Ministry of Defence

Joint Concept Note 2/17

Future of Command and Control

Development, Concepts and Doctrine Centre

Joint Concept Note 2/17

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Foreword

'How can we deliver agile command and control, to offer decisive advantage in response to operational complexity?'; one of the nine future force development challenges identified and agreed by the Chiefs in Joint Concept Note 1/17, *Future Force Concept*. This joint concept note aims to answer that question: how Defence should best develop and sustain an enduring and agile command and control (C2) capability. Exploiting information, being more integrated as a force and being more adaptable to changing circumstances are the three central ideas of enhancing joint action; which is the heart of the *Future Force Concept*. Delivering agile C2 is not only critical to enhancing joint action, but it is seen as the pre-eminent future force joint function, a fundamental requirement to help deal with complex, uncertain and rapidly changing contemporary and future operating environments.

Agile C2 can improve our operational gearing by enabling strategy to be better connected to tactical actions, across all domains – cyber, space, maritime, land and air – and in a full-spectrum and multinational context. But achieving this agile – or edge – C2 will require us to change our military culture. 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.

This joint concept note should be read and understood by anyone with an interest in improving our command and control system; so everyone. In particular, it must be read by those responsible for force and capability development and by operational commanders and staffs as they consider how to better operate in the contemporary and future operating environment. It must also be read by the staff and students at the Joint Services Command and Staff College and single-Service warfare centres.

As CDS has said: "Another significant shift…which I believe has been under resourced…is how we command and control as a **capability**".

Director, Development, Concepts and Doctrine Centre

"

The nature of persistent state-on-state competition continues to challenge traditional, linear crisis response command and control processes and structures. Defence, therefore, requires an applied operating concept, doctrine and new approaches for command and control to reflect a multi-domain, full spectrum approach.

"

Joint Concept Note 2/17,
Future of Command and Control

Preface

Purpose

1. Joint Concept Note (JCN) 2/17, *Future of Command and Control* contributes to coherent force development at the strategic, joint and operational command levels, beyond current policy and resource horizons. As an authoritative high-level concept, it is coherent with JCN 1/17, *Future Force Concept* and supports balance of investment decision-making to shape the design and development of command and control (C2) capability out to 2035.[1]

2. Our future C2 must be designed for a state of persistent competition, able to adapt to a broad range of crisis and conflict situations, operating with various actors in different configurations across a full spectrum approach and remain effective under a variety of stresses. Achieving this will require us to change our military culture, create greater agility and coherence of our military C2 structures and processes across government, as well as with those of our international partners and, where possible, with non-governmental organisations. 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.

Aim

3. The aim of this JCN is to present a view on how Defence should best develop and sustain an enduring and agile C2 capability. In doing so, the UK will establish and maintain its competitive edge in response to future threats and challenges, both expected and unexpected.

Context

4. This JCN reflects the realisation that the UK and its allies need more innovative approaches to C2. The intent behind this change is to help us cope more effectively

1. It should also inform the single-Service applied concepts that support investment decisions. It does not try to provide detailed solutions. Instead it identifies key trends and challenges to provide a basis from which strategists, policy-makers and capability staff officers can develop further work.

with increasingly complex and uncertain crisis and conflict situations and compete with other state and non-state actors who may be using a wide variety of approaches to gain advantage. Change in the operating environment is driven by both the relentless pace of scientific, technological and engineering advances and similar, related changes to society and threats that challenge traditional military approaches. In addition to *Global Strategic Trends – Out to 2045* and the *Future Operating Environment 2035*, this JCN draws heavily on JCN 1/17 and the *National Security Strategy and Strategic Defence and Security Review 2015*.[2] This JCN has been informed by the Warfare in the Information Age work led by the Defence Science and Technology Laboratory (Dstl) and supported by Joint Forces Command.

Scope

5. This publication aims to address the future of C2 at the operational level out to 2035. However, many of the insights are also likely to apply to other levels of command, as the interdependencies between levels require. The insights and key deductions, in particular, are intended to guide strategic, joint and command force development and also inform future balance of investment decisions.

Structure

6. JCN 2/17 is divided into four chapters and an annex.

   a. Chapter 1 – Context. This chapter describes how and why our C2, as a national enterprise, is constantly being questioned and challenged, demonstrating that our current C2 doctrine, structures and processes are all products of the industrial age and shaped by the communications, mass, lethality and reach of that era.

   b. Chapter 2 – Evolution of command and control and the need for agility. As we begin to understand the opportunities and threats of the information age, this chapter makes the case for agility by examining C2 terminology, the UK approach to C2 and thus identifying the implications for commanders, structures and doctrine.

2. Available at https://www.gov.uk/government/publications/national-security-strategy-and-strategic-defence-and-security-review-2015

c. **Chapter 3 – Agile command and control.** This chapter identifies the critical aspects of agile C2 and considers how C2 might be conceptualised for the future. It also examines a programmatic approach to delivering agile C2 as a capability.

d. **Chapter 4 – Enabling future command and control.** This chapter explores the complex interactions between people, structures, technology and processes that enable effective C2, to identify the challenges faced in making coherent, sustainable change to C2 capability.

e. **Annex A – Understanding complex problems.** Annex A briefly outlines a model intended to assist commanders and staff to understand the concept of complexity in the context of addressing real-world problems and opportunities.

Contents


WITHDRAWN

Chapter 1

Context

Command and control is the pre-eminent Joint Function, critical to enabling joint action.

Commander Joint Forces Command, 2012

Section 1 – The contemporary operating environment

1.1. The Development, Concepts and Doctrine Centre (DCDC) publications *Global Strategic Trends – Out to 2045* and *Future Operating Environment 2035* characterise the likely evolution of society and the geopolitical context over the next 20 to 30 years.[1] They describe an era of constant competition between states, enabled by continually accelerating technological advance, particularly in the digital and information arena. The future operating environment will become ever more dynamic and complex as the number of significant threats and the range of actors continue to grow in both quantity and diversity, mirrored by the number and variety of actors with whom we need to collaborate in response. Operational leadership may shift between allies and between the military and other government departments, and will require increasing levels of collaboration with non-governmental organisations within a full spectrum approach.

1.2. Evolving threats and responses are no longer constrained to physical domains, with a growing tendency amongst a variety of actors to challenge, through the virtual and cognitive domains, our political will to respond. This is typically achieved by creating and maintaining high levels of uncertainty whilst simultaneously undertaking probing actions to identify the threshold at which we will or can react. In response, our military activities increasingly need to incorporate the often subtle and ambiguous interplay between cyber,

1. Available at https://www.gov.uk/government/groups/development-concepts-and-doctrine-centre

electromagnetic and information activities which must be integrated, as required, with kinetic effects. This will enhance joint action,[2] and therefore our influence,[3] through exploiting information, being more integrated as a force and more adaptable to changing circumstances. Only command and control (C2) can enable this, hence, no other joint function is as decisive as C2 and, as such, is the pre-eminent joint function.

1.3. This approach will need us to adopt new ways of thinking and organising of our C2 structures, assisted by new technologies which will remain an essential element to gaining advantage and an important driver of military change over the next 20 years and beyond. The tempo of technological change will accelerate and production costs will continue to fall, allowing sophisticated technologies to proliferate. The most significant changes are likely to come from the rapid development of information technologies, new sensors and novel weapons, developments in artificial intelligence, material and biosciences and a rapid growth of remote and automated systems. Accessing and developing the knowledge, skills and experience to recognise and respond quickly to transformative ideas and technologies, many of which will be driven by the private sector, will be a primary challenge.

1.4. Computers will more frequently connect to, and collect and share data with, other devices without human intervention or awareness. Vast data storage will be available on micro-scale devices and processing of this data will be enabled by continuing growth in computing power. Combined, these will enable new data analytics techniques to assist humans in extracting greater understanding from large volumes of volatile, variable 'big data'[4] which will help with making sense of the complexity of contemporary and future conflict.

1.5. The speed, capability and availability of fast and sophisticated algorithms such as those for network analysis will increase, potentially providing a competitive advantage in high-tempo decision support.[5] New

2. Joint action is defined as: the deliberate use and orchestration of military capabilities and activities to affect an actor's will, understanding and capability, and cohesion between them to achieve influence. Joint Doctrine Publication (JDP) 3-00, *Campaign Execution* 3rd Edition.
3. Influence is achieved when the behaviour of a target group is changed through the combination of words, images and actions. JDP 3-00.
4. Big data refers not only to data sets that are large, but also to those that have a wide range of data types, that change rapidly and are disseminated at high speed or have different, often uncertain, levels of reliability. Royal United Services Institute (RUSI), 'Big Data for Defence and Security', *RUSI Occasional Paper*, September 2013, pages 5-6.
5. Owens, I and Holland Smith, D. *A horizon scanning perspective on command and control out to 2025*, Defence Science and Technology Laboratory (Dstl), 2016.

human/machine interfaces, synthetic environments and remote presence will change the way people work and interact with each other and automated software agents, machines and robots. In addition, advances in machine learning will offer opportunities to provide more capable automated aids to planning and strategy development. These technological developments offer the potential to assist commanders and staff in making sense of, and navigating through, more complex operating environments. Annex A provides further explanation of the meaning and nature of complexity in a military context.

Section 2 – Command and control in the contemporary and future operating environments

1.6. An over reliance on technology will continue to be of significant concern and should be avoided. For more advanced actors, offensive space or ground-based anti-satellite systems could disrupt the UK's reliance on space capabilities. Cyberspace will be contested by more people. Offensive and defensive cyber capability will offer specific advantages to competitors, disrupting our information networks and systems, while countering our offensive cyber operations. The challenge to information and infrastructure security and resilience will be significant, with cyber attacks anticipated to grow in scope, frequency and impact.

1.7. Alongside non-traditional threats, the nature of persistent state-on-state competition will continue to challenge our traditional, linear crisis response C2 processes and structures. These have generally been designed for industrial age war fighting at scale, and shaped by prior assumptions on communications, mass, lethality and reach. Figure 1.1 shows the different states of continuous confrontation within which a C2 system must function. Increasingly, our traditional understanding that there is a clear distinction between peace and a state of war is being challenged, although our permissions, authorisations and operational phasing remains fixed on the 20th century notion of war, more suited to scenario 'A' in the diagram, whereas scenarios 'B' and 'C' would require different approaches to C2.

