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THE IMPLICATIONS OF COMPLEX ADAPTIVE SYSTEMS THINKING FOR FUTURE COMMAND AND CONTROL

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ABSTRACT

Complexity is an old problem *and* a new way of thinking. The natural world and human societies are replete with systems that are complex in structure and behaviour. The world is becoming an even more complex place: globalisation and technological advances mean that the world is more connected and changing more rapidly than ever before in human history. Modern militaries, including the Australian Defence Force (ADF), are not immune to these influences: terrorism, information technology and more complex tasks all challenge the way they operate and their Command and Control (C2) systems. Simultaneously, a relatively new science has appeared, called Complexity Science, that illuminates aspects of this complexity. This paper introduces some of the ideas emerging from Complexity Science that have implications for current and future C2 systems. These suggest there is great advantage to be gained from further investigation of the following areas:

- More flexible organisational C2 structures and processes, able to deal with a wider range and greater variability of environments.
- Processes that autonomously generate working C2 structures from the bottom up
- Schemes for the education and training of individuals to operate in such flexible C2 systems under greater uncertainty and changeability.

INTRODUCTION

In the last thirty years, a paradigm shift has taken place that spans fields as diverse as physics, biology and ecology through to economics, medicine and sociology. This has arisen from the 'discovery' that large systems (such as those that make up the natural world and human societies) often exhibit a far richer range of behaviours than can be explained by an analysis of the behaviour of its component parts alone. This is the domain of *Complexity Science*, which seeks to more fully understand and better manipulate such systems.

A *system* is composed of a number of heterogenous entities interacting dynamically through a variety of relationships. A system is considered *complex* when its global behaviour cannot be completely described from an examination of its constituent entities and their interactions alone.[1] Such a system may be *adaptive*, when the structure and behaviour of the system

[1] *Complex* is often confused with *Complicated*. A complex system and complicated system both have a large number of interacting parts. However, the overall behaviour of a complicated system is the predictable sum total

changes over time in a way which tends to increase its 'success', continually calibrating itself to environmental changes. This enables such a system, called a *Complex Adaptive System* (CAS), to be better equipped to thrive and survive, lending it the emergent properties of robustness, resilience and agility. Examples of CASs are ecological systems,[2] economic systems, societies and organisations.

These systems possess properties that make them identifiable as CASs. CAS can be sensitive to the initial conditions and system history, so that small changes may cause large changes in the evolution of the system over time. They are often nested, with systems within systems and patterns appearing at different levels. However, these patterns cannot be completely understood by simply analysing the patterns or components at the lower levels. In addition, CAS can form organised, dynamic structures without centralised direction.

It is important to note that the science of CAS is continually developing. Consequently, this paper does not comprehensively review the topic, but instead highlights those aspects of complexity the authors' consider of most relevance to command and control.

WHY ARE THESE CONCEPTS IMPORTANT TO DEFENCE AND C2?

Complexity has been an enduring feature of warfare and conflict. The "fog and friction" of war are aspects and attributes of this complexity. Good military commanders have intuitively understood the nature of complexity and nonlinearity on the battlefield.[3] One prime example is the concept of the 80/20 rule and leverage points. This concept informs us that the same action need not always produce the same result, the outcome being dependent on the specific context (place, time, target, disposition of forces etc) of that action and that good military planning needs to incorporate this.

Complexity is being driven higher in our modern defence systems by a number of factors: the geometric increase in the amount and movement of information made possible by the information technology revolution[4]; advances that enable increased physical mobility and reach; the widening roles given to the ADF; more complex environments; the larger number and types of other agents, both individuals and groups; and the widening and closing of options for actions caused by technology, political context and societal changes. The diversity of entities in the structured network of diverse relationships, as illustrated in Figure 1, renders it essential to analyse the ADF using the tools of complexity theory.

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of the behaviour of the individual components (eg. an aircraft). This is not the case for a complex system (eg. an organisation).

[2] Ecological systems are the classic CAS. They have a multitude of organisms (entities) that interact in a variety of ways (relationships), including predator-prey, mating, cooperation and competition. While individual organisms die, species and particular ecosystems survive and persist over time.

[3] In turn, the science of complexity may reveal the underlying basis of these intuitive truths.

