A Dialectic for Network Centric Warfare

Dale Lambert and Jason Scholz

1. Introduction

Network Centric Warfare (NCW) has been endorsed as an enabler for warfighting in Australia, and an Australian conception of NCW has recently been developed (Directorate of Future Warfighting, 2004). More generally, NCW has gained international prominence, largely as a result of bold pronouncements campaigning for a new era in the effective utilisation of military capability,

> Power to the edge[1] is a result of technological advances that will, in the coming decade, eliminate the constraint of bandwidth, free us from the need to know a lot in order to share a lot, unfetter us from the requirement to be synchronous in time and space, and remove the last remaining technical barriers to information sharing and collaboration – Mr John Stenbit, (Alberts & Hayes, 2003:pp.xiii).

Despite the leadership imperative, NCW remains a fledgling concept, leading some to question its merits (Giffin, 2002; Giffin & Reid, 2003 Cantos 1 and 2; Reid & Giffin, 2003; Borgu, 2003; Kaufman, 2004). For example, from a standpoint of Popperian methodological falsificationism (Popper, 1934), Reid and Giffin (2003, Canto 2) argue that NCW is based on a philosophy of inductivism, which though epistemologically discredited since Hume (1748), remains dominant in the Western military community. As a consequence, Giffin and Reid (2003a) state,

> We believe that the NCW thesis is animated by a flawed theory of knowledge and knowledge development, with profound adverse consequences for the thesis as a whole. (Giffin and Reid, 2003a:pp.3).

Prima facie then, the scene is set for a classic struggle between dogmatism and scepticism. Dogmatism arises with NCW proponents presenting the NCW vision as an inevitable advancement. Scepticism counters with NCW opponents casting the NCW dream as a flawed religious excursion. Who is to be believed? Should we embrace the NCW ideology? Is it an inevitable advancement or a flawed religious excursion?

In this paper the authors expand upon the tensions between dogmatism and scepticism noted above to argue that neither standpoint should be endorsed, while concurrently acknowledging that both standpoints are necessary to progress. The 19th century German philosopher George Hegel is famed for, *inter alia*, introducing the dialectical method as a means of acquiring understanding (Hegel, 1817).

1. The dialectical method begins in stage 1 with a dogmatic *thesis* being embraced by a community.
2. Over time, sceptical concerns surface inadequacies with the thesis, leading to its denial in the form of an *antithesis* in stage 2.
3. This is followed by stage 3 in which a *synthesis* (Aufhebung) is formed that unifies the thesis and antithesis, while avoiding the myopic dispositions of each.

Of course the synthesis may in turn become a thesis if the dialectical process is to continue. We do not believe a Hegelian dialectic is the only way to progress a dialogue on NCW,

[1] 'Power to the edge' may be interpreted directly as NCW. It is the most recent in a line of NCW publications by several of the original authors.

however, given the strength of established NCW dogma and sceptical positions, we considered it a useful instrument.

David Alberts recognises that to reach its full potential, NCW as conceptualised circa 2000, is far from the last word and that a process is necessary to make progress,

> It will be decades before the real book on Network Centric Warfare will be written. This effort is designed to help prepare for the journey that will take us from an emerging concept to the fielding of real operational capability. … In a journey such as this, the process becomes the concrete objective for those who are guided by a vision. … The CCRP is continuing to work with others to undertake research and outreach initiatives aimed at developing a better understanding of network-centric concepts and their application to national security. We are interested in hearing about your efforts and ideas. (Alberts *et al*, 2000:pp.xiii)

In the spirit of Alberts journey and his invitation to participate, the remainder of this paper is loosely structured upon a Hegelian sentiment. Section 2, entitled "A Thesis: Network Centric Warfare", presents a case for NCW. Section 3, entitled "An Antithesis: False Dreams", delivers a case against NCW. Section 4 is titled "A Synthesis: Ubiquitous Command and Control". It forwards a refinement of a conceptualisation, originally promoted by Lambert (1999a), that the authors contend represents a synthesis of the dogmatic and sceptical views. Section 5 offers concluding remarks.

2. A Thesis: Network Centric Warfare

2.1 What is NCW?

NCW is inspired by the commercial and economic drivers of the information age,

> "Given that information has always been important in warfare, why suddenly does it make sense to invest relatively more in information than other military assets?" The answer is very simple. The Information Age has changed the economics of information, making it far less expensive to attain greater richness and reach for a given investment. This change in the economics of information makes it relatively cheaper than platforms or personnel. This, in turn, then makes the ROI for a dollar spent on information greater than it was before. (Alberts, 2002:pp.20)

NCW has now attained the status of a community thesis. Few within the community are prepared to publicly challenge its authority. One of the earliest accounts of NCW can be found in Alberts *et al*, (1999),

> As in the commercial sector, it all begins with infostructure. This in turn enables the creation of shared battlespace awareness and knowledge. This awareness and knowledge is leveraged by new adaptive command and control approaches and self-synchronizing forces. The 'bottom line' here is increased tempo of operations, increased responsiveness, lower risks, lower costs, and increased combat effectiveness. (Alberts *et al*, 1999:pp.86).

The US variant of NCW has since been refined into the following more compact form,

> The **tenets** of NCW are:
> 1. A robustly networked force improves information sharing.
> 2. Information sharing and collaboration enhance the quality of information and shared situational awareness.
> 3. Shared situational awareness enables self-synchronization.
> 4. These, in turn, dramatically increase mission effectiveness. (Alberts, 2002:pp.7-8).

An overarching conceptualisation aids in comprehending the significance of these four tenets. This conceptualisation is a feature of the synthesis to follow in Section 4. Lambert (1999b) in effect suggests that we can understand (military) *action* as the utilisation of *capability* to achieve *intent*, given *awareness*. The trinity of capability, intent and awareness depicted in Figure 1 is founded on mutual tension. For example, if capability is held fixed and awareness is reduced, achievable intent is also reduced, and so forth.

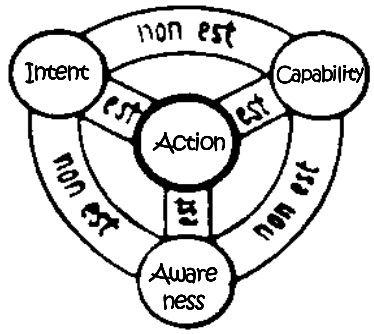

Figure 1: The action trinity.

Intent is in some sense the foremost of the trinity, driven by an underlying will. Intent establishes future goals and forms the basis for so called 'effects-based (military) operations'. To illustrate, at some time t an individual may harbour the intended effect i_{t,k_1} for future time k_1 and intended effect i_{t,k_2} for future time k_2. Figure 2 illustrates these intended goals on a time line. At time t, these future goals are framed against some awareness of the current situation, represented in Figure 2 by a_t. To achieve the intended effects i_{t,k_1} and i_{t,k_2}, various capability options c_j can be considered. A capability option is viewed as anything that has a capacity to change one's awareness of the world, typically by changing the world. This is a much broader sense of the term 'capability' than is commonly applied in military contexts, which often restrict the focus to military equipment. The cascading of capability options offers a number of potential states of awareness of the world, with the best course of action being the set of capability options $\{c_1, c_3, c_7\}$ that delivers the states of awareness $\{a_{t,<1>}, a_{t,<1,3,7>}\}$ that deviate least from the intended effects $\{i_{t,k_1}, i_{t,k_2}\}$ at times k_1 and k_2 respectively. This choice of capability to achieve intent given awareness can be formulated as a dynamic programming problem if we care to do so. Of course things change, so the best course of action at time t may not remain the best course of action at some time t' greater than t.

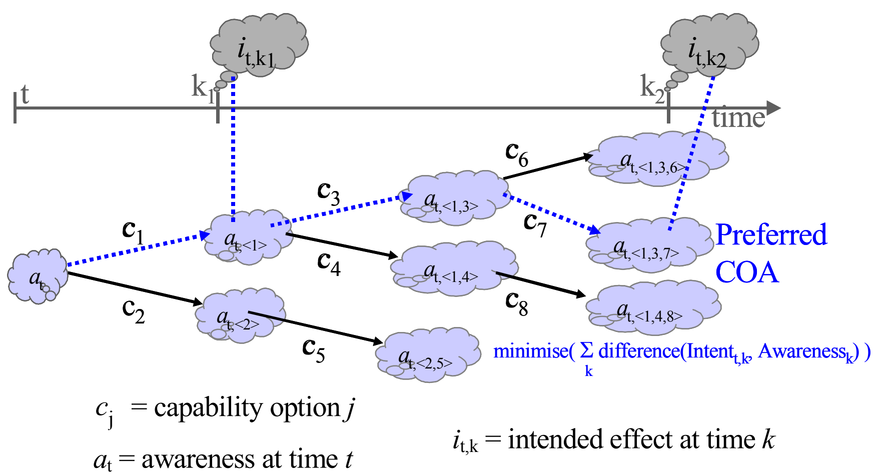

Figure 2: A conceptualisation to aid in understanding the NCW tenets: 'Act to use capability to achieve intent, given awareness'

From this perspective, NCW is about the *socialisation of (military) action* through the *socialisation of each of intent, capability and awareness*.

By "socialisation" we mean the process by which an individual enters into relationships and/or the process of being transformed into an individual who is capable of entering into relationships. For example, the *socialisation of capability* in NCW is described (Cebrowski and Garstka, 1998) as "a shift from platform-centric computing to network-centric computing", and "a fundamental shift from what we call platform-centric warfare to something we call network-centric warfare", the latter attributed to ADM Jay Johnson. The *socialisation of awareness* is the process of achieving what is described as "shared awareness", and the *socialisation of intent* is not described. Socialisation is *liberating* if relationships afford the individual some kind of new freedom. For example, socialisation may allow new degrees of movement, new capacities for expression or creativity, or opportunities for the fulfillment of one's dreams. Socialisation is *oppressing* if entering into relationships inhibits or constrains the individual in someway.

1. Tenet 1 asserts that improved networks facilitate improved communication.
2. Tenet 2 asserts that improved communication facilitates improved shared *awareness*, which can in turn engender collaborative *intent*. The socialisation involves "shared" awareness and "collaborative" intent.
3. Tenet 3 asserts that this shared awareness and collaborative intent can allow the self-synchonised use of *capability*. Capability is socialised through "self-synchronization".
4. Tenet 4 asserts that more effective mission *action* will result from the shared awareness, collaborative intent and self-synchonised use of capability. Socialised "mission" action is more effective when intent, capability and awareness are *all* appropriately socialised.

