12th ICCRTS

"Adapting C2 to the 21st Century"

Scientific Support to the Development of the UK's Future C2 Concept

Topics: C2 Concepts, Theory and Policy or Organizational Issues

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INTRODUCTION

As part of its process of transformation, the UK Ministry of Defence (MOD) is considering whether it is possible to enhance Command and Control (C2) in the networked era. Evidence from a broad range of studies, experiments and operational lessons suggests that Network Enabled Capability (NEC) will allow UK forces to operate quicker and better, and with reduced risk of fratricide. It also highlights that enabling dynamic collaborative working can improve operational capability, particularly when agility of command and control (C2) is combined with improvements in the quality of information available.

In 2006, the UK MoD held a senior workshop to explore how C2 might be adapted and optimised for expeditionary operations in the 2020 timeframe. A co-ordinated programme of science (analysis, experimentation and human factors research) was put in place to test the ideas for future C2 that emerged from the workshop. This involved a diverse range of methods to address the impact of ideas across all lines of development.[1]

The workshop and its associated programme of scientific testing was described at ICCRTS11. This follow-on paper presents further detail of the testing now underway and the emerging findings that are supporting the development of the UK MOD's Concept for Future C2. The aim of this paper is to provide early insights from the existing science base of the risks and benefits of four potential Command and Control (C2) models in order to support the development of the UK draft Interim Concept for Joint C2.

SCOPE OF THE PAPER

1. The four potential C2 models have been derived for scientific testing based on the insights generated by the senior workshop. They are a starting point for the development of the Future Concept for C2 and are intended to help test the envelope of possible models that may exist.

2. The four cases as shown in Table 1 are:

   - Case A, which is the current C2 model and provides the baseline for comparison.
   - Case B, which explores the impact of greater geographical separation of commanders and their staff than is currently the norm, but otherwise uses the current model. In this case the commander will go forward whilst the majority of staffs are co-located in the rear. The idea is that this will reduce the forces' footprint in theatre by reducing the requirement for force protection and consequent requirement for support capabilities. The test for Case B will be if those benefits can be realised without reducing C2 effectiveness.
   - Case C, which explores a C2 structure that is task-based; i.e. it replaces the Environmental Component Commanders with cross-environment task groups. These Task Groups are formed by the Joint Force Commander (JFC) in accordance with his Command Intent, and remain in being until the task for which they were formed is completed. They then either merge into new task groupings, or rejoin a pool of contingent forces until needed as part of another agile task group. The ebbing and flowing of these Task Groups over time is

[1] Training, Equipment, Personnel, Information, Doctrine, Organisation, Infrastructure, Logistics

bounded by the JFC's Intent, on the basis of the effects he wishes to create. Under a developing Comprehensive Approach, non-military participants will be integrated into Task Groups as required by the task/role they are conducting and based on the needs identified through the Estimate Process.

- Case D, which is as Case C but with greater geographical separation of commanders and their staff than is currently the norm. For instance, environmental Subject Matter Experts and a set of Core Functions will be held at the Joint Task Force HQ (JTFHQ), which is located within the Joint Operations Area (JOA), and Task Group HQs will be staffed only for the functions critical to their task, with reachout to the JTFHQ for other support.

	Commanders and their staff are co-located (in the JOA)	Commanders and the majority of their staff are separated (but still in JOA)
Current C2 Model	Case A	Case B
Task-based C2 Model	Case C	Case D

Table 1: Initial cases to understand the envelope of possible C2 models

STRUCTURE OF PAPER

3. Recent work has proven that NEC can deliver improved effects but only if all Defence Lines of Development are taken into account. This has been captured in the NEC Benefits Model at Figure 1, which has previously been validated against evidence from science [1]. The C2 cases outlined at Table 1 can be thought of as different variants under the Agile Groupings building block. Since the NEC benefits evidence indicates that all the other building blocks need to be robust in order to realise agile C2, the evidence that follows has been structured to reflect the components of the NEC benefits chain.

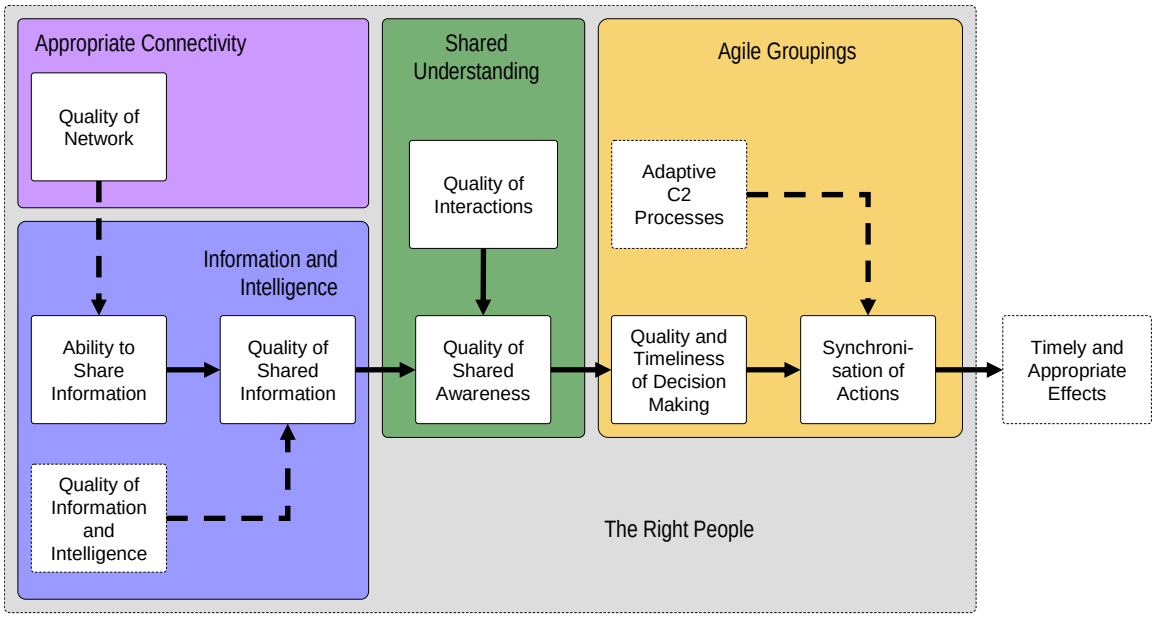

Figure 1: ***Evidence-based NEC Benefits Chain***

CAVEATS

4. The evidence presented is drawn solely from existing scientific evidence that has been collated over the last few months. Thus it does not yet represent the full extent of existing knowledge; work will continue over the coming months to ensure that all relevant knowledge has been exploited.

5. Care needs to be taken in using the evidence as presented. Each piece of evidence is taken from an individual operational experience, experiment or study. However, not all of the impacts reported are independent of each other and hence the combined potential impact of each C2 case will not be the sum of each individual piece of evidence.

QUALITY OF NETWORK

6. [A, B] An experiment considered the effectiveness of geographically separating the 1* Joint Task Force Commander from the main HQ. The commander was located in a forward HQ with only a few staff officers supporting him (in a specific role). The experiment found that the provision of a "chat" facility was instrumental in maintaining shared situational awareness [2]. This is confirmed by a study considering collaborative work on intellectually demanding tasks which showed the importance of informal (i.e. short, unplanned and unstructured) communications [3].

QUALITY OF SHARED INFORMATION

7. [A, B, C, D] An experiment considered the effect of informational redundancy (the degree of overlap in access to information) and found that it has the potential to be good or bad. It can be good as it enables checks and balances on team members to operate but it can be bad if it leads to failure to attend to particular information (each assumes the other with access is dealing with it). The experiment found that teams with highly redundant members[2] were able to gather a great deal more information for each decision than relative to low redundancy teams. The damaging effects of low redundancy were especially strong for teams with low cohesiveness [4].

8. [B,D] The experiment mentioned in Paragraph 6 considered locating the commander in a forward HQ with various levels of support from four staff officers to just one staff officer. The experiment found that staff adapted to each new structure by anticipating their colleagues' requirements for information and changing their own information sharing behaviour accordingly [2].

QUALITY OF SHARED AWARENESS/UNDERSTANDING

9. [B,D] Separation increases the likelihood that team members will have differences in their situational awareness - they will be more likely to have a different understanding of the common operating picture [4], [5]. Although dispersed team members may have access to the same explicit operational picture, their way of interpreting it in the light of their specific role and geographical location (including separation from 'ground truth') leads to the generation of different implicit schema

[2] 'Redundant members' refers to the members of the team who had the greatest overlap of information.

(or mental models). The role of implicit and explicit understanding is central to the communication of command intent.

10. [B,D] A study considered how effectively the commander's intent had been communicated through a simulated distributed Coalition Task Force HQ during a multinational experiment (MNE03). The study found that the effectiveness of command intent communication was most influenced by organizational proximity to the Commander, not geographical proximity. In addition, in this instance, military experience did not seem essential for understanding the command intent [7].

11. [B,D] The experiment mentioned in paragraphs 6, 8 considered locating the commander in a forward HQ with various levels of support from four staff officers to just one staff officer. The experiment found that situational awareness was generally high in all cases, however, there is evidence that the commander's own situational awareness was slightly negatively affected in the case with just one staff officer collocated with him [2].

QUALITY OF INTERACTIONS

12. [A,B,C, D] Experiments have shown that teams which have a shared mental model[3] perform better [8], [9], it can even overcome degraded performance caused by fatigue [10]. With a shared mental model in place, the team can rely on implicit coordination, particularly when workload is high meaning that team members anticipate their colleagues' information needs and therefore require less explicit communication [8], [11].

13. [A, B, C, D] If a team does not have experience of working together and has not been able to build up a shared mental model, communication is key to successful working. In particular, successful teams share more information, articulate their plans more and have more acknowledgements [10], [8]. Therefore, suitable communications media must be in place for this to happen.

14. [C, D] The creation of a team shared mental model probably depends on the extent to which the team's method of working is pre-defined or institutionalised (a "shell"). When a team has a "shell" and team members have prior training and/or experience of this shell, then it will be easier for them to adopt a shared mental model. Where a team has been created to perform an ad-hoc task and no such shell exists, a distributed team is likely to spend considerable time, effort and energy establishing a joint modus operandi, before they can work effectively together. This is of course also true for a co-located team, but the restricted communication channels typically available to the distributed team make creating this model more problematic.

15. [A, B, C, D] Experiments have found that because of the existence of shared mental models, teams whose members are familiar with each other are better coordinated which leads to improved team performance [4], [13]. However, changes in team membership are more damaging for familiar teams than unfamiliar teams [4]. Changes to the membership of staff teams require some adjustment and accommodation. This requires frequent practice, a factor which may be important

3 A mental model is assumed to be a cognitive mechanism that provides an organised framework, based on past knowledge and experience, within which a current situation can be made meaningful.

when considering agile mission grouping. On one occasion, when forced to deploy (due to world events), the HQ Chief of Staff, mindful of the need for an ability to conduct regular re-adjustment, arranged local, low-level practice sessions at the home base (involving 6-20 staff). The differences this training made included lower general noise levels in the HQ and more efficient routine briefing (counted both in preparation time and delivery time).

16. [A, B, C, D] Research into the way of command has demonstrated the importance of the difference between explicit and implicit command intent. Explicit intent relates to communication by written and verbal orders, and implicit intent is communicated by non-verbal means, such as tone of voice, physical presence and cultural norms [14], or remains undeclared, being built up from personal, professional and cultural expectations during education, shared experience and socialisation. In dispersed teams, many of these aspects of implicit intent would be lost and thus hinder effective communication between leaders and command staff. The necessity for leader presence has also been demonstrated to enhance motivation and morale, due to the positive effects produced as the result of a visible role model who commands respect and following. It is evident that many of these leadership aspects may be more relevant for commanders at lower levels in the hierarchy, due to the importance of motivating soldiers in front line combat. However, the benefits of implicit command intent, leader presence, and a positive role model are relevant for all teams that depend on direction and support.

17. [B,D] Person management skills have been found to benefit most from face-to-face contact. The negotiation necessary in the delegation of tasks is more successful when leaders and subordinates are co-located [15]. The lack of face-to-face monitoring also depersonalises feedback, and makes any assessments of team states more difficult. Verbal-only interaction could lead to less honest responses by team members who may wish to hide current concerns if they feel that they could be open to criticism. When the commander is not located with his staff he will find it more difficult to gauge stress levels and fatigue as they are more amenable to assessment through visual contact. Consequently, the coordination of task and team performance is likely to be much more difficult within ad hoc and dispersed teams.

18. [B,D] When a team is dispersed, leader monitoring of team performance is likely to rely on increased use of verbal communication (e.g. via radio, intercom or telephone), due to the absence of implicit cues. As explicit communication takes more time and effort than that provided by observation, then it is likely that either the monitoring will be reduced, or the commander’s workload will be increased. A study into teamwork in sustained operations found that despite comparable performance in “normal” operation, the performance of distributed teams was more negatively affected by sleep deprivation than co-located teams [16].

19. [A, B, C, D] Participants of a multinational experiment (MNE3) expressed concern that the absence of the commander and limited guidance and interjection given were a source of distrust. This was felt to be due to the formal nature of the distributed environment preventing uninhibited conversation that contributes to the development of interpersonal relationships and trust in fellow participants [7]. This is particularly important in a distributed multinational environment. Similar findings were reported from studies of ad-hoc multinational teams which were geographically distributed during operations in Bosnia in 1996.

QUALITY OF DECISION MAKING

20. [A, B, C, D] An experiment showed that teams with good team members who made reliable judgements did better than those which did not but only if the team leader could accurately assess the team members' ability to make judgements [4]. This assessment would be more difficult if the team leader is not collocated with the team.

21. [B,D] A lack of face-to-face communication can lead to problems with decision making. Consensus in team decision making has been found to take twice as long when the team is dispersed [17]. This in itself may create a significant problem for dispersed command teams due to the effect on the speed of the decision cycle.

22. [A, B, C, D] Modelling has shown that 'delayering' by reducing command layers, increasing the flexibility of assigning support units and increasing the level of command freedom led to increased operational tempo and a reduction in average vehicle loss ratios in a warfighting scenario. However, it did increase the overall level of losses and increase the spread of possible operational outcomes (probably due to lack of direct control over groups of platforms) [18].

23. [A, B, C, D] If command layers are reduced, implementation must be carefully considered. In 1974, the British Army removed Brigade Headquarters from its overall chain of command so that Divisional Commanders were directly responsible for 5 battle groups. This arrangement was found to be unworkable for two reasons. Firstly the span of command was considered to be too great and secondly the communications system was not able to support it.

AGILE GROUPINGS

24. [C,D] An example of the benefits of agile mission grouping was identified by stochastic simulation of kill chains. The analysis illustrated that the ability to prosecute a high priority target through network-enabled fire using any of land, sea and air systems reduced the time taken and increased the ability of decision-makers to choose the most suitable assets. The main measure of effectiveness was the time taken to prosecute the target; this allows decision makers to include agile mission grouping when considering alternative ways of improving the capability to prosecute time sensitive targets.

SUMMARY OF INITIAL INSIGHTS

GEOGRAPHICAL SEPARATION OF COMMANDERS AND THEIR STAFF (CASES B AND D)

25. Much of the evidence located to date is relevant to Case B but will have implications for Case D. Initial insights appear to be:

    a. Successful separation is critically dependent on the right connectivity, in terms of bandwidth to support real-time high-volume communications.

    b. No evidence has been found to date to confirm the potential benefit of reducing footprint. This has to be balanced against the evidence from

human sciences research such as the possibility that decision-making can take twice as long when a team is dispersed, and that the performance of distributed teams is more negatively affected by sleep deprivation than for co-located teams, and that understanding of command intent may be less good in dispersed teams.

c. Evidence is inconclusive regarding whether understanding of command intent will be affected in this case. Research suggests that the implicit communication of commander's intent is a key part of sharing his intent. This would be more difficult if the commander was not able to meet face to face with his staff. However, during a multi-national experiment the level of understanding of the commander's intent was measured and it was found that organisational proximity to the commander was more important than geographical proximity. There is evidence to suggest that if the commander along with a small number of staff is geographically separated from the main HQ then they are likely to adopt a different shared mental model even with access to the same information.

d. A commander may find that his workload increases as monitoring his headquarters' staff will require more explicit communication and identifying stress and fatigue may be more difficult. It has been demonstrated that leader presence can enhance motivation and moral due to the positive effects of a visible role model.

TASK BASED STRUCTURE (CASE C)

26. Little extant evidence has been identified that deals specifically with the assessment of a task-based structure. Initial insights that may be drawn are that a task-based structure could mean that staff working together are less familiar with each other as individuals and with each other's organisations. This makes it harder to adopt a shared mental model and hence would take longer to be working together effectively as a team. This has implications for the type and quantity of collective training needed to mitigate this risk. Until this shared mental model is established the team will need more explicit communication which could cause problems when work load is high.

REDUCING LAYERS OF COMMAND (ALL CASES)

27. There is evidence that reducing the layers of command can bring greater agility and improved effectiveness. However, command layers have been reduced unsuccessfully in the Army in the past; key reasons were that the span of command for the higher level was too great and because the communications infrastructure was not in place to support it. The latter problem could be overcome with appropriate investment, but the span of command issue is a limitation of human performance and is therefore a more severe limitation on change.

The evidence collated so far appears to be particularly related to the separation of commanders and their staff. Therefore the programme of current work is focussed on testing the task-based case and whether there are benefits to be had in terms of reducing footprint by separating the Command from the main HQ.

CURRENT WORK

AIM

28. This stage takes the output from the workshop and tests the hypothesis that "Adopting the options for future C2 are better than maintaining the current one". Interviews with relevant decision-makers identified that to test this hypothesis, a number of high-level questions would need to be answered. These are:
    - Q1: Are any of the Future C2 cases better in realising military effect than maintaining the current one?
    - Q2: Will any of the Future C2 cases enable more effective/efficient delivery of our capability, and how will this impact on overall future force structures? In particular how will this impact on HQ and command structures?
    - Q3: What is the impact of the Future C2 cases on manpower and training requirements?
    - Q4: What is the impact of the Future C2 cases on the shape, number and priority of future communication, battlespace management, and ISTAR equipment capabilities?
    - Q5: What is the impact of the Future C2 cases on the UK force's ability to work in a coalition and inter-agency environment?

WORK PROGRAMME

29. The complexity of these questions requires that a number of different methods are used, across the spectrum of human sciences research, operations research and experimentation.

    a. Man-in-the-loop wargaming is one of the methods that will be used to explore the impact of the proposed C2 model on operational effectiveness (Question 1 above).

    b. Spreadsheet modelling will be one of the methods used to test the impact of the proposed C2 model on force structure (Question 2 above). These tools are part of a suite of tools which are employed to inform on UK future force structures by taking information on the cost of assets within the foece structure and what capability is required to meet Defence policy.

    c. Human Sciences research will inform Question 3, on the manpower and training implications. In particular, the STORM (Socio-cultural Teamworking for OR Models) model (briefed at 11th ICCRTS) will be used to address the impact on teamworking within the HQ of each of the cases and the mitigation factors.

    d. Constructive simulation will contribute to testing the impact on future equipment capabilities and priorities. One of the methods that will be used has been successfully applied over the past few years to test the sufficiency of the UK's planned communications infrastructure in the light of demands placed upon it by ISTAR systems.

CREATING COHERENCE BETWEEN THE STUDIES

30. The most challenging aspect of the Test phase is to achieve sufficient coherence between each study and experiment, so that the findings are collectively robust. Each study and experiment needs to understand how it relates to others in the

programme, and the data dependencies that exist between them. To aid this, it is planned to exploit work the NATO C2 Conceptual Model.

CONCLUSION

31. This paper has described the ongoing programme of UK work to help inform MOD on whether it is possible, in the networked era, to enhance the Command and Control of expeditionary operations at the operational and tactical levels. Phase 1 of the Test stage, which provides insights from existing science base of the benefits and risks of four potential Command and Control models, is complete. Phase 2 of the Test stage, which applies a broad range of science to test Command and Control models, will be complete by the time of the 12th ICCRTS.

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