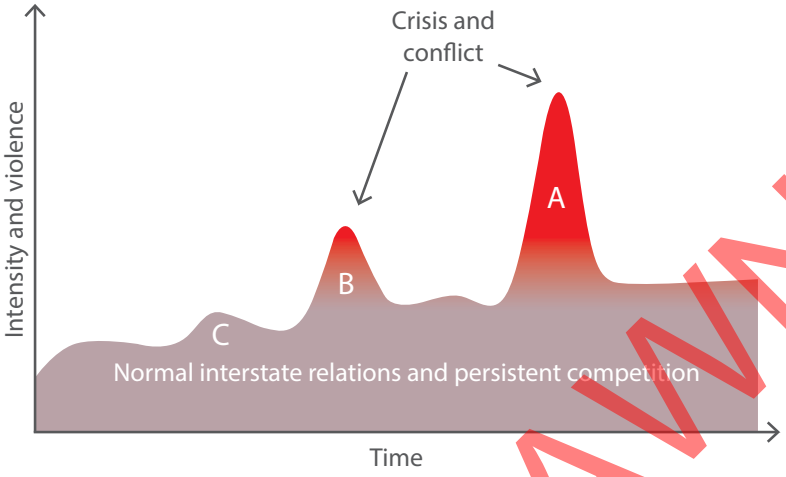


Figure 1.1 – Crisis, conflict and persistent competition

1.8. Conflict can rapidly spill over both national and regional boundaries while expanding into multiple domains.[6] However, our C2 is traditionally constructed according to domain, function and a specific and bounded joint operations area; or to address the different nature of crises arising in the UK or abroad.

1.9. Command and control in an era of persistent competition will need to recognise that many tactical decisions may take place at the strategic level when operating short of conflict. The highly politicised nature of deterrence activity needs a carefully planned posture and narrative that is in tune with a 24-hour news cycle. Such strategic compression and blurring of levels of warfare will be further compounded by public attitudes to military intervention and the impact of the political and public demands for accountability which were reflected in the report following the instructions to the Iraq Inquiry, commissioned by the Prime Minister.[7] There will be greater domestic and international legal scrutiny, due to a combination of civil society demanding better standards and accountability, a more interconnected world and the impact of specialist, well-funded international pressure groups concentrating on specific issues.

6. Maritime, land, air, space and cyber, underpinned by information.
7. *The Report of the Iraq Inquiry, Executive Summary*, Report of a Committee of Privy Counsellors. Ordered by the House of Commons, July 2016. More information can be found at www.iraqinquiry.org.uk.

1.10. Within this challenging context, C2 must itself be considered a complex socio-technical system, whose purpose is to direct, align and coordinate the intent and activities of the joint force as part of a full spectrum approach, across multiple domains. To improve the UK's C2 capability will require the crossing of organisational, domain and capability programme boundaries, and will require judicious exploitation of developments in a number of academic and scientific disciplines. As such, operational-level C2 cannot be dealt with in isolation and must be viewed as part of a wider C2 enterprise designed to achieve national objectives and effectively integrate capabilities and activity across all domains.

1.11. The required changes will be delivered by suitably experienced, trained and educated commanders and staff, who will be required to innovate and demonstrate genuine creativity. This will allow different C2 approaches to be adopted for different endeavours, each with parameters tailored and optimised for the specific circumstances and mission. The staff must drive a need for adaptation and agility and oversee the adoption of new ideas and technology, underwritten by resilient structures and effective reversionary modes. The vignette, below, demonstrates the problem.

Task Force Helmand (2010-11)

The Task Force failed to respond sufficiently to the complex environment and began to sub-divide into two C2 structures: official and informal. An informal networked structure began to emerge responding effectively to the complex environment, while the formal C2 structure became increasingly irrelevant.

North Atlantic Treaty Organization, STO Technical Report, STO-TR-SAS-085, Task Group SAS-085 Final Report on C2 Agility, September 2013

Key deductions and insights

- The considerations for future command and control design are as follows:
  - a system that is persistently integrated with the North Atlantic Treaty Organization (NATO);
  - with the ability to integrate rapidly with *ad hoc* partners;
  - consistent with the full spectrum approach;
  - compatible with constant competition and operations below the threshold of war;
  - embracing the enduring requirement for mission command;
  - recognising and responding to transformative ideas and technologies, including those from the private sector; and
  - driven by commanders and staff who embrace innovation and demonstrate creativity.

Notes:

Chapter 2

Evolution of command and control and the need for agility

> Another significant shift...which I believe has been under recognised... is how we command and control as a capability...
>
> Air Chief Marshal Sir Stuart Peach, Chief of the Defence Staff, Royal United Services Institute speech, December 2016

Section 1 – Command and control terminology

2.1. Command and control is an institutional, compound and contested term. It can be a process, a capability, a system or a structure. It can also be treated as a single whole, 'command and control', with a different meaning to the separate words 'command' and 'control'.

Command is defined as:
The authority vested in an individual of the armed forces for the direction, coordination, and control of military forces.

NATOTerm

Control is defined as:
The authority exercised by a commander over part of the activities of subordinate organisations, or other organisations not normally under his command, that encompasses the responsibility for implementing orders or directives.

NATOTerm

2.2. Although the term 'command and control' is widely used, there is no authoritative formal UK or North Atlantic Treaty Organization (NATO) definition for it. Most nations simply merge the definitions of 'command' and 'control', which results in a statement that typically includes commander, authority, direction and assigned forces. These terms, and their affiliated concepts and culture, may encourage a rigid hierarchical approach that underplays the need to collaborate and influence, particularly within a full spectrum approach where partners may not understand or agree with the terms and associated concepts. Whilst current behaviours are evolving to meet emerging challenges, they may be constrained by extant command and control (C2) terminology. UK command philosophy and much of the existing C2 terminology will remain valid and command authority will remain essential for the effective use of the military instrument during times of stress. However, other new C2 concepts and doctrine will be required.

> "…the difference between command and control on the one hand, and adapt and collaborate on the other, was the difference between success and failure."
>
> General Stanley McChrystal[8]

2.3. The commander must appreciate that a single approach to C2 will not deliver operational advantage. The ways and means associated with effective C2 have changed over time and continue to develop. The future of C2 will not be as we understand it to be today. Indeed, the term itself may be a barrier to progress. In the quote above, General McChrystal refers to 'adapt and collaborate' rather than C2. Other descriptions, such as John Boyd's 'leadership and appreciation'[9] and David Alberts' 'focus and convergence'[10] are similar attempts to reflect a related but slightly different purpose of C2. Despite these concerns, this JCN will continue to use the term 'command and control' to facilitate understanding, noting that it may lose currency in the future.

2.4. Definitions help us understand and apply meaning. This JCN proposes the following definition for 'command and control capability'.

8. McChrystal, S. *Team of Teams – New Rules of Engagement for a Complex World*, 2015.
9. Osinga, F. *Science, Strategy and War: The Strategic Theory of John Boyd*, 2006.
10. Alberts, D.S. *The Future of C2: Agility, Focus and Convergence*, Defense Technical Information Center, 2007.

For the purpose of this publication command and control capability is defined as:
A dynamic and adaptive socio-technical system configured to design and execute joint action.

JCN 2/17, *Future of Command and Control*

2.5. Command and control is a complex system, which must be capable of adapting to meet the requirements of changing environment, context and mission – being 'agile'. This requirement will be considered in Chapter 3. It must also encompass behaviours, tools and techniques, enabled by the interactions between people, structures, technology and processes; this will be considered in Chapter 4.

2.6. In considering future C2, it is necessary to define the purpose of C2 and consider how this will be achieved. The following definition for 'purpose of command and control' is proposed.

For the purpose of this publication command and control is defined as:
To provide focus for individuals and organisations so that they may integrate and maximise their resources and activities to achieve desired outcomes.

JCN 2/17, *Future of Command and Control*

2.7. In thinking about whether a particular approach to C2 is appropriate for a given mission and situation, it is helpful to look at the essential functions we need C2 to accomplish to achieve its purpose. These essential functions include, but are not limited to:

- creating shared awareness (including awareness of command intent);
- allocating resources to create effects;
- assessing progress; and
- recognising the need to change our approach to C2 and/or the plan of action.

Section 2 – Command and control – a UK Defence perspective

2.8. The increasing complexity of many security challenges suggest that it will be unusual for UK Defence to operate in isolation in the future. We may not routinely command expeditionary operations at the strategic or operational level but must retain the capability to do so, both unilaterally and as part of a coalition. We need the ability to manage UK equity, in accordance with UK objectives in a multinational framework. As part of a full spectrum approach, this may include integrating C2 capability with NATO and other allies, *ad hoc* partnerships and non-governmental organisations and host nation governments.

2.9. The current deployed force structure usually requires the full provision of J1 - J9 functions to enable routine campaign management and assessment. These functions are provided either by the Permanent Joint Headquarters (PJHQ), Standing Joint Force Headquarters, or by single-Service headquarters in certain discrete or standing operations. For major NATO operations and war fighting, the functions are undertaken by NATO Force Structure Headquarters, including the UK-led Maritime Command and High Readiness Force (Land) Headquarters, Allied Rapid Reaction Corps. However, for non-NATO expeditionary operations of greater scale and complexity, these functions are most likely to be split between PJHQ and a theatre of operations. This forward focus is essential for achieving unity of purpose and integrating effects across multiple domains. At all but the smallest scale, it requires a multi-domain and multi-functional operational-level headquarters or set of C2 nodes to be deployed in theatre.

2.10. On recent coalition operations, collaboration with multiple nations and attempts to reduce uncertainty through increased data collection within traditional C2 approaches, has created overly large headquarters. This increase and the consequent complexity has caused friction and challenged our ability to undertake timely analysis and decision-making. This has resulted in headquarters that are logistically expensive to deploy and sustain and difficult to protect from near-peer threats. Therefore, we must consider how to better address uncertainty and engage with more partners, without simply adding more staff. We will need to further develop applied concepts and doctrine on distributed and dispersed command to deliver effective C2 in the future.[11]

11. Distributed command is the ability to leverage cross-governmental, defence-wide expertise while deploying bespoke forward functionality. Dispersed command sees staff and selected tactical functions deployed forward, but not centrally located.