In Australia, NCW has been defined with five tenets:

> 1. Professional mastery is essential to NCW.
> 2. Mission command will remain an effective command philosophy into the future.
> 3. Information and intelligence will be shared if a network is built by connecting engagement systems, sensor systems and command and control systems.
> 4. Robust networks will allow the ADF and supporting agencies to collaborate more effectively and achieve shared situational awareness.
> 5. Shared situational awareness will enable self-synchronisation, which helps warfighters to adapt to changing circumstances and allows them to apply multidimensional manoeuvre. (Directorate of Future Warfighting, 2004:pp.2-2)

The first two tenets have no equivalent representation in US NCW and are unique to Australian NCW. These two tenets provide some recognition of human aspects of NCW. Tenet 3 maps to US tenet 1, tenet 4 maps to US tenet 2, tenet 5 maps to US tenets 3 and 4. Throughout the following, we will retain a focus on the four US tenets, augmented by the human aspects of the Australian tenets.

2.2 Why NCW?

2.2.1 A View on the Genesis of NCW

The United States long ago recognised the need for joint integration in its cold war structured forces,

> After a series of operational failures in the 1970s and 1980s, Congress passed the Goldwater-Nichols Act to integrate individual service capabilities into a more efficient joint team. … in an era in which precision weapons make massive forces lucrative targets, the effectiveness of joint operations will depend more on integrating service maneuver and precision strike capabilities than on marshalling large service components. (Sheehan, 1996:pp.42)

Sheehan (1996) further asserted the need for an evolution in operations from "specialized joint", to "synergistic joint", to a vision of "coherent joint". The US Joint Vision 2010 (Chairman of the Joint Chiefs of Staff, 1996) aims to achieve just that. According to Sheehan, the 1990s Operation Desert Storm represented "specialized joint" warfare, with multi-service and multi-national forces operating towards a common operational objective of ousting Iraqi forces from Kuwait. At this level, US forces effectively were a coalition, with emphasis on de-confliction and reducing fratricide. The degree to which US forces have transformed to synergistic[2] joint or coherent[3] joint is debatable. The reason for this is likely the difficulty in transforming the US culture uniquely founded on the notions of independence and liberty, which emphasises individualism over unity. Considering that unity in North American culture is often motivated by accomplishment (Renwick, 1991:pp.48) forged through *external* competition, the transformationists surely view NCW as a useful vehicle for improving unity through *internal* transformation from industrial age military "stovepipe" hierarchies to an integrated information organisation.

At a technological level, with inspiration from the Internet, the US formulation of NCW has been conceived as a means of establishing the 'lens' of the Joint Vision, namely 'Information Superiority' (Chairman of the Joint Chiefs of Staff, 1996), likely as an adaptation of the success of 'air superiority' from the 1990s Gulf War.

2.2.2 A View on Australian NCW

In Australia, NCW is seen more as a form of support or enabler for joint warfighting rather than an integrator for unifying forces. This is why, like the UK, the language of network-*enabled* warfare (or operations, or capability), rather than the *integration*-focused term network-*centric* warfare has common favor (Borgu, 2003) despite the organisational decree to use the term 'network centric warfare'.

There is an Australian vision for integration. In 'Force 2020', Barrie (2002), calls for a 'Seamless Force',

> A seamless force will remain fundamentally dependent upon single Service competencies and maximizing the synergies between our capabilities as a Defence Force. (Barrie, 2002:pp.18)

To Australians, integration is more like 'ironing out seams' or maximizing (existing) synergies, rather than achieving coherence or transforming a culture of individualism to one of collectivism.

Indeed, compared with the US, Australian Joint is already more collaborative. This is in part because the scale of the Australian Defence Force (ADF) is much smaller than the US military. However, the cultural drivers are strong (Renwick, 1991:pp.47). Diversity is a strength as a result of a general culture of egalitarianism (Australians are 'levelers' that defer expression of desire for 'achievement'), but is balanced with the culture of 'mateship' providing unity. Mateship emerged historically from mutual needs in a tough country, but has attained mythical proportions. It is an expectation of support that can exist in any relationship between Australians who suddenly share a challenge. It is perhaps not surprising then that no real transformation movement in Australia exists, because none is perceived to be needed. The ADF await technological advancement, not cultural change.

By including the importance of professional mastery and asserting the continued effectiveness of mission command, the Australian NCW tenets also make a distinction from US NCW. Professional mastery includes skilled competencies in command and leadership, and mission

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[2] Synergistic joint involves common doctrine across services and orchestration for common tactical objectives.
[3] Coherent joint involves common operational and tactical objectives and natural rhythms and cycles.

command states a philosophy of command. The Australian concept of 'mission command' has its roots in the German concept of *auftragstaktik*. Most Western allies use a philosophy of Command and Control derived from this core concept, though known by other names such as 'mission control', 'directive control', or 'mission-oriented command'. The beginnings of auftragstaktik can be dated to 1806 (Widder, 2002). The notion was developed to foster independent thinking and acting among subordinates. A key principle is for the subordinate to act within the guidelines of their superior's intent, with the subordinates deciding how they are to achieve that intent. It is based on a relationship of mutual trust and support. As a command philosophy it offers its greatest advantages in an information-rich environment such as NCW because it allows for the decomposition of the command load and reduces the cognitive burden of complexity.

In Australia, NCW has been situated in the hierarchy of doctrine and plans to enable "multi-dimensional manoeuvre" (Directorate of Future Warfighting, 2004:pp.1-1). Multi-dimensional manoeuvre is defined by the authors in terms of the synthesis in Section 4.7.

2.3 Is there Merit to NCW?

Is there any point at all to NCW? Yes. NCW moves war fighting further along the continuum from a culture of individualism to a culture of collectivism. The potential benefits are perhaps best illustrated through a simple example. Adapted from Stilman (2000), Figure 3 shows the starting state for a battle situation between the forces of darkness and light involving high value assets, fighters and bombers. In the Dark Strike Operation, the dark bomber intends to destroy the high value light target (bottom right). In the Light Strike Operation, the light bomber intends to destroy the high value dark target (top left). The situation is highly contrived in that the bombers and fighters have unrealistic movement and strike capabilities, while the competing light and dark forces can only move one asset at a time, and must take turns, with the forces of light making the first move. The value of the illustration is not its realism, but its ability to show the potential merits of a collective approach when confronted with multiple options and constraints.

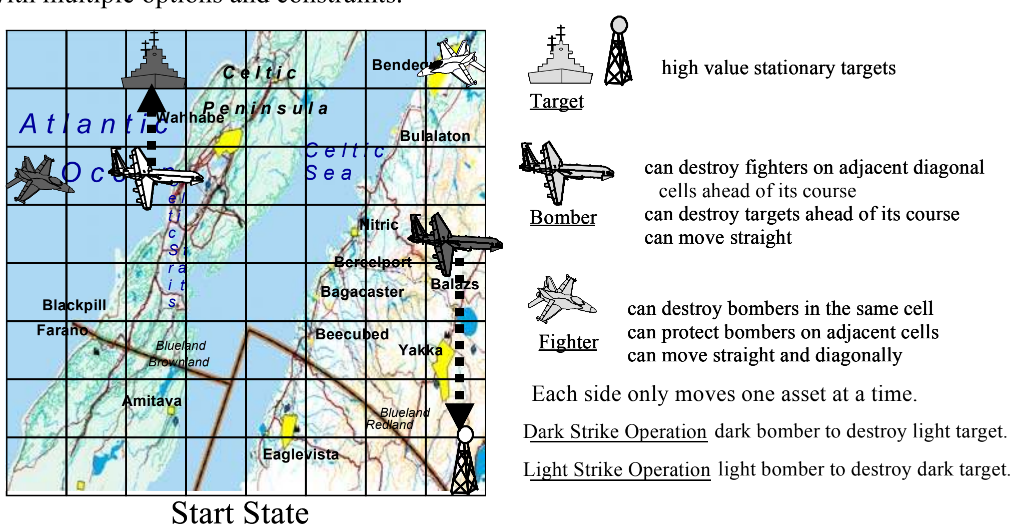
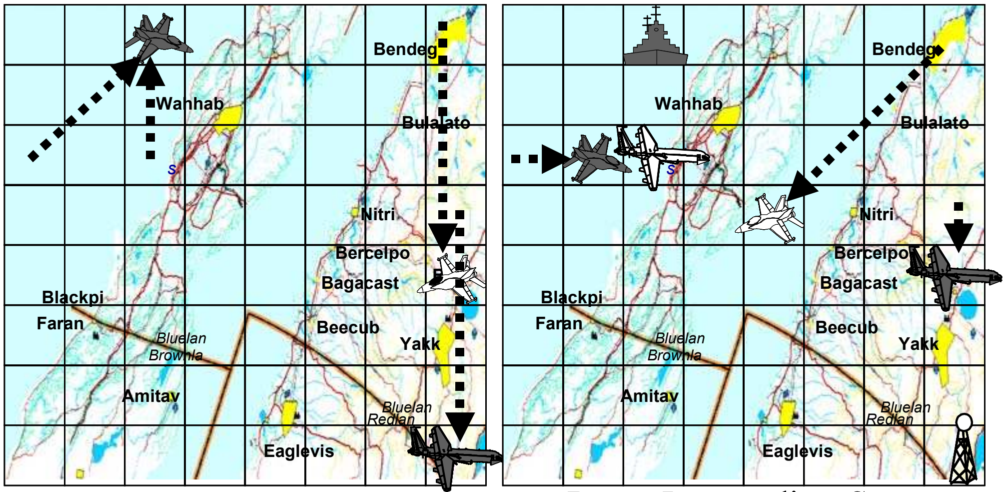


Figure 3: Start state and interaction rules of an illustrative game to demonstrate benefit of NCW.

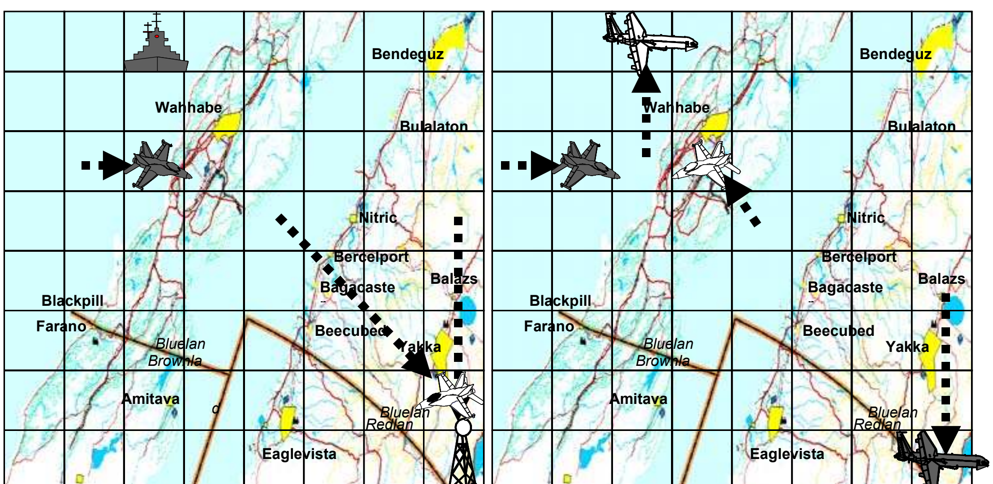
If each side pursues its strike mission individually, then the outcome favours the forces of darkness, at least from an attrition standpoint. The left image in Figure 4 shows a typical outcome in which the light bomber destroys the high value dark asset, but is destroyed by the dark fighter in the process. In the meantime, the dark bomber successfully destroys the high value light asset, with the light fighter being ineffective. On an attrition count, the forces of darkness win by retaining both a fighter and a bomber, while the forces for light manage only to retain a fighter.



