The concept of C2 as a capability

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Introduction

The UK Joint Concept Note 2/17: Future of Command and Control (JCN 2/17) argued that Command and Control (C2) capability is "…a dynamic and adaptive socio-technical system". It also proposed that C2 should be developed as a capability that requires coherent effort across all Defence Lines of Development[1] (DLOD) but did not cover the rationale behind inclusion of the concept or how it might be implemented. The C2 as a Capability concept has gained some acceptance in the UK and its partner nations since publication of JCN 2/17, but despite this, tangible changes are rare. This paper seeks to explain why the concept has not been fully embraced and offers suggestions for its implementation as an established way of working. The paper discusses: (i) how military capability is currently realised; (ii) why 'emergence' is important when developing C2 capability; and (iii) specific challenges that need to be addressed. In summary, the paper should enhance understanding of the concept amongst the Defence capability development community and aid their efforts to develop C2 as a capability.

Misunderstandings on the nature of military capability

Before we consider C2 capability, it is necessary to explore the general defence concept of military capability and how this has changed since the Smart Procurement and Acquisition Organisation Review[2] (AOR) in 1997. During one of the AOR workshops, the Chief of Defence Procurement (CDP) presented views on capability. In response, questions were posed on who was responsible for deciding on required capabilities and who was responsible for ensuring all necessary changes across the Defence Lines of Development (DLODs) would be enacted to create the desired and intended capability. CDP responded that the Procurement Executive (PE) – now Defence Equipment and Services (DE&S) – was only responsible for delivering equipment as it only had influence over this DLOD component. Whilst reasonable in terms of conveying the bounds of his authority, this response highlighted a persistent confusion within the defence sector between "equipment" and "capability". Associated with this is a lack of understanding of who is responsible for overall capability development and sustainment of capabilities. These deficits have been particularly damaging for C2, given its human-centric nature, and because its development is dependent on coherent activity across multiple DLODs.

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1   Training, Equipment, Personnel, Information, Doctrine and Concepts, Organisation, Infrastructure, Logistics, and Interoperability.

2   Blackmore, M. (1998). EVM - The UK MoD Perspective, Directorate of Procurement Management Policy, UK Ministry of Defence, pp. 7., https://apps.dtic.mil/sti/tr/pdf/ADA403168.pdf

The equipment-centric perspective conveyed by CDP in 1997 continued until at least 2003, when the first definition of UK MOD capability can be found: "*The capacity afforded by an equipment to a unit or force element to perform a task in a given environment or operational context*"[3]. Subsequently, MOD added the need for through-life capability management, when the then Director of Strategy for the Defence Logistics Organisation (DLO) noted that MOD "*has encouraged industry to focus on selling a product, not on sustaining a capability through its life*"[4]. This elaboration started to broaden the concept of capability development and the need for a:

> "*whole-system outlook taking an integrated approach to delivering all of the components of military capability not just the equipment*"[5].

More recent capability definitions are difficult to find, but a 2020 UK National Audit Office report on defence capability described it as follows:

> "*The Ministry of Defence (the Department) develops and operates military capabilities in order to meet its strategic requirements and objectives. A military capability is not simply a piece of equipment such as a tank. Rather, it is a tank with a trained crew that: can communicate with others on the battlefield; can meet identified threats; and can be properly maintained and repaired during its lifetime.*"[6]

This brief history shows that since the discussion with CDP in 1997 there has been a gradual shift towards the view that defence capability development should take a more holistic approach. However, there is no definitive authoritative description of military capability that covers the need to treat capability in a holistic manner. Such a statement would provide a stable reference point for C2 capability development. Because this stable reference point was missing, JCN 2/17 explained the problem created in the context of C2, noting that:

> "*Technology alone will not deliver the capability leap we need. As a socio-technical system, this will require planned change in the whole of our C2 system – people, processes, structures and technology – if it is to be match fit for the information age and able to exploit the cognitive advantages of both human and machine. This change will need to be led across organisational, environmental and capability programme boundaries. This needs C2 to be treated as a capability in its own right and delivered in a programmatic way, with a clear Defence lead responsible and accountable for the change.*"

3   Finn, A. (Ed.). (2010). Innovations in defence support systems – 1. Vol. 304. Springer, pp. 30.

4   Mark, B. (2004). Defence logistics: The challenge of effectiveness and efficiency. RUSI Defence Systems, 7 (2), pp. 30-31.

