2007 ICCRTS

ADAPTING C2 TO THE 21st CENTURY

Adaptivity Led Networked Force Capability

Topics: Networking, Adaptivity

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Abstract

A significant fraction of the ten-year Defence Capability Program budget of the Australian Defence Force is focused on implementing an NCW-capable combat force. But what defines being NCW-capable? How do we network the force so as to develop significantly enhanced capability in increasingly complex and uncertain broad-spectrum operations?

In this paper, we will explore the hypothesis that engendering adaptivity in all its forms is the necessary key to enhanced capability for future operations, and that doing so should drive the networking of force capability. We will argue that this can be achieved through application of a previously developed conceptual framework for adaptation. All four classes and five levels of the conceptual framework will be addressed, at several scales of application. These will generate consequences for the topology and dynamic properties of the networks, for force organisation and C2 processes, and for how information is sought, managed and disseminated. Issues, opportunities and risks arising from this approach to implementing NCW will be identified and discussed.

1 Introduction

Australia, along with many other nations around the world, is migrating to a networked force capability. Over the next 10 years the Australian Defence Capability Plan (DCP) is acquiring the building blocks for an NCW-capable force. These include a large number of projects that will deliver a new generation of network capable aircraft, ships, land systems (both platforms and individual soldier systems) the underpinning networking infrastructure including: communications, command and control (C2), and battle management systems. These new systems will bring with them a range of new and enhanced capabilities across the spectrum of firepower, precision, sensing, protection, mobility and supportability. However a major challenge will be to shape and integrate these individually optimised building blocks, plus a variety of legacy capabilities, into a more effective, survivable and adaptive force capable of meeting the challenges of future complex operations [1].

Networking is often proposed as the solution to the problem of integration as well as delivering potentially significant enhancements to force capability. However, what dimensions of enhancement will networking actually deliver and how will these enhancements be realised? This paper seeks to address some of these issues.

Previous studies [2] into the force networking (particularly for the Land force) have indicated that the primary benefits from NCW will be realised by designing forces to utilise the new capabilities to effectively address higher levels of operational complexity. This has become a corner stone of the

Australian Army's NCW concept [3] and is aligned with the Army's Future Land Operational Concept – Complex Warfighting [1]. In this approach networked forces will be create with:

- the ability to undertake more complex operations than previously, with similar forces and with acceptable levels of success and risk;
- the ability to achieve a greater degree of success in the same operations as previously, with acceptable levels of risk; and
- the ability to achieve the same or more successful outcomes in current operations at lower levels of risk.

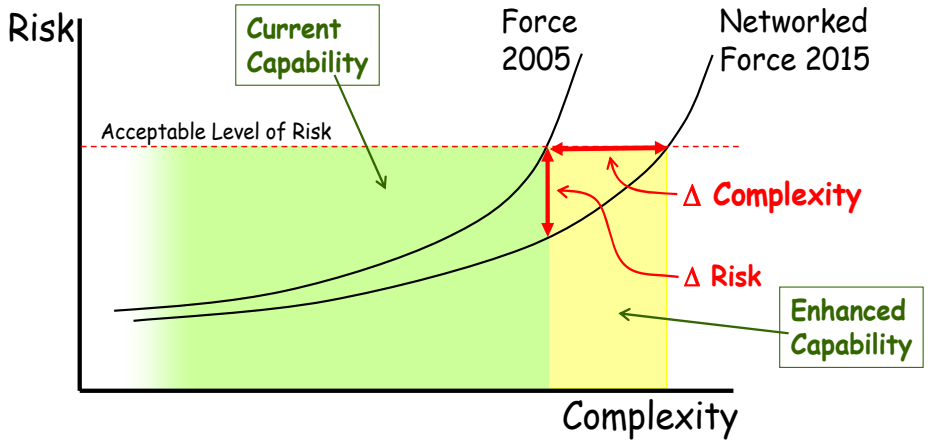


Figure 1: Illustration of the networking advantage hypothesis comparing the range of operational complexity at a given level of risk for the current force with the networked force of 2015.

This hypothesis is illustrated in figure 1, which plots illustrative curves of risk against complexity for the current force and a future NCW-capable force in 2015. Thus, the enhanced information sharing, situational awareness levels, coordination and synchronisation abilities of the networked force should increase the capacity of the force to cope with complexity. This will then provide a greater range of options to decision-makers, and enable the networked force to undertake missions and operations that would currently present too great a risk. Similarly, operations that would be currently viable could be undertaken at a lower level of risk. In other words, coping with increased levels of complexity such as we expect to find in urban operations, can be achieved in three ways: through reducing risk, through increasing the level of complexity which can be successfully dealt with, and through increasing the degree of success that can be achieved.

