Complexity Implications for Defence, and Command and Control

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This concept information note is the first in a series of five being made available unedited to support DCDC's **command and control in the future** project. The information notes are designed to introduce the thinking and themes of the joint concept note that will publish in late 2024.

Concept information note 1

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Introduction

1.1. It is a truism that change in the world continues apace, despite commentators, such as Fukuyama[1], suggesting that certain aspects of society have reached a degree of stability. Given this continued change, there is an ongoing debate about where we have ended up and hence how to describe our current state, with alternatives including: post-industrial society, the information age, the post-truth era, or the post-information age. For some, these descriptions suggest that we remain on the path of a continuum of change in society that first emerged in the 16th century. For others, the descriptions suggest that we have entered an entirely new age. Regardless of which view one subscribes to, we have unarguably transitioned into a world which is very much more complex, and each one of us will find it difficult to escape from being enmeshed in that complexity[2]. By using this characterisation, we do not intend to imply that reality and complexity exist separately from the place and role of humans. Rather, we suggest that complexity arises mostly because of changes in human behaviour, and also because of changes in the scale and nature of their interactions with each other, sometimes mediated in new and different ways via emergent technology.

1.2. One might ask what has led to this increase in complexity, and to respond to this, it is necessary to consider some of the macro-level trends affecting us. These include:

- An increasing pace of change in technology, especially informational, with greater digitisation and sophistication of processing, including recent accelerations in AI;
- Increasing interconnectivity with global, light-speed transmission of media, reporting, commentary and disinformation;
- Climate and biosphere degradation impacting on society, trade and supply chains;
- A more multi-polar world, with significant global hyper-competition[3];
- Increasingly hybrid conflict with competitive and conflictual actions being taken

1 Fukuyama, F. (2015). The end of history?. In Conflict after the Cold War (pp. 16-27). Routledge.

2 Jackson, M. C. (2019). Critical systems thinking and the management of complexity. John Wiley & Sons.

3 Freier, N. et al. (2018). Game on or game over: hypercompetition and military advantage, US Army College, War Room.

by state and non-state actors across multiple domains and environments;

- Increasing instability of politics, international norms and value-sets;
- Opinion-forming and influencing communities that lay outside the control of conventional media and authorities that are not geographically constrained.

1.3. Crucially, there is no single or primary trend that is driving change or complexity; rather, it is the confluence of multiple factors and their frequently unpredictable interactions that are of greatest concern. These will be the primary source of challenge for Command and Control in the future in coping with the inherent complexity of conflict and crisis from now until 2040 and beyond. The fact that this is the case should not be surprising as it has been recognised for some time in other sectors. For example, in 2010 an IBM survey of chief executive officers believed that rapid escalation of complexity was the biggest challenge facing them[4]. Similarly, the OECD[5] in 2017 noted that *"Complexity is a core feature of most policy issues today; their components are interrelated in multiple, hard-to-define ways. Yet governments are ill equipped to deal with complex problems."*

The nature of complexity in the context of Command and Control

1.4. There is a significant challenge with attempting to provide a concise explanation of complexity, as is needed for this short paper. The reason is the multitude of different perspectives and opinions on its perceived nature. However, one academic[6] critiqued such repeated disclaimers and suggests that this is merely the result of mixing up a description of a field of study (in this case complexity or complexity science) with more detailed explorations of its many different parts. As an example of the latter, there are several papers which define a multitude of different types of complexity[7] including organised/disorganised complexity, chaotic dynamics, Kolmogorov complexity, Kauffman's complexity, irreducibility etc.

1.5. The academic's critique also offers another observation, in that there appears to be more agreement on the nature of complexity than is first apparent. He notes that, for example, in 1962 Herbert Simon said *"Roughly, by a complex system I mean one made up of a large number of parts that interact in a nonsimple way". Then some 60 years later a more recent paper[8] stated that "a complex system is (a) a collection of objects or agents with high cardinality, which (b) interact with one another in a nontrivial way such that (c) the collective behavior of the system is unexpected or different from, or not immediately predictable from, the aggregation of the behavior of the individual parts."*

4 IBM (2010). Capitalising on complexity: insights from the global chief executive officer study.

5 OECD (2017). Systems approaches to public sector challenges: working with change. Paris: OECD publishing.

6 Holme, P. (2021).What complexity science is. https://petterhol.me/2021/12/27/what-complexity-science-is/

7 (i) Lloyd, S. (2001). Measures of complexity: a non-exhaustive list, IEEE Control Systems Magazine 21:7, (ii) Couture, M. (2006). Complexity and Chaos – State-of-the-Art; Formulations and Measures of Complexity, DRDC Valcartier, TN 2006-451, (iii) Mitchell, M. (2009). Complexity: A Guided Tour. Oxford University Press, Oxford. SE Page, 2011. Diversity and Complexity. Princeton University Press, Princeton NJ.