[4] This occurs independently of the large push for the concept of Network-Centric Warfare in defence forces around the world, and additional complications it entails.

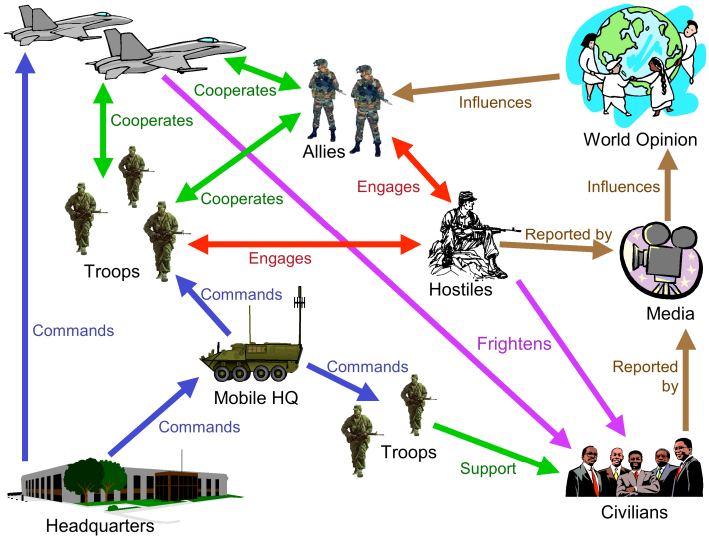

Figure 1 Some relationships on the modern battlefield (Dekker, 2005, pers. comm., 25 Oct)

Understanding the ADF using the science of complexity is a multifaceted undertaking—the ADF can view itself as a collection of CASs interacting to form the ADF; as a CAS in its own right interacting with a number of other CASs; as a subsystem of a larger CAS; or some combination of the above. To a large extent, the view taken depends only on the scope and substance of the particular problem under investigation.

If the ADF is viewed as a CAS in its own right,[5] it is seen to be composed of a number of entities (personnel and equipment) that have a variety of relationships (authority-based, informal, information transfer, etc). While the exact state of the organisation can never be predicted, it does have a generally stable structure and mostly predictable behaviour (both being different types of patterns), that arises from doctrine, training and culture. The organisation adapts over time, attuning its structure and processes to the environment in which it finds itself[6]. Not only this, but different internal organisational components (services, groups, individuals, etc) have the same attributes described above and thus can be characterised as CASs in their own right. Externally, the view is similar. Other groups of people, including coalition partners, Australian government agencies, non-government agencies, international organisations, civilian populations and terrorists, have the attributes of complex adaptive systems.

CAS thinking is central to two modern military concepts: Network Centric Warfare (NCW) and Effects-Based Operations (EBO). Both of these involve systems and systems-of-systems that have the building blocks and properties of CAS. NCW relies on understanding how creating information relationships between entities can be leveraged to produce more effective forces. At the heart of EBO is the requirement to understand yourself, the adversaries, and other players as interacting systems and devise the most useful actions to produce the desired outcomes. Thus, for the ADF to make these concepts operational, an understanding and application of CAS thinking is important.

[5] The main difference between ecological systems and organisational systems such as the ADF are that the latter have mostly been purposefully designed.
[6] While the ADF have the basic components to be a CAS, the design follows a predominantly top-down approach that constructs a formal ADF structure and processes to minimise sensitivity to disturbances and maintain the structure and functions of the ADF.

Command and control (C2), as the process and system responsible for developing plans and actions within the complex context outlined above, must be designed to cope with the constraints of and leverage the opportunities within complexity. As we shall see, complex adaptive systems display characteristics that are, at once, familiar and unexpected. C2—the process of making sense of the environment and then making decision about how to best shape that environment towards specific ends[7]—will be challenged by these characteristics. However, for an organisation prepared to embrace new ways of thinking and acting, these challenges may become opportunities.

WHAT ARE THE RELEVANT CAS CONCEPTS?

The current understanding of CAS identifies a number of concepts and issues of interest to future C2. While some of these could be deduced from other means such as strategic thinking, organisational behaviour and military analysis, these commonalities simply emphasise the applicability of the study of CAS to military affairs.