5   National Audit Office (2003). Through-life management. Report Number: HC 698, pp. 7., https://www.nao.org.uk/wp-content/uploads/2003/05/0203698.pdf

6   National Audit Office (2020). Defence capabilities – Delivering what was promised, Report. https://www.nao.org.uk/reports/defence-capabilities-delivering-what-was-promised

More recent publications have been helpful. For example, a MOD guide from 2020 states:

"There are a number of factors that the Military Commands must consider when making decisions on Military Capability. These factors combined are known as the Defence Lines of Development (DLODs) and are used to ensure that an integrated, secure and comprehensive Military Capability is delivered."[7]

Other defence documents are also supportive: for example, the Target Operating Model[8] discusses the concept of pan-DLOD coherence and JSP 906[9] refers to the need for capability management to be underpinned by systems thinking, and a defence systems approach to change management.

Impact on C2 capability development

Constrained views of the nature of capability have influenced the structuring of defence procurement and capability management organisations and amplified problems associated with C2 capability development. Aligned with the CADMID[10] process and the development of equipment capability, MOD created organisations with responsibility for end-to-end development and delivery of equipment programmes. Those focused on Command, Control, Computers and Communications (C4) programmes constrained themselves to information technology infrastructure (i.e. computers and communications), with little attention given to command and control. The consequence, despite various publications expressing the need for a pan-DLOD, systems approach to capability, has been a long-standing equipment-driven perspective for C2 capability development. This equipment-centricity has obviated the need for Defence to decide who is responsible for C2 aspects of a wider C4 capability. Clarity is thus needed to ensure the pan-DLOD coherency as described in recent guidance and policy. JCN 2/17 noted that the need for coherency creates a challenge, given that responsibilities for DLOD elements are dispersed across many parts of the defence enterprise. Hence no individual has the authority to address coherency except at very senior level, one which is inappropriate for management of an individual capability. It is for these reasons that JCN 2/17 stated:

"Changing C2 is not just concerned with changing technical enablers; as a socio-technical system, this will require planned change to be implemented across organisational, environmental and capability programme boundaries", and "To deliver the necessary change, Defence must allocate a champion at senior level who 'owns' and directs C2 as a Defence capability, its development and related change initiatives."

7   How Defence Works, 2020, https://assets.publishing.service.gov.uk/media/5f6a2232e90e073fd9f7f466/20200922-How_Defence_Works_V6.0_Sep_2020.pdf.

8   http://data.parliament.uk/DepositedPapers/Files/DEP2014-0141/20130722_TOM_V3_Draft_5_Final.pdf

9   Defence Principles for Coherent Capability, Part 2: Guidance.

10   Concept, Assessment, Demonstration, Manufacture, In-service and Disposal / Termination (CADMID/T), see: https://assets.publishing.service.gov.uk/media/648b14895f7bb7000c7fab50/20230615_JSP_815_Volume_2_-_Element_7_-_Equipment_Design__Manufacture_and_Maintenance_V1.1_GovUK-O.pdf.

A related challenge is that a single authority is unlikely to have the capacity and expertise to manage (or govern) capability development across the entirety of the defence enterprise as C2 practices (and associated capability needs) vary dependent on operating environments (Air, Land, Maritime, Space and Joint domains). It is therefore likely that a federated approach to capability management will be required. Similar issues will apply to C2 in its broader and more generic form[11], i.e. when considering capability management to enable alignment and interoperation of capability with national and international partners and allies.

Another significant problem for C2 is the nature of the traditional approach to capability development. That is, there is a strong connection between the concept of systems, requirements and a 'lifecycle' approach. In MOD, with an equipment-centric focus, capability development has tended to employ a variant of CADMID/T[12] (an instance of the 'waterfall model'[13],[14]) that is designed for equipment development where clear, stable and standardised requirements can be written. Two implications of applying CADMID to C2 are discussed below.