8 Torres, L., Blevins, A. S., Bassett, D., & Eliassi-Rad, T. (2021). The why, how, and when of representations for complex systems. SIAM Review, 63(3), 435-485.

1.6. To understand why complexity is difficult for traditional science it is worth diving into the detail just a little.

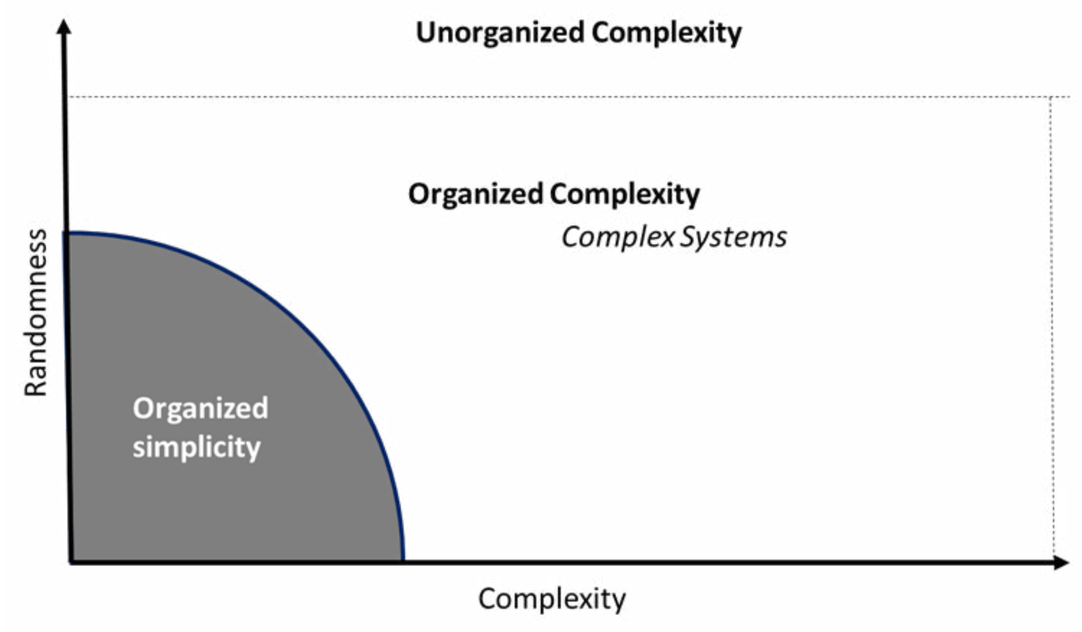

Figure 1: Types of complexity (from Jackson 2009)

1.7. Jackson concisely described the challenge of complexity for science, in the form of a diagram (see Figure 1 above). What this diagram attempts to convey is that, initially, science was able to deal with problems of organised simplicity, where there are a small number of elements that are related to each other in predictable ways. The mathematical tools which can be used to describe such systems are those of calculus and differential equations. Later, problems of unorganised complexity, were also addressed, where there are large numbers of components exhibiting high degrees of unpredictability. The appropriate mathematical tools for these problems are those of statistical mechanics and probability theory. The implied problem created by this is that mathematics deals only with the extremes of complexity or randomness. This leaves a huge gap in the middle, which unfortunately is where most real-world problems lie, in the region of Organised complexity. These problems are too complex for analytical approaches and too organised for the application of statistics, and this is arguably also the region of 'systems'. Problems of this type[9] predominate in the life, behavioural, social and environmental sciences and require:

> *".....science to make a third great advance, an advance that must be even greater than the....conquest of problems of simplicity or the....victory over problems of disorganised complexity. Science must, over the next 50 years, learn to deal with problems of organised complexity."*

9 As noted by Weaver. See Weaver, W. (2003). Science and complexity. In: Systems Thinking (ed. E.E. Emery), 377-385. London: Sage.