At the most basic level, a CAS consists of number of heterogeneous entities and relationships that dynamically interact. One key feature of these relationships is that they are *nonlinear*, that is, a given input may produce anything from a disproportionately large effect to no effect at all and this may change over time.[8] Another feature is that many of these relationships combine to form *feedback loops*, which means that a single cause will produce effects that propagate and return to impact the original causation in some way.

CONSTANT CHANGE

CAS are in a constant state of flux. While patterns and situations are recognisable, they are never quite the same as before. However, over time and depending on the internal and environmental influences, the components of the system will change and even the patterns within may change significantly.[9]

DYNAMIC PATTERNS

While CAS are dynamic and continually changing, they also exhibit some degree of stability in the form of patterns that persist. These patterns, while relatively stable, change over time and have a recognisable lifespan.[10]

INHERENT UNCERTAINTY

The number and different types of components in a CAS and the dynamics of any real CAS (especially those involving people), are such that uncertainty can never be removed completely. Uncertainty is a fundamental, characteristic property of CAS and while it can

[7] A general concept of command and control has been applied here. In essence, this paper defines the C2 process as 'perceiving and making sense of a given problem or situation and then deciding on a coarse of action in order to direct the context towards some established or identified goal'. This sense-making—decision-making construct incorporates notions of feedback and review, reassessment and revision, but using a simple framework.
[8] In linear systems, output is *always directly proportional* to input.
[9] This change can be gradual or rapid, expected or unexpected.
[10] These life spans can vary greatly in size. The important point is not the actual size but the ability of an agent to recognise and influence that pattern.

vary in size depending upon the information, state and the attribute of interest of the system, it can never be reduced to zero.

While 'Change', 'Patterns Persist' and 'Uncertainty' are all features of complex systems, they may also apply to reasonably complicated dynamical systems, which are amenable to reductionist approaches to analysis and control. The following three concepts are unique to complex systems or complex adaptive systems:

EMERGENT PROPERTIES

Emergent properties are system-level properties that arise from interactions[11] at the local level. Importantly, the emergent properties only exist at the system level, and have no correlate at the level of the individual parts. Hence, the performance of the system is more than the sum of the agents' individual behaviour and the group is "fitter" for its role than would be expected from analysis of the individuals alone. The catch phrase often used to explain emergence is 'the whole is more than the sum of the parts'. But it is worth noting that emergence, as a property, may also be described as 'more is different' after Anderson (1972): that is, that a property arises at some higher level within a system, but that this same property does not exist at the lower levels. The two perspectives are subtly different, but complimentary.

> It can be argued that Adam Smith pre-empted modern CAS ideas when he introduced his concept of the "invisible hand" in 1776 which would now be called an emergent property. He contended that individuals acting selfishly in a free-market can produce an overall benefit for everyone. In this free-market model, the overall societal benefit emerges from interactions between self-centred individuals.

SELF-ORGANISATION

Complex systems may organise themselves without any external direction or imposed structure. That is, sub-parts of the system may spontaneously achieve coordination without top-down management of agents or groups of agents, but through a bottom-up flow of effects.[12] Self-organisation and emergent properties are often confused. A good discussion of the subtle differences can be found in a paper by De Wolf and Holvoet (2005).

> The food supply in a typical city is approximately two weeks, and this is achieved without any food plan or food manager. Instead, the town self-organises in response to interactions such as demand and supply within the system.

[11] Interactions can be cooperative or competitive. Consequently, emerging properties may be the consequence of tensions within the system, rather than unity of action or purpose.

[12] A special case of self-organisation is self-organised criticality, where complexity emerges in a robust manner and does not require fine-tuning of the system components. Such behaviour lies on the boundary between total order and total disorder, as exemplified in the contrast between a mountain that is stable over a long period of time and the occasional occurrences of rock slides and avalanches on that mountain. Military equivalents may be breakthroughs, which can occur at a range of scales, from local through to an entire front. Other examples are the sudden collapse of otherwise stable civilisations, stock-market crashes and the extinction of species between geological epochs. These examples contribute to the property of (rapid and unexpected) change discussed earlier.