Operation GRITROCK was an example of a full spectrum approach

Section 3 – Command and control – a commander's perspective

Understanding

2.11. The commander's ability to provide organisational focus is underpinned by the need for individual and collective understanding. Understanding is defined as: the perception and interpretation of a particular situation in order to provide the context, insight and foresight required for effective decision-making.[12] A key benefit of understanding is to allow the commander and staff to map emerging patterns to identify new opportunities and threats. The development of this understanding can be supported by data analytics and visualisation, enabled by the single information environment and single intelligence environment,[13] as discussed further in Chapter 4.

12. Joint Doctrine Publication (JDP) 04, *Understanding and Decision-making,* 2nd Edition, page 3.
13. The *Defence Information Strategy* describes the single information environment as '… a logical construct whereby assured information can pass unhindered from point of origin to point of need', the single information environment will incorporate a single intelligence environment.' Defence will provide a secure, reliable, and agile enterprise wide information environment for UK forces and mission partners across the full spectrum of operations. For more information see https://www.gov.uk/government/publications/defence-information-strategy/latest-amendment.

2.12. As well as understanding the situation, commanders also need to be able to understand the socio-technical system known as C2. This system is likely to be under attack and stressed in other ways. Knowing what to reasonably expect in terms of information sharing and the development of shared understanding is critical.

Enduring critical elements of command

2.13. The traditional model of C2 would require a unity of aim, typically set by the commander. However, as part of a full spectrum approach, with multiple actors and diverse aims, this will not always be achievable. Instead the commander must seek to align organisations through unity of purpose. The critical elements required to provide this focus are described below and apply to all organisations at all levels, including tactical military command.

a. **Determining the context.** Using up-to-date intelligence allows the commander and staff to make sense of facts and recognise their significance. By analysing the context we gain greater insight of the problem; applying judgement to this insight generates understanding.

b. **Create intent.** Creating a clear vision and intent is a way of articulating foresight, which is the principal outcome of understanding. At the operational level, the commander's intent will determine the campaign design. However, to understand the wider context, the commander also need to analyse and comprehend the intentions of allies and partners.

c. **Decisions and plans.** Planning at an appropriate tempo will remain central to delivering effective C2, providing both the commander and their subordinates the ability to make appropriate, timely decisions. These will include routine decisions we know commanders have to take; decisions we expect, but do not know when they will occur, and unforeseen decisions, including those with an unknown impact. The challenge for the staff is in optimising the planning activity to support the breadth of decisions, ensuring they are taken at the appropriate level. The focus of this activity is not the production of large and complex operational orders, but providing timely and concise direction and guidance.

d. **Setting freedoms and constraints.** Exploring and setting freedoms and constraints, ensuring organisations know what resources and rules of engagement are extant remains essential. This also requires the consideration and understanding of the same factors in relation to allies and partners and appropriate adjustment, so they are sufficiently aligned.

Command approach

2.14. Traditionally, with the notion of force elements in our operational area being 'under command', it is assumed that we 'control' them. However, as part of a full spectrum approach, this is not routinely achievable. Similarly we cannot 'control' the emerging properties of a complex system. Depending on the nature of the partners, different approaches will be required to drive, or influence internal and external organisations and systems, with the intent of shaping the environment to increase the likelihood of achieving the desired outcomes.

a. **Directing.** The authority most traditionally associated with a commander who has a defined level of command authority over identified military units.

b. **Collaborating.** This is the means by which a commander and staff can interact with a range of actors working jointly to achieve the same, or similar, intent or outcomes, but where the commander has no authority to direct. Collaboration drives innovation and the more complex a task the greater the collaboration required.[14]

c. **Influencing.** In this context, we are not referring to the use of influence to sway the views and behaviours of adversaries, but rather the persuasion of allies, partners and neutrals to share our focus and undertake activities that allow us to achieve desired outcomes. Whereas collaborators 'work jointly'; influence is 'perceptible only in its effects'.[15]

> The cornerstone for effective enduring collaboration among coalition members is information-sharing which enables coalition compliant planning, resulting in successful execution of campaign goals and objectives.
>
> General Joseph L. Votel, US Central Command

14. QinetiQ Collaborative Decision-making Environments First Technical Report, 15 June 2017.
15. *Concise Oxford English Dictionary*, Edition 12, 2011.

2.15. Each of these approaches will have different applicability and all will be applied simultaneously based on differences in context and organisational needs and capabilities. For example, at the lower tactical level, where external relationships are reduced and linear hierarchies are likely to dominate, command will be largely directive in nature. However, at higher levels, where partners and other actors will be more numerous, collaboration and influence will become increasingly important and the use of a direct approach will be less prevalent and effective. This leads us to examine different C2 approaches and the degree to which they allocate decision rights, including using centralised and decentralised models using distributed and dispersed C2 nodes. Given that commanders at various levels are empowered to different degrees in different circumstances, this begins to demonstrate a clear need for C2 agility; that is, the ability to change required C2 approaches with speed and ease.

Section 4 – Command and control states and structures

2.16. The degree of authority (such as operational control and tactical command) are defined by NATO to provide boundaries between hierarchical chains of command.[16] The realities of multinational operations will stress these boundaries, but during combat operations they provide agreed direction for pre-defined command structures operating through a military focused **unity of command**. However, when the military is supporting, rather than being supported, authorities and decision rights will be even more complex and will require a more bespoke approach with organisations working instead to a **unity of purpose**.

2.17. The joint force commander, together with operational commanders both home and abroad, are beholden to the National Security Council, with the military strategic headquarters providing the touch-points into the cross-government aspects of the full spectrum approach. However, in the more complex, dynamic and multi-domain operations of the future, current command structures may lack the depth and degree of adaptability needed. Future structures will need to adjust their C2 approach to fit rapid changes, thus reducing the risk against delivering successful outcomes. Defence will also be

16. Allied Joint Publication (AJP)-3, *Allied Joint Doctrine for the Conduct of Operations*, paragraph 0194.

required to develop joint competencies to understand the military instruments of power integrated with inter-agency, intergovernmental, and multinational partners.

2.18. Structures in our current operational headquarters are, often stove-piped, J1 - J9 staff branches. These structures are maintained for ease of cooperation with similarly organised staff branches in other operational headquarters, rather than for addressing the full breadth of full spectrum activity and associated missions and tasks. This may be addressed with a structure that is more outcome focused,[17] rather than functionally organised. Breaking out of the J1-J9 structure will be challenging, accepting that previous attempts to adopt new structures have failed, but in some circumstances different structures may be necessary, to aid collaboration with non-military organisations.

United States Southern Command (SOUTHCOM) – Operation UNIFIED RESPONSE, 2010

'SOUTHCOM's reorganisation [2008] was focused on addressing its daily mission requirements, which included addressing challenges that impacted the security and stability in the region and required interagency solutions. In order to support interagency solutions, SOUTHCOM developed an organisation structure that transitioned the command out of the traditional joint staff organisation structure to a staff structure with three mission directorates [Security and Intelligence, Stability, and Partnering] and three functional directorates [Policy and Strategy, Resources and Assessments, and Enterprise support].

'SOUTHCOM's combatant commander made a decision within the first week of Op UNIFIED RESPONSE (the Haiti disaster) to return the command to a traditional joint staff organisational structure to address the weaknesses [lack of planning for future operations, sub-optimised for large-scale contingencies, difficulty communicating with its subordinate commands, and difficulty in augmenting military personnel].'

US Government Accountability Office,
Defense Management: US Southern Command Report,
July 2010

17. The Standing Joint Forces Headquarters structure based on understand, design, operate and enable offers one alternative model.

2.19. Alternatives to J1-J9 structures, may bring about greater benefits in managing complex interrelated and dynamic problems. Different options should be considered including the decentralisation of decision-making where appropriate, as demonstrated in Figure 2.1. By placing authority for action close to the source of the complexity, de-centralised and adaptive C2 processes provide the most flexible and effective mechanisms for improving synchronisation and maintaining the drive towards unity of purpose. Such ideas and approaches are essential components of mission command. However, we should not underestimate the remaining challenges, such as achieving sufficient commonality of intent in a diverse grouping or coalition.

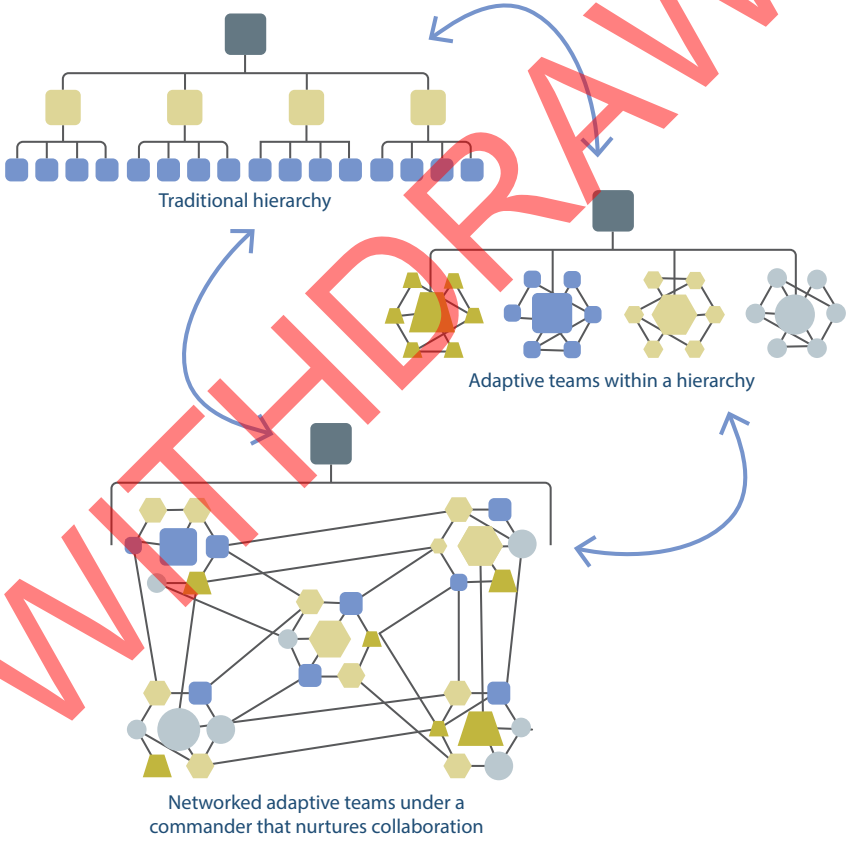


Figure 2.1 – Transitioning between different models of command and control

2.20. Due to these uncertainties, our structures, supported by technology and behaviours, must be adaptable to different models as the context and environment demands. Individuals and organisations within the base and deployed environments must be able to work collaboratively in support of different organisational models, enabled by delivering a single information environment. Delegated authority will allow subordinates to act to seize the initiative in circumstances where communications are lost, but having an effective single information environment in place will also greatly assist decentralised decision-making, as delegated authority will be enhanced by access to information known to the wider enterprise.