The first implication relates to recognition within MOD of the need for alternative approaches, as discussed in a recent review of responses to the House of Commons Defence Committee. Specifically, the MOD's has now promoted the Integrated Procurement Model[15] which proposes a policy of "*Spiral by default to drive pace*" and "*a cultural shift to put greater value on pace*". However, there are some potential differences of perspective on the purpose and benefits of taking a more evolutionary (or spiral) approach. In the context of C2, a primary benefit is the ability to constantly monitor and take account of the impact of technical system changes on the "socio" aspects, and effectiveness of the overall capability. That is, asking whether the capability is being improved, enhanced or degraded by changes. There are techniques that can be used within an evolutionary approach to help guide development, for example combining research and improvement, and referred to as action research[16]. In contrast to this perspective, the perceived benefit of evolutionary-type lifecycles implied in recent publications such as the one on integrated procurement above, appears to be focussed on more rapid technology development and acquisition. Whilst this is one of many potential benefits, it is not the most helpful for C2 capability.

The second implication is that, historically, CADMID has insufficiently explained the need for, and the ways to, consider pan-DLOD issues. This situation has also improved recently, and there is now more guidance available. For example, a MOD "How to guide"[17] states that its purpose is to "*ensure that the Defence Line of Development*

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11   See Concept Information Note 5: "If not C2" for a more comprehensive discussion on this point.

12   Concept, Assessment, Demonstration, Manufacture, In-service and Disposal / Termination (CADMID/T).

13   https://en.wikipedia.org/wiki/Waterfall_model.

14   Apparently misattributed to Royce, as contrary to received wisdom on who said what about the waterfall model, elements of it can be found in earlier papers from Benington and Hosier, and Royce proposed an iterative approach. https://en.wikipedia.org/wiki/Winston_W._Royce

15   MOD Integrated Procurement Model, February 2024. https://assets.publishing.service.gov.uk/media/65e07110cf7eb16adff57ff4/Integrated_Procurement_Model.pdf

16   https://en.wikipedia.org/wiki/Action_research.

17   Service: Programme Definition Coherency, A Supervised Practitioner's How to Guide, Version: 4.03, 9 August 2022.

(DLOD) projects within a programme form a coherent set" and that key dependencies and assumptions are identified. This includes the identification of combinations of viable DLOD changes to collectively enable the achievement of programme objectives and to fill a capability gap. Despite the availability of new guidance, experience suggests that for C2 capability, it is typically not followed, perhaps through lack of awareness and/or understanding of how to put it into practice. In addition, there is a tendency for such guidance to be written from a "hard-systems" engineering perspective. Consequently, broader matters, such as organisational change management which are important for strongly socio-technical systems such as C2, receive insufficient attention.

Capability – Design versus Emergence

Figure 1 highlights the importance of a pan-DLOD[18] approach and introduces the distinction between the design and emergence of capability[19]. To allow emergence a different type of design is needed based on flexibility, constraints and purposefully leaving some options open[20].
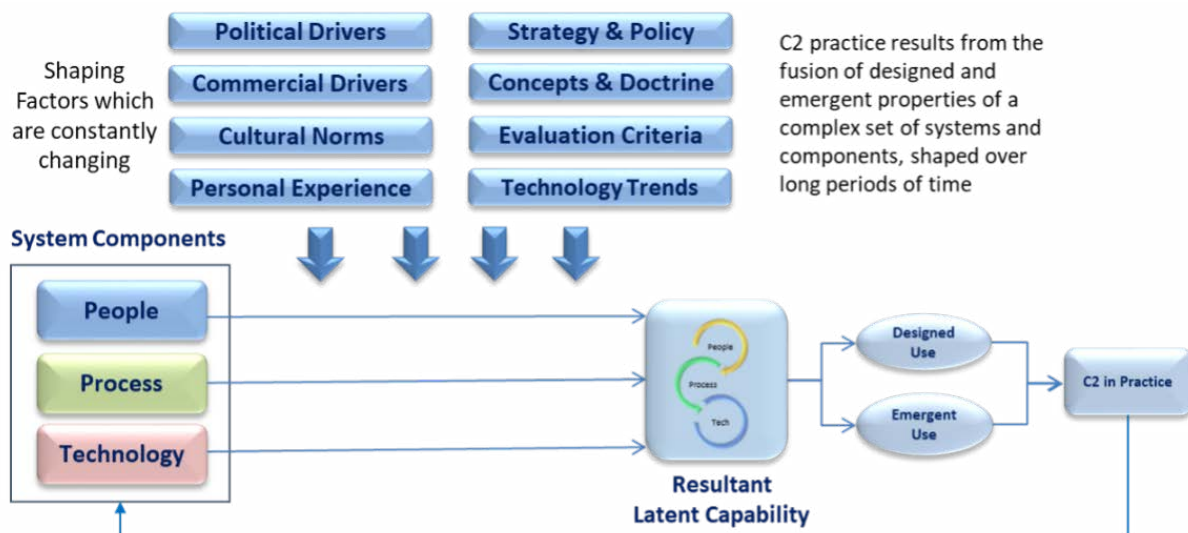