SUB-OPTIMALITY

Real CAS are often sub-optimal, meaning that their effectiveness is not maximised, just good enough to continue to survive. This has a couple of consequences. Firstly, *any optimality is transient*. Since change is never-ending and uncertainty is unavoidable, any optimisation is true only briefly. Thus, it is rarely worth the effort to create maximum efficiency. Secondly, *sub-optimality permits robustness and adaptability*. Being sub-optimal and just good enough means that the system can allocate resources to maintaining reserves and variety so that the system can be more robust, resilient and adaptive. However, greater variety tends to generate greater complexity and less efficiency, so that an appropriate balance must be found. As a result, there is no optimum state or perfect design, and designers should not attempt to chase the mirage of maximum efficiency too far.

> This is analogous to the principle of diversification as a strategy for investment. Diversification is the technique of spreading your investment across (and within) different asset classes (typically cash, bonds, property and shares). It is based on the notion that a poor return in one investment can potentially be offset by a better return in another investment. This is done to reduce the risk and smooth volatility of the overall investment at the expense of maximum potential performance. In other words, the optimal financial performance is traded for greater robustness in investment returns.

WHAT ARE THE MILITARY AND C2 IMPLICATIONS?

In this section some of the main consequences that follow from the application of the CAS concepts introduced in the preceding section will be presented. Any discussion of CAS concepts and the implications is difficult because of the strong interdependencies between them. While the following implications are divided into sections, it should be noted that there is strong connection and overlap between many of them.

INFLUENCE, NOT CONTROL: *PERFECT CONTROL MAY BE UNATTAINABLE*

(Key drivers: Constant Change, Dynamic Patterns, Inherent Uncertainty, Emergent Properties)

Complex adaptive systems cannot be completely controlled, but they can be coped with and influenced.

The intrinsic uncertainty, continual change and emergent properties of CAS renders perfect knowledge, understanding, foresight and (perhaps most importantly) perfect control unattainable. As a consequence, any action can have unpredictable and unintended consequences.

However, the existence of patterns provides an opportunity for exerting influence. Once these patterns are understood and the important characteristics and features of the system identified, it is possible to devise actions to produce desirable outcomes. Since system evolution cannot be perfectly predicted, there is a need for continual monitoring, feedback and readjustment. The activity is guided through strong and continuing feedback loops where it follows a pattern

of probing, sensing and responding[13]. In fact, this interaction between probing a system and observing its behaviour is part of learning about the patterns and features of the system.

This is a methodology supported by the Cynefin Framework (Kurtz & Snowden, 2003, p468). It consists of a set of concepts with which to identify and manipulate key aspects of a CAS. The model and associated approaches show considerable promise in enabling decision makers to intervene appropriately in C2 and associated organisational systems, and is being used in a growing body of activity in Defence (e.g. Bergin et al. 2005).

A direct consequence of a Complex Adaptive System's structural heterogeneity and characteristic nonlinear interactions is that some of the nodes and links have a stronger influence on the system by virtue of more or stronger interactions, or by virtue of occupying a point in one or more feedback loops within the system. This gives rise to the concepts of Leverage Points, Centres of Gravity, and the well-known heuristic, the 80/20 rule[14]. The value of understanding the features of a system can be found when considering the balance between decision speed and decision quality. Traditionally, decision speed (the cycle through the OODA loop) is considered to be critical to maintaining control of the situation. But when acting on a CAS, a series of fast decisions that are poor in quality (that is, that don't act on leverage points) may well produce a worse outcome than fewer or slower decisions of higher quality (that act on leverage points).[15] That is, the current assumption that operating inside the enemy's OODA loop is critical may not necessarily be true.

This principle is understood by good national leaders and military commanders when dealing with adversarial military systems, and also when interacting with friendly and neutral ones. It has even greater applicability in modern times, when there appears to be a requirement for closer cooperation with government, non-government and international agencies, and for dealing with adversaries with a greater range of organisational structures and dynamics, such as terrorists and militia. It also hints at an alternative way of managing and operating your own C2 system: *instead of relying on strong control, choose the appropriate balance of control and influence*.

> In an analysis of the US Air and Space Operations Center (Norman 2004), it was argued that there is a fundamental inability to control such a large and complex system, and that to engineer such a system requires the application of "selective pressure" to guide the system towards a desirable outcome rather than imposition of a detailed design.