2.21. A challenge in attaining a more adaptive and agile organisation is that not all partners will be able to operate with a potentially novel, networked and collaborative command organisation and systems. We must, therefore, retain the ability to operate alongside less capable and agile organisations and systems.

Section 5 – The levels of warfare

2.22. Continuing to base our approach to operations and C2 on the construct of the levels of warfare is arguably more a consequence of military culture than of being essential to meeting current and future needs. In fact, C2 approaches, based on the levels of warfare create seams that make us less effective and agile. These levels were developed in an era of industrial age warfare, and were largely focused on physical environments rather than the multidimensional, information heavy problems we face today. The operational level in particular was designed for the effective application of the military instrument in warfare at scale, and for state-on-state conflict and operations conducted outside the home base. Over the last few decades the change in the character of the operating environment has led to this level becoming compressed and blurred. It is more suited to linear warfare, and is less appropriate in a continuous hybrid confrontation, which is intentionally kept below the threshold of conflict. Finally, it is a model that means little to our partners within a full spectrum approach.

2.23. Our thinking, training and use of technologies must evolve to reflect this changing character of warfare. The consequence of not changing our approach results in the operation being shoehorned into a pre-defined framework, rather than the framework providing an agile and effective means to understand and

direct the operation. As a potential alternative, the term 'operational gearing'[18] may have more utility than 'operational level' when discussing the orchestration of tactical activity to meet strategic objectives in this changed context. Using this term and concept instead of a 'level' allows us to think differently and to consider the need for collaboration within a complex network, rather than sustaining current hierarchical silos. However, we will need to consider the context and the concepts, organisation, training and lexicon of our partners to ensure appropriate levels of technical interoperability and organisational cooperation.

Key deductions and insights

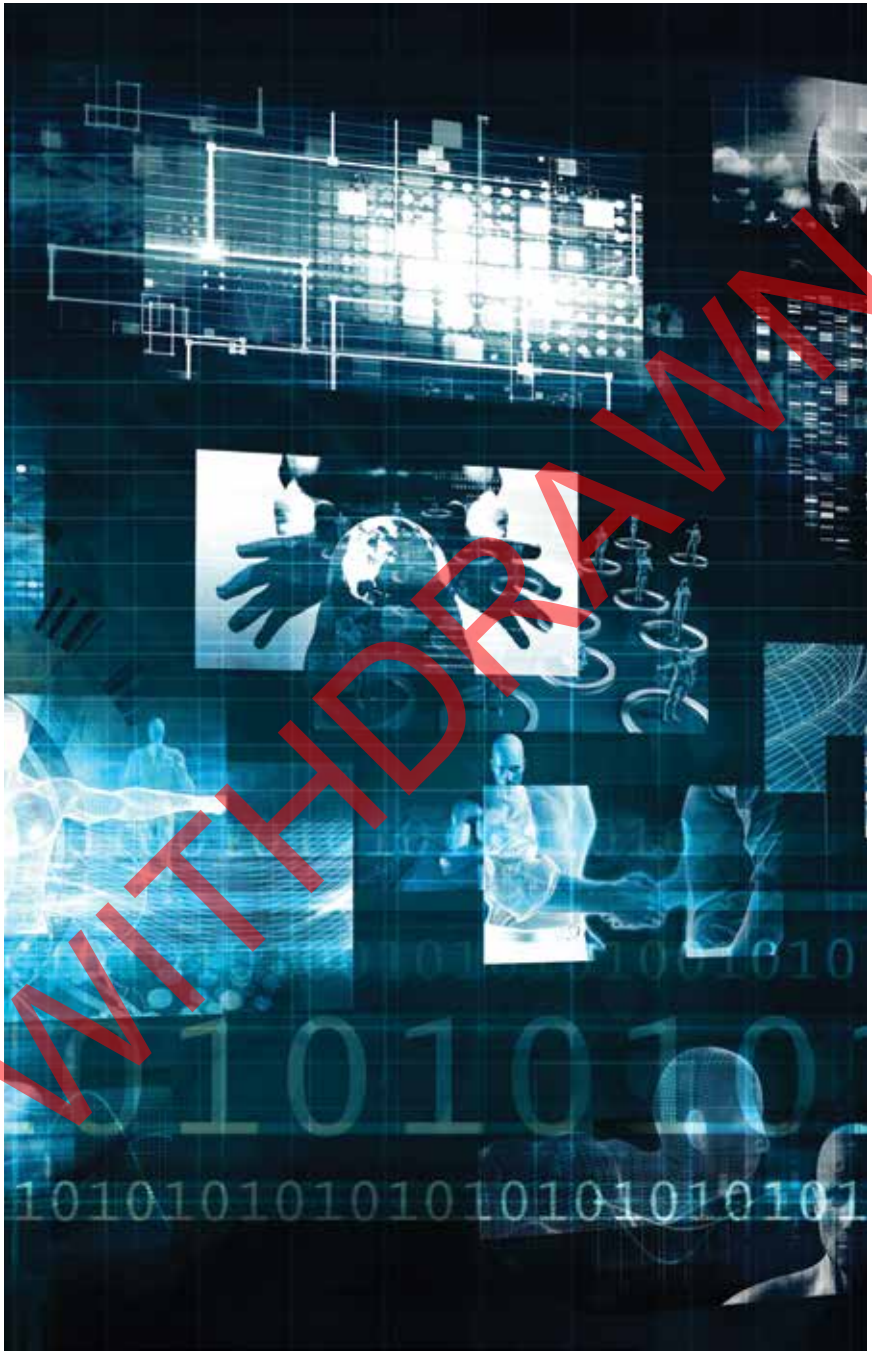
- The nature of persistent state-on-state competition continues to challenge traditional, linear crisis response command and control (C2) processes and structures. Defence, therefore, requires an applied operating concept, doctrine and new approaches for C2 to reflect a multi-domain, full spectrum approach.

- Defence will require mission configurable systems to facilitate integration with the North Atlantic Treaty Organization (NATO) and other potential allies and closer working with partners and *ad hoc*, non-traditional actors. As our C2 matures, we must retain the ability to operate alongside less capable and agile organisations and information systems.

- Future C2 requirements necessitate the need for both the single information environment and single intelligence environment to support improved understanding and effective decision-making.

18. 'Operational gearing' was used in a Development, Concepts and Doctrine Centre thinkpiece, *The Operational Level of Warfare in the Contemporary Environment – A Strawman*, to describe '...the orchestration between strategy and tactical actions for a particular endeavour...'.

Notes:



Chapter 3

Agile command and control

Section 1 – Explaining agile command and control

3.1. Previous chapters provide the backdrop for agile command and control (C2), namely the need to evolve our C2 approach in a timely manner in relation to the changing environment, context and mission. We cannot follow a single inflexible approach and expect success. Command and control should be viewed as a system that has a number of parameters, which will need to be purposefully altered for each given approach. One example is the North Atlantic Treaty Organization (NATO) C2 approach model represented in Figure 3.1.

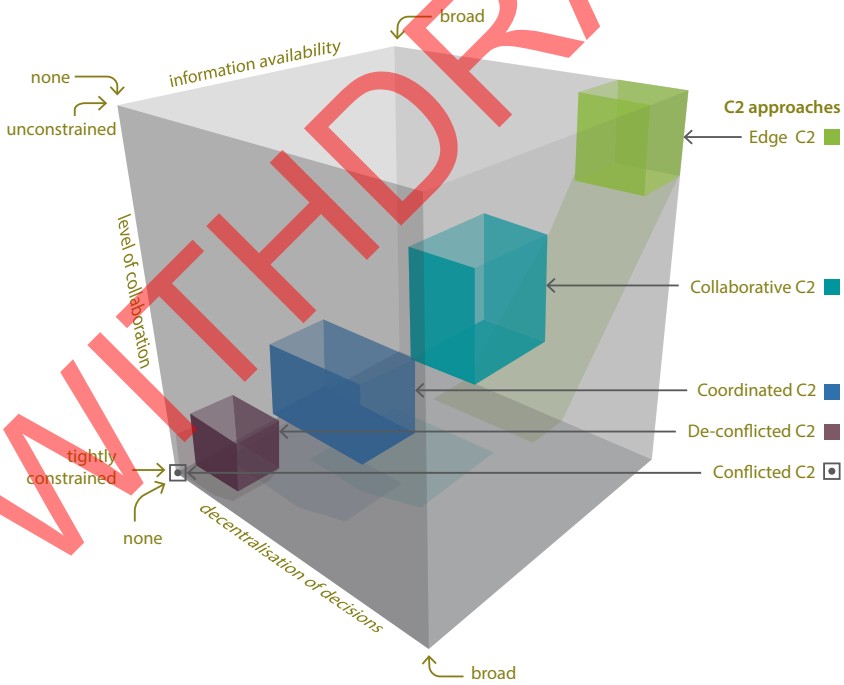


Figure 3.1 – The NATO command and control approach model[19]

19. Based on North Atlantic Treaty Organization (NATO) STO Technical Report, STO-TR-SAS-085, Task Group SAS-085 Final Report on C2 Agility.