1.8. However, despite all of the above, the term “complexity” is still not sufficient to fully explain the nature of the challenges that defence, and hence C2, will be increasingly facing. The competitive, crisis and conflict situations of the future will increasingly produce challenges that are also known as wicked problems[10] i.e. unstable situations that ‘resist being solved by classical problem-solving’[11]. Such problems can also be referred to as ‘messes’[12] or ‘social messes’, given they concern multiple stakeholders and there is no single agreed understanding of the problem, let alone agreement on how to solve it, with no one actor having access to all the means necessary to bring about systemic change. Further, some theorists have conceived of a further category, that of super-wicked problems, denoting those problems, such as climate change, which are considered to be near-irresolvable due to additional confounding factors being in play.

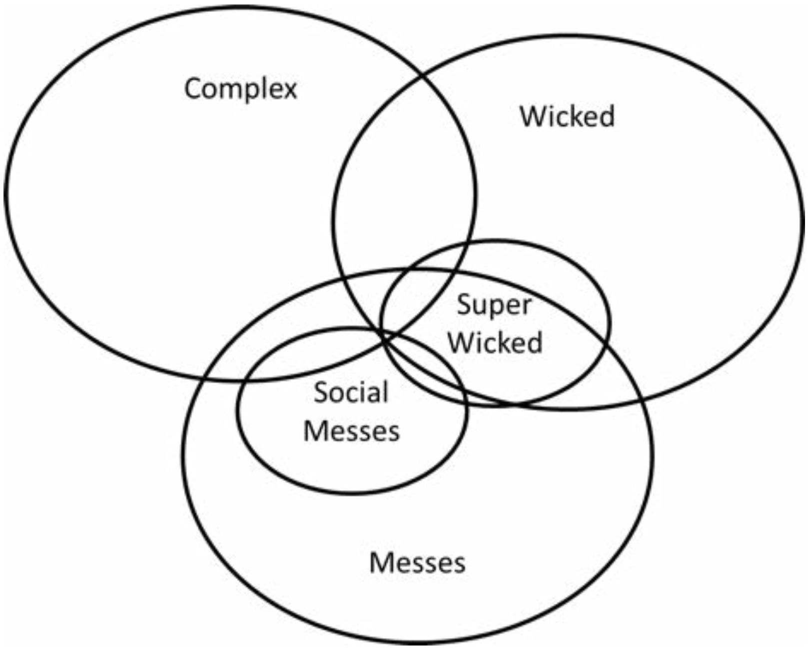

Figure 2: Problem types

1.9. There is no easy and concise way to explain how the various problem classes relate to each other, but they are related, and they do overlap in terms of some of their properties, as Figure 2 above attempts to portray[13].

10 Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a general theory of planning. Policy sciences, 4(2), 155-169.

11 Note that complex problems are not the same as wicked problems, but they are related. For example, Conklin suggests that Rittel and Webber (the originators of the term wicked problems): ‘distinguished a new domain of problem type, as opposed to, say, a new way of solving complex problems. Problem wickedness is not about a higher degree of complexity, it is about a fundamentally different kind of challenge to the design process, one that makes solution secondary and problem understanding central.’ Conklin, J., Basadur, M., & VanPatter, G. K. (2007). Rethinking wicked problems–Unpacking paradigms, bridging universes. NexD Journal, 10(1).

12 Ackoff, R. L. (1997). Systems, messes and interactive planning. The Societal Engagement of Social Science, 3(1997), 417-438.

13 This diagram is only intended to be illustrative and will not be correct. The literature contains a multitude of attempts to better characterise and relate the problem types, for example see: Alford, J., & Head, B. W. (2017). Wicked and less wicked problems: a typology and a contingency framework. Policy and society, 36(3), 397-413.

The implied challenge for C2

1.10. The more traditional form of Command and Control we experience today in terms of its concepts, processes and organisation, was developed in the era of industrial age warfare. Thus, it was strongly influenced the by ideas of the time, which were based on the use of machines for mass production, enforcing machine-like behaviour from humans, using principles of scientific management[14], and including an analysis of workflows to achieve economic efficiency via the use of optimised and standardised processes. This perspective also imposes itself on the nature of environmental problems that organisations experience and attempt to address. It assumes that the world can be sufficiently understood, that problems can be analysed and reduced to their component parts, that solutions to the various parts can be found, and hence solutions when applied will resolve "the problem[15]. There is thus a linearity of thinking and process that is put in place, which includes how planning of problem resolving activity is conducted. Implicit in this type of planning is a reliance on simple causal reasoning, which due to inherent complexity and 'wickedness', will in many cases will be flawed. That is, we assume from experience that if A happens, then B will necessarily follow. However, without a decent explanation as why this should be so, especially in particular settings with a multitude of different variables, such reasoning is more than likely to be in error[16]. The consequence of such errors is that we continue to, and increasingly misjudge crisis and conflict situations and hence the eventual outcomes are far from those desired. It is perhaps useful at this juncture to consider some further helpful words from Jackson, to help reinforce the previous points[17]:

> *"What help can decision makers expect when tackling the messes and wicked problems that proliferate in this age of complexity? They are usually brought up on classical management theory that emphasises the need to forecast, plan, organise, lead, and control. This approach relies on there being a predictable future environment in which it is possible to set goals that remain relevant into the foreseeable future; on enough stability to ensure that tasks arranged in a fixed hierarchy continue to deliver efficiency and effectiveness; on a passive and unified workforce; and on a capacity to take control action on the basis of clear measures of success. These assumptions do not hold in the modern world, and classical management theory provides the wrong prescriptions.*
>
> *They pander to the notion that there is one best solution in all circumstances and seek to reduce complex problems to the particular issues they can deal with. They concentrate on parts of the problem situation rather than on the whole, missing the crucial interactions between the parts. They fail to recognise that optimising the performance of one part may have consequences elsewhere that are damaging for the whole. They often fail to consider an organizations interactions with a rapidly changing environment. Finally, they don't acknowledge the importance of multiple viewpoints and internal politics…..Fundamentally, ….they're not systemic enough."*

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14 Taylor, F. W. (1914). Scientific management: reply from Mr. FW Taylor. The Sociological Review, 7(3), 266-269.

15 There is also an assumption of an ability to 'control' what is happening in the environment, whereas the reality for complex systems, especially those which are adaptive, is that they will either unpredictably or purposefully prevent such control having its desired effect.

16 Hume, D., Enquiries concerning Human Understanding and concerning the Principles of Morals Reprinted from 1777 edition, Third Edition, L. A. Selby-Bigge (ed.), Clarendon Press, Oxford, Sect. XII, Part III, p.165.

17 Jackson, M. C. (2019). Preface. Critical systems thinking and the management of complexity. John Wiley & Sons (pp. xix)

1.11. Arguably, the divergence between the challenges faced in complex operating environments, and our current traditional approach to C2 is getting ever wider[18], such that the likelihood and severity of a future national security catastrophe in the timescales of the intended Future C2 concept will increase to a considerable and frightening extent. The challenge for defence is that these outdated industrial and scientific management perspectives, and many implicit assumptions derived from them, are deeply engrained in the defence institution, in its culture, in its concepts and doctrine, in its education, and even in its selection and promotion processes for personnel.

Where solutions might be found

1.12. The discussion above has focussed on some of the challenges created by complexity. However, in doing so it has avoided covering other problem types that Defence has to deal with. In this regard it is perhaps worth noting that not all problems are complex or wicked, and not all aspects of even complex problem situations are themselves complex. To help untangle these distinctions it is helpful to use a framework for thinking, and the one most often employed in this context is Cynefin[19], which seeks to determine during sensemaking whether a situation is clear, complicated, complex or chaotic. The framework quite reasonably suggests that we employ the appropriate approach to the relevant situation, that is, we don't apply overly sophisticated methods to clear and complicated problems or try and address complex ones with overly simplistic and standardised solutions, as discussed earlier in this paper. However, because the focus of this paper is on what we need to do differently, and not what we can safely re-use from the past, the remainder of what comes next will describe in brief terms what needs to change in C2 to better cope[20] with complexity.

1.13. Because we don't sufficiently understand the nature of complex, wicked, messy problems[21], finding ways to resolve, or cope with them better is also extremely challenging. Therefore, there is no one single approach or method sitting on the shelf that one can employ. Neither the disciplines of science nor management have developed a definitive or commonly agreed approach. What this probably entails is that defence will need to develop its own approach for dealing with these problem types, in a way that is workable in its context, and in a way that can operate without too much friction with more routine approaches for dealing with clear and complicated problems. Unlike in the past, whatever this approach is, it cannot remain static, otherwise it will just become tomorrow's obsolescent way of working. It therefore needs to become an ever evolving, adapting and improving "thing"; more like an evolving organism[22], than a stable, scientific management machine. It almost certainly needs to be based on a learning organisation approach, with constantly reflective practice.

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18 Perhaps a useful example of this discrepancy is how military planning is currently conducted. The assumptions of a feasible end-state and deterministic relationships between actions, effects and conditions do not hold in conditions of complexity.

