innovation should focus on Commercial off-the-shelf (COTS) elements and their exploitation on an opportunity basis – which is poorly matched to standard acquisition approaches. It is an acknowledged source of frustration among suppliers that some innovation activities within the Defence Enterprise explicitly *exclude* innovations arising from combinations of elements at high TRLs, or from mature products used in a new way.

Findings

By virtue of considering the extant UK Defence Enterprise from a systems perspective, we find that:

- The Enterprise-level Defence Innovation System can be defined in terms of Innovation Models, Innovation Constructs and Holistic Innovation Pathways.
- The Defence Innovation System is at heart a Human Activity System, which means that human behaviour is critical to understanding the workings of the System.
- Given the scale and complexity of the Enterprise, not all of the elements can be directly managed or controlled. An ‘ecosystem’ approach to innovation management is therefore likely to be more effective than a centralised ‘controlling mind’ approach.
- Analysis of the extant landscape indicates that some 12 Innovation Models are in operation, although they may not necessarily be recognised as such.
- There are many-to-many relationships between Innovation Models and Constructs within the extant landscape.
- Mapping Models and Constructs to the DOM shows that each element of the Enterprise has its own unique ‘innovation footprint’.
- There is a need for inter-Construct handover and orchestration to deliver end-to-end innovation across the DOM.
- The current landscape does not adequately integrate across the whole Enterprise, in particular between the public and private sectors.
- There are many sources of potential and actual friction within the extant Defence Innovation System, which can be traced back to key common causes such as lack of awareness, unavailability of resources, incoherence of system elements and insufficient motivation/rewards.

Coming next

To exploit system insights and overcome the undesirable consequences of system friction, in Part Four we propose an approach to the design of the Defence Innovation System managed as an Enterprise-change activity, involving ‘as-is’ and ‘to-be’ architectures with clear transition pathways between these states. There is a well-understood set of tools[46] that can be used in support of successful changes in enterprise systems, including vision, goals, benefits planning, blueprints and so on. We refer to such tools as appropriate during the discussion.

46 Miller, D. & Proctor, A. (2016) “Enterprise Change Management: How to Prepare your Organization for Continuous Change”, Kogan Page Ltd.

4 Forming the Defence Innovation System

Introduction

In this section we outline the steps necessary to build the Defence Innovation System before making recommendations in Section 5 on how this might be implemented. The vision of a Defence Innovation System and its elements contained herein is based on decades of experience of innovation within Defence and the lessons from successful and unsuccessful attempts to encourage greater innovation through Niteworks' projects. Nevertheless, we offer this vision not as a fully formed solution, but as the basis for discussion across the Defence Enterprise. We believe it is essential that the first instantiation of a Defence Innovation System should be informed by experiences broader than just our own and that, once created, it will need to continue to adapt to the changing circumstances of Defence.

The description of innovation as "the perennial gale of creative destruction"[47] (see Schumpeter sidebar) highlights the tempestuous nature of the process as it challenges the status quo. The formation and maintenance of a Defence Innovation System will therefore require strong leadership and the support of stakeholders across the Defence Enterprise involving public and private sectors.

Some might argue that the formation of the Defence Innovation Initiative (DII) has already led to a Defence Innovation System. Here we observe that Defence has to-date focused its efforts on creating ideas which, as explained, offers an important but incomplete view of innovation. We argue that Defence should now seek to build on the DII to complete the system by placing the Operate Function at the heart of its innovation efforts and by embedding end-to-end innovation cycles across the whole capability lifecycle (and each of its elements).

Schumpeter

Schumpeter[S7] described the process of innovation upon an economy as "the perennial gale of creative destruction", a mutation that "incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one".

S7 Schumpeter, J.A. (2010 [1943]) *Capitalism, Socialism and Democracy.* Abingdon: Routledge Classics, p.73.

47 Schumpeter, J.A. (2010 [1943]) Capitalism, Socialism and Democracy. Abingdon: Routledge Classics, p.73.

System design

We turn now to discuss the top-level design of the Defence Innovation System building upon our understanding of the elements of the innovation system and frictional factors discussed in Section 3. Our goal is to establish a system design blueprint comprising innovation models, constructs, hubs, target systems and holistic innovation pathways that enables ideas to develop and move between the Enterprise functional areas so that their value can be released.

To aid familiarity we draw upon existing DOM language of Direct, Acquire, Enable, Generate & Develop and Operate to define the landscape before characterising the innovation needed at each location in the DOM. As innovation can occur in any function of the DOM – and the nature of the idea in context determines the nature of the innovation required – each must be served by the appropriate Constructs with expertise in utilising the most effective Model(s).

To establish the high-level innovation system design we firstly establish the relationship between the Enterprise functional areas and the requirements for innovation. This emphasises the *push* and *pull* of innovation across the Enable, Generate and Develop, and Operate Functions working alongside and with the Direct and Acquire Functions. Note we sub-divide Generate and Develop into three stages (Concept Development & Assessment, Implementation and Pan-DLOD Integration) highlighting the increased capability maturity[48] through the processes (see Figure 4). This shows how the system *pushes* Basic Concepts, Developed Concepts, Products and Services and Integrated Capabilities[49], that inform and are informed by the *pull* of Operational Needs, Sustaining Needs, Disruptive Needs and Long-term Positioning. These counter-flows generate the opportunity for creative *Coupling* between the matched elements of the combined cycle creating opportunities for innovation. They also highlight the need to create longitudinal linkages to allow the outputs of one part of the system to be accepted as the input of the next to achieve coherence and deliver end-to-end innovation.