3.2. The NATO C2 approach model shows just three of a larger number of possible interdependent parameters that can be adjusted to adapt an organisation's C2 approach to match its mission context and capabilities. Within this particular model, each approach occupies its own region, ranging from highly centralised and stove-piped hierarchies to loosely coupled networks. In the literature supporting the model, five recognised approaches are described.

a. Conflicted C2 is characterised by individual contributors exercising C2 only over their own forces. Hence, there is no shared collective objective, or any C2-related information distribution or other kinds of interaction between the C2 nodes.

b. De-conflicted C2 is characterised by the C2 nodes partitioning the problem space to avoid adverse cross-organisational impacts. This requires limited information sharing and limited interactions between the C2 nodes.

c. Coordinated C2 involves the development of a degree of common intent and an agreement to link actions in the various plans being developed by the individual C2 nodes It is characterised by:

- seeking mutual support for each other's intent;
- developing relationships and links between and among a C2 node;
- plans and actions to reinforce or enhance effects;
- some initial pooling of non-organic resources; and
- increased sharing of information.

d. Collaborative C2 is characterised by collaboratively developing a single shared plan. Collaborative C2 involves a considerable amount of delegation of decision rights to the collective; it aims to develop synergies by negotiating and establishing collective intent as well as a shared plan; establishing or reconfiguring roles, coupling actions, rich sharing of non-organic resources, some pooling of organic resources, and increased shared awareness.

e. Edge C2 is characterised by a robustly networked collection of C2 nodes having widespread and easy access to information, sharing information extensively, interacting in a rich and continuous fashion, and having the broadest possible distribution of decision rights.

3.3. The C2 approaches are not mutually exclusive. For example, an Edge C2 capable organisation can easily interact with a de-conflicted C2 organisation. In general, complex missions should tend towards an Edge C2 approach but conflicted C2 should not be considered negatively as such an approach may be appropriate, for example, a national nuclear firing chain. Therefore, no one approach is necessarily better than any other, it will depend on circumstances.

Task Force Helmand

Data from Helmand Province (2010-11) shows that mission complexity was very high, which required an Edge C2 approach. There was a clear progression of the C2 approach through the six-month period as the actual C2 approach moved from Conflicted to Edge.

The allocation of decision rights transitioned from narrow to broad; availability of information transitioned from vertical-narrow-push to lateral-push-pull; and collaboration increased from tightly constrained to unconstrained.

NATO STO Technical Report STO-TR-SAS-085,
Task Group SAS-085 Final Report on C2 Agility

3.4. The model is useful in visualising the changing nature of C2 approach, such that it is tailored specifically for the environment in which it is required. For example, to achieve an approach closer to Edge C2 for a complex mission, the critical elements of C2 would be:

- broadening information availability through extending and integrating information networks;
- maximising collaboration through adopting appropriate structures and behaviours; and
- maximising decentralised decision-making by adopting an appropriate command culture.

3.5. Agility cannot be achieved without a means to measure and assess our C2, deciding how and when to adapt and identifying who makes the decision at the outset. We must have a C2 model which has the ability to collect and distribute

data and transform it into intelligence, execute rapid decision-making, with the ability to direct forces, across multiple domains and missions. The following sections provide some ideas on how future C2 development could be assessed.

Section 2 – Assessing agile command and control

3.6. For C2 to be agile, the system or organisational parameter values will need to be continuously evaluated to ensure they are set correctly. As we gain experience of adapting for different missions and circumstances we will enable organisational learning and innovation. Headquarters and the wider C2 enterprise will need the ability to analyse performance and effectiveness, even while running operations. This will require data collection, analytical techniques and tools to understand the trade-space between risk, advantage and cost. We require the ability to know when to change or adjust our C2 approach, what to change to, and what an effective and safe transition mechanism will be. Adjustments come at a cost and we must therefore know that the benefit of adjusting outweighs the costs of not doing so.

3.7. It follows that a culture of learning[20] must be at the heart of our C2 capability with a governance and a support function that drives changes in C2 through organisational and experiential learning. To sustain a healthy C2 enterprise, we must also develop ways and means to exploit the Defence and commercial research that continues to explore how we model, understand and adapt C2.

Command and control adaptability can be considered as the ability to change parameters individually and collectively, whilst agility is the ability to change the parameters with speed and ease.

3.8. Experimentation through exercises, war-gaming and using synthetic environments will allow us to explore, assess and tailor C2, the distribution and connectivity of force elements and specific partnering arrangements. Our maturing

20. As described within MOD, Defence Organisational Learning Strategy. Available at http://defenceintranet.diif.r.mil.uk/Organisations/Orgs/JFC/Organisations/Orgs/DJW/JW/Lessons/Pages/OrganisationalLearningTeam.aspx

technical ability to link multiple exercises and experiments via distributed networks affords the opportunity to align in more innovative ways the enterprises that have previously remained discrete.

3.9. When assessing C2 we need to measure the parameters of the wider C2 enterprise and C2 nodes. While the NATO C2 approach model allows us to consider the C2 enterprise there is also a requirement to provide a common framework that may be able to help a headquarters improve and sustain its competence and effectiveness.

The Headquarters Maturity Model

3.10. The Headquarters Maturity Model (HQMM), shown in Figure 3.2 describes five levels defined as a theoretical continuum along which headquarters may progress from basic capabilities at level 1 to advanced capabilities at level 5. This demonstrates increasing levels of effectiveness and competence.

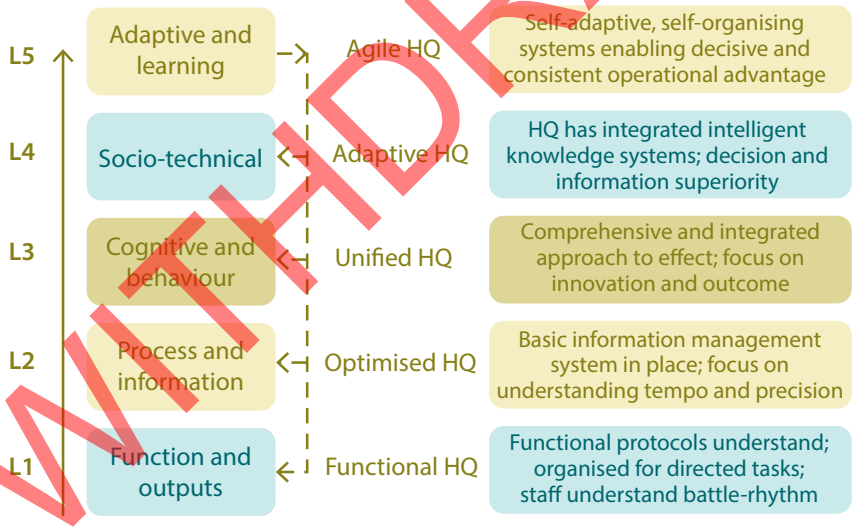


Figure 3.2 – The Headquarters Maturity Model[21]

21. Patel, J. and Pattison, G., *Headquarters Maturity Model: An approach to optimising a HQ for operational advantage*, DSTL/WP099947/v1, 2017 (under development).

3.11. The levels in the HQMM are not strictly hierarchical as progress can be made at multiple levels in parallel. However, some measure of progress has to be made at lower levels as a basis for building those competencies necessary for operating at higher levels.

a. **Level 1: functional headquarters.** The initial operating capability of headquarters is generally defined by disorganised and rudimentary behaviours, practices and processes. It can be described as function and process focused – the staff are organised for directed tasks with outputs driven by the battle rhythm. A functional headquarters is easily disrupted by a change in command identity, staff churn and a change to the mission or force profile. In addition, any degradation of cyber-related capabilities will potentially create dysfunction.

b. **Level 2: optimised headquarters.** The headquarters structure and functions are defined on the basis of a clear understanding of purpose and operational objectives. It is an efficient headquarters that is focused on tempo and precision nested within a clearly understood operational narrative that allows the battle rhythm and effects process to be optimised. The level of headquarters may be able to recognise critical cyber-related degradations, but will have difficulty mitigating the effects.

c. **Level 3: unified headquarters.** This is an effective headquarters at an advanced level of maturity where innovation and self-aligning processes deliver a higher quality of support to commanders to enable more timely and effective decision-making. It has a clear identity, is unified in purpose and can reorganise for a variety of effects and missions in stride. A unified headquarters will be able to make some adjustments changing network connectivity and performance.

d. **Level 4: adaptive headquarters.** This is a currently achievable version of a socio-technical system composed of humans and intelligent (software) agents[22] working in parallel to support the commander's decision cycle. Human/machine teaming enables enhanced decision-making and improved information exploitation through faster processing of information and seamless access to expert knowledge and systems. Intelligent agents also

22. In artificial intelligence, an intelligent agent is an autonomous entity which observes through sensors and acts on an environment using actuators (*i.e.* it is an agent) and directs its activity towards achieving goals.

ensure continuity in corporate knowledge and provide a buffer against mission and human churn. This level of headquarters will be able to adapt in response to changes in network connectivity and performance.

e. **Level 5: agile headquarters.** This is an aspirational headquarters, the pinnacle of competence and the exemplar of a true socio-technical system. It demonstrates an ability to learn in real time and dynamically adapt to a fast evolving situation. In this futuristic headquarters, staff work is primarily carried out by advanced intelligent agents, that is, those that can automatically learn from experience, under the supervision of humans. Such capability may be essential in situations where the main conflict occurs where decision execution cycles are increasingly rapid, for example, in cyberspace. Embedded intelligence in our communications and information networks will make it possible to defend against all but the most sophisticated cyber attacks and provide headquarters staff with the information they need to adapt C2.

3.12. The HQMM attempts to embody two desired features for military headquarters: improving its information capabilities; and becoming more adaptive and agile. The implicit development path within the HQMM, requires Defence to provide the following.

a. **An instrumented operational headquarters.** Embedded instrumentation automatically collects a host of information about how the headquarters is functioning. This information is not only critical to efforts to monitor C2 functions but will also support both experimentation and lessons learned.

b. **A training and experimentation environment.** Federated experimentation facilities consisting of information technology infrastructure where new and emerging technologies and ways of working can be trialled.

c. **A command and control learning and development centre.** A facility that collects lessons and best practice on C2 from military and civilian organisations. It then uses these to educate and train future headquarters staff, as well as potentially developing heuristics for intelligent agents that could be used at HQMM Levels 4 and 5.