This is a different approach to many of the descriptions of NCW. The primary driver for NCW outcomes is no longer more rapidly undertaking those missions and tasks to deliver potentially marginal improvements of the things it already does well. Rather, the primary benefit from a networked force (as illustrated in figure 2) would be found in the enhanced effectiveness of the force in undertaking operations that are either currently difficult or at too high a level of risk to be considered. It should be on more effectively undertaking missions and tasks required for complex operations but which are currently challenging for the force to achieve. The next stage would develop the capacity of the networked force to undertake tasks that have significant potential to enhance its effectiveness in complex operations, but lie outside that scope of the current force capability (at least at acceptable levels of risk).

Given the need to develop force capability able to cope with higher levels for operational complexity, our thesis is as follows:

1. The key to enhancing both the level complexity that can be handled and achieving success in addressing the higher operational goal is to enable greater levels of force adaptivity.
2. This enhanced adaptivity is achieved through:
    a. A holistic force-level approach to the design of an inherently adaptive networked force capable of evolving to meet the dynamic challenges of the future battlespace.
    b. Implementation of a truly evolutionary development process that seeks to deliver networked forces the adaptive force capacities.

The following sections will present a case for this thesis. Moreover, we will argue that the issue is not about designing a networked force on paper, and then going about an implementation plan of connecting the bits, but rather of employing a truly evolutionary process of force integration supported by iterative concept development, experimentation and evaluation, so that the capability grows in a coherent and cost-effective way. In doing so we will utilise the conceptual framework for adaptation [4] to identify some of the key drivers, issues, opportunities and risks in developing an adaptive networked force.

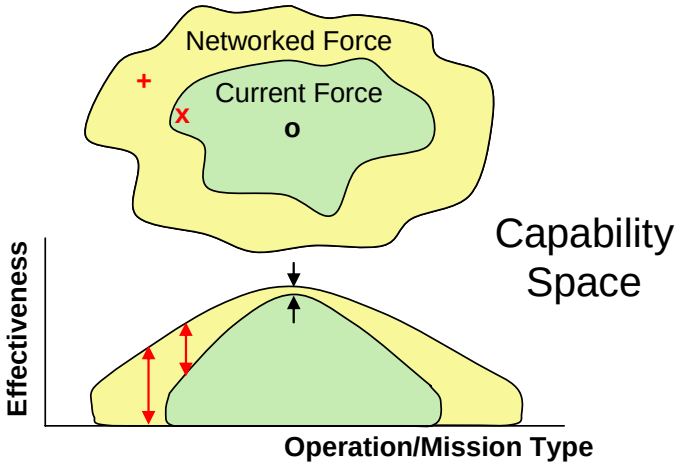


Figure 2: Illustration of areas of current land force capability (green) and potential networked force capability (yellow), indicating that the primary enhancement will be gained for those missions at the limits of the force's capabilities rather than for what it already does well.

2 Adaptivity and Complexity

- Increased force adaptively is the key to coping with complexity (refs….)
- Include a brief overview of the conceptual framework for adaptation.

3 Designing for Adaptive Networked Force

In the main the design of networked forces has tended to focus on the design of component networked systems and on information systems standards that will enable a base level of systems interoperability. However, a networked force is more than just a collection of locally optimised parts that will somehow automatically integrate to deliver an effective force. It is a force-level system-of-systems operating in dynamic and stressful environments. As such it requires active design and the associated trade-off decisions in order to effectively integrate and function as a coherent system [5].