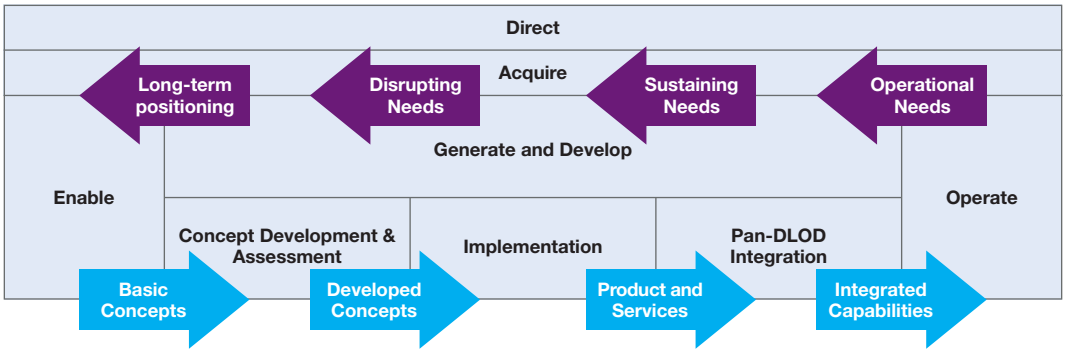


Figure 4: Mapping requirements onto the Enterprise Functional Areas

48 Idea and concept maturity can be codified using a number of different systems such as Technology Readiness Levels (TRL) and Systems Readiness Levels (SRL), originally developed by NASA.

49 For simplicity, within Integrated Capabilities we include the resourcing and configurational aspects normally included within Capability Generation.

We can now map the Innovation Models onto the Enterprise Functional Areas and requirements (see Figure 5). To interpret this correctly it helps to understand that models:

- Represent a specific innovation approach focused on different stages of the capability lifecycle;
- Only show where innovation is applied; they do not show activity that would be considered routine;
- May be thought of separately or jointly, but in cases where multiple innovations are required this will require pathways to be established to longitudinally link innovation activities together to deliver end-to-end innovation;
- Are non-linear and may be joined at any stage of the lifecycle.

In order to realise operational advantage/value from innovation the innovation models must interact with the routine mechanisms of Defence, as the majority of them do not deliver operational value on their own. To achieve this a culture of innovation is required, whereby everyone within the system recognises their responsibility to innovate; however, importantly, it is not necessary for innovation to be contiguous in the end-to-end journey; innovation activities can be concentrated in one or more phases of the lifecycle and routine activities can be found in the others. Another way of making this point is to say that novelty can be sought in any phase of the capability lifecycle and exactly where novelty is sought is a characteristic of the different innovation models. Ultimately, what is important is that innovation and routine activity can seamlessly intertwine.

Figure 5 shows where the innovation focus is for each model and the input/output points between models. The elements exchanged between different stages are indicated in the blue arrows. Each row is an end-to-end innovation journey, illustrating the innovation focus for each model. So, for example, the Technology Incubator model is focusing on novelty in the first stage of generation and development, namely Concept Development & Assessment. In this stage a basic concept is the input and, via suitable development and improvement with the incorporation of significant novelty, a developed concept is the output. This output can be taken forward through routine further stages, or be provided as the input to further innovative stages (via other innovation models).