VARIETY, NOT HOMOGENEITY: *DIVERSITY PROVIDES ROBUSTNESS*

(Key drivers: Constant Change, Inherent Uncertainty, Sub-optimality)

[13] This can be compared to the OODA loop which tends to be interpreted with first observing and then acting (despite the fact that Boyd considered the activities in the OODA loop to be both cyclical and with other feedback loops).

[14] The 80/20 rule (also known as the "Pareto Principle" and the "Law of the Vital Few" and associated with "The Law of Diminishing Returns")) is a well-known heuristic that manifests itself in the popular literature as a number of statements: "a minority of causes give rise to the majority of the effects", "80% of the outcome is produced by 20% of the inputs" and as "the first 80% of a project takes 20% of the total time".

[15] This is in line with a famous quote attributed to Napoleon: "Never interrupt your enemy when he is making a mistake."

Organisations are able to purposefully develop a certain degree of variety within their processes and structure, to both hedge against likely (or even unlikely) futures and to foster innovation. This purposeful variety allows the organisation to be robust under changing circumstances, but may render the organisation sub-optimal (or less effective) within the current context. Variety can imply the existence of several parallel command and control structures (the formal, alongside a range of informal ones), the use of a range of tactical, operational or strategic responses to given circumstances or the process of divergent analysis to inform debate within a headquarters.

As an example of variety used to hedge against possible futures, the availability of both formal and informal command structures allows a decision-maker to switch between them where necessary or beneficial, protecting against a single point of failure.[16] An agile organisation with the right level of specialisation across a number of diverse components is capable of avoiding such failure. While such variety may mean reduced efficiency and effectiveness or loss of clarity, it can payoff in terms of increased resilience to change and uncertainty.

A diverse range of specialisations or interpretations within the organisation, if managed well, can also mean more potential sources of innovation (similar things and thinking will give rise to a limited number of innovations). The lesson for any command structure is to ensure that the individuals that occupy it are of sufficient diversity, that any innovative behaviour has an opportunity to be tested, and if found useful, can be adopted by the organisation. All of these forms of variety can be assessed for fitness, and therefore selection can occur to allow the C2 system to adapt to changing circumstances.

AGILE PEOPLE, AGILE ORGANISATIONS: *BOTH ARE IMPORTANT FOR SUCCESS*

(Key drivers: Change, Patterns, Uncertainty)

Continuous change means people, structures and processes need to be able to adapt appropriately. Study of CAS indicates that an agile organisation can be built on the basis of individuals with a simple but effective set of rules and the ability to communicate and adapt. A study of the Regional Assistance Mission to the Solomon Islands (RAMSI) showed that the ADF has functioned effectively in the past through the use of informal networks (Cause et al. 2005). Organisational rigidity has been seen by those within the system as a restriction that reduces effectiveness to some extent. Rather than attempting to address this by finding the perfect C2 structure, CAS ideas promote the use of individual initiative through informal networks as part of our C2 culture and not just as a tolerated "work-around".

For example, the C2 concept of Mission Command (MC) is an attempt to deal with change and uncertainty, and provides for a flexible response from the system, possibly at a risk to unity of action. Distance command provides much higher degrees of unity of action, but at the cost of flexibility under uncertain circumstances. Both have their strengths, the former dealing with external dynamics and the latter controlling uncertainty within the organisation. An agile organisation needs to be able to use the method that suits its immediate needs. Other authors have also proposed a broadening of the concept of MC to provide greater organisational responsiveness (Atkinson & Moffat 2005; Scholz & Lambert 2005).

[16] The robustness of networks and defence systems has been extensively studied by Anthony Dekker of DSTO (eg. Dekker, 2005; Dekker & Colbert, 2004)

THERE IS NO SUCH THING AS THE PERFECT PLAN (OR ORGANISATION)

(Key drivers: Constant Change, Dynamic Patterns, Inherent Uncertainty, Sub-optimality)

Military commanders at all levels already have an understanding of the limitations of operational planning as evidenced by these quotes: Helmuth von Moltke is the originator of the famous saying, "No plan survives contact with the enemy."[17] and George S. Patton is purported to have stated that "A good plan violently executed *Now* is better than a perfect plan next week." (Tsouras 1992, p.324). The study of CAS did not uncover this well-known idea but gives some theoretical basis for it. If an agile organisation is to be achieved it will need to be supported by a planning and operational process that is continual and interacting (an example is Scholz and Lambert's concept of "Diverse Appreciation" (Scholz & Lambert 2005)). Developments in CAS science provide a means to study alternative planning concepts and also their application.