Typical End State   Better Intermediate State

Figure 4: End and intermediate states

The image on the right of Figure 4 shows a more successful strategy for the forces for Light. While the Dark fighter moves to strike the Light bomber and the Dark bomber moves to strike the high value Light asset, the Light fighter moves to an intermediate position between the two strike zones. Study of this contest shows that in moving towards this better intermediate state, Light needs to note only the first two moves by Dark. Indeed, this intermediate state is a culmination point in the contest, where dynamic social coordination may guide the response of the Light fighter. By positioning the Light fighter between the two operations, it can react into either zone and force a draw.



Typical End State   Typical End State

Figure 5: Typical end states

Figure 5 shows two typical end states. If the Dark fighter strikes the Light bomber first, then the Light fighter can move to destroy the Dark bomber before it can strike the high value Light target. A draw results, with both sides retaining a fighter and their high value asset. Alternatively, if resources are directed so that the Dark bomber strikes the light target, then the Light fighter can move to protect the Light bomber that then strikes the high value Dark asset. Again a draw results, with both sides retaining both a fighter and a bomber. Though somewhat unrealistic, the example nonetheless demonstrates much of the motivation for

NCW, by showing how through *dynamic social coordination*, forces are able to at least secure an attrition draw, rather than the loss that would otherwise eventuate.

In this example, *electronic* information flow is introduced to the classical problem to provide dynamic social coordination. The introduction of any new capability will bring new potential vulnerabilities. For the case of say, a US Navy carrier battlegroup, which is highly-protected both physically and electronically, their location and capabilities are likely to be no surprise to an enemy. However, within this umbrella of protection, dynamic social coordination may work. It is not surprising then that the USN, through VADM Cebrowski, was and remains a key US military advocate for NCW.

As illustrated in this example, dynamic social coordination results in a larger strike footprint or spatio-temporal effect at-a-distance, providing several other factors are satisfied. Responding units must have adequate manoeuvrability, and their electronic information flow must not impart unintended awareness to the enemy.

2.4 Social Coordination

Historically, mission success in cases like the above example has relied on one or more additional individuals to perform the social coordination. This has engendered political and military hierarchies. NCW transforms hierarchies into networks to the extent that it challenges the idea that individuals are required to govern collectives. Ambassadors for NCW argue this case in terms of 'power to the edge'.

> Power to the edge is about changing the way individuals, organizations, and systems relate to one another and work. Power to the edge involves the empowerment of individuals at the edge of an organization (where the organization interacts with its operating environment to have an impact or effect on that environment) or, in the case of systems, edge devices. Empowerment involves expanding access to information and the elimination of unnecessary constraints. For example, empowerment involves providing access to available information and expertise and the elimination of procedural constraints previously needed to deconflict elements of the force in the absence of quality information. (Alberts & Hayes, 2003:pp.5).

The proximity of 'power to the edge' NCW to the Marxist dictum *"From each according to his abilities, to each according to his needs!"* (Marx, 1874) has been noted by our colleague, Glen Smith. Complex military operations seem well suited to a Marxist transformation, whose dialectical materialism is itself an heir of the Hegelian dialectic tradition. In military operations, the ruling class or bourgeoisie often has a poor awareness of the localised consequences of higher-level orders and the ruling class are generally time consuming to engage. NCW empowers the proletariat to become less reliant on that ruling class. And under NCW, the Marxist theme pervades all the way down to the instantiation of NCW technology, where the philosophy surfaces explicitly in such areas as the 'publish-subscribe' information architecture (JBI Program, 2003), which is touted for the US Global Information Grid (GIG).

2.5 Defending Criticisms

Section 2.1 outlined what NCW is; Section 2.2 outlined why NCW is needed; Section 2.3 offered some hope for thinking that NCW's dynamic social coordination may have practical utility; and Section 2.4 observed that NCW's empowerment themes are not too distant from well established sociopolitical ideologies. A preliminary defence of the existing embryonic state of NCW would be incomplete, however, without some discussion of criticisms of NCW. Giffin and Reid (Giffin, 2002; Giffin & Reid, 2003a (Canto 1); Giffin & Reid, 2003b (Canto 2); Reid & Giffin, 2003 (Canto 3)) are among the most strident critics of NCW. Their objections are largely philosophical, and so a brief excursion into Philosophy is warranted.

Giffin and Reid revisit many of the old wounds in Epistemology and Philosophy of Science. Canto 2 aligns NCW with Empiricism, projecting NCW as a scientific activity steeped in naïve inductivism. And as naïve inductivism has experienced severe difficulties as an epistemological basis since Hume (1748), by association[4] NCW rests upon a flawed epistemological foundation.

> The NCW thesis and its four tenets only make sense if we grant inductivist methodology and the view of science as a process of objective observation, inductive generalization, empirical justification and deductive prediction. The two stand or fall together. And they have definitely fallen. (Giffin and Reid, 2003b:pp.14).

In the true spirit of antithesis, Canto 3 proposes a version of Rationalism, historically the epistemological nemesis of Empiricism, as the more appropriate epistemological foundation. In particular Giffin and Reid endorse Popperian methodological falsificationism, a standpoint that sits mid-way along an increasing scale of scientific scepticism from naïve scientific realism through Salmon (1966), Popper (1934) and Kuhn (1962) to the epistemological anarchism of Feyerabend (1975).

> In this paper, we use an alternative outlook called critical rationalism, and we contend that this significantly clarifies the challenge of exploiting information and communications technology in the military domain. A central point is that critical rationalism is corroborated by deep insights of pure mathematics that deal with logic, reasoning, information, computation, complexity, and randomness, while inductivism conflicts with these important results. In contrast to inductivism, critical rationalism describes rational thinking as a process by which propositions are developed and tested by attempting to refute them against the evidence. Information merely conveys observational facts, which must always be regarded with suspicion. Propositions are never fully tested, and in accord with the theorems of incompleteness, the single right answer **is not** inevitable given a sufficiently large volume of collected facts. The truth does not lie buried in the data, and information does not lead to knowledge. …
>
> Popper found that the problem of demarcation between empirical statements and metaphysical statements is simply that the former are falsifiable, testable in a court of experience, while statements of the second variety are not. This logical property of falsifiability is central in the critical rationalist philosophy. (Reid and Giffin, 2003:pp.3-5).

While Giffin and Reid correctly highlight an impoverished intellectual calibre evident in some of the NCW literature, including the epistemologically uninformed progression of data, information, knowledge and wisdom, at another level, their critique of NCW is not without shortcomings of its own.

The first shortcoming is that Giffin and Reid appear to conflate (NCW) understanding with epistemology.

> And note that it is not just the NCW thesis that possesses a heavy epistemological component: the entire body of military thought is imbued with it. This is so first and foremost as a matter of principle. Military thought as a whole is, after all, a quest for knowledge: precisely the focus of epistemology. Moreover, the substance of military thought is full to overflowing with claims concerning the nature of knowledge, methods for achieving knowledge as well as particular knowledge of various sorts. Our theory of principles of war is knowledge derived from historical experience. Our theory of the estimate of the situation and the operational planning process purport to describe rational thought processes, making use of and resulting in knowledge. The concept of Intelligence Preparation of the Battlefield (IPB) asserts some relationship between observation and knowledge. The NCW thesis itself is just a recent nugget of *knowledge about knowledge* resident in military thought. The very aim of all of our theoretical and doctrinal efforts is *knowledge* about war and battle. We seek to generate and justify hypotheses. ... Military thought by its very nature is an epistemological exercise, just as much as is any other intellectual undertaking. (Giffin and Reid, 2003b:pp.8).

[4] A pun for the Humean scholars!

Lambert (1995) rejects the contention that understanding is grounded in knowledge. This again returns us to dogmatism and scepticism, for there is apparent scope for an infinite regress once such considerations are raised. By considering how to deal with the question of deciding how to deal with a given question, we induce a further question to be decided. The reply is that

> … *all public understanding must rest upon some elected foundation, though not necessarily permanently upon the same foundation*. … So the *dogmatic thesis* of the doctrine is that all public understanding is reducible to dogmatic foundations, for this is ultimately the only means by which scepticism may be arrested, while the *sceptical thesis* of the doctrine asserts that any particular foundation may prove transitory, in time perhaps being surpassed by another.
>
> … public understanding unfolds from a dialectic interplay between the questions asked and the answers proposed, with each question and answer potentially inciting a further instance of the other. The particular interplay of questions and answers (methods) that a philosopher selects, defines what I term their principia intellectus, or principles of understanding, and it is the consequences of these skeletal *principia intellectus* that ultimately delimits their public understanding or worldview. The primacies and dependencies attributed to knowledge, existence, meaning, method and mind in a philosopher's public understanding are therefore shaped by the manner in which they are apportioned within that same philosopher's *principia intellectus*. By examining only the dependency structure formed between knowledge, existence, meaning, method and mind, and not the details giving rise to them, it becomes possible to bundle philosophers of similar ilk into identifiable principia intellectus classes.
>
> As patterns of dependency between knowledge, existence, meaning, method and mind, *principia intellectus* classes provide a simple means of classifying worldviews. Historically just three of the five alternatives have been applied as a basis for a worldview dependency structure. The first secured its dogmatic basis when querying *what there is*; the second reached its dogmatic conclusion when questioning *what is known*; and the third found dogmatic comfort in pondering *what is represented*. Michael Dummett is credited with referring to these as the age of ontology; the age of epistemology and the age of language respectively. §B.2 of Appendix B describes examples of these three foundational stances by presenting thumbnail sketches of the outlooks of Aristotle, Descartes and Wittgenstein. (Lambert, 1995:pp.119-122).