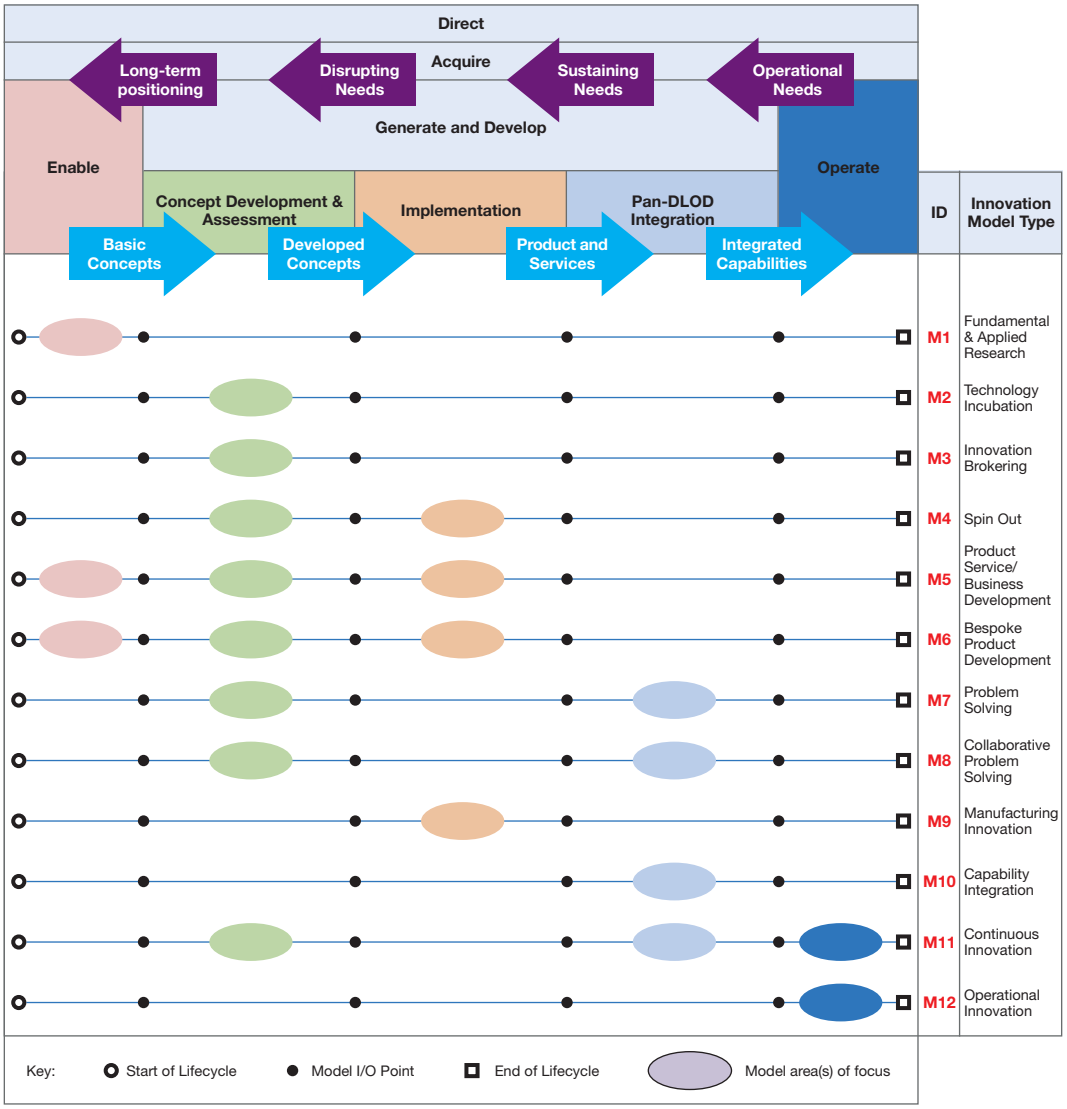


Figure 5: Innovation Models mapped to the Capability Lifecycle

Noting the earlier point that not every phase of the capability planning cycle always needs to be innovative, although it is feasible to deliver end-to-end innovation using a single Innovation Model (when combined with routine activities), in most cases we anticipate an innovation pathway will draw upon multiple models. We turn now to look how Innovation Pathways are constructed through combinations of models.

Creating innovation pathways from models

In order to understand the use of pathways in the system we explore the following scenario:

- The Enable Function has undertaken some innovative research within the S&T research programme. The output of this work is a set of concepts having the potential to disrupt future capabilities. The research was initiated at some earlier date as a result of a priority identified to the research programme. (This corresponds to model M1.)
- The Generate & Develop Function notes the availability of the research output and engages the supply network to explore potential capability concepts to exploit the innovative research and to develop and initiate plans for further activity. A collaborative approach involving industry is selected as the optimal mechanism as the focus is on the development and assessment of novel concepts, as well as resolution of pan-DLOD capability integration issues. The output of the work is a set of de-risked concepts and artefacts necessary to support acquisition. (This corresponds to model M8.)
- The Generate & Develop Function identifies a requirement for an innovative bespoke system development, which it initiates through a task placed on the Acquisition Function. (This corresponds to model M6.) The Acquisition Function undertakes a competition for the bespoke development. The selected supplier determines that the solution will require some bespoke development relating to the novel concepts developed by the Enable Function but will also incorporate existing OTS products and services developed independently. (The OTS elements correspond to model M5.) The outcome of this stage is a complete equipment solution ready for pan-DLOD integration.
- The Generate & Develop Function oversees the pan-DLOD integration of the new system, which then becomes operational. No further innovation is required or sought during this integration activity.
- Once operational, the full potential of the new capability becomes apparent. The Operate Function conducts further innovation based on operational learning to optimise the utility of the capability. (This corresponds to model M12.)

The resulting pathway from this approach is shown in Figure 6.

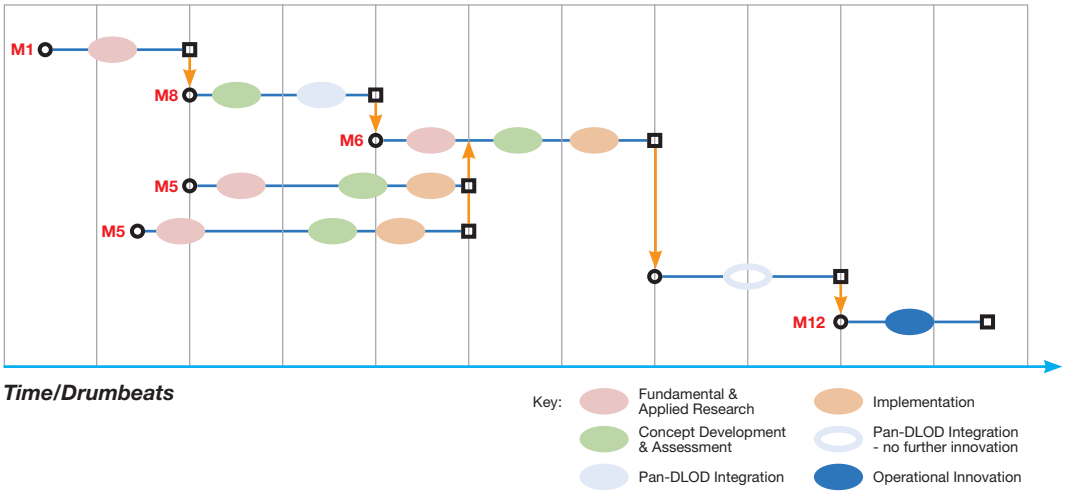


Figure 6: Innovation Pathway

The scenario described above corresponds to the situation where capability management is being conducted on a 'standard' basis, with changes triggered either by external factors or by a drumbeat[50] within the capability management lifecycle.