A related concept is that of *Information Latency*. This is a phenomenon that is also well known to military personnel, where information becomes less relevant and reliable over time, so that information gathering and processing needs to be balanced against the time taken. This emphasises the need for the military decision-maker to have the skills and experience to make this judgement and that the C2 processes need to both accommodate and support this.

On longer time scales, it also means that no organisation or C2 system can or should be fixed permanently. They should be monitored periodically to measure their continuing effectiveness and change if this effectiveness is in decline. Implicit, in this discussion is that the organisation has the mechanisms that enable this change to occur.

CONSTRUCTING C2 FROM THE BOTTOM-UP RATHER THAN THE TOP-DOWN

(Key drivers: Self-Organisation, Emergence)

Self-synchronisation is one of the foundational concepts underlying NCW. However, putting such a concept into operation has been troublesome. The twin CAS concepts of self-organisation and emergence[18] provide some basis for believing that it may be possible. However, work still needs to be undertaken to understand the general process and to be able to implement it within the military context. One potential area of investigation is that of the fundamental tactical rules that individuals should follow that would result in desirable operational and strategic outcomes without directive control.

A broader idea is that C2 structures may be formed, not through top-down control but permitting the personnel to self-organise into a functioning system. This is an approach where resources can be efficiently allocated and functioning processes can be established from a diverse collection of people and equipment without a detailed initial design. This has ramifications for the entire ADF C2 structure and facilities.

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[17] A somewhat pithier version of the original translation: "No operations plan will ever extend with any sort of certainty beyond the first encounter with the hostile main force." (Tsouras 1992, p323)

[18] While related, these two concepts are different. See De Wolf and Holvoet (2005) for a discussion.

METRICS AND MONITORING

(Key drivers: Patterns, Emergence, Self-Organisation)

The ability to measure and monitor effectiveness is essential to the adoption of CAS principles. All personnel will need to have confidence in the efficacy of the different, and perhaps changeable, decision-making and planning processes and lines of authority and responsibility. Complexity theory already offers a suite of tools and metrics to monitor the state of a CAS for course-of-action analysis. Such tools include network analysis and agent-based modelling and simulation (including simulation of social factors[19]). Various metrics such as attrition/ information entropies and fractal dimensions are already studied measures of effectiveness. However, CAS metrics for C2 systems is a field still undergoing theoretical development. Increased computing power offers the promise of real-time monitoring of the effectiveness of a military C2 system with human-in-the-loop decision making processes so as to guide and influence the system with a view to achieving favourable emergent structure in a shifting dynamical environment[20]. Implicit in this is the development of CAS tools and applications to test concepts in experimentation prior to implementation and to analyse unfolding operations and perhaps suggest suitable courses of action.

TRAINING AND EDUCATION

(Key Drivers: Change, Patterns; Uncertainty)

The uncertainty and constant change associated with complexity, coupled with dynamic patterns and time pressures typical within the C2 environment, require a balance in decision-making methods between analytical/rules-based processes (such as decision trees or check lists) and experiential/intuitive methods. Training in the command and control environment should focus on expanding and refining relevant experience and on building higher level cognitive skills (especially in the area of situational assessment). The process of posting commanders into different organisational settings, and even into different organisations as liaison officers, provides one means for expanding experience and building informal networks of relationships that can prove critical for dealing with the complicated domain space of modern military operations, but a broader examination of educational approaches should be considered.

THE DECISION-MAKER AS THE FOCUS FOR THE C2 SYSTEM

(Key Drivers: Patterns; Uncertainty; Self-Organisation)

The decision-maker plays a central role in a more adaptable C2 system. First, they are the agents for change (and stability). Secondly, they are the perceivers of patterns. Those with the appropriate knowledge are best able to discern patterns and to respond appropriately to them, suggesting that authority and responsibility for decision-making should be connected, if possible, to expertise and only secondarily to organisational structure.[21] In many cases, the

[19] See the *Journal of Artificial Societies and Social Simulation* at http://jasss.soc.surrey.ac.uk/JASSS.html

[20] Associated with this goal is the determination of the parameters that characterise C2 systems. This is the aim of the NATO SAS-050 Panel on "Exploring New Command and Control Concepts and Capabilities" of which Dr. Anne-Marie Grisogono of DSTO is a participant.