Figure 1: Evolution of C2 capability

There are two points to consider. Firstly, with a typical systems engineering approach, it is assumed that well-defined requirements enable the design and delivery of a capability that gives predictable outcomes. This approach works for well-understood engineering systems that have clear and bounded requirements. However, to build a capability

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18   Simplified here to just three components: people, process and technology.

19   "*Emergence is the production of global patterns of behaviour by agents in a complex system interacting according to their own local rules of behaviour, without intending the global patterns of behaviour that come about. In emergence, global patterns cannot be predicted from the local rules of behaviour that produce them. To put it another way, global patterns cannot be reduced to individual behaviour*". From Stacey, Ralph 1996, Complexity and Creativity in Organizations. San Francisco: Berrett Koehler, pp. 287.

20   This is based on the concept of 'enabling constraints' which positively contribute to coherency, emergence and innovation. "*It is important to reiterate that, in complexity theory, individuals matter; they are not pawns of collectives. Their actions matter; they are not simply reactions to external stimuli. Their behavior is in-formed by the self-organized dynamics that define them. That said, it is the workings of enabling and constitutive constraints—among individual entities, processes, and actions—that generate novel properties.*" From Juarrero, A. (2023). Context changes everything: how constraints create coherence. MIT Press. pp. 31.

(such as C2) that needs to deal with diversity, complexity and the evolving nature of the operating environment, the capability must be built with adaptability, agility and resilience in mind so that it can cope with diversity[21] and unpredictability. For C2, the adaptive agents are individuals and collectives (teams, organisations and enterprises). Because of the adaptive nature of this class of system[22], the interplay between people, processes, and technology is not predictable, and therefore neither requirements nor designed features can ever be fully anticipated. This leads onto a second consideration: one of how to deal with complexity in the operating environment.

Complexity is the subject of CIN 1, which argues that a fully defined and predictable system for the entirety of defence C2 capability would be undesirable. Instead, many parts of our C2 capability need to remain undefined, to provide freedom to be adaptive, agile, and resilient[23] to cope with increasingly dynamic and changing operating environments. At multiple organisational scales (enterprise, organisation, team, individual) we need to understand how best to exploit feedback to remain effective in the face of constantly shifting imperatives from the operating environment, which will also include changes required to respond to the actions of allies, neutral actors and adversaries. Such ideas are not new – they can be traced back at least to 2007[24] – but they have, so far, not been implemented. Another way of looking at adaptation is to consider it from the perspective of emergence[25], as much C2 practice will come about through a process of emergence at the point of use. With reference to CIN 1 on complexity, emergence is itself a property of a complex system and C2 capability is, similarly, a complex adaptive (socio-technical) system. Emergence comes about through the uncontrollable interactions between components of the C2 system (simplified in Figure 1 to People, Process and Technology). What emerges from such a system can range from extremely detrimental to highly beneficial; in each case monitoring performance is important from a learning perspective and to provide evidence for future capability development[26]. These two considerations indicate that balance is needed between design and emergence when building a C2 capability. There is only so much that can be designed; the rest will emerge in the moment due to humans interacting amongst themselves[27] and with the other system components (and in future perhaps with more adaptable technology driven by AI). However, what is designed will enable and constrain that which can emerge, so considerable care is required with design. In addition, components of a C2 capability are not static.

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21   The Future of Command and Control – Evolution or Revolution? Dr Gordon Niven, Lt Gen Sir David Capewell, Dstl, UK. https://assets.publishing.service.gov.uk/media/65e85098ce8540001112c48c/Evolution_or_Revolution_GOV.pdf

22   Note the more general use of the word "system"; this is not a reference to collections of technology. https://en.wikipedia.org/wiki/System.