We now explore a variant of this scenario (see Figure 7 below), where the Generate & Develop Function combines with the Operate Function and Acquire Function to implement a Continuous Innovation model (M11). The triggers for change are then provided by a drumbeat of decision events where operational priorities are assessed against capability enhancement opportunities to determine the optimal 'next step', which can include the initiation of activities that may not be ready for exploitation for several drumbeats.

50 Drumbeats establish a tempo for an activity that promotes progress by setting the expectation of advancement within a set time period.

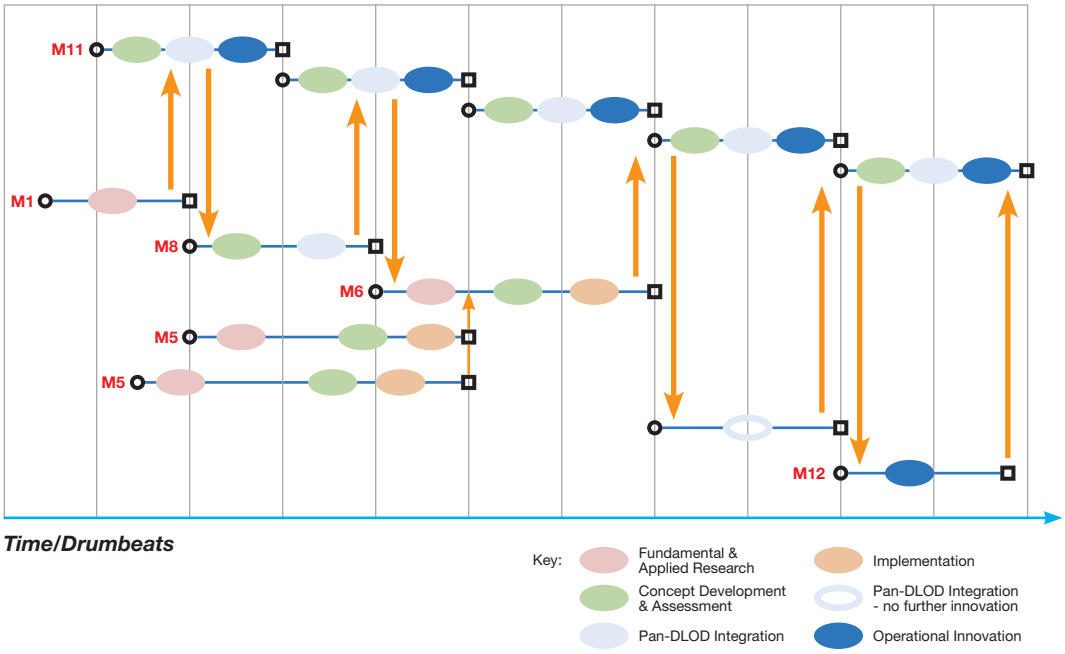


Figure 7: Continuous Innovation Model Pathway

This is a more complex scenario that has the advantage that multiple threads of capability enhancement can be 'in-flight' simultaneously and learning from demand/supply-side experience can be more readily taken into account.

In another variant of the Scenario (Figure 8), the Continuous Innovation Model (M11) has instantiated a live-mirror demonstration environment, in which the impact of potential changes to the live system can be explored. In certain circumstances, the demonstration system can be deployed into a live environment, either in parallel to the normal live system or as an augmentation of the live system. This could, for example, be achieved by enabling the Collaborative Problem Solving activity (M8) to incorporate a 'live demonstration'.