19 Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. Harvard business review, 85(11), 68.

20 Note that we cannot truly "manage" complexity. In that regard Prof Michael Jackson was counselled against using the phrase "the management of complexity" in the title of his book. He agreed that we need to navigate through complexity, and that we can't manage it. However, he also believed there are some aspects of complexity that we can manage and additionally that "managing" can also carry the meaning of handling, coping, and getting by, not just "controlling".

21 Note that a problem could simultaneously be all of these.

22 Morgan, G., (2006), Images of Organization, 2nd ed. Sage Publications.

1.14. If one accepts the argument above, this still leaves the question of where to start, and how to start, the process of change. The good news is that there are many sources of inspiration that can be used. A necessary precondition is that, whatever approach is considered, it needs to be founded on the concepts of treating systems as wholes (systems thinking/critical systems thinking)[23], and it has to be based on an acceptance of all of the uncertainty, and unpredictability that emerges from complexity. As an example of such potential starting point, Snowden and Rancati recently published a so-called field guide[24] to help managers better cope with complexity, a publication sponsored by the EU. A second potential source is from the 'multi-methodologists', such as Midgely, Jackson and Flood who have taken the view that we need to understand better what assumptions we are making when we employ a systems theory and approach, to ensure that we apply theories, concepts and approaches that are appropriate to particular problem types. Hence, they devised the so-called "System of Systems Methodologies"[25], which attempt to classify methods and approaches according to a best fit with a problem type. They did this by using two dimensions, one of which is a simplification of Cynefin (with just simple and complex types) and the other is the nature of the relationship between participants involved in problem resolution (unitary, pluralist, coercive), which refers to participants having shared views, aligned views or potentially conflicting views. Neither of the above provides a "ready to go" solution[26], but each contains a wealth of ideas and potential seeds from which to grow something usable, which could be gradually honed and adapted through practice for defence use.

1.15. To conclude this discussion, it is necessary to note that we have so far only addressed the appropriateness of concepts, theories and approaches. This is obviously just one aspect, and leaves many others unexplored, such as how to organise C2 better to cope with these more complex, wicked and messy problems. The latter observation assumes that the types of approach referred to in this document are unlikely to be practiced well in a conventional C2 organisation. However, such discussion is beyond the scope of this paper, and will be explored in a concept information note on enterprise organising.

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23 Note prior attempts by Dstl to embed systems thinking in HQ, for example via the Alternative Thinking Team concept.

24 Snowden, D., & Rancati, A. (2021). Managing complexity (and chaos) in times of crisis. A field guide for decision makers inspired by the Cynefin framework (No. JRC123629). Publications Office of the European Union.

25 Jackson, M. C. (2019). *Critical systems thinking and the management of complexity*. John Wiley & Sons.

26 These are merely examples, and thus it is recommended that a careful and considered approach is taken to the selection of concepts from these sources for experimentation and potential development, and also that the pool of such sources is expanded to increase the likelihood of finding those which are most effective and practical for defence use.

Summary

1.16. This paper has sought to summarise the following chain of argument:

- That change in the future operating environment will likely continue along already observable trends, along with some surprises and unpredicted occurrences, and the result of this is increasing complexity in both the operating environment and in the nature of the problems faced by C2 within the wider national security enterprise.

- Whilst there remains significant debate about the nature of complexity, there is also considerable agreement about its primary features, and thus also in its implications.

- Future competition, crisis and conflict will most likely reside in the complex and chaotic domains[27], where cause-and-effect relationships are unclear and unpredictable.

- Relying solely on traditional C2 methods that are based on theories and concepts which no longer apply, especially in these types of situations, is likely to lead to failure, with the potential to be catastrophic.

- There is a need to include, in the context of complex environments and complex adaptive systems, a recognition that we can no longer assume an ability to effectively ‘control‘ what is happening in the environment.

- Therefore, it is crucial to embrace the required change very soon and adopt and develop new approaches, as will be further expanded in a future concept information note (If not Command and Control then what?).

- By recognising the limitations of traditional C2, and adapting our approaches to better cope with the ever-changing nature of competition, crisis and conflict, the UK national security enterprise will be better able to maintain effectiveness in the face of new threats and challenges, i.e. those that will inevitably be hiding in future complexity.

27 Note that the use of ’domain‘ here is in the sense that the author of Cynefin (David Snowden) intends, and not in the sense of multi-domain integration or operations.