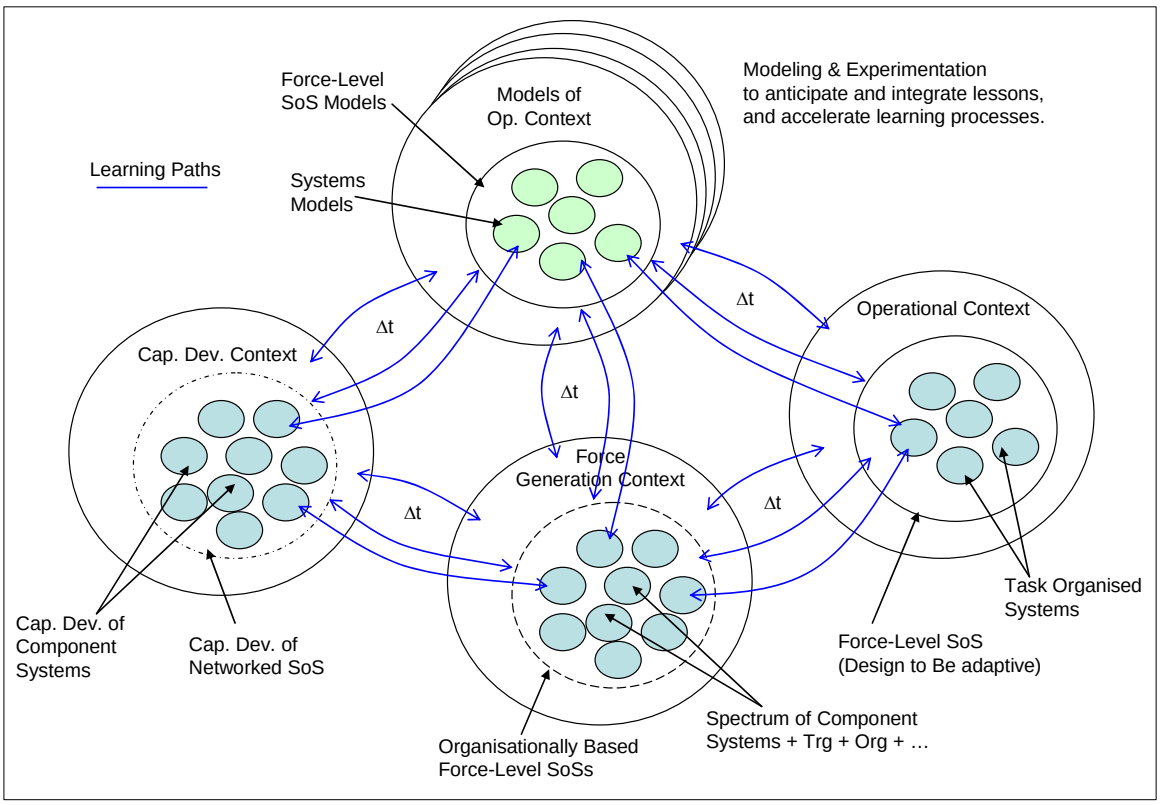


Figure 3: Simplified schematic of the capability development and implementation process showing the stages from systems acquisition by projects to actual force level operational capability. It also highlights the potential of modelling and simulation to accelerate the learning processes to enable a more adaptive capability development process.

Figure 3 illustrates a simplified conceptual model of the Australian capability development and implementation process. It is divided into 3 primary components:

1. Capability Development …

2. Force Generation …

3. Operations …

The figure includes some of the feedback and learning paths across the development process. These feedback paths connect the contexts, SoS levels and component capabilities of each of stage. Thus, lessons learnt about the operational context will influence the force generation context and more indirectly the capability development context. Similarly, lessons on the force level SoS and the component networked capabilities will be shared across the development process. Unfortunately there is usually a significant delay in capturing and applying the lessons from on stage to another. In

particular, there has been a historic tendency for a significant delay between the realities and lessons learnt in the operational context to filter back to the force development let alone the capability development stages.

Figure 3 also incorporates a modelling, trials and experimentation (MTE) capability. This element is essential in accelerating the overall adaptivity of the capability development and implementation process. It provides an ability to test and explore options in order to accelerate learning outcomes. MTE capability provides the operational context with rapid turn around insights to accelerate the understanding of the operational context and support the insertion of new concepts, tactics and systems to address operational requirements. The services provided to the force generation and capability development stages tend to be more orientated into the future and harness the ability of a range of modelling, simulation and trials approaches to anticipate future requirements and challenges for the operational force. In period of low operational tempo this capability can play central role in ensuring that future force capabilities are not focused on wining the last war. In periods of high operational tempo, the capability provides a complement to the lessons from the field, and assists in ensuring that the forces are able to address a broad range of military operations.

There are a variety of approaches that might be taken to the design of a networked force. In a highly stable battlespace context, with known adversaries, environments and tactics a classic top-down system engineering approach to the implementation of a networked force might be effective. In such a context most of the design degrees of freedom would be concentrated in the systems acquisition stage. The drivers for adaptation would tend to primarily come from advances in technology, with relatively minor changes to force generation to adapt the doctrine, TTPs and training to take advantage of the new technologies. Adaptivity within the operational force would be limited to low level tactical applications and immediate responses to the battlespace. This design approach is often a legacy of Cold War attitudes and has frequently influenced approaches to force networking.

A different approach is needed to address the challenges of an increasingly diverse and complex battlespace (as is now faced by in most future theatres of conflict). In this approach we need to design for far higher levels of adaptivity in both the force generation and operational contexts. This will result in a significant increase in the degrees of freedom provided in both these contexts, with a consequent increase in the potential for adaptation. Operational commanders will have greater options at their disposal to adapt to and learn from the battlespace. Similarly, force developers will have greater freedom to responsively adapt force doctrine, TTPs, training, etc. to address systemic operational trends. However, a balance is needed between an increase in operational adaptivity and force effectiveness. Appropriate design decisions need to be made at each the 3 capability development stages so that commanders are provided with higher degrees of freedom, without burdening them with large force integration and design problems while trying to conduct operations. Thus, we need to design for the maximum level of force adaptivity at each stage of the capability development process that is still consistent with high levels of force effectiveness.

Networking capabilities offer the potential to enable an increase of adaptivity while maintaining high levels of effectiveness. This will require appropriate design of the networked force across all stages the capability development to harness networking capabilities such as the potential of networked systems to: support decision-makers; share and manage information; coordinate and synchronise effects; coordinate the manoeuvre of distributed forces; facilitate distributed collaboration; enhanced situational awareness; provide reach back services; and capture, process and disseminate key lessons-learnt.

The following sections will primarily focus on the operational and force generation contexts.