The worldview of Giffin and Reid accords with an age of epistemology outlook and so they are inclined to characterise NCW in those narrow terms. Lambert (1995) subscribes to neither the age of epistemology account of understanding, nor its established age of ontology or age of language alternatives, preferring instead a non-well founded doxastic and methodological interdependency. Understanding is not the product of a hierarchy rooted in knowledge, nor existence or meaning. It is about interplay between dogmatism and scepticism. It is about balancing a network of tensions over time, between an evolving world of processes (the methodological) and embedded individuals who form beliefs about that world (the doxastic). Much of the sting of the Giffin and Reid argument vanishes if we do not concede that NCW is, or needs to be, epistemologically based.

The second shortcoming with the Giffin and Reid account stems from its Popperian emphasis on refutation. Popper rejects inductivism, arguing that scientists propose conjectures and then seek to expose the merit of those conjectures by attempting to refute them using logically valid *deductive* inferences. Popperian methodological falsificationism has two inadequacies. In terms of the dogmatism-scepticism framework outlined above, conjecture delivers dogmatism while refutation serves as the basis for scepticism. From this standpoint, methodological falsificationism is a patently unbalanced account, emphasising scepticism over and above dogmatism. As a consequence, the process of conjecture is poorly understood in Popperian terms. The second inadequacy follows from Popper's account of scepticism as *deductive refutation*, which reports an idealistic, rather than practised, basis for scepticism, and again presumes an epistemological basis for understanding.

The philosophical critiques of Giffin and Reid do impact on NCW because the proponents of NCW at times also purport misconceptions like an epistemological basis to understanding, but because they are misconceptions from the authors' standpoint, NCW is not defeated by these philosophical critiques.

3. An Antithesis: False Dreams

The spirit of unity afforded by NCW in Section 2 comes at a price of dealing with individual differences. One might be forgiven for concluding from the US tenets in Section 2 that one only has to provide the underlying communication infrastructure, and the rest will follow, tending to *"... dramatically increase military effectiveness"*. Each of the four tenets may in fact stifle military effectiveness.

We might view the NCW tenets as being like "lies to children" (Pratchett, Stewart & Cohen, 2002). Simplifications allow for a first step in explanation on matters of great complexity to an immature audience. But strong simplifications are usually wrong; the issue is how badly and what decisions are made on their naïve basis? These over-simplifications have another insidious property, in that they appeal to the dreams of their society (Lucky, 1997). The NCW tenets promise to fulfil military dreams – the dream of omnipresence, the dream of omniscience, the dream of empowerment, the dream of omnipotence: and 'all' that is required to achieve it is the "field of dreams"[5], namely investment in a network.

3.1 Tenet 1: Improved Networks – the dream of omnipresence

> A robustly networked force improves information sharing (Alberts, 2002:pp. 7-8).

3.1.1 More is Not Necessarily Better

Networks deliver virtual presence and the dream of omnipresence. As described by the (then) CEO of Bell Labs (Lucky, 1997), the telecommunications industry records a litany of expensive failed attempts to predict markets by adopting the engineer's 'field of dreams' approach, advocated by the first tenet, and described by Alberts *et al* (1999) as 'the entry fee'. It was this failure to understand deep psychological motivation for communication that inspired Lucky to adopt an approach to consider 'what people really want' through understanding the 'dreams of society'. The inclusion and prominence of the human condition is a noticeable difference between the US and Australian accounts of NCW, as presented in Section 2.1. Just as more and better telecommunications networks and services do not make for assured societal uptake or profits for telecommunications companies, more and better networks in military operations do not necessarily lead to improved military effectiveness.

The first NCW tenet is symptomatic of an implicit assumption that more is better. There is a tendency to assume:

a. more detailed information is better;
b. more reliable information is better;
c. more direct control is better; and
d. more communication is better.

In fact experiments with command teams conducted by the University of Melbourne show that all four of these assumptions can break down (Omedei *et al*, 2004).

[5] The "Field of Dreams" is a 1989 film adapted from W.P. Kinsella's baseball novel "Shoeless Joe". In the film, Kevin Costner stars as Iowa farmer Ray Kinsella, who hears the mysterious words "If you build it, he will come," and is compelled to build a baseball diamond in the middle of his cornfield. His leap of faith results in none other than Joe Jackson appearing who brings some of the other tarnished 1919 "black sox" with him to play together.

a. more detailed information is better – individuals can become information overloaded, fail to realise that they are overloaded and mission effectiveness suffers.
b. more reliable information is better – individuals can be informed or observe that some sources are only partially reliable, fail to pay sufficient attention to the reliable information from those sources and mission effectiveness suffers.
c. more direct control is better – individuals can seek greater control, fail to realise they have insufficient situation awareness to support that level of control and mission effectiveness suffers; and
d. more communication is better – individuals can communicate to an extent that communication bottlenecks occur, fail to acquire sufficient situation awareness and mission effectiveness suffers.

The Australian rendition of NCW may be superior in its recognition of the human aspects, but recognition is not resolution. The experimental results harbour some deep complexities that must be understood before NCW can succeed operationally.

3.1.2 Architecting Networks

The Australian approach to achieving agreed funding and design of NCW, as described in the Information and Superiority concept document, will be through an 'architectural approach'. This approach essentially seeks to describe the design of improved networks – future topologies and flows of information in networks linking military platforms and systems. The document describes,

> An architectural approach will provide: … a visual representation of capability issues and connectivity requirements across the networked force regardless of owner or usage; a common language underpinned by standards applicable to the whole force; a structured, disciplined and consistent framework; …. (Department of Defence, 2004:pp.28).

The 'architectural approach' is based on the US DoD Architecture Framework or 'DODAF' (Department of Defense Architecture Framework Working Group, 2003), which in turn was based on the C4ISR Architecture Framework (C4ISR Architecture Framework Working Group, 1997). The former is mandated in the US to ensure a common approach to describing architectures, with the implicit hope that common interoperability and capabilities will result. The main output of the approach is 'architecture products' defined as 'graphical, textual, and tabular items' (DODAF Working Group, 2003:pp.4-1). The assertion is that these products will lead to cost and mission effective interoperability. There are at least two problems with this assertion: the sufficiency of architecture products as a means of articulating a capability, and the feasibility of a capability described by architecture products.

Concerning the first problem, we assert that the use of 'graphical, textual and tabular' architecture products to articulate information flows across a future networked force will be insufficient. Even for design of *static* networks this follows from merely considering the dimensionality of the problem. A network with just ten platforms represents around 2^{10} or 1024 possible collaborative group structures alone. Of course each individual platform would usually contain a number of unique systems (including roles, processes, information systems, et cetera…). With say, only five systems on each platform, this results in the order of $(5x2)^{10}$ or 10 Billion unique potential combinations of information flows and their complementary fusion systems. Of course, predefinition of a fixed command structure and constrained flows reduces this figure, but it is also likely to significantly constrain the necessary dynamics required for that group to adaptively respond to any given situation. And unfortunately the real situation in warfare is much worse, as information flows and hence the networks are *dynamic*. That is, they may change significantly in the event of unexpected loss or unavailability of a platform, connection, or failure of a system within a platform. The combinations of alternative modes of operation and failures are astronomical and beyond the scope of the DODAF concept. As noted by our colleague Don Gossink, the architectural approach hinges on the foundation of *predefined* information exchange. Considering that information flows are contextually dependent on the situation, it seems unrealistic to assert that they can be defined at the operational level ‘regardless of owner or usage’. Even if we were to consider it sufficient to consider only interconnectivity at the system level, we are similarly faced with the question of which systems should we choose *not* to connect to others considering all possible dynamics?

Regarding the second problem, the call for strict adherence to this ‘architectural approach’ means a focus on *information architectures* rather than *architecting information*.

> … there must be a mechanism for incorporating information technology consistently, controlling the configuration of technical components, ensuring compliance with technical “building codes,” and ensuring efficient processes. Architectures provide this mechanism by serving as a means for understanding and managing complexity (DODAFWG, 2003:pp.2-1).

The development of a ‘structured, disciplined and consistent framework’ of standards compliant operational, systems and technical view products and plans, gives a false sense of confidence. These products do not imply that the information system design can be uniquely understood by any given designer or result in a consistent design, nor do they in any way guarantee the security, correctness or feasibility of even static and very simple networks. If these architectures were to provide such design guidance they would need to be underpinned by quantitative elements such as design equations, performance proofs, supporting analysis, models, simulations, design heuristics, *et cetera*… The emphasis instead, needs to be on the components and meta-level principles by which operational capability can be assembled, disbanded and socially coordinated. We describe this further in the synthesis section.

In summary, extant design frameworks attempt to enforce designs based on ill-formed structures, and the architecting of networks continues to suffer, as there is no *theory of design*.

3.2 Tenet 2: Shared Situation Awareness – the dream of omniscience

> Information sharing and collaboration enhance the quality of information and shared situational awareness (Alberts, 2002:pp.7-8).

Section 3.1 shows that the value of communication networks depends upon how they are used. The perceived wisdom is that shared situation awareness will result by using the communication networks to disseminate a ‘common operating picture’ (COP). This exhorts the “dream of omniscience”. There are at least two problems with the combined notion of shared awareness and COP: information content and presentation, and the meaning of common.

3.2.1 Information Content and Presentation

The first difficulty lies in the nature of the information and its presentation. Endsley (1988) defines situation awareness as,

> Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1988).

Lambert (2001) points out that the track information and associated “dots on maps” displays currently associated with a COP, only address the perception aspect of situation awareness. They identify some objects of interest in space and time, but they fail to disclose the significance of those situations (comprehension), and they fail to identify the consequence of those situations for our own intent (projection). As noted in (Lambert, 1999a), the US Cooperative Engagement Capability (CEC) approach seeks to secure shared situation awareness through the dissemination and display of perception-level data. A more effective approach to shared situation awareness for NCW is to be able to push and pull the story behind the data, and not just the underlying data.

3.2.2 The Meaning of "Common"

A second problem concerns the meaning of "common". At a situation awareness symposium in 1998, the first author suggested three interpretations of "common". The third interpretation is discussed in Section 4.3.2.

The first, "common as identity", involves disseminating an identical picture to each person in the collective. This mistakes identity for unity. The Great Irish Potato Famine of the 1840s led to a significant number of deaths and refugees. It resulted from a uniform dependency on an identical food source (potatoes) that became infected. The distribution of an identical picture beckons analogous concerns, as an infected picture might ensure *everyone* has the *wrong* understanding. Biology teaches us of the fragility of uniform identity and the robustness of diversity.

Another drawback with "common as identity" is that not everyone wants to see an identical picture. Different individuals are interested in different aspects of the environment and at different levels of granularity. Two sector area defence commanders may be interested in two discontiguous regions of space. A mission commander and a subordinate sector area commander may share overlapping spatial regions of interest, but their interest in those regions is at different levels of granularity. The "one size fits all" approach delivers a poor interpretation of "common".