Section 3 – Delivering agile command and control

3.13. As a socio-technical system, particularly at the operational level, C2 crosses organisational, domain and capability boundaries as well as a number of academic disciplines. Figure 3.3 illustrates the cross-cutting nature of C2 which rarely corresponds to Defence financial and budgetary structures or delivery organisations. This results in a large C2 stakeholder community with a wide range of interests, which are often misaligned or divergent. These tensions reduce the probability of delivering potential benefits for Defence and result in significant and often unquantified risk being carried in C2 capability.

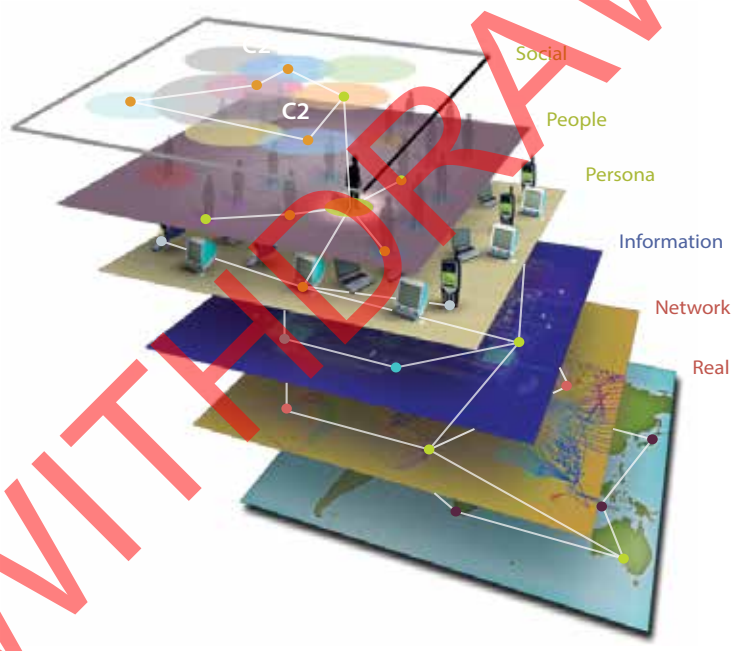


Figure 3.3 – The cross-cutting nature of command and control

3.14. If C2 capability is to be addressed effectively we will require governance and a programmatic approach that manages effectively all appropriate lines of development, including interoperability. Indeed, we are mandated to deliver capabilities in this way. This approach will need to draw on the expertise of the

research community and develop a thorough understanding of the risks that Defence is carrying against C2.

3.15. 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. This champion must set the conditions for change by promoting the principles of future C2, creating a culture and mindset for the development programme and providing support and advice to senior leadership and staff who will be central to the delivery of change. This will be achieved through comprehensive governance as summarised in Figure 3.4.

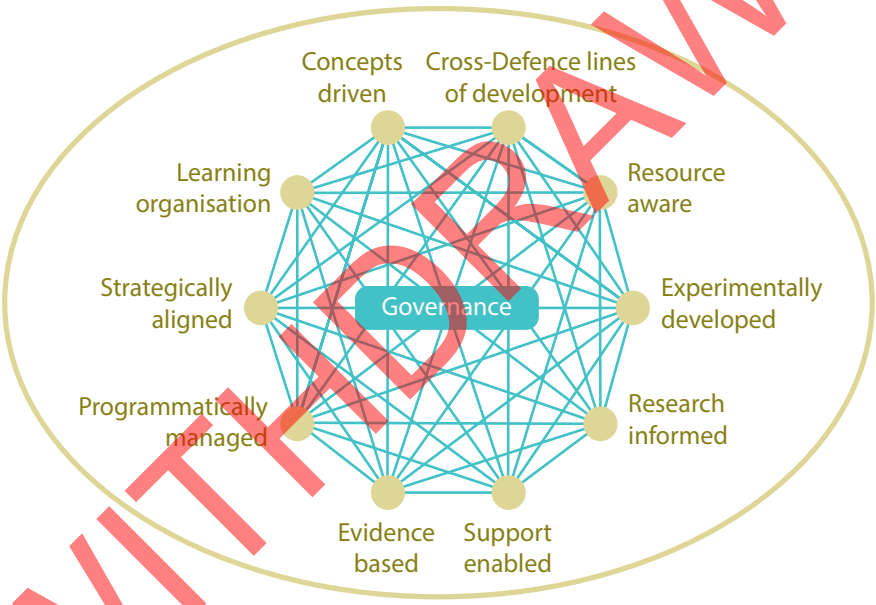


Figure 3.4 – Delivering command and control as a capability

3.16. The C2 capability programme must be evidence-based; concepts driven; resource aware; and strategically aligned. A programmatic approach should be adopted that considers cross-Defence lines of development, drawing on experimentation and research using enabling support, underwritten by a culture of organisational learning.

Key deductions and insights

- We need to deliver agile command and control (C2) as a capability through a programmatic approach.
- We require the ability to know when to change or adjust our C2 approach, what to change to, and what an effective and safe transition mechanism will be. Any adjustment will come at a cost and we must therefore know that the benefit of adjusting outweighs the challenges of not doing so.
- To support the delivery of agile C2, Defence should establish:
  - a champion at senior level who can direct cross-Defence lines of development interventions and understand the risks that Defence is carrying against C2;
  - a C2 learning and development centre;
  - An instrumentation of our headquarters in order to monitor C2 functions; and
  - a federated experimentation environment where new and emerging technologies and ways of working can be trialled.

Notes:

Chapter 4

Enabling future command and control

Section 1 – Command and control interdependencies

4.1. Command and control (C2) systems emerge from the complex interactions between people, structures, technology and processes. In the future there will be significant advances and changes in each of these individual areas that will impact directly or indirectly on each other. This change will be uncertain and we will need a process of timely adaptation to deliver an appropriately tailored system to meet the needs of a specific environment and context. Whilst accepting the extensive interrelationships between these elements, it is nonetheless useful to consider each separately, as highlighted in Figure 4.1, allowing us to identify emerging opportunities.

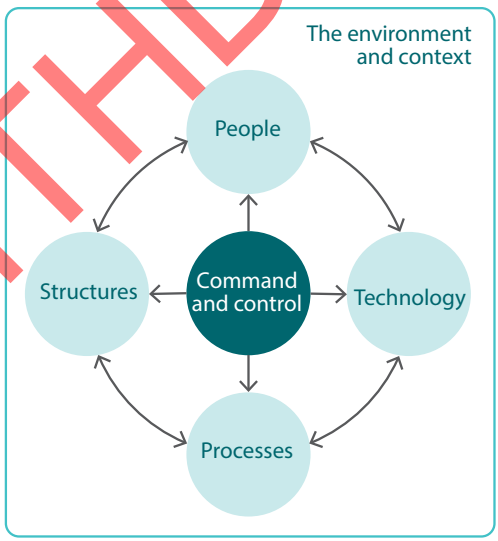


Figure 4.1 – The interdependencies of command and control capability

'...first, an intellect that, even in the darkest hour, retains some glimmerings of the inner light which leads to the truth; and second, the courage to follow this faint light wherever it may go.'

Carl von Clausewitz,
On War

Section 2 – People

The commander

4.2. To achieve agility we will require intuitive and experienced commanders who are comfortable with dynamic command structures and groupings. They will need to adopt a culture of learning to complement necessary experience and intuition. They must be prepared to adapt their thinking and ideas in light of relevant evidence rather than falling prey to confirmation bias. We must develop leaders who are knowledgeable in how to optimise every component of the task force and headquarters, understanding the political, social and informational dimensions of their role. They will continue to need intellectual agility, personal robustness and appropriate experience built upon formal and self-education. These elements are essential to cope with the significant demands placed upon them, which will often be unexpected and unfamiliar.

4.3. Leadership will be significant in achieving and maintaining agile C2. Just as a joint commander today understands the capabilities and strengths and weaknesses of a weapon system, in the future they must study and have experience of the critical new tools of their trade, such as information technologies, sensors, developments in artificial intelligence and automation. They will need to be open to new ideas and inculcate a culture of adaptation. Ultimately, it is the commanders of the future that will first authorise the employment of human/machine teaming and intelligent agents and develop the policy and understanding for the C2 of automated systems.

4.4. Those selected for higher command will need to adopt new styles of leadership to cope with the increasingly complex character of operations. Whilst the central role of the commander, supported by their staff, will remain 'the art of decision-making, motivating and directing',[23] the temptation to lead as the

23. Allied Joint Publication (AJP)-01, *Allied Joint Doctrine*, Chapter 5, Section I – Command Philosophy.

ultimate decision-maker, controlling each move of the organisation, must give way to an approach of enabling and catalysing rather than directing. Future leaders will increasingly need to act as the enablers who create and maintain the C2 ecosystem in which the organisation operates.

4.5. The commander must nurture organisation-to-organisation collaboration and create a culture of mission command by ensuring that subordinates are enabled by the delegation of decision authority, freedoms, resources, information and time. This will require the space to innovate, including the confidence to allow learning through failure. Outwardly-focused organisations are more likely to succeed in a complex environment. We must avoid behaviours that are inward-looking and only support the continuous feeding of information to a commander, requiring them to make an excessive number of decisions.

Selection of commanders and staff

4.6. Understanding the characteristics of decision-makers who are resilient and incisive in complex scenarios will inform the selection of those best suited to the task. New identification and selection techniques, supported by data analysis technologies, will allow us to identify individuals with the potential to develop adaptive expertise and cognitive flexibility. Improved techniques for diverse thinking and leadership will enhance specific decision-making skills. Decision-makers will be selected for their ability to act decisively, respond well to uncertainty and avoid data overload. In addition, commanders will need to understand the effect of physiological states and contextual conditions on their own emotions, concentration, anxieties and attitudes to risk.