3.1 Current Force Adaptivity

Adaptivity is not entirely new to military forces. 5000 years of military operations have evolved current military forces with a range of adaptive mechanisms and processes. Some of these processes include:

- A hierarchical command structure provides the ability for forces to simultaneously operate at and adapt across multiple physical and temporal scales. So that while lower level forces may be responding to immediate combat pressures, senior commanders can be shaping the longer term battle.

- The mission command concept facilitates local initiative and adaptation within the context of an agreed framework of command intent and the forces allocated to the commander.
- Training is both the mechanism to forge personnel into responsive and robust teams, and one of the key vehicles to test and explore new ideas within the context of existing Doctrine.
- Lessons-learnt are the primary mechanism for insights from the operational context to be disseminated across the force and to influence both the force generation and capability development stages. Unfortunately, lessons-learn mechanisms have until recently tended to take far longer than would be ideal
- Modular forces enable commanders to rapidly combine force elements to generate forces for various missions and to dynamically adapt force groupings to adjust as required to the battlespace.
- Redundancy in both organisation and equipment enhanced force resilience to enemy actions and environmental factors, as well as providing increased capacity to cope with unforseen events.
- Specialisation
- Multi-rolling:

In designing more adaptive networked forces it is important build on these mechanisms and processes.

4 Adaptivity Insights within the Operational Context

The increasing levels of operational complexity faced by future networked forces places a significant premium on force adaptivity. Although the scope of available options and timeframes varies significantly, this need for greater adaptivity applies from the lowest tactical levels to the strategic domain. Opportunities for force adaptivity can be found in each of the 3 elements of the operational context as illustrated in Figure 3. The component capabilities need to be task organised into integrated joint and combined arms teams to meet the mission requirements. These task organised teams will constitute force level systems-of-systems (ranging in scale from combat teams thought to task forces) that will need to adapt to the challenges of the operational context. Understanding and influencing this context (both directly though combat or via more subtle mean) will also offer opportunities for force adaptivity. This adaptivity will be manifested in the way forces undertake and implement: planning; orchestration; decision making; coordination of manoeuvre; synchronisation of fires; information capture, filtering, processing and dissemination; teaming; training; and a range of administration and support functions. It will also include how operational forces deal with lessons-learnt within the operation.

4.1 Responsiveness

Military forces have evolved to be highly responsive to operational challenges, as rapid and effective response to battlespace conditions is essential to for war fighting success. Much of the NCW literature has focused on the potential of the new networking technologies to enhance force responsiveness. Consideration must also be given to the actual military benefit of making things faster. Some functions and actions, such as the responsive application of fires, will potentially be greatly enhanced through an increase in tempo. However, simply speeding up processes may provide very limited impact on war fighting effectiveness if:

- processes being accelerated are already providing timely responses;
- other associated process are the principle constraints / bottleneck; or
- associated processes are not co-adapted.

4.1.1 Implications for networked force design

Responsive action is critical to the effectiveness operational forces. This is where the actions of the force are transformed into effects and the force can adapt to the dynamically changing battlespace. As a consequence discussion on networked force responsiveness is usually focused at the action level. Some of the insights for force networking that can be derived from a consideration of how to enhance responsive action include:

- The need to develop networked systems tools (battle management systems) and processes that will accelerate the speed and quality of decision making. Where possible these tools should

automated so as to free the decision-makers to concentrate on the higher-level conceptual issues and decisions.

- Facilitate the application of both local and networked information management processes to dynamically provide decision-markers with the appropriate information within the operational context [6]. Although there are many possible information management approaches and architectures (centralised, decentralised, adaptive networked, …), the responsively of force action will not be enhanced by providing all the information to everyone and drowning the decision-makers in superfluous information (even if the bandwidth was available).
- Enhanced levels and dissemination of blue situational awareness to rapidly feed into the information management and decision-making processes. If effectively utilised, it will provide commanders with increased understanding of the location and status of their own forces and enable commanders to more effectively and responsively manoeuvre and their forces, deliver effects, and provide logistics and other support services. It will also plan a significant role in the minimisation of friendly fire incidents thereby potentially increasing the options available to commanders.
- The networking capabilities have the capacity to accelerate the provision of joint and coalition fires by rapidly passing the targeting, blue force and other collateral, and battle damage information between the sensors, controllers and effectors in the battlespace.
- The need to develop networked systems tools and processes that will accelerate the speed and quality of intelligence generation and its appropriate dissemination within the tactical force. This might employ a combination of automated tools, filters, fusion engines, decision support tools and reach-back services.
- Enhanced sharing of appropriate information and distributed command and control systems will create the potential for teams to be more rapidly formed and reformed as required. This will be of particular importance in the type of urban contexts described by the US Marine Corps 3 block war concept [7].
- Since it is unlikely that there will always be sufficient information exchange capacity, the networking systems will need to dynamically manage the available capacity. This will require a combination of information management and network management as well as effective interaction between them to ensure that the network does not become a bottleneck for enhanced force responsiveness.