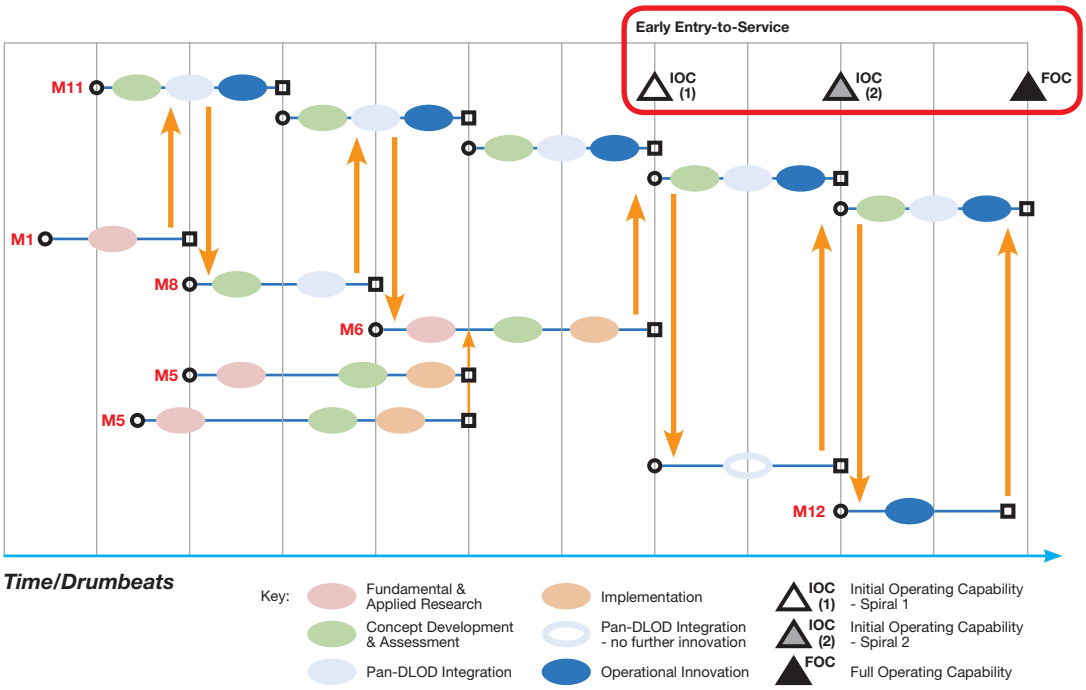


Figure 8: Continuous Innovation Pathway with Early Entry-to-Service

This approach is advantageous where there is an urgent need for capability, and where the operational imperative is sufficient for the limitations related to early service entry to outweigh the implicit penalties. The ability to incrementally enhance capability based on demand/supply-side experience is again a feature of the approach. Further benefits to exports and prosperity may also follow.

Design considerations to overcome systemic friction

Up to this point we have presented a high-level, conceptual, view of what the Defence Innovation System might look like. Readers would be well-justified in wondering how this should be applied in practice. A further level of design detail is evidently required, which must be guided by a design rationale. It is well-known that the majority of innovation initiatives fail to deliver as expected, so we adopt a strategy of addressing 'barriers'[42] so that they can be managed in the detailed design.

This section describes the design considerations and the following section defines an overall framework for the design of the innovation system that can be used to guide further work.

Leadership

All business change activities require appropriate senior sponsorship and leadership if they are to succeed[51]. The MOD introduction of the Defence Innovation Advisory Panel, for example, is recognition of the need for greater pan-government coordination and greater cooperation. Typically, a visible and vocal senior leader is necessary to overcome organisational inertia, in particular human tendencies to resist change. It can also help stimulate collaborative behaviours, provide the authority for governance activities and secure the required resources. If we consider the Defence Enterprise and its desire to transform via innovation, it is obvious that such leadership is a prerequisite to effective change.

In our engagement with the Niteworks partnership, it has frequently been remarked that innovation seems to be easier to deliver when there is an external pressure, say for example in a conflict situation that creates an urgent need for the introduction of new capabilities. The ability to innovate in such circumstances is often ascribed to the removal of barriers within the Urgent Operational Requirement (UOR) acquisition process. Whilst this is no doubt a factor, we believe that the fundamental reason is more to do with the external pressure itself, which drives less parochial and more effective goal-driven behaviours than the norm. It follows that, in the absence of external pressures, to generate the same kind of behaviours it is the responsibility of senior leadership to create the same kind of pressure but from within the Enterprise.

Whilst high-level leadership can provide a climate for change, actual change must be delivered through the various constructs within Defence. In this sense, leadership must flow down organisational functional lines as well as across the capability lifecycle; as our vision for innovation is systemic, it must be delivered in that way. Commercial leadership in particular is necessary to unblock many of the cultural barriers to innovation. We understand that DE&S is already developing a range of commercial models suitable for modern acquisition and this best practice needs to be understood in the context of innovation and that understanding shared across Defence.

Common understanding

Our discussion of the barriers to innovation identified many issues falling under the broad heading of ‘incoherence’. A key driver for incoherence is the lack of a shared understanding of many aspects of Defence innovation, including Defence goals, the scope and boundaries of innovation, as well as best practice methods and techniques.

Many of these issues could be addressed by ‘Innovation Thought Leadership’ to match the change leadership discussed above. (In her study, Murrin pointed out that the distinction between Innovation and Transformation needs to be made more clearly.) A key function of this kind of leadership would be to establish a common understanding of the current innovation landscape coupled with an understanding of the desired end-state. In short, common understanding is about ’how does and should innovation

51 Drucker, P. F. (2011) Innovation and Entrepreneurship Practice and Principles, Abingdon: Routledge.

work within Defence'. This kind of commonality of understanding is a prerequisite for improved coherence among the innovation community, as recommended by Murrin.

As well as enabling coherence, a common understanding is a prerequisite for collaboration, as each construct needs to understand what part it plays within the overall system and how, therefore, it needs to interact with other constructs within the system. A reciprocal exchange of understanding between MOD and its suppliers is needed, so that suppliers understand MOD's priorities and MOD understands the 'art of the possible' in those priority areas.

We believe that some of the ideas presented in this paper could be used to underpin a communications initiative. These ideas include: a focus on realising value through change and not just creating ideas; the variety of innovation models and articulation of their role; explanation of how models are instantiated by constructs and; how end-to-end innovation can be embedded across the capability lifecycle. Organisationally, an innovation hub construct would provide a suitable vehicle for coordination and delivery of Innovation Thought Leadership.

Innovation management, delivery and business as usual (BAU)

It will likely remain a subjective matter as to whether innovation should be viewed as a managed process subject to central strictures, or as an emergent property of a permissive system. Whilst our natural inclination is to value the freedoms inherent in *laissez-faire* over-centralised control, the structure, scale and complexity of the Defence Enterprise cause us to advocate a hybrid 'designed ecosystem' approach – a purpose designed system that delivers the innovation objectives of Defence and is subject to central *orchestration* (as distinct from control), where permissions are in place for localised path-selection, self-organisation and adaption. We believe that this is consistent with Murrin's recommendation on the need for coherence in the process of innovation.