4.7. Commanders and key staff will need to avoid known decision error types and biases, such as hyperbolic discounting, loss aversion, and information bias.[24] Staff must be cued to the likelihood of succumbing to a known error or bias. Further opportunities to develop staff attributes may flow from initiatives such as the Ministry of Defence's (MOD's) Strategic Edge Through People 2040[25] and

24. Hyperbolic discounting refers to the preference of an individual to select an outcome that arrives sooner rather than later. Loss aversion refers to the tendency for people to prefer avoiding losses than acquiring gains. Some studies suggest that losses are as much as twice as psychologically powerful as gains. Information bias is a type of cognitive bias and involves a distorted evaluation of information. An example of information bias is believing that the more information that can be acquired to make a decision, the better, even if that extra information is irrelevant for the decision.

25. Strategic Edge Through People (SETP2040) is an innovation project that aims to enhance future human capability through the exploitation of world leading science and technology. For more information see http://www.defencehumancapability.com

Thinking to Win,[26] but military-only headquarters need to be counterbalanced with the need for diversity, alternative thinking (to avoid institutional group think) and specialists with deep skills, such as data scientists. Experience, authority, training and skills are the main factors, rather than rank and age. This requires further analysis of alternative career models, including for lateral entry, secondments and flexible employment.

Training commanders and staff

4.8. How we train decision-makers will need to adapt in line with changing technology and processes, noting that in the past the training pipeline has often lagged behind other lines of development for C2 capability. Improving commanders' and staffs' reflective analytical skills will improve agility by allowing accurate and swift identification of lessons within a continual cycle of adaptation. Training in challenging situations where no 'right answer' exists will enhance their ability to handle uncertainty and comprehend complex and chaotic situations. Within a changed culture, commanders must be allowed to fail, and fail fast, in a safe to fail environment (for example, wargaming), assessing their agility rather than their ability to conform to a process.

4.9. The use of wargaming allows commanders to practise C2 in a complex adversarial environment where failure teaches vital lessons. Wargaming can be undertaken simply and cheaply but immersive, simulated C2 environments will need to be developed to model adversarial human behaviours in addition to existing variables such as platforms, weather and terrain. The range of human agents (enemies, refugees or simply unknown human actors) and their reactions and emotions will need to be replicated in future simulations to add value for training commanders and staff. Future capabilities such as adversarial artificial intelligence will also need to be modelled in such simulated environments.

4.10. It will be important to capture all competencies of staff to ensure suitably qualified and experienced staff are educated and then employed in operational headquarters. In particular, the development of joint competencies will be key to ensuring a full understanding of all aspects of military power and the delivery of joint action.

26. Thinking to Win is an RAF cultural change programme with a goal to inspire innovation, assert Air Power influence and transform the RAF's thinking at the operational and strategic levels. For more information see http://www.raf.mod.uk/rafcms/mediafiles/28DBDA58_5056_A318_A8AA043B147E9F02.pdf

Section 3 – Structures

4.11. Our C2 structures at the operational level are dependent on the threat, technology and level of collaboration with an enduring requirement to dock into the North Atlantic Treaty Organization (NATO) C2 structure and *ad hoc* coalitions. Such collaborative C2 will offer greater organisational effectiveness and agility than traditional coordination models. It will require new headquarters designs, such as the layout of physical and virtual spaces to enable interactions between people and increasingly, between people and machines.

Headquarters size and mobility

4.12. Headquarters have grown in size and complexity to deal with the increasing demands of information management and exploitation. Headquarters that could previously have expected to manoeuvre, or at least to move frequently, have become fixed and hence, more vulnerable. Future technologies and behaviours will allow headquarters to be much smaller and more mobile, agile and dispersed including small forward headquarters that can reachback to additional staff and data lakes through cloud technology. There will continue to be a trade-off between location, security (physical and information) and access to information, but the ability to change at the required tempo will remain critical.

Headquarters Allied Rapid Reaction Corps, deployed Headquarters 2015

> There has been a consistent belief that adding manpower to command posts is a good thing. It is not. It is counter-productive, but that is not obvious. There is an optimum size for groups of human beings who interact. It is a balance between dividing a job up between more people to reduce the time taken, against the increased time needed to brief all the members of a large group. As command posts get bigger, they get inefficient. They are clearly well beyond their optimum size… HQs have become so big that it is almost impossible to train them. Staff training has become a big, unwieldy process often conducted only once a year.
>
> Jim Storr, Ten Years Observing Command and Control, *Military Operations Journal* Volume 3, Issue 1, Spring 2015

Span of command

4.13. It could be assumed that providing automated systems would permit the span of command to be increased. This assumption is based on the prior premise that unlike human-led units, automated systems will be more consistent in their understanding and execution of the directives which they have been given, hence they will need less monitoring and correction. However, adding automation may simply transfer the problem from the realm of span of control and improved consistency to a more challenging one of limitations and overload. That is, automated systems typically have harder limits and less ability to continue functioning in situations that are outside their design parameters. They will therefore tend to either fail catastrophically, or recognise that they are reaching their limits, and at the typical point of highest stress in an operation, hand over the problem to an insufficiently engaged human. Thus, we should reduce our expectation that automation will permit an increase in span of command. Instead we should recognise that careful consideration and design, and rigorous testing in the most difficult of situations, will need to be carried out before such burdens can be safely undertaken by automated systems.

Section 4 – Technology

4.14. The most significant changes in how we approach C2 are likely to come from the rapid development of information technologies, sensors, developments in artificial intelligence and automation. The combined effect of vast growth in processing power and connectivity will fundamentally shape how the world lives and works. Advances in data-to-decision technology, exploitation of efficient and effective human machine interfaces, data-to-decision and cloud solutions all offer the potential to enable the evolution of C2 from its current form to an information-centric foundation and migrate from a single to multi-domain C2 construct.

4.15. Increasingly, defence and security capabilities will rely on exploiting commercial research and innovation. Whilst there are inherent risks and vulnerabilities that come with adoption and dependence on such technology, the potential advantage necessitate their use. There are many areas of opportunity, such as the use of analytical systems to enhance evidence-based decision-making at speed, as summarised in Figure 4.2.

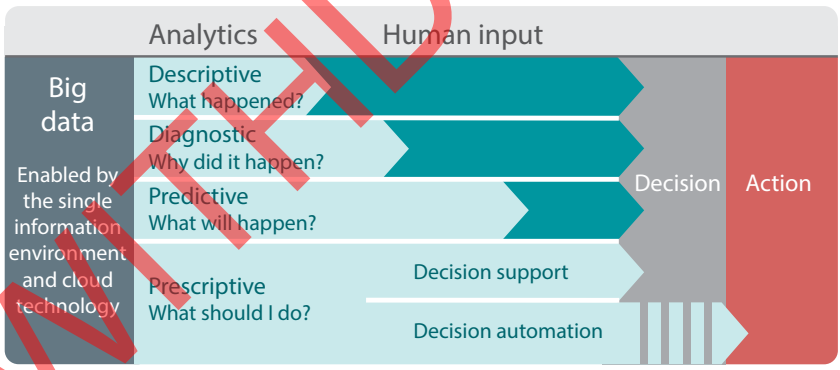


Figure 4.2 – Types of analytics capability[27]

27. Adapted from 'Gartner Says Advanced Analytics Is a Top Business Priority', October 2014. Available at http://www.gartner.com/newsroom/id/2881218.

Decision support

4.16. We will see a progression beyond the use of machines to support the intelligence cycle, towards human/machine planning, decision-making and mission execution. Ultimately, humans and technology should be parts of the same team, with either technology providing personal assistance or with humans and machines being agents of the team.

4.17. Human/machine integration will be a key enabler to all understand functions. Advances in interface technology (including voice activation, virtual immersive environments, command walls and three dimensional command tables) will provide more natural interaction and improve situational understanding. Machine learning and greater processing power will allow for the generation and critiquing of hypotheses, potential courses of action and outcomes. First adopters of this emerging technology for decision support will achieve significant advantage over adversaries, but users will need to consider the legal, moral and ethical factors surrounding decision automation, particularly relating to creating lethal effects. It is likely that as the use of such systems become more common in everyday life, any potential military application will become less contentious.

Humans and technology should be part of the same team

Operational management

4.18. Operational management, including assessment, currently relies extensively on human intervention for analysis, coordination and tasking. Data analytics and exploitation of machine learning techniques can potentially assist with gaining situational awareness. Coupled to new visualisation techniques, automation can reduce the cognitive load, improve information management and exploitation, generating improved tempo, understanding and contributing to near real-time battle management. Automated information processing systems will reduce the burden on headquarters staff, relieving them from tedious and complicated tasks to focus on higher-value activities if, indeed, they are required at all.

The single information environment

4.19. To complement the necessary changes in thinking, culture and training, achieving agile C2 will require evolving and disruptive information technologies. Our information and communication services will underpin the single information environment (SIE) and must have shared, ubiquitous standards, be backwards compatible and able to connect to unanticipated partners, as well as established allies. They must support connections at different classifications and, with varying levels of trust, facilitate our 'need to share' and 'need to collaborate', as well as our requirements to protect information. NATO Federated mission networking[28] serves as the enabling framework, within which the UK must develop its own affiliated network and gateways whilst continuing to support and influence NATO capability development.

4.20. Future information capabilities will rely on a combination of civil technology and military systems. These will use a diverse range of connectivity options to ensure continual robust communications and access to data through emerging cloud technologies.[29] The continued use of beyond-line-of-sight capabilities, including high altitude platforms, will provide additional options for access to the high-bandwidth, high-assurance global communications needed to support C2 in the most likely areas of operation. Other technologies will include

28. Federated mission networking is a key contribution to the Connected Forces Initiative (CFI), helping Allied and Partner forces to communicate, train and operate together better. Available at https://dnbl.ncia.nato.int/FMN/SitePages/Home.aspx
29. Data and information services are located and managed remotely and accessed through a secure network.

ad hoc networks, sophisticated network intrusion detection, laser direct point-to-point systems and quantum key distribution networks.[30]

Resilience

4.21. New information technologies will be susceptible to new vulnerabilities and additional threats, as a result of hostile action or technical failure. Degradation, loss or denial of C2 systems will be potentially catastrophic and therefore systems must be survivable, with self-healing and self-forming networks and reversionary 'off-line' modes to complement alternative procedures. If our communications are denied, we need military experts in network architectures to provide the ability to reconfigure damaged networks rapidly, as well as being able to recognise cyber attacks and defend against them through cyber or network awareness. Ultimately, we must be able to operate without access to assured space-based services.