By considering some of the higher levels of force responsively it is possible to gain additional insights, beyond the above standard networking drivers derived from the action level. Examining the learning level of responsiveness the following insights can be identified:

- Mission command is essential to ensuring that the opportunities for increased adaptivity are available throughout the networked force and that all commanders have the opportunity to learn from their (and hopefully from other force elements) actions and adapt the approaches, teams, and tactics to meet the challenges of the battlespace.
- The decision support tools within the networked force need to be able to be shaped to adapt to the needs of commanders as they adapt to the changing requirements of the operation. Where possible this should occur automatically, but still guided by the commanders requirements.
- The information management policies that drive the information management processes (both manual and automated) need to adapt to continue to deliver: effective information dissemination, intelligence produces, fusion, filtering, … These processes must be established to identify and implement appropriate policies to meet the needs of the decision-makers.
- Processes need to be in place to capture, evaluate and implement the lessons from operations to evolve the future actions of the force. Networking and information technologies offer the potential to support and accelerate the collection, analysis of these lessons to not only identify the first order insights by to extract trends that will enable commanders to anticipate enemy actions and adapt their forces tactics and approaches accordingly.
- Networking will offer a wider range of approaches to the coordination, synchronisation and delivery of fires. Commanders will need to learn when the different modes of joint / coalition fires (see force generation section below) are appropriate within the operational context.

Similarly additional insights into the enhancement of networked force responsiveness may be derived from the learning to learn level. Networking capabilities can be used to change the way learning is undertaken within the operational context using approaches such as:

- Utilising reachback support services to provide augmentation of negligence and other high-level processes to assist commanders in understanding the operational context.
- Utilising reachback support services to provide analytical support to extract tends and options from the lessons-learnt.
- Changing the ways in which information and uncertainty are handled. Information shown in the decision support tools is not confused for 'truth' (particularly the intelligence) and that processes and procedures are developed to capture, display and address the uncertainties in the information. Moreover, networking will not eliminate the fog of war and commanders need to be utilise the networking capabilities to develop adaptive and innovative approaches to respond to unknowns and potential surprises in the battlespace rather than believing it to represent the infallible outcome of 'information superiority'.

The primary measure of operational success will remain mission success. However, additional insights can be derived from the perspective of enhancing force adaptivity to address increased operational complexity, including:

- Within the mission command context, success will need to be increasing conscious of the effects any action generates (on their own forces, the enemy, neutrals, civilians and the environment) and how these effects will contribute to or impact upon the higher level operational intent. Similarly, senior commanders will be able to utilise networked capabilities to monitor lower level effects generated and adapt their own strategies and tactics to either build up or moderate these effects.
- Re-evaluation and refinement of key assumptions on the enemy, environment and own forces will be a key factor in increasing force adaptivity. These assumptions will underpin the decision on how the networking systems will be utilised and the parameters within them set to provide the commanders with networked capabilities able to enhance force responsiveness.
- Networking will tend to amplify the need to take a team and team-of-teams perspective within the operational context. This will shape performance metrics to focus on the effectiveness of the teams and how well they interact to meet the overall intent.
- Care will need to be taken not to confuse measures of force effectiveness with efficiency measures. Networking capabilities will be able to collect large amounts of information, particularly on containment processes and overheads. Unless solidly embedded within metrics to assess the mission effectiveness that can be miss-used (particularly in peace time) to significantly constrain the force options and adaptivity available to commanders.

- Co-adaptation
  - Shaping and influencing the context
  - Across scales
  - …

4.2 Resilience

Military forces require high levels of resilience or robustness if they are to function effectively in hostile battlespace environments. Future complex warfighting operations will tend to increase the risks faced by military forces. Operations will range across nation states, ethnic conflicts, counter insurgency, and nation building, often complicated by the need to integrate with a variety of joint, coalition, interagency, UN and non-government organisations. Forces must be designed to be inherently robust and be able to adapt rapidly to remain effective despite damage to key elements of the force. This has traditionally been achieved through a combination of protected systems (e.g. armour), equipment and force redundancy, cross training of personnel, and a capacity to regroup to adjust to force losses.

Networking offers the potential to greatly enhance force resilience. However, it can also be the source of dramatically increased force vulnerabilities. Thus, it becomes vital to identify these strengths and weaknesses and design the networked capabilities so as to build on the former while managing the latter.

The operational context will set the resilience requirements that the force generation and capability development stages will need to provide. Once within the operational context, the resilience will depend on how effectively the networked force can adapt the capabilities provided to address the battlespace stresses.

4.2.1 Implications for networked force design

- Increased Resilience:
  - Adaptive / ad hoc networks
  - Adaptive IM and IM Policies for
    - Variations in demand
    - Variations in comms capacity
    - Errors and uncertainty
    - Information culture differences
  - Distributed forces and C2
    - Reduced vulnerability
    - Reduced physical footprint
  - Design for graceful degradation
  - Ability to function autonomously
    - Mission command
    - Data pre-positioning
    - Replication of Data
- Decreased Resilience:
  - Fragile networks
    - Catastrophic Network Failure
  - Lack of interoperability
  - Increased centralisation
    - Increased vulnerability
  - Poor IM
    - Information overload
    - Inappropriate information
    - Reduced Trust
    - Assumption of info superiority
    - Reduced management of uncertainty
    - One size fits no one data
  - Increased EM footprint

- To realize the potential for increased force resilience it is suggested that future military forces to be resilient by design. Consciously incorporating those factors that will increase force resilience and clearly understanding both the strengths and limitation of the force to enable suitable force architectures, doctrine, TTPs and training to be developed. Simply defining a number of technical standards is necessary but not sufficient to deliver the required force resilience.