In her study, Murrin also advocated that the process of Innovation must *penetrate the core programme* and not be a peripheral activity. Under the leadership topic above, we already proposed that the delivery of innovation needs to be systemic. We would interpret this as meaning that innovation must be evident at all organisational levels and across all elements of the capability lifecycle. In other words, responsibility for innovation is shared locally across all elements of the Defence Enterprise and that responsibility persists across time, including across all stages of the lifecycle. In particular, innovation should not be considered as an activity undertaken by a centralised body or as special activity.

Our rationale for advocating the hybrid approach is to take advantage of a system design that provides coherent end-to-end innovation through which value flows to the Operate Function, whilst retaining the tactical freedom to develop localised pathways, making it sensitive to local needs and promoting the need for excellence. This way, the system will reward those parts that are successful, whilst requiring unsuccessful elements to reform or perish as appropriate. Essentially, the hybrid system should be

thought of as innovation's equivalence of Mission Command, enabling disciplined innovation initiatives within the commander's intent at the local level. This way, creativity is encouraged and channelled to desired and productive outcomes.

Conscious innovation planning and management

As a complex system consisting of innovation models and constructs, in which innovation has a multi-local footprint and 'hybrid' command and control, it is incumbent on each actor to consider the implications of embedding innovation as BAU within their domain of influence. In practice, this means being aware of Defence goals and undertaking *conscious innovation planning and management* to ensure that innovation delivers value.

At the very minimum, this requires innovation to be embedded in all BAU processes, and for consideration of innovation to be undertaken across the capability lifecycle. The onus on anyone responsible for any aspect of any element must be to consider all relevant factors, such as how innovation could be introduced, how funding will be secured (if required), how Intellectual Property Rights will be handled, how risks will be managed, and to broker appropriate agreements on how their activity will hand its outputs on to the next stage in the lifecycle. To avoid this being a 'tick-box' activity, there needs to be cultural alignment across Defence, brought about by leadership and a shared vision. Note that this applies beyond MOD and into the supply network.

There is a key role for Innovation Thought Leadership here in helping the various actors to understand what best practice looks like and how they should gather evidence and take decisions. The metrics for successful innovation proposed by Murrin in her study are also important here. As mentioned in Section 1, she said that Defence innovation should:

- Be for a clearly identified Client;
- Always lead to outcomes that are either cheaper, quicker or both;
- Not 'compete' with existing global capabilities, but focus on UK expertise;
- Have impact within five years;
- Support prosperity.

Organisationally, the embedding of innovation could be supported by a Programme Management Office (PMO) construct instantiated as a PMO Innovation Hub. This could be combined with the Innovation Thought Leadership Hub to provide a single support focus across Defence. It is an obvious thought that the recently established DASA or the Defence Growth Partnership (DGP) could potentially fulfil this role. It is important to emphasise that such a role is not about providing a 'controlling mind' but about creating the conditions for an innovation ecosystem to flourish.

Innovation system design framework

This section offers a framework for detailed innovation system design that can be used to gain insight into the additional work that would be required to complete the system design, prior to its implementation. The proposed approach merges together the perspectives of 'enterprise as system', enterprise architecture and operating model design[52].

The Defence Innovation System Design Framework is a high-level description of the innovation system and how it delivers the innovation strategy of the UK Defence Enterprise. It describes three groups of elements characterising the Defence Innovation System:

- Concepts and design principles underpinning the design of the system;
- Primary elements of the system and;
- Secondary elements of the system.

We believe that the first group, the underpinning concepts and design principles, has already been described in this paper, at least in a sufficiently mature form to stimulate debate.

The primary system elements include:

- Sponsorship, leadership and culture;
- Vision and mission for innovation in the Defence Enterprise;
- Outputs and/or outcomes that the overall Defence Innovation System is accountable for;
- Major groupings of activity (models, constructs and holistic pathways) that deliver the outputs and/or effects (including finance);
- Inputs and information flows required in order to deliver the outputs and/or outcomes;
- Governance structure required to support the processes and deliver the outputs and/or outcomes;
- Behaviours required to deliver the outputs and/or outcomes;
- Knowledge, skills and experience required to deliver the outputs and/or outcomes.

The elements listed above are the primary elements of the Enterprise framework, ie they are essential and must be included in the definition of the Defence Innovation System. Without any one of them, or without coherence across the Enterprise, the Defence Innovation System will not be able to deliver the intended outputs and/or effects.

52 Currie, F. (2017) Niteworks Method & Technique – Operating Model Development, NW/CR/0495/732 v4.0, dated 05/07/2017.

There are several secondary elements, which are open to variation depending on how the various elements of the Enterprise wish to operate, and they are also subject to more frequent change. Additionally, there are potentially many levels of detail that can be described for these elements – but only with significant effort. These secondary elements within the Enterprise framework are the:

- Processes that describe how major groupings of activity deliver the outputs and/or effects;
- Organisational constructs that must undertake the processes in order to deliver the outputs and/or effects;
- Tools utilised in order to support the delivery of outputs and/or effects.

All of the framework elements are shown in Figure 9.