23   As long as the staff are educated, trained and experienced in how to best exploit this freedom.

24   "*Moreover, we will argue that the issue is not about designing a networked force on paper, and then going about an implementation plan of connecting the bits, but rather of employing a truly evolutionary process of force integration supported by iterative concept development, experimentation and evaluation, so that the capability grows in a coherent and cost-effective way*". From Unewisse, M., Grisogono, A.M., Adaptivity Led Networked Force Capability, 12th ICCRTS, June 2007.

25   See earlier footnote explaining emergence.

26   Such as workarounds: "We should see workarounds as valuable feedback, rather than turning a blind eye", Beerepoot, I. Workarounds; The Path From Detection to Improvement, PhD Thesis, http://www.irisbeerepoot.com/phd-thesis/.

27   Eisenman, M., Paruchuri, S., & Puranam, P. (2020). The design of emergence in organizations. Journal of Organization Design, 9, 1-6.

They are shaped by internal drivers (designed or un-designed) and by external drivers (e.g. adversary action) which the defence enterprise does not control. Shaping by internal and external drivers will also occur over longer periods (even decades), with unpredictable results. As examples, personal experiences can be both a limiting and an enabling factor. Equally, the culture, values and norms of an organisation can shape and limit its people.

One final issue to consider is the freedom of defence C2 to be adaptive. If one considers an arc, where left of arc is a fully constrained system and right of arc is one with total freedom and flexibility, neither extreme is desirable as one side is completely fixed and the other would tend towards chaos and anarchy. The key question is: how far to the right of arc does an adaptive C2 system need to go and how far can it go, given the current constraints of defence organisations? The further one moves to the right, the more likely it is that new challenges will emerge (e.g. adverse human behaviours and an inability to cope with the degree of internal dynamism and variety). If there is too much freedom, for example, even ethical and legislative boundaries may be crossed. A balance should be struck between how much adaptability is needed, and how much can be permitted. As noted above, constraints can also be a necessary enabler rather than a barrier to emergence and innovation[28].

The consequence of capability shaping and driving activities is shown in Figure 1 as "*resultant latent capability*", i.e. something which is brimming with potential but may also be hamstrung with limitations. When the point of use is reached, design and emergence will likely re-appear. That is, C2 practitioners will design a 'system' that is a reasonable first approximation for what is required for anticipated operational circumstances, knowing that some C2 capability aspects will emerge in an adaptive manner from the interaction between its components. Over time, the observed C2 will be the result of design, and both long-running and nearer-term emergence phenomena. However, current C2 practices have probably emerged and evolved more by default than by design.
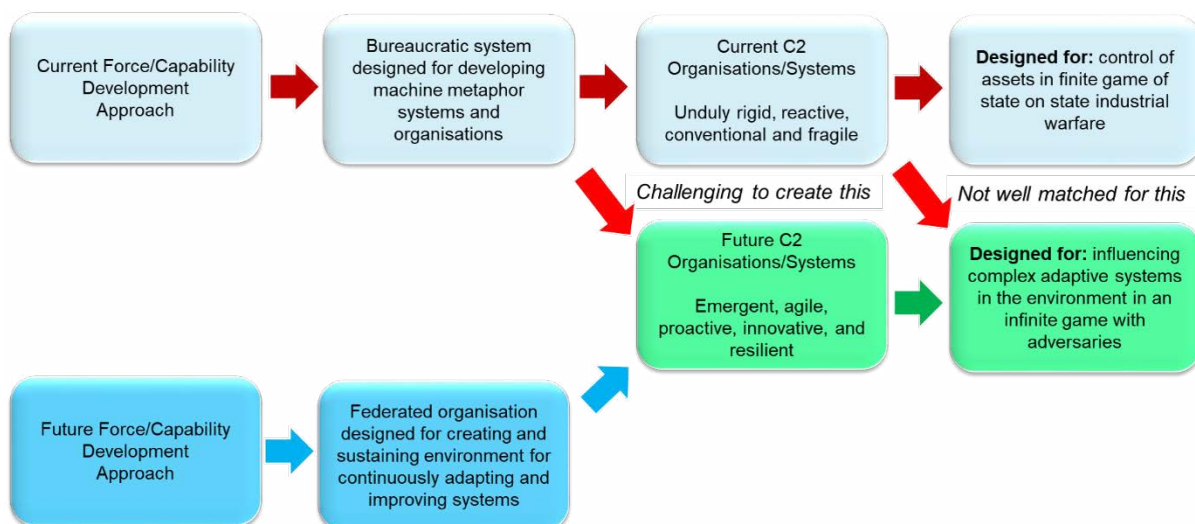