4.3 Agility

4.3.1 Implications for networked force design

- The ability of forces to rapidly switch from one mode of operation to another is critical in dealing with complex operations.
- USMC 3 block war concept (c.f. LNCW Characteristics)
- Both sequential changes and diverse concurrent operational modes.

- NCW has the potential to support enhanced force agility.

- Two broad approaches - centralized &. decentralized (Mission command)

- Centralised approach achieves force agility through a highly integrated approach to networked force implementation. Decision making tends to be focused in one of few nodes, with the other force elements subordinate to these centralized decision makers. It facilitates responsive application of effects and a concentration of effort to achieve overall force outcomes. This approach is closer to the original NCW concept that was based on the integration of a maritime battlegroup into a single efficient combat force.

- The decentralised approach to implementing is based on the application of mission command. …

- [Outline of simplified C2 model. Comd / Control ???]

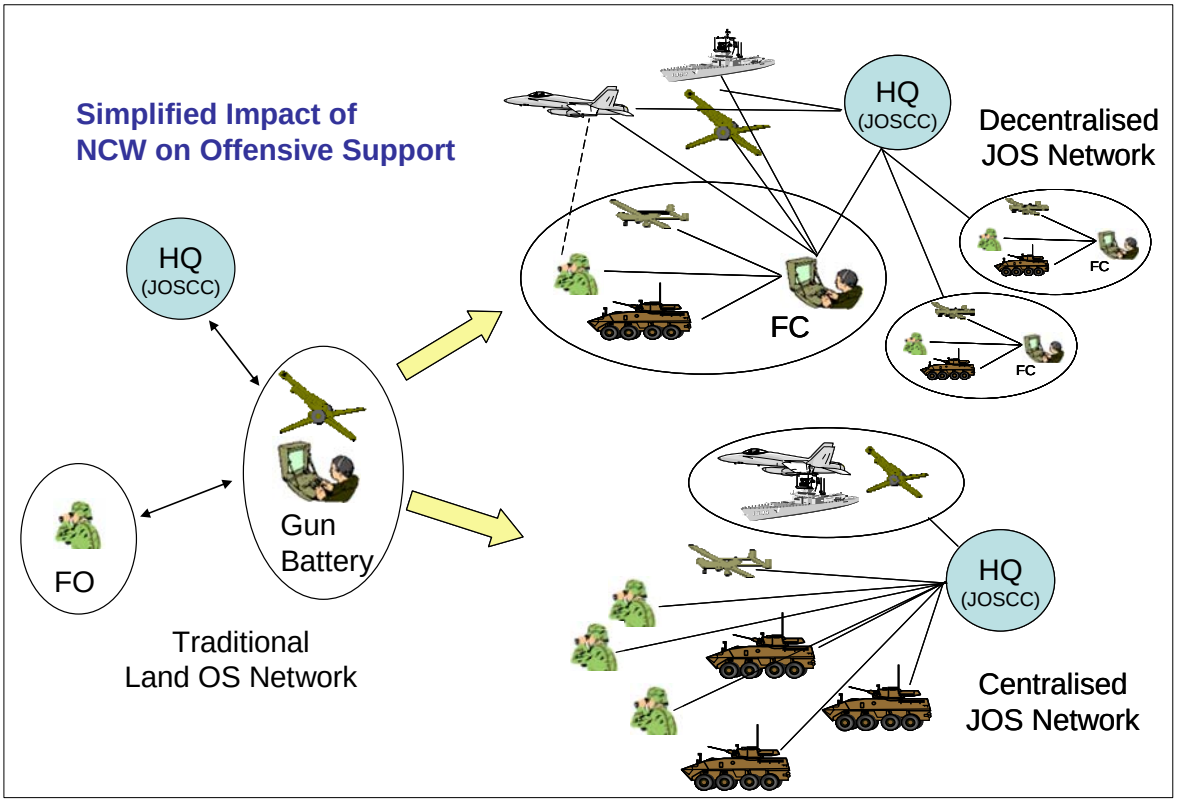
- For complex operations in a joint / land context, it is likely that a primarily decentralized approach based on mission commend will provide the maximum force agility. Centralized control would then be exercised on a by exception basis.

- NCW does not need to be limited one extreme or the other. To deal with the challenges of future complex operations it is important that forces be able to rapidly adapt their mode of operation across a broad spectrum of C2 approaches. Key characteristics include:

    - Ability to shift modes
    - Ability to run concurrent modes
    - Applying agility faster than the enemy (or the enemies capacity to respond)
    - Learning when different modes are appropriate and identifying the queues/triggers to change
    - Ability to rapidly regroup force elements to facilitate modes as appropriate. For example shifting from decentralized support and reconstruction efforts to a warfighting mode with mutually supporting, concentrated effects.