[21] Ideally, the two should correspond where possible, as is typically the case for purely military problems, but this won't always be the case where the military implications of a decision are only part of the broader range of issues that need to be considered.

appropriate sense-making and decision-making skills may reside in groups rather than individuals, further pushing the model away from a focus on organisational locus. The supporting system for C2 needs to be able to bring the right people to the problem, suggesting the need to support informal and transient networks and collaborative environments (issues that have already been raised, but that need emphasising again here).

This has a direct implication for the individual. He or she must be equipped with *suitable knowledge* and the right *cognitive skills* to make decisions and perform actions appropriately. The nature of modern conflict extends beyond the purely military and into the realms of the economic and socio-political. Actions in any one domain will result in a complicated set of interactions into others. This broadens the issue of context that applies to the decision maker, and thus broadens the experiential set the decision-maker needs to have access to and the organisational locations from which the decision-maker needs to be drawn.

CONCLUDING REMARKS

While it is acknowledged that the CAS concepts and implications are intimately intertwined, the implications will be packaged by examining their impact on two key aspects of the C2 system: the individual and the organisation.

CAS IMPLICATIONS FOR THE ORGANISATION

For the ADF to become an "Agile Organisation", it needs to have the flexibility in its structure and processes to be able to respond to its changing environment. A fundamental enabler of this is a flexible and adaptable C2 system that can transform itself appropriately and react quickly, but that remains robust.

This can be achieved with the application of both formal and informal structures and processes. The formal structure that provides the unifying structure will need to allow for the emergence and formation of informal structures, which provide additional flexibility. These informal structures will tend to be transitory, some lasting longer than others. However, the participants and decision makers then need to monitor these informal networks and select the informal structures that are beneficial and restrict/eliminate the ones that are not. [22]

In order to supply organisational flexibility, some authors have suggested a broadening of the traditional Mission Command. Control would then be vested to the appropriate levels, more informal, "trusted" structures would be adopted and these would be bounded by the overall intent and more interactive planning and guidance. Going further, there may be situations where it is better to completely devolve control and so allow individuals and teams to self-organise within the boundaries provided by intent.

The organisation must ensure that it has enough diversity of elements (in people, equipment and processes) that can provide innovation. It must be willing to continually test current practices and experiment with new ones. It must be willing to accept that complete control and perfect design is impossible, and that a process of influence, guidance and evolution provide an alternative methodology for achieving desirable outcomes. In recognising the

[22] This does not mean that informal structures should or could be directed or planned by higher management.

existence of CAS everywhere, the ADF may need to adopt different tools and applications that can measure and analyse these systems more effectively.

CAS Implications for the Individual

In the case of discussing C2 systems, understanding the role, limitations, differences and decision-making approaches of the individual is paramount to a successful design and ultimately successful operation. Individuals must be trained and educated to operate successfully as a node in the CAS, and the supporting organisational structures and processes must enhance, and not diminish, the ability of that individual to act effectively. Individuals must be comfortable with change and uncertainty and adapt their behaviours to best exploit the unfolding situation. Ultimately, they must be able to sense, make decisions and act in a manner that contributes to the overall goal of the ADF (and Australian government).

The changes in the C2 systems described in the previous section require specifically that commanders have the ability to devolve command and that the personnel have the capabilities to carry out that task, including access to information required to make decisions. All personnel, but in particular commanders, have the additional challenges of knowing how and when to devolve or re-establish control and what is the appropriate balance for a given situation.

All of the above hypotheses are likely to involve significant cultural change. Generally speaking, this includes devolving command (both downwards and horizontally), allowing informal organisational structures to form across the formal structure, a process of C2 that controls less and but provides boundaries based upon overall intent and a more dynamic C2 process that concentrates on continuous interaction. For example, it should allow group decision-making, dissociate the decision-making role from a given organisational locus, foster a culture of debate and diversity, implement systems to support flexibility in both virtual and physical space and move away from a reliance upon check list processes and analytical approaches. Importantly, the organisation must support the development of the individual with the right knowledge, experience and behaviours.

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