The second interpretation is "common as consistency". Instead of disseminating an identical picture, consistent databases and/or information feeds are disseminated. This allows different individuals to generate their own picture of interest from the same underlying consistent information. But consistency is not as desirable as it first seems. If a fusion system receives assertion α from source X and assertion not(α) from equally trusted source Y, then which assertion should be entered into the consistent database? If the wrong one is entered, then the wrong information is propagated to *every* individual in the environment. "Common as consistency" lacks robustness because it eliminates diversity.

It is worth examining the sources of inconsistency in order to appreciate the magnitude of the second difficulty. There are at least three.

A first source is *error*. The errors may be mechanical or human. Figure 6 illustrates an example, where tracker X may suggest α while tracker Y proposes not(α), because tracker Y has lost its track and is in error. People are also prone to making mistakes. Our psychologist colleagues have a plethora of examples in which humans will reliably make errors in relation to perception, comprehension and projection illusions.

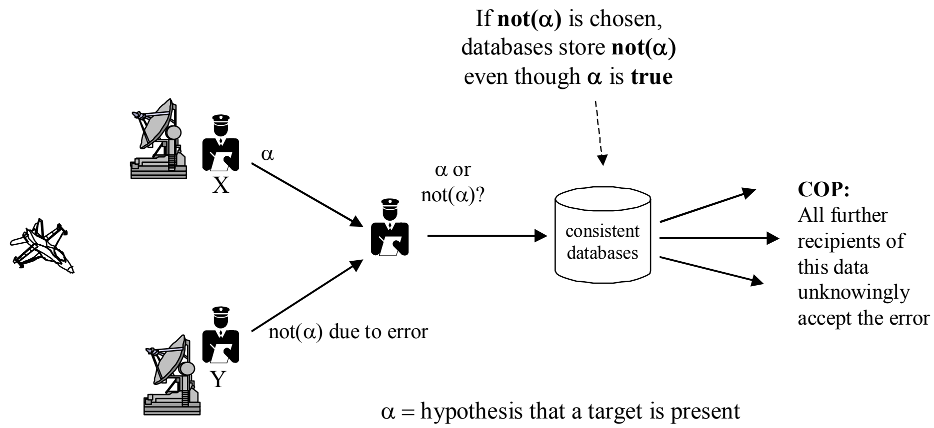


Figure 6: Example of how error leads to inconsistency.

A second origin of inconsistency is *conceptualisation*. Not all inconsistencies derive from someone or something incorrectly registering the way the world is. Some inconsistencies arise because the world can be more than one way. An instance in which inconsistent decisions arise from different conceptualisations of the same spatiotemporal event occurred during the Cuban Missile Crisis and is reconstructed in the '13 Days' movie. Admiral George Anderson (played by actor Madison Mason) conceptualised advancing Russian container ships as a blockade situation, and in accordance with procedure, ordered the firing of star shells as a warning. Secretary of Defense Robert McNamara (played by actor Dylan Baker) conceptualised the same advancing Russian container ships as communication between Premier Khrushchev and President Kennedy, and ordered star shells not to be fired. Each conceptualised the same spatiotemporal event differently and reached mutually inconsistent conclusions.

A third origin of inconsistency is *partiality*. Even when we have the same conception toward the same spatio-temporal events, inconsistencies can arise inferentially without anyone or anything making a mistake. This is illustrated in Figure 7. Upon receipt of a consistent report, individual X may form a consistent theory by adding assumption α to the report, while individual Y may form a consistent theory by adding assumption not(α) to the report. X and Y then have mutually inconsistent consistent theories. We frequently need to make assumptions in order to make information more complete. An attempt to maintain awareness in the face of partial information can lead to mutually inconsistent consistent theories.

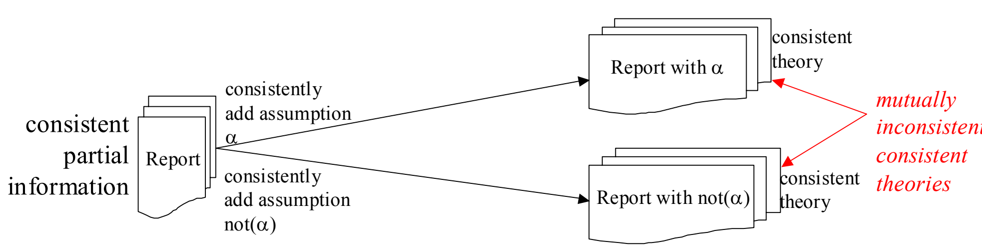


Figure 7: Example of how partiality leads to inconsistency.

Inconsistencies are inevitable in any NCW system. The 'common as consistency' approach of pretending that they will not occur is an untenable solution. 'Common as consistency' mistakes consistency for unity and lacks robustness because consistency eliminates diversity.

3.3 Tenet 3: Self Synchronisation – the dream of empowerment

> Shared situational awareness enables self-synchronization (Alberts, 2002:pp.7-8).

Self-synchronisation challenges military hierarchies. However, in the spirit of antithesis, we note that as structures, hierarchies have some attraction. For example, a single root node branching down through a limited 'span of control' over several layers, connects *N* nodes with the minimum required number of *N-1* links and creates a command chain of length only $L \propto \log N$ links in depth. With a low enough 'span of control', hierarchies avoid overload, can be highly scalable and can be practically efficient. Besides being a gross oversimplification for actual social structures, hierarchies are not always appropriate. Indeed, self-synchronisation is not always appropriate either.

A significant problem with NCW is that no-one ever says *how* the self-synchronisation of capability is to be done? There are at least three issues related to this: Mission Command, Levels of Awareness, and the Joint Military Appreciation Process (JMAP).

3.3.1 Mission Command

> Mission command will remain an effective command philosophy into the future. (Directorate of Future Warfighting, 2004:pp.2.2).

Mission Command is to be retained under the Australian concept for NCW. Mission command is suited to layered hierarchies, which paradoxically is precisely what self-synchronisation challenges. Mission command assembles capability through an *a priori* authority-based hierarchical decomposition of intent, in which the sub-goals of the plan at each layer of abstraction are provided as intent, along with appropriate awareness, to the layer below. There are two key problems with this. Firstly, the uppermost level plans might be completely inappropriate when attempts are made to finally instantiate them with the lower level details. Secondly, the process of revision must pass through *all* successive layers. This makes mission command inefficient in the sense that resolution of *achievable* intent may take more time than is necessary. This need for layered revision becomes increasingly problematic in dynamic situations, especially when networking means that awareness may be available at all levels simultaneously. Furthermore, sensitive aspects of operations may contextually require dynamic control, rather than specific layers constraining control through successive layers. NCW demands a more efficient connection between intent and capability than that afforded by mission command. Due to the importance of tempo in operations, an increase in efficiency may equate to increase in effectiveness, in the spirit of John Boyd's insight (Boyd, 1976).

3.3.2 Levels of Awareness

The self-synchronisation of capability to achieve mission intent is not always possible because the level of awareness in the environment may preclude it. This is illustrated in Figure 8, through a linearised version of the Cynefin matrix (Kurtz & Snowden, 2003). The horizontal axis in Figure 8 shows a transition from order to disorder.

- The "known" domain has visible order, with reaction as response. For example, a relief operation that involves flying a C130 transport aircraft to the fictional island nation of Mussoria, requires a military operator to enact *standard operating procedures*.
- The "knowable" domain involves hidden order, with a response typified by classical planning. For example, a service protected evacuation of Australian civilians from Mussoria would initially require *deliberative planning*.

Both of these domains involve predictability through awareness of repeated and repeatable patterns of behaviour.

- The “complex” domain is unordered, with probing required to provide explanation. For example, Special Forces landing in a state of civil unrest in Mussoria will need to probe the situation and adapt their actions accordingly.
- The “chaos” domain is also unordered, with immediate action required before sensing and response. For example, if a bus transiting Australian citizens in Mussoria during a service protected evacuation is involved in a crash, then the military personnel on board must immediately act to attend to wounded and secure the crash site.

Both of these domains are unpredictable; that is, the awareness of patterns of behaviour is novel and without repetition.

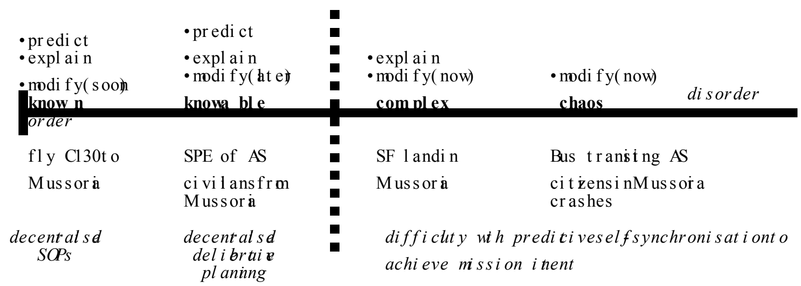


Figure 8: Linear version of Cynefin, illustrating impact of reducing order on levels of awareness and response.

Under NCW, “shared situational awareness enables self-synchronization”. Having already noted the difficulties with a process for obtaining shared situation awareness, there is now also the added difficulty of levels of awareness. Battle is often marked by confusion and ambiguity. When the situation is “complex” or “chaotic”, it is often impossible to perform predictive self-synchronisation to achieve the original mission intent. The awareness is simply insufficient to properly utilise the available capability. A Commander’s intent must also match the uncertainty (level of awareness) of the environment. If the intent is too constrained the synchronisation may not be appropriate, and if the intent is too broad, battlefield activities are likely to be coordinated only by coincidence (Shattuck, 2000).

3.3.3 Joint Military Appreciation Process (JMAP)

When self-synchronisation of capability to achieve the mission intent is possible, the question of *how* to do it remains. The Australian Defence Force (ADF) employs a method of planning called the Joint Military Appreciation Process (JMAP). The process involves four sequential steps of (i) mission analysis, (ii) Course-of-Action (COA) development, (iii) COA analysis, and, (iv) decision and execution, as described by Zhang *et al* (2000). Though specific to ADF operational-level planning, the core process of problem solving is interoperable with the Crisis Action Planning Process (USMC) and the Appreciation Process (NATO).

It is unlikely that JMAP or some decentralised JMAP will be appropriate for self-synchronisation, or indeed any of the domains characterised as “complex” or “chaotic”. Complexity is inherent in human decision-making processes. Figure 9, adapted from Conklin (2004), illustrates the linear “Waterfall model” process of progressing from problem to solution enshrined in doctrine (illustrated by the JMAP stages dashed line), compared with an example from an experiment with a team of designers (solid line).