Legal and policy issues

4.22. The legal and policy issues around automated technologies will need to be reviewed in line with current practice as and when they are studied, developed, acquired or adopted by the UK. Whilst the obvious legal and ethical concerns will relate directly to the use of lethal autonomous robots and systems, there will also be uncertainty surrounding the use of automated systems for C2, where decisions result in the employment of lethal force. It is reasonable to expect that domestic civil law will be adapted to take into account increasing automation.

4.23. International law applicable to our Armed Forces has always evolved and been interpreted to take into account new technologies, as happened for submarines, aeroplanes and cyber tools. The military will have to ensure that they are fully represented in the legal, policy and ethical debates, domestically and internationally. They must ensure their views are fully and accurately considered, as otherwise potential adversaries may gain considerable advantage. We must avoid restrictions being placed on our Armed Forces which may not be applicable to our adversaries, particularly non-state adversaries, who may be able to buy and weaponise civilian technologies.

30. Owens, I. and Holland Smith, D., *A horizon scanning perspective on command and control out to 2025,* Defence Science and Technology Laboratory, 2016.

Section 5 – Processes

4.24. Processes are important in providing a means to develop and deliver effective C2, but they are not an end in themselves. It may be argued that we have recently focused too much on process and staff work and not enough on the ability to actually deliver required outcomes. At all levels, as we seek to meet the myriad of challenges associated with future C2, we must develop processes that leverage the very best of our people, structures and emerging technologies to the clear benefit of partners and subordinate organisations.

4.25. Our current doctrine stresses the importance of the tempo of decision-making and execution. We have designed our processes to cycle through the stages of plan, refine, execute and assess as efficiently as possible, often exhausting the staff and commander in the process. While this may be appropriate for complicated problems and known-unknowns, it is not suited to the complex problems we are likely to encounter at the operational level, characterised by unknown-unknowns, where identifying courses of action, end-states and cause and effect is, by definition, impossible.

4.26. Operational art will continue to reflect the orchestration of tactical activity to meet strategic objectives, but must also take into account the complex and emerging patterns of the situation at hand. Operational design remains the vital methodology to make sense of a complex environment, but we must constantly review and adapt our tools and techniques in order to make the most of emerging processes and supporting technologies. We must also specifically consider how effectively these processes and tools enable coordination, collaboration or de-confliction with other government departments and non-military actors.

Key deductions and insights

- We will not routinely command expeditionary operations at the strategic or operational level, but must retain the capability to do so. For such command, experience, authority, training and skills are the critical factors, rather than rank and age.
- Analysis of alternative career models and a shift from a sole reliance on annual appraisals to a formal unbiased assessment including potential use of data collection and analysis technologies is required.
- To counter the threat from anti-satellite weapons, Defence must be able to operate without access to assured space-based services.
- New information technologies offer increased opportunities for command and control, but also increase our vulnerability. Defence must maintain reversionary 'off-line' modes and practices as a matter of course.
- There is a requirement for further study into the employment of automated decision-support technology to understand their implications and the legal, ethical and moral implications.
- We need to develop joint competencies and then manage our personnel in such a way as to ensure headquarters appointments are filled effectively.

Annex A

Understanding complex problems

A.1. Complexity theory relates to uncertainty and non-linearity. In the context of command and control (C2), it describes how organisations adapt to their environments with complex structures and dynamic interactions. Relationships are adaptive; individual and collective behaviours transform and self-organise in response to events in the system.

A.2. Based on experimental research of decision-making behaviours,[31] we can model a successful C2 system, avoid gathering excess information, focus rigorously on outcomes and progress to intermediate goals that have a high probability of success. There is therefore an extremely valuable empirical research base available that deals more effectively with complex problems. However, as an introduction to the concept it is useful to offer commanders and staff a simple model of how to approach real-world problems, such as the Cynefin[32] framework in Figure A.1.

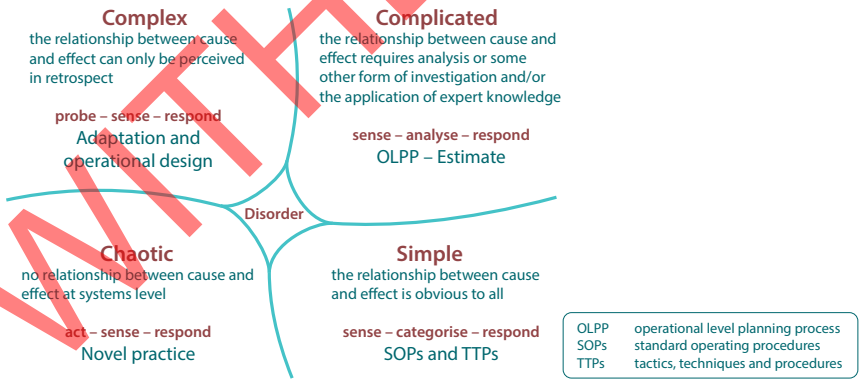


Figure A.1 – The Cynefin framework[33]

31. Dorner, D., *The Logic of Failure – Recognising and Avoiding Error in Complex Situations,* 1996.
32. Cynefin, is a Welsh word that signifies the multiple factors in our environment and experience that influence us in ways we can never understand.
33. Adapted from the original model by David J. Snowden and Mary E Boone in 'A Leader's Framework for Decision Making'. *Harvard Business Review*, November 2007.

A.3. The Cynefin framework sorts the issues facing leaders into five contexts defined by the nature of the relationship between cause and effect: **simple, complicated, complex, chaotic** or **disorder**. The first four require leaders to diagnose situations and to act in contextually appropriate ways, whereas disorder is applied when it is unclear which of the other four is predominant.

a. Simple problems. Simple problems are characterised by clear cause and effect relationships and 'known-knowns'. The solutions are self-evident and decisions are rarely questioned due to a shared understanding. The response to the problem is normally by means of a standard operating procedure or use of well understood tactics, techniques and procedures.

b. Complicated problems. Complicated problems are the realm of 'known-unknowns', with a number of possible courses of action. Cause and effect are connected linearly, though not necessarily obviously. While leaders in a simple context must sense, categorise, and respond to a situation, those in a complicated context must sense, analyse, and respond. Good practice, for example, the operational-level planning process or formal estimate, is more appropriate than standard operating procedures.

c. Complex problems. The complex domain is the realm of 'unknown-unknowns'. It is the domain where the operational level now usually sits. Information is invariably incomplete and we understand causal links only in retrospect. Intelligible patterns can emerge if the leader conducts experiments that are safe to fail. Instead of attempting to impose a course of action, leaders must allow the path forward to reveal itself. They need to probe, then sense, then respond. Leaders who try to impose order on complexity are likely to fail.

d. Chaotic problems. The relationships between cause and effect in the chaotic domain are impossible to discern as they shift constantly and no manageable patterns exist. This is the realm of the unknowable. A leader's immediate job is to stabilise the crisis. They must establish order, sense where stability is present and where it is absent, then respond to move the situation from one of chaos to complexity, where it becomes possible to identify emerging patterns.

Lexicon

Part 1 – Acronyms and abbreviations

AJP	Allied joint publication
AAP	Allied administrative publication
C2	command and control
DCDC	Development, Concepts and Doctrine Centre
Dstl	Defence Science and Technology Laboratory
HQMM	Headquarters Maturity Model
JCN	joint concept note
JDP	joint doctrine publication
JFC	Joint Forces Command
MOD	Ministry of Defence
NATO	North Atlantic Treaty Organization
PJHQ	Permanent Joint Headquarters
SDSR	*Strategic Defence and Security Review*
SIE	single information environment
SIntE	single intelligence environment

Part 2 – Definitions and additional terms

This section explains additional terms and provides definitions where appropriate. First, we list proposed new definitions for this publication which have not yet been ratified or added to the UK Terminology Database. Second, is a list of endorsed terms and their definitions (sources in brackets). Finally, current terminology without endorsed definitions are explained.

New definitions introduced in this publication

command and control capability
A dynamic and adaptive socio-technical system configured to design and execute joint action. (JCN 2/17)

purpose of command and control
To provide focus for individuals and organisations so that they may integrate and maximise their resources and activities to achieve desired outcomes. (JCN 2/17)

Endorsed definitions

command
The authority vested in an individual of the Armed Forces for the direction, coordination and control of military forces. (NATOTerm)

control
The authority exercised by a commander over part of the activities of subordinate organizations, or other organizations not normally under his command, that encompasses the responsibility for implementing orders or directives. (NATOTerm)

interoperability
The ability to act together coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objectives. (NATOTerm)

joint action
The deliberate use and orchestration of military capabilities and activities to affect an actor's will, understanding and capability, and cohesion between them to achieve influence. (JDP 3-00)

joint force commander
The operational commander of a nominated joint force. (JDP 0-01.1)

operational art
The employment of forces to attain strategic and/or operational objectives through the design, organization, integration and conduct of strategies, campaigns, major operations and battles. (NATOTerm)

understanding
The perception and interpretation of a particular situation in order to provide the context, insight and foresight required for effective decision-making. (JDP 04)

Additional terms

hybrid warfare
A form of warfare combining conventional and unconventional military and non-military actions to achieve a specific goal.
(Proposed definition awaiting NATO agreement)

full spectrum approach
A full spectrum approach draws on a range of levers available to a state actor in a coordinated way to achieve (geo)political and strategic objectives. This can include overt and covert activities and the use of political, cultural, diplomatic, economic, military and other levers. The UK applies its levers of national power within the rules-based international system.
(*Full Spectrum Approach Primer,* March 2017)

single information environment
A logical construct whereby assured information can pass unhindered from point of origin to point of need. The SIE will include a single intelligence environment.
(*Defence Information Strategy 2017*)

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