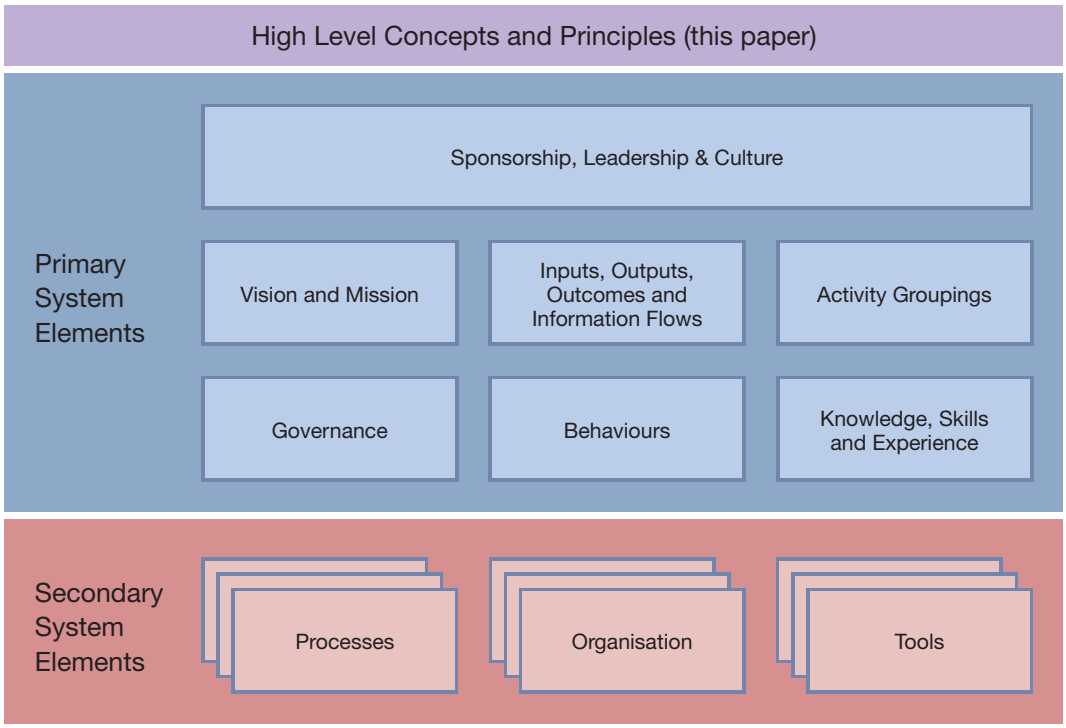


Figure 9: Innovation System Design Framework

At this stage, we are not in a position to recommend in detail how the implementation of the innovation system should be structured – but it would be wise to make such a significant change gradually and over a period of time. In this way, learning from the establishment of elements of the innovation system can be captured and built on in an iterative manner, providing an effective means of controlling implementation risks.

Findings

Building upon our understanding of the elements of the innovation system and frictional factors discussed in Section 3, we find that the top-level design of the Defence Innovation System should incorporate the following concepts:

- Innovation *Coupling* can be realised by establishing *push* and *pull* counterflows across the capability lifecycle – ie across the Enable, Generate & Develop, and Operate Functions within the DOM (working alongside and with the Direct and Acquire Functions).
- It is useful to understand Generate & Develop as three stages (Concept Development & Assessment, Implementation and Pan-DLOD Integration), highlighting the increased capability maturity through the processes.
- Each of the innovation models can be profiled across the capability lifecycle to show where the focus of innovation lies for that model.
- Aligning innovation flows across the capability lifecycle highlights opportunities to link the outputs of one part of the system as the input of the next to achieve coherence and deliver end-to-end innovation.
- Holistic Innovation Pathways can be characterised in terms of these linkages between innovation models and this framework can be used to support explicit innovation management.
- Visible and vocal high-level leadership will be needed to sponsor and guide the changes required to deliver the Defence Innovation System and then to sustain internal pressure for innovation.
- Innovation Thought Leadership will also be required to design the Defence Innovation System and to act as a source of authoritative guidance. This could be realised via an Innovation Hub Centre of Excellence.
- A common understanding of the Defence Innovation System is required across the Enterprise, which will require an effective communications initiative.
- The Defence Innovation System will need to be established as BAU across the Enterprise, including at local level. This will require support from a PMO Innovation Hub, acting under guidance of the Innovation Hub Centre of Excellence.
- A key facet of the embedding of innovation and its ongoing delivery will be the establishment of explicit innovation planning and management practices.
- An Innovation System Design Framework can be readily established based on well-known concepts from ‘enterprise as system’ [Section 3], enterprise architecture and operating model design.

Coming next

Having established a high-level design for the Defence Innovation System and outlined some of the elements required to change from the existing landscape to a more coherent future state, Section 5 will summarise the key findings and propose a set of high-level recommendations.

5 Observations, Insights, Conclusions and Recommendations

Observations and insights

We observe through our research and see on a daily basis that there is no shortage of innovation across the Defence Enterprise, which results in the UK developing, introducing and operating world leading capabilities. The Defence Enterprise continues to be staffed by talented, highly motivated individuals who collectively aspire to do a good job, and who are proud to serve the Armed Forces. A casual observer may therefore be confused as to why there is a stated requirement for more innovation.

This is answered by a further observation that the pace of change in the global landscape is such that the ways of working that have served the past are increasingly ill-suited to meet the demands of the future. Defence is having to manage two conflicting forces: on the one hand systems complexity has increased, resulting in elongated decision-making timelines and more time taken to develop capabilities and to reach full operational capability; on the other, the demand for adaptation at pace has increased, exacerbating the need for novel and agile approaches to enable Defence to reconfigure to meet its future challenges more rapidly, affordably and sustainably. Such challenges require changes to the way capability is introduced, to the way processes integrate and cohere with strategy, to the way organisations interact and align, and they require new ways of working and ways of thinking to be adopted (see Design and Architecture sidebar).

Design and Architecture

Defence employs talented, determined and highly skilled people who have bright ideas and are willing to challenge. The job of the innovation system is to link their individual contributions into coherent capability. We argue that this cannot be achieved without adequate system design within a fully articulated and widely understood overall architecture.

Of course this is not a new phenomenon as it is one that Defence has faced many times in its past and will doubtlessly confront again in the future. Nevertheless, we argue that the pressures across Defence are such that now is the time to apply fresh thinking and refocus the innovation strategy to help deliver the reforms needed to manage the complexity of the defence innovation landscape.

Conclusions and recommendations

This paper has shown that useful insights into Enterprise-level Defence Innovation can be derived by considering the Enterprise as a system and using a systems approach to understand and propose improvements to the system. Our preliminary work has, for the first time, articulated the basic structure of the UK Defence ‘innovation problem space’, including innovation models, constructs and end-to-end innovation systems, and by

analysis of this space illustrated the kinds of insights that can be extracted and used to inform the 'solution space' for the Defence Innovation System.

Throughout this White Paper we have outlined insights from our research. We do not repeat them all here but instead draw out one key recommendation:

> **To enable successful Defence Innovation an Enterprise-level Defence Innovation System should be designed, developed and implemented (across MOD and its supply chain) to generate and deliver improvements over existing piecemeal approaches.**

To underpin this recommendation and support overall Defence innovation system coherence, the observations contained within the paper have been distilled into a draft set of Enterprise level architectural assumptions and design principles, as set out below.

1. To address the diversity of innovation requirements across Defence, a broad understanding of innovation is required. In particular, we note that:
   - Innovation can arise from any kind of novelty, including product, process, market, organisation or operation.
   - However, innovation is not exclusively about novelty, it also requires exploitation via change to realise value (from the perspective of the Operate Function) – we call this 'end-to-end innovation'.

2. To address the complexity of UK Defence and meet Defence aspirations, innovation needs to be considered holistically as a system at the Enterprise level. In particular, we note that:
   - As Defence is a complex enterprise, it requires a matching Enterprise-level innovation system embracing all relevant enterprise elements (eg policies, governance, information, technology, people and processes).
   - Different stages of the capability lifecycle require different innovation approaches matched to their characteristics, including timescales for change. For example, fast-spin (continuous) capability development requires tight integration of the innovation system with the operational capability.
   - A full spectrum of innovation approaches is required, including sustaining and disruptive innovation, as well as open innovation based on combinations and research driven innovation.

3. The extant Defence Innovation System can be understood as a Human Activity System (HAS) characterised in terms of Innovation Models, Constructs and Holistic Innovation Pathways. In particular, we note that:
   - As the Defence Innovation System is a HAS, human behaviour is critical to understanding the workings of the System.

- Analysis of the extant landscape indicates that some 12 Innovation Models are in operation, although they may not necessarily be recognised as such.
- There are many sources of potential and actual friction within the extant Defence innovation landscape, which can be traced back to key common causes such as lack of awareness, unavailability of resources, incoherence of system elements and insufficient motivation/rewards.

4. To address friction across the Defence Innovation System, it needs to be designed such that innovation models are selected and configured to span the Enterprise in an end-to-end manner capable of achieving diffusion of innovation from idea to fielded capability, representing a clear and understood value chain. In particular, we note that:
   - The innovation *Coupling* model can be realised by establishing *push* and *pull* counterflows across the capability lifecycle – ie across the Enable, Generate & Develop, and Operate Functions within the DOM (working alongside and with the Direct and Acquire Functions).
   - To support detailed innovation management, the Generate & Develop stage can be refined into three stages (Concept Development & Assessment, Implementation and Pan-DLOD Integration), highlighting the increased capability maturity through the processes.
   - Each of the 12 innovation models can be profiled across the refined Capability Lifecycle to show where the focus of innovation lies for that model and this framework can be used to determine Holistic Innovation Pathways to support explicit innovation management.

5. For the Defence Enterprise to become entrepreneurial it needs to regard innovation as part of everyone's responsibility and inseparable from business as usual activity. In particular, we note that:
   - Given the scale and complexity of the Enterprise, not all of the elements can be directly managed or controlled. An 'ecosystem' approach to innovation management is therefore likely to be more effective than a centralised 'controlling mind' approach.
   - A key facet of the embedding of innovation and its ongoing delivery will be the establishment of explicit local innovation planning and management practices.
   - A key function of the 'ecosystem' orchestration will be achieving coherence of demand signals and responses as part of the *Coupling* approach.

6. To ensure the success of the Defence Innovation System, the introduction of the Enterprise-wide system needs to be managed as a business transformation exercise, with appropriate sponsorship and pan-Enterprise coordination. In particular, we note that:
   - Visible and vocal high-level leadership will be required to sponsor and guide the changes required to deliver the Defence Innovation System.

- A common understanding of the ‘as-is’ and ‘to-be’ Defence Innovation System is required across the Enterprise, which will require effective training and communications.
- An innovation hub construct provides an appropriate structure to act as the focus for Innovation Thought Leadership and Innovation PMO support across Defence. The DASA or DGP could be considered for this role.
- An Innovation System Design Framework to develop the detailed system design can be readily established based on the principles set out in this paper.
- The implementation of the Defence Innovation System should be gradual and with iterative learning in order to control risks.

These concepts and principles, and the structuring analysis underpinning them, are commended to the Defence Enterprise as the foundation for the holistic design of its Innovation System. However, we have no reason to believe that similar principles and methods would not apply to other complex enterprises.

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