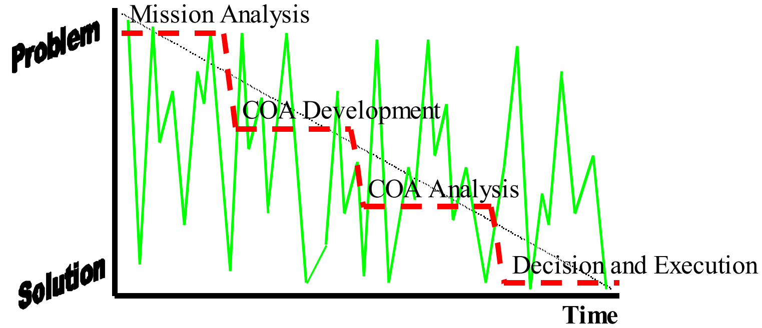


Figure 9: How groups of human experts faced with a novel problem, reason in arriving at a solution (solid line) as opposed to doctrinal guidance of JMAP (dashed line).

The following describes their experiment and key result:

> A number of designers participated in an experiment in which the exercise was to design an elevator control system for an office building. All of the participants in the study were experienced and expert integrated circuit designers, but they had never worked on elevator systems before. Indeed, their only experience with elevator systems came from riding in elevators. Each participant was asked to think out loud while they worked on the problem. The sessions were videotaped and analyzed in great detail.
>
> The analysis showed, not surprisingly, that these designers worked simultaneously on *understanding the problem* and *formulating a solution.* They exhibited two ways of trying to *understand the problem:*
>
> - efforts to understand the requirements for the system (from a one page problem statement they were given at the beginning of the session); and
> - mental simulations (e.g. "Let's see, I'm on the second floor and the elevator is on the third floor and I push the 'Up' button. That's going to create this situation….").
>
> They would start by trying to understand the problem, but they would immediately jump into formulating potential solutions. Then they would jump back up to refining their understanding of the problem. Rather than being orderly and linear, the line plotting the course of their thinking looks more like a seismograph for a major earthquake, as illustrated.
>
> In particular, the experiment showed that, faced with a novel problem, human beings do not simply start by gathering and analyzing data about the problem.
>
> It is also striking, from (the) figure, that problem understanding continues to evolve until the very end of the experiment. Our experience in observing individuals and groups working on design and planning problems is that, indeed, their understanding of the problem continues to evolve – forever! Even well into the implementation of the design or plan, the understanding of the problem, the "real issue," is changing and growing.
>
> This non-linear process is not a defect, but rather the mark of an intelligent and creative learning process.
>
> As chaotic as this pattern of activity appears, it reflects a deeper order in the cognitive process. It shows that people formulate possible solutions and try them out in order to better understand the problem. The new insights into the problem gave them fresh ideas about the shape of the solution. (Conklin 2004:pp.2-3)

A linear process may be used to justify the rationality of a solution post-hoc, however, faced with a novel problem it would appear to fail to support the non-linear process natural to human individuals and their social cognition, when engaged on novel problems. Indeed, it is not surprising to discover that the practice of JMAP may not accord with the theory, as summarised in table 1.

JMAP in Theory	JMAP in Practice
Advocates an effects-based decomposition of intent.	Asset assignments are second-guessed. It is also questionable whether sufficient awareness would accompany true effects-based intent.
COA Development might, for example, engage teams to develop up to four COAs.	There are often less teams than COAs required. One COA is usually preferred, or is claimed to be all there is time and resource available to achieve, resulting in limited diversity.
Each team develops a COA by canvassing alternatives to choose the best options.	Each team develops a COA by pursuing a particular solution with a top down and "depth-first" search strategy, considering alternatives only when options are untenable.
The commander decides on a preferred plan and THEN execution follows.	A less agile "plan then execute" commitment strategy runs the risk of the situation changing before execution.
Each of the four phases contains a sequence of detailed and complete process steps.	Process is treated as a "check list" rather than a sequence. The check list is recognized to be incomplete.

Table 1. Contrast between the theory and practice of JMAP.

3.4 Tenet 4: Mission Effectiveness – the dream of omnipotence

The **tenets** of NCW are:

1. A robustly networked force improves information sharing.
2. Information sharing and collaboration enhance the quality of information and shared situational awareness.
3. Shared situational awareness enables self-synchronization.
4. These, in turn, dramatically increase mission effectiveness. (Alberts, 2002:pp.7-8).

Given the significant shortcomings in effectiveness identified individually for each of the first three tenets, there appears to be little hope that the fourth tenet, representing the collective sequence or *product* of the first three, could be afforded anything other than a more pessimistic assessment.

Further, it is unclear from tenet 4 what *effective* really means. Our trinity of Figure 1 expresses intent as the foremost notion of intent, capability and awareness. Yet, this notion is not explicitly evident in the NCW thesis. Considering the NCW genesis in information superiority, we might look to this as a source for understanding effectiveness, but would be disappointed to find, of course, that possessing information superiority alone does not ensure mission effectiveness. Indeed, possessing firepower superiority alone does not ensure mission effectiveness, either. According to ADM William Owens[6],

> Never in history … has a military commander been granted an omniscient view of the battlefield and an enemy force to allow vital maneuver and devastating firepower to deliver the coup de grace in a single blow. Today's technology makes that possible. (Owens, 2000:pp.14)

So, Owen's thesis for mission effectiveness emphasises information superiority (indeed omniscient awareness), *and* superior manoeuvre and firepower (capability), but again the notion of intent is weak and highly constrained toward the implied destruction of enemy force elements (omnipotence).

[6] ADM Owens was Vice Chairman of the US Joint Chiefs of Staff in 1994 and 1995, during the period of development of Joint Vision 2010 and the supporting information superiority concept (which was launched publicly in 1996).

A key issue for effectiveness in NCW will be how it contributes to the *achievement of intent* (a notion of mission effectiveness not identified in the NCW thesis), and how this achievement is *balanced* against capability and awareness, for which research has uncovered some insights using adversarial abstract games (Smet *et al*, 2003; Calbert *et al*, 2005).

4. A Synthesis: Ubiquitous Command and Control

Section 2 posits the NCW thesis and touted some of its advantages. Section 3 presented the antithesis, noting why NCW cannot succeed under its current exposition. This section offers a synthesis that attempts to capture the benefits hailed in Section 2 without the showstoppers of Section 3.

In the spring of 1998, before NCW had come to prominence, the first author wrote a paper (Lambert 1999a) entitled "Ubiquitous Command and Control", abbreviated UC^2 (pronounced "you see too" – pun intended). The thesis considered at the time was CEC, the antithesis questioned the meanings of "common" and UC^2 was a synthesis. The Hegelian dialectic is presented pedagogically, as a way to understand UC^2 in the context of more recent NCW developments. Section 2.1 of that paper offered "7 defining tenets of UC^2 systems". The following synthesis extends these tenets to nine by making explicit the tenet of *adaptability*, which exposes the context for UC^2, and expanding the original text on UC^2 requirements into the tenet of *UC^2 design*.

The synthesis is about rebalancing the form of socialisation to achieve intent through capability, given awareness. It is about 'unity *with* diversity'. It balances the robustness but instability of diversity, with the stability but fragility of unity.

4.1 Adaptability

4.1.1 Context of UC^2

Temporal diversity, or change, was an implicit theme in the initial UC^2 paper. A "process philosophy" (Browning, 1965) was assumed, in which identity (temporal unity) is defined on the basis of change (temporal diversity), rather than defining change on the basis of identity. That is, in an object philosophy, identity is assumed and then you choose how to deal with change, whereas in a process philosophy, change is assumed and you choose how to assemble identities. Consequently, adaptability is a way of understanding the world, rather than something to be understood about the world. Adaptability therefore provides a way of understanding the process that engendered the context in which UC^2 was born.

4.1.2 Adaptation of Location

Adaptations in transportation and telecommunications have altered the extent to which presence is influenced by distance.

- Villages were the centre of social organisation when horses were the primary personal means of transportation, because the speed of the horse constrained the rate at which one could change the location of their physical presence. Virtual presence required the physical presence of a messenger.
- The development of the telegraph in 1837 allowed a degree of influence over considerable distance with minor delays, though this species of virtual presence still offered noticeably less influence than physical presence.
- The invention of the telephone in 1876 provided a more effective mechanism for virtual presence, though telephones did not reside in almost every home in Australia until the 1960s.
- Private motor vehicles had superseded horses and public transport as the principal means of personal transportation for every home by the 1950s. This resulted in the proliferation

of highways during the 1950s and 1960s. The resulting interaction between larger centres of population reduced the importance of villages and smaller towns as a social cluster of influence.

- Overseas air travel usurped ocean travel during the 1960s and 1970s to provide more accessible international presence.
- More recent advances in satellite communications, mobile telephones, text messaging, video conferencing and the Internet have all contributed to a substantially richer capacity for virtual presence.

With each of the advances in transport and telecommunications, the effect has been to increase the scope for both presence and virtual presence. The outcome of this effect has been to shift the sphere of influence from localisation to globalisation.

> The world of the industrial revolution is giving way to an era of global economy, powerful information technologies and relentless change. (Hammer and Champy, 1993:pp. 216.)

4.1.3 Adaptation of Function

The adaptation of location is engendering an adaptation of the function performed by individuals and organisations. Increased presence and virtual presence has increased both the nature and number of players that can influence a function. The effect is to increase the scope for both competition and collaboration.

- Competition increases because an external presence can be more easily imported to perform a function.
- Collaboration increases because one can more easily export functional expertise as a component within broader functions.

The outcome of these competitive and collaborative forces has produced an increased focus on competitive strength. Individuals and organisations have been compelled to understand the functions that they can competitively perform and then apply them collaboratively in strategic alliances with individuals and organisations possessing expertise in complementary functions. The management literature has been preaching collaborative advantage through strategic alliance since the mid 1980s, where a strategic alliance is a cooperative agreement on,

> … joint research efforts, technology sharing, joint use of production facilities, marketing one another's products, or joining forces to manufacture components or assemble finished products. (Thompson and Strickland, 1995:pp. 165).

The motor vehicle industry typifies the approach (Burgers *et al*, 1993). Companies are increasingly understanding themselves as "Lego blocks" of functional capability within a global economy. A recent growth area has been in metalevel businesses that integrate other "Lego block" businesses.

4.1.4 Adaptation of Structure

The adaptation of function is inducing an adaptation of structure. Walker (1992) observes that,

> Companies typically divide themselves into chunks according to some logical differentiation. At the same time, they seek to find ways to glue these chunks together as a coherent enterprise. Walker (1992:pp.136).

Differentiation (diversity) allows the organisation to form smaller units that can be more focused and better managed. Differentiation is usually undertaken on the basis of product, function or market. *Integration* (unity) provides competitive advantage through efficiencies, synergies and combined value adding (*ibid*).

Under the early industrial model, industries were centrally located, usually opportunistically based on geographic features, and were operated under the ideals of specialisation in production and a division of labour. As the size and complexity of firms increased, the roles became more specialised, encouraging a hierarchical integration to manage the centralisation of differentiated function. The hierarchical management structure has, in principle, remained until current times, and influences the conception of strategic planning. Through an analysis of texts, Mintzberg (1990) identified the following three propositions as basic premises of the classical strategic management framework:

1. strategy formation should be a controlled conscious thought process, which is economically based and rationally determined;
2. responsibility for the conscious thought process rests with a single individual at the top; and
3. strategy proceeds in a linear top down fashion through development and then to implementation.

The effect of an increase in competition and strategic alliance is to erode the classical hierarchical structure to include networked structures. This induces a number of outcomes.

1. Command and subjective "rational" decision-making will be tempered by negotiation. Command and control will be supplemented by collaboration.
2. Single minded emphases, such as the economist's focus on profit or the militarist's focus on force, will increasingly need to be understood and applied against a broader diversity of motivating goals.
3. The presumption of control will increasingly be understood as a question of managing change in a complex environment.

4.1.5 Adaptation of Adaptation

The adapted networked structures will increase the diversity available to an organisation, and this in turn, *will intensify the pace of change.* As the tempo of change increases, organisations must learn to adapt "Lego block" capability to satisfy intent, with an awareness "… equivalent to the craftsman's feel for the clay" (Mintzberg, 1987:pp.109).

> At work, the potter sits before a lump of clay on the wheel. Her mind is on the clay, but she is also aware of sitting between her past experiences and her future prospects. She knows exactly what has and has not worked for her in the past. She has an intimate knowledge of her work, her capabilities, and her markets. As a craftsman, she senses rather than analyzes these things; her knowledge is "tacit". All these things are working in her mind as her hands are working the clay. The product that emerges on the wheel is likely to be in the tradition of her past work, but she may break away and embark on a new direction. Even so, the past is no less present, projecting itself into the future (*ibid*.).

This also affects how we understand the identity (unity) of an organisation. Organisations have traditionally understood themselves as persistent, and as a consequence, changes in organisational location, function and structure have often been violent. A process view of organisations, as intimated by Senge's (1990) "learning organisations", counters this violence.

One outcome of a process conception of organisational identity is that organisational change becomes less a centralised decision and more of an environmental effect of adaptations in location, function and structure. A second outcome is that competitive strength no longer lies solely in knowledge and strategic alliance, but also in their adaptation. Innovation and the ability to form dynamic relationships become the basis for competitive strength. In an information economy in which information is rapidly traded, innovation becomes the new means of production.

Adaptability is a fundamental tenet of the synthesis in that it is a feature of all of the following tenets, each of which successively builds upon its predecessors. The benefit of adaptation is the ability to operate in changing environments.

4.2 Decision Devolution

> UC^2 systems represent a devolution of decision making power from C^2 centres to platforms which are designed to provide alternative functionality. Under this proposal, command and control becomes an additional function performed on the likes of frigates, fighters, unmanned vehicles, and missiles. This signals a significant shift in emphasis toward the tactical level, and in particular, to the warfighters. C^2 centres, as we now know them, may continue to exist, but their utility will diminish (Lambert, 1999a:pp.35).

Decision devolution aligns with the "power to the edge" sentiments expressed by NCW practitioners in Section 2.4. Decision devolution is founded upon the idea that additional individuals or entities are not always required to govern collectives. When appropriately equipped, collectives can sometimes govern themselves. The sense of decision devolution suggested here therefore allows for mission command, as discussed in Section 3.3.1, but it also accommodates extensions beyond it in which the hierarchical overhead is absent. In the business context, the latter accords with the strategic alliance functionality of Section 4.1.3 and the networking structures of Section 4.1.4. In the military context, the latter signals dynamic liaisons adaptively forming from operational assets without the oversight of a command headquarters.

The conduct of military operations without the oversight of a command headquarters is of course an anathema to current military practice, and might well foster allegations of heresy against the authors. But large-scale collectives can successfully operate without a ruling class. Command involves the creative expression of intent to another. Control involves the expression of a plan to another, and the monitoring and correction of the execution of that plan. Processes akin to these operate within eBay on a significant scale, without the oversight of a ruling class. Command resembles the vendor expressing the intent of sale, with any member of the collective potentially being a vendor. Control resembles the process by which the purchaser acquires the sale item, with any member of the collective potentially being a purchaser. Control works in eBay because the collective is largely self-monitoring and self-correcting. Customer satisfaction with each transaction is recorded and made visible to all in the collective. Ideally, this monitoring mechanism then facilitates correction, by steering prospective purchasers away from exposed historically fraudulent vendors.

Decision devolution means that decisions run across the collective,

> … once the environment cranks up the rate of change required for competitive performance, complex tasks must be correspondingly repartitioned, and human capital correspondingly reallocated. And absent some infinitely capable overseer, this repartitioning problem must be solved by the same individuals who have to perform the task of production. The result, in a successful firm, is a continual swirl of problem-solving activity and ever shifting interactions between the problem solvers, each of whom has information relevant to the solution of a particular problem but none of whom knows enough to act in isolation. Nor does any one person know precisely who knows what; hence, problem solving is a matter not just of forming the necessary combination of resources … but of searching for and discovering those resources in the first place. (Watts, 2004:pp. 269)

The potential benefits of decision devolution are flexibility and redundancy. Flexibility can arise through the ability to share the load throughout the collective, often through mobile platforms. Redundancy ensues because the conduct of military operations can still proceed even if its command centre becomes inoperative.

4.3 Ubiquity

> Ubiquitous C^2 systems are so named because they advocate a C^2 capability on *every* platform. Indeed, individual platforms will generally have several autonomous C^2 components. The term "similar" is chosen to reflect a requirement for inter-operability, so that each platform based C^2 component can effectively communicate with the others in the UC^2 system. It

equally acknowledges scope for differences, both in terms of the underlying C^2 architectures resident on platforms, and in terms of the knowledge and opinions held by those C^2 components. (Lambert, 1999a:pp. 35).

The ubiquity tenet argues: (i) for a C^2 component on *every* platform; and (ii) that these components should be *similar*, not identical.

4.3.1 Graceful Degradation

A C^2 component on *every* platform allows command and control to degrade gracefully under strike by reconfiguring C^2 among the remaining assets.

> In the Information Age, C^2 centres have become the enemy's centre of gravity, and are therefore the prime targets for precision strike. In defending against precision strike, one approach is to build a duplicate C^2 centre. The neutralisation of the C^2 centre is then less catastrophic, as the duplicate centre can assume its function. But redundancy offers only one level of reprieve. By enabling C^2 functionality to re-configure as necessary, ubiquity offers greater sustainability, by enabling the quality of defence to degrade gracefully, rather than instantaneously, under the threat of surgical strike. In principle, defeating a UC^2 system amounts to defeating all of its assets (Lambert, 1999a:pp. 37).

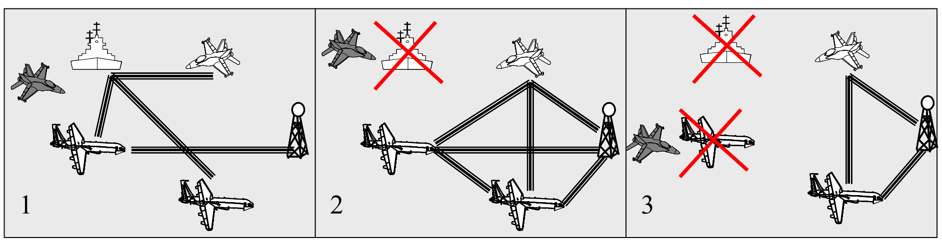


Figure 10: Reconfiguring C^2 under strike.

Figure 10 illustrates the point. In frame 1 a forces of darkness fighter approaches a UC^2 system with malevolent intent. In frame 2 the fighter destroys the commanding ship and C^2 reconfigures in response. In frame 3 the fighter destroys a C^2 significant bomber, and again C^2 reconfigures. In each successive frame the quality of C^2 diminishes but is not extinguished.

4.3.2 Agreement

Having *similar*, rather than identical components, offers a balance between unity and diversity, in the spirit of synthesis. Section 3.2.2 canvassed two extant notions of "common", "common as identity" and "common as consistency", and highlighted the shortcomings of both. The presentation from which these derived advocated a third alternative, termed "common as agreement". "Common as agreement" allows individuals to harbour both public and private views, with the former being a product of agreement with other individuals, while the latter retains alternatives should they be required. In the example of Section 3.2.2, under the weight of public opinion, individual Y might be persuaded to accept some statement α, but is free to privately retain his or her reasons for endorsing not(α). This might subsequently prove to be invaluable if it turns out that not(α) is in fact correct. Inconsistencies should be managed, not discarded. Agreement facilitates social unity while retaining the robustness of diversity.

Authority is fundamental to any consideration of C^2. Indeed allied doctrines generally *define C^2 with respect to* a specific *authority*. For example, Operational Command is defined as,

> The authority granted to a commander to specify missions or tasks to subordinate commanders, to deploy units, to re-assign forces and to retain or delegate operational control, tactical command and/or tactical control as may be deemed necessary. It does not of itself include responsibility for administration or logistic support. (ADDP 00.1, 2001:pp.7)

And Operational Control is defined as,

> The authority delegated to a commander to direct forces assigned so that the commander may accomplish specific missions or tasks which are usually limited by function, time or location; deploy units concerned and retain or delegate tactical control of those units. It does not include authority to allocate separate employment of components of the units concerned. Neither does it, of itself, include administrative or logistic control. (ADDP 00.1, 2001:pp.8)

Authority as defined here is a means to achieve unity. In these two examples, the authority to ‘assign’ missions or ‘direct’ forces given missions, respectively, provides division of labour by division of intent into two independent parts, and the connection of each part to a specified individual provides the focus or unity.

However, authority has a paradox. Given the inevitable shortcomings in awareness described in Section 3.2, and the potential shortcomings in intent that may arise from that, one might ask: how can someone have the right to force their intent on another if it is misguided? Shapiro contrasts,

> One who obeys a command, therefore, treats the command as a content-independent reason, because he complies for the reason that he was commanded, not because he has reasons to act on the content of the command.
>
> An autonomous person, by contrast, never treats a command as a content-independent and peremptory reason for action. The demands of authority mean nothing to the autonomous agent, for such a person never allows his will to be determined by the will of another. She cares solely about the act commanded, not the command itself, and will acquiesce only when convinced that there are good reasons to act on the content of the command. (Shapiro, 2000:pp. 12-13)

These two extreme cases both see the function of authority as *mediation* between reasons and persons, whether the reason for obeying is content-dependent, content-independent, or some combination. Shapiro (2000) posits an alternative to this incoherent mediation model, where the function of authority is *arbitration* between rival parties.

> According to what might be called the “Arbitration Model,” the function of authority is to act as an arbitrator between subjects. Authorities are legitimate for a given subject just in case the acceptance of the process as binding by some of the parties generates a moral obligation for the subject to abide by the outcome. The type of acceptance, the parties that must accept the process, and the nature of the moral obligation generated by such acceptance will vary depending on the type of Arbitration Model. A social contract theorist, for example, would understand the acceptance as an act of consent by the subject and the obligation generated to be a promissory one. A fair play theorist, on the other hand, would understand the acceptance as the willing receipt of the benefits of the process by the subject and the obligation generated would be one of fairness, i.e., that parties shoulder the burdens of a process when they also willingly accept the benefits from it as well. (Shapiro, 2000:pp. 78)

In this arbitration (agreement) model of authority, it is the acceptance of the process as binding by some of the parties that is the basis of legitimacy. Obedience then, is the moral price that parties must pay in order to secure the compliance of others.

This model of social cooperation is not practically sustainable without the availability of procedures for the resolution of conflict. Democratic or other procedures may be employed to allow individuals some input into the resolution of their disputes. Section 4.7 describes protocols to achieve this arbitration or social coordination. These protocols may embody authority within the machine, not unlike the example of eBay described in Section 4.2.

4.4 Automation

> Automation is the primary mechanism for acquiring a similar C^2 capability on every platform. Some decision-making can be fully automated. Other aspects will perform better with human interaction, with the choice between the two being mediated empirically. This promotes the role of automated decision makers and automated decision aids within UC^2 systems, with a similarity in C^2 components emanating from a similarity in the automated decision makers and aids. The automated decision aids will vary in their reliance on human cognition, ranging from elementary structured interfaces through to complex decision advisory systems (Lambert, 1999a:pp. 35-36).

The automation tenet argues that some expertise should be automated through software, and indeed, that this is the mechanism by which ubiquity might be achievable.

4.4.1 Automated Decision-Making

The intention is that automated software expertise should facilitate automated decision makers as well as automated decision aids. The proliferation of automated decision-makers within society generally was noted in Lambert (1999a).

> Smart decision software is steadily becoming a ubiquitous commodity throughout our society. It pervades throughout our homes, our work, our transportation, our health, and our leisure. The military environment too, has experienced the proliferation of smart decision software within its assets. The upshot is that something like a C^2 capability is steadily emerging within our assets, and the communications to efficiently link them is improving (Lambert 1999a:pp. 36).

Since then that trend has only increased. Our automobiles, for example, now integrate the driver with a society of automated decision-making components developed by a disparate group of strategically aligned global partners.

The prospect of automated decision-making in a military context is controversial. Some might contend on moral grounds that military operations should be immune from the automation progression otherwise evident in society. There are two responses to this. First, automation will proceed in military operations whether or not it should. In 2000 the US congress ordered that a third of the ground vehicles and a third of the deep-strike aircraft in the military must become robotic within a decade. In addition, a recent New York Times article stated that robots with machine guns will be operationally deployed in Iraq in April 2005. Second, there is a case for including automation within military weaponry. Automobiles rival wars as a contributor to human death, and yet the automobile industry is one of the leaders in integrating automated decision-makers. Much of the manufacturer's motivation is to make automobiles safer. A similar motivation could apply in a military context. If a missile that has been instructed to destroy a train bridge observes or is informed of a passenger train traversing that bridge as it approaches, then we would want the missile to exercise moral judgment and defer its strike on the bridge until after the passenger train has departed the scene. This might be achieved by building in Rules of Engagement (ROE) into the missile that ensure conformance with national moral intent.

4.4.2 Ubiquity Through Automation

The advantage of automated software expertise is that it is easily replicated, adapted and distributed. The benefit is that automated software expertise is more readily transferable, which enables the ubiquity of C^2 capability.

> The fact that we can readily duplicate software then becomes the crucial attribute, because duplicated software encoded human expertise is the mechanism that facilitates the ubiquitous capability (Lambert, 1999a:pp. 36).

An illustration of the theme occurs in the movie "The Matrix" when the character Trinity, played by Carrie-Anne Moss, suddenly needs to be able to fly a nearby helicopter. The following dialogue ensues,

> Neo: "Can you fly that thing?"
> Trinity: "Not yet." *Trinity dials on her cell phone.*
> Tank: "Operator."
> Trinity: "Tank, I need a pilot program for a V2-12 helicopter. Hurry."
> Tank: *Tank downloads the program.*
> Trinity: *Trinity turns to Neo.* "Let's go."

This expresses the idea, but in the near term we would download expertise relevant to that person and the helicopter, to the helicopter or the person's personal automated agent, not the person. Our Chief of Division, Alan Burgess, has promoted the idea of military staff cultivating a personal agent that encapsulates some of their expertise and experience as they progress through their military careers.

The encapsulation of expertise in software will gain in currency as two mind set changes become more pronounced. The first is an acceptance of *semantic machines*. Computers are so named because they were conceived during a wartime calculation boom as rapid number crunching devices. Nowadays computers are instead viewed as something akin to post office boxes that serve as repositories in which people store information, so that they or other people can access that information subsequently. The machines themselves have no understanding of the information they hold. I might be able to retrieve the statement "Saddam Hussein bought munitions from Mussoria" through a syntactic search on "Saddam", but I cannot retrieve it through a semantic search on "Iraq" – until recently! Nowak and Lambert (2005), for example, reports recent software applications using the five-tiered conceptual structure of Figure 11, taken from Lambert (2003a). It is symptomatic of a new shift toward a "semantic web" and semantic machines that associate meanings with the information they hold about the world by constraining possible interpretations through formal logics.

> Social: group, ally, enemy, neutral, own, possess, invite, offer, accept, authorise, allow, …
> Cognitive: individual, routine, learnt, achieve, perform, succeed, fail, intend, desire, belief, expect, anticipate, sense, inform, effect, approve, disapprove, prefer, …
> Functional: sense, move, strike, attach, inform, operational, disrupt, neutralise, destroy, …
> Environmental: land, sea, air, outer space, incline, decline, number, temperature, weight, energy, …
> Metaphysical: exist, fragment, identity, time, before, space, connect, distance, area, volume, angle, …

Figure 11: Tiers of Semantic Primitives for Military Operations.

The second mind set change is an acceptance of *cognitive machines*. Computers are currently viewed as machines that hold information that people reason about. In time computers will come to be understood as machines that have agents that people reason with. Over a decade ago the first author developed a software agent system called ATTITUDE, initially for dynamically managing a phased array radar on an Airborne Early Warning aircraft. ATTITUDE is so named because it is programmed at the cognitive level in terms of propositional attitudes like beliefs, desires and expectations (Lambert, 1999b). Figure 12 illustrates the cognitive model associated with an ATTITUDE agent's "mind".

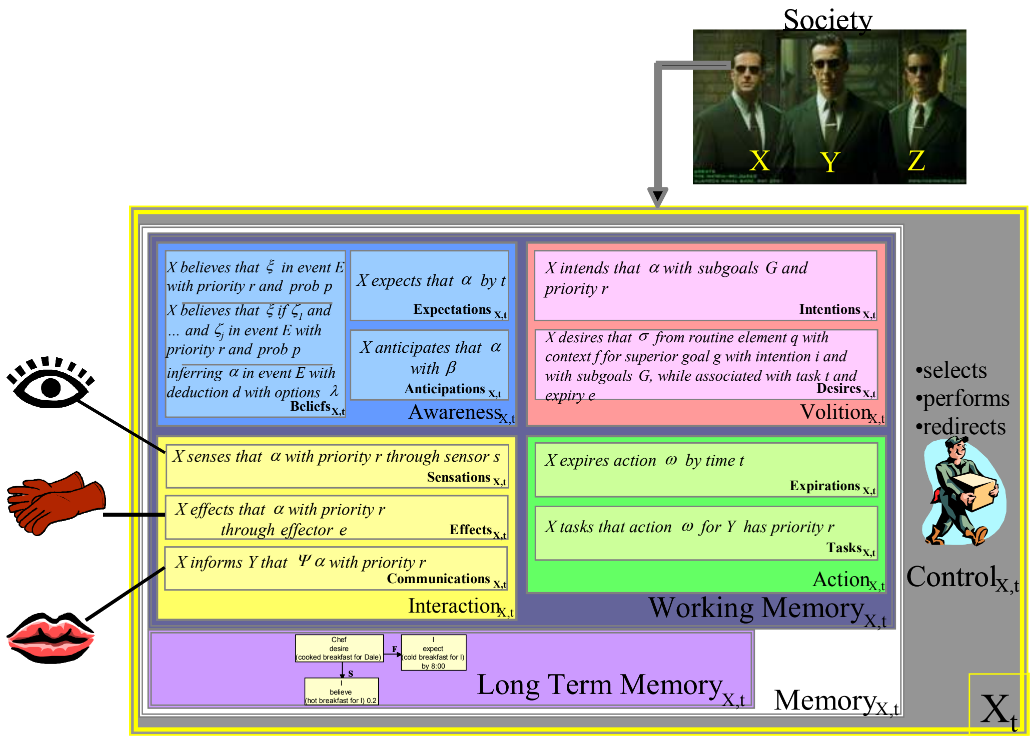


Figure 12: ATTITUDE Cognitive Model.

Lambert (2003b) outlines a strategy for capturing cognitive routines as ATTITUDE software.

4.5 Integration

The integration tenet addresses the integration of people and machines. It makes two points, one in relation to mixed initiatives and the other in relation to improvements in interaction.

4.5.1 Mixed Initiative on Authority, Responsibility and Competency

> In UC^2 systems, the automated and human decision making is fully integrated, with each assessed equally on it merits. This includes the currently controversial option of allowing the machine to at times override the human. The introduction of automated rules of engagement components (essentially legal expert systems) within weapons and weapon systems illustrate the point. The resulting "moral weapons" will have the ability to assess and decline targeting requests when rules of engagement violations are deduced. Decisions to override these moral weapons can be logged for subsequent review (Lambert, 1999a:pp. 36).

In UC^2 systems, the automated and human decision-making is fully integrated. Integration exists to complement the weaknesses in some parts of a UC^2 system with strengths in other parts of a UC^2 system. This includes the division of labour between people and machines. James Reason, who has undertaken extensive research on human expertise and error, captures the intent beautifully from the human perspective, through contrasting "the human as hazard" with "the human as hero". People can exhibit great flexibility, adaptation, recovery and improvisation to perform heroic acts. Apollo 13 and Chess grand masters, who can play simultaneously against over forty Chess players while blindfolded, are examples of the incredible capability of humans. But humans also make errors, commonplace errors of little consequence and uncommon errors with serious consequence. The shooting down of the Iranian passenger aircraft by the US Navy in 1987, and the Challenger space shuttle disaster, are examples of the human as hazard. And most importantly, the