- An example is the potential impact of NCW on the application of joint and coalition fires.

- …



4.4 Flexibility

- Although flexibility is needed in the operational context, it is a more major driver of the force generation and capability development stages

4.4.1 Implications for networked force design

5 Adaptivity Insights within the Force Development Context

- Force integration of component capabilities
- Development of Doc, TTPs, …
- Personnel, Education and Culture
- Training – individual and collective
- Grouping of force elements to undertake operations

5.1 Responsiveness

5.1.1 Implications for networked force design

- Learning
  - Determining who needs to be networked, how much and why
  - Building on Mission command
  - Adapting IM to deliver improved IM processes: dissemination, intelligence, fusion, filtering, …
  - Incorporation of lessons-learnt on the application of networked forces
  - How to adapt networks to adjust to varying battlespace requirements
  - Re-evaluating and refining assumptions
- Learning-to-learn
  - Changing the way in which SA and intelligence is interpreted
  - Adapting lessons-learnt processes, including using reach-back
  - Changing the way in which information and uncertainty are managed
- Defining Success
  - Focus on the effects generated (Blue, red, grey, white)
  - Team rather than individual focus
  - Strategic reassessment of assumptions

5.2 Resilience

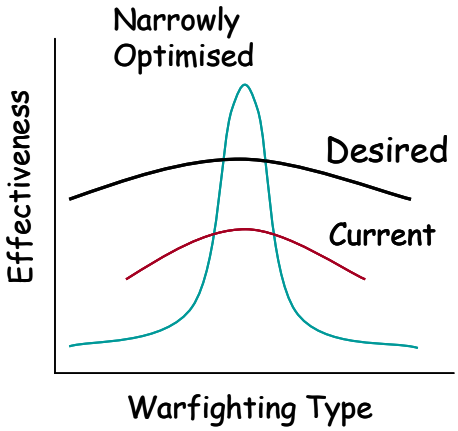
5.2.1 Implications for networked force design

5.3 Agility

5.3.1 Implications for networked force design

5.4 Flexibility

Early concepts of NCW grew out of a desire to generate an integrated maritime battlegroup and from the context of potential force-on-force warfighting of the cold war era. This resulted in a vision for NCW that was aimed at optimising forces to meet a narrow and well defined threat. More recent warfighting experiences have shifted the focus of warfighting to counter-insurgency and similar complex warfighting scenarios. This change has increased the awareness that force flexibility, the ability to effectively operate across a broad range of warfighting types, is an essential characteristic of military forces and a major driver for future force design. If forces are too narrowly optimised for a particular type of operation there is a great danger that when suddenly faced with a challenge outside this narrow range that the force will find itself unable to adapt. Figure XX schematically illustrates the need to migrate from the current force capability to one which can address a broader range of operational types at a highly level of effectiveness. In particular, it contrasts its goal with approaches to networked force implementation that would result in highly effective but inflexible military capability. In the latter case an opponent would simply have to move outside the narrow band of optimal force effectiveness to rapidly render the force ineffective.



Networking technologies are capable of supporting a wide range of warfighting types. In deigning future networked forces decisions must be made about spectrum of operations that the force will be designed to address. Like all exercises in design, the implementation of a networked force will require trade-offs in the way the physical network, doctrine and TTPs, training and command and control are implemented. If flexibility is a major design driver this will result in consideration being given as to how to address force responsiveness, resilience and agility across a wide range of contexts. However, it must be remembered that for any particular operation the flexible force will be less effective than one specialised for that type of operation. This trade-off can not be continued indefinitely. The force will need to be bounded in its potential scope of operations or the effectiveness of the force will become too dissipated. Thus the degree of force flexibility must become one of the cornerstone design characteristics in implementing a future networked force.

5.4.1 Implications for networked force design

6 Scales of Complexity

NCW has the potential to enhance the effectiveness and adaptivity of individual force elements. More effective information sharing can facilitate enhanced responsiveness of the individual force component and its ability to synchronise its actions with other force elements. However, the primary impact of NCW on the adaptivity of military forces is at the higher levels of scale. The sharing and appropriate management of information will enable enhanced situational awareness, coordination of actions, control of manoeuvre and the synchronisation of effects. These in turn provide the opportunities for the adaptation of the force level behaviours across the classes and levels of adaptivity identified in the CAS framework.

6.1.1 Swarming versus teaming

Swarming and some of its conceptual variants (informed swarm) are sometimes perceived as a mechanism to facilitate enhanced force adaptivity. It is argued that large numbers of force components operating under a shared intent and utilising modern networking systems to share information, will able to rapidly self-synchronise to adapt to varying battlespace requirements. It is argued that these largely independent force elements will be more responsive to dynamic changes than a traditional military force and that more effective force-level behaviours will emerge from the cumulative, self-synchronised actions of the comment force elements. This argument draws on the element of the theories of emergent behaviours in complex systems and to a degree on the drive in business practices for flatter organisational structures.