Figure 2: Alternative approaches for C2 capability development

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28   https://www.chriscorrigan.com/parkinglot/constraints-that-enable-emergence/

Thus, the central argument of this note is that designing C2 capability, to purposefully influence both intentional and emergent aspects, would be more beneficial than current approaches. Defence's capability development thinking and processes are not currently configured for such an approach, as illuminated by Figure 2 above, but new thinking related to procurement is encouraging. For example, the Integrated Procurement Model[29] referred to earlier advocates:

> *"Delivering a minimum deployable capability quickly, and then iterating it in the light of experience and advances in technology – rather than waiting for a 100% solution that may be too late and out of date."*

In conclusion, the challenges described in this note may explain, in part, why building, managing and governing C2 as a Capability has proved difficult. We should also not expect that a complex, multi-faceted, dynamic and adaptive capability such as C2 can be successfully handled by traditional, slow, complicated and overly bureaucratic management approaches (again see Figure 2). It is also worth noting that the UK is not alone – some of our allies have experienced similar barriers to progress in improving their C2 capability[30].

Summary

This note has discussed some of the factors that have impacted Defence's ability to progress the concept of 'C2 as a Capability' that was introduced over seven years ago in JCN 2/17. These, and related ideas for enhancing the development of C2 as a complex socio-technical capability, are summarized under five interconnected themes below. This summary also implicitly includes ideas on how to transition C2 as a Capability from a concept to a routine business activity.

1. **Think holistically.** C2 should be viewed as a holistic capability by Defence rather than a group of individual components and activities. This requires Defence to address the different elements that constitute C2, spanning the DLODs and including people, enterprises and organisation, processes, and technology. It should change how C2 capability is developed to ensure the effectiveness of the whole anticipates and responds to future needs.

2. **Leadership.** A Defence lead is required, who is responsible and accountable for long-term continuous improvement. This will be challenging, as making coherent changes at pace across the DLOD will require crossing of organisational, domain and capability programme boundaries. It will also require judicious exploitation of socio-technical developments from academia, industry and the defence science communities. However, a single authority is unlikely to be able to direct the management (or governance) of C2 capability across the entirety of the defence enterprise, not least because C2 practice varies dependent on the environment in which it is operating, and across the different partners and allies with whom one is working. Therefore, a more federated approach to capability management may be required.

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29   MOD Integrated Procurement Model, February 2024. https://assets.publishing.service.gov.uk/media/65e07110cf7eb16adff57ff4/Integrated_Procurement_Model.pdf

30   NATO Research in the HFM Exploratory Team 184, "C2 Capability Lifecycle Management", identified challenges under the themes of: Limited Ability to Evaluate C2 Capability, Limited Ability to Manage C2 Capability, Challenge of C2 Development, Resistance to Change and Lack of Organisational Learning. https://www.sto.nato.int/publications/HFMET184. A follow-on Research Task Group (HFM RTG342) will report additional findings.

3. **Continuous Development at Pace.** C2 does not operate in a vacuum so the capability needs to be adapted in response to emerging opportunities, risks, issues and threats, at a more appropriate pace, relative to changes within Defence and within the operating environment. C2 thus requires a continuous improvement approach rather than a one-off 'change programme'. The importance of C2 means there is an imperative for Defence to encourage and drive capability change faster than current practices allow.

4. **Balanced Investment.** Adopting a holistic approach to C2 capability development entails the need for more balanced efforts and investments across all DLOD, rather than continuing with the historic focus on technology/equipment. Investment in new or improved technology is still important, but the benefits need to be weighed against those accruing from investing in other DLOD.

5. **Bespoke models for capability development.** There is a need to move from linear lifecycle models (such as CADMID) to a more continuous development model for C2, exploiting as much as is possible of the new MOD guidance, which includes making iterative approaches to capability development the default. This should address some of the pace of change issues noted above but will require new processes, a culture shift, and development of skills to enable building of C2 capability in a way that exploits and balances both design and emergence and addresses the socio-technical nature of C2.

To conclude, the intention of this note was not to provide an exhaustive list of challenges associated with adoption of the C2 as a Capability concept, nor to enumerate all the mitigations that may be required. Instead, it should be viewed as an initial primer for those with responsibility for developing C2 capability.