Such an informed swarm approach may well produce some enhancement to the immediate responsiveness of a force. The force will, if composed o sufficient numbers, be relatively robust as it will readjust rapidly to the elimination or degradation of any particular swarming component. However, by flattening the command structures, the force is being optimised for efficiency within a narrow band of force behaviours. Moreover, the gains delivered by the informed swarm approach will tend to be at the expense of the ability of the force to effectively adapt at higher levels of scale. In particular, the ability of the force or even major subsets of the force to demonstrate high levels of agility let alone flexibility will tend to suffer from significant inertia as they will not be able to respond as an integrated whole. Thus, adaptation of the higher order force behaviours will be severely limited. Overall force effectiveness will also tend to suffer, as the force will be composed of a large number of local optimisations for each of the individual force components, rather than an attempt to maximise the overall force effectiveness. The force will also tend to operate on relatively short conceptual timeframes that match the timeframes of component elements. The smaller the swarming elements the more immediate will be their conceptual horizon. As such the ability of the overall force to anticipate and plan for future threats and option will be severely constrained.

An alternative approach is based on teaming. …

- Small world networks (get further input form A-M G)
- Inherits bottom up complexity and adaptation advantages
- Enable adoption at higher order scales
    - Physical, time, conceptual
    - Forward planning
- Shaping and orchestration of the lower scale teams
    - Mission Command
    - Still enable local addition within intent
    - Networks and IM shaped to team needs
- Design and architectures to maximise teams

Reference companion paper on Multiscale Adaptivity.

Networking and force integration offer the opportunity to consciously design enhanced adaptivity into the future force.

Co-adaptation

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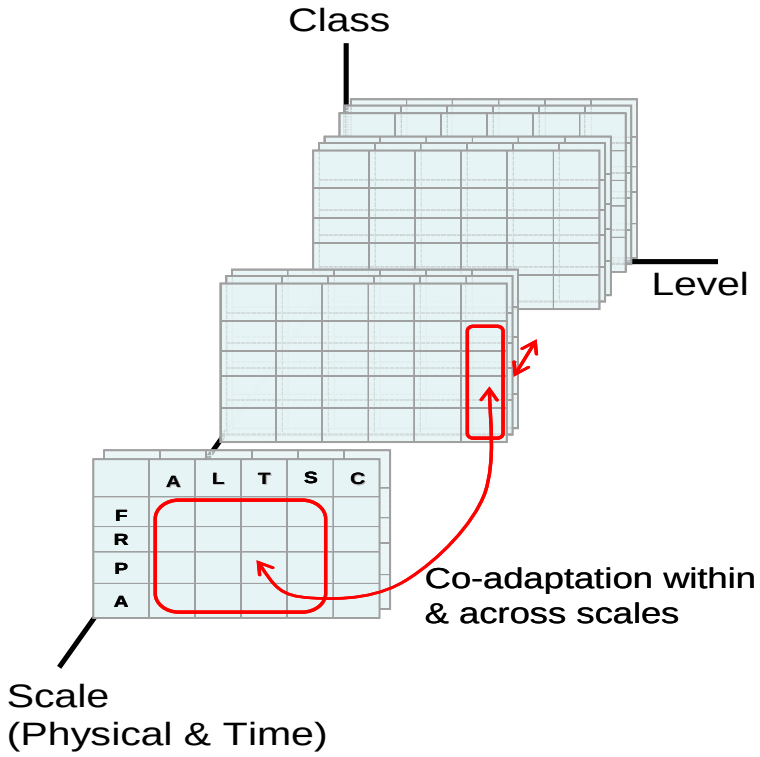

Conclusions

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Refs

1. Department of Defence, *Future Land Operational Concept: Complex Warfighting, Future Land Warfare*, Army Headquarters, Edition 1, May 2004.
2. M.H. Unewisse, J.M. Pratt, M.J. Tregenza, D. Sands, D. Krause, B. Kirby, A. Perry, and S.A. Wilson, *A Review of the Progress Towards an NCW-Capable Land Force*, DSTO Report, DSTO-TR-1779, 2005.
3 *Networking the Army Campaign Plan*, Army Headquarters, 2006.
4. A-M. Grisogono, *The Implications of Complex Adaptive Systems Theory for C2*, CCRTS 2006 – State of the Art State of the Practice, San Diego, 2006.
5. M.H. Unewisse, S. Wison, A. Perry and C. Boyd, *An Australian Approach to Assessing Force-Level Network-Centric Warfare (NCW) Readiness*, ICCRTS '06 Cambridge UK, 2006.
6. G. Coombs, M.H. Unewisse and D. Sands, *Concepts for Managing Information on the Land Tactical Battle Management System Network*, Lamd Warfare Conference '05, Brisbane, 2005.
7. Commander USMC, *Sustaining the Transformation*, WHITE LETTER NO. 3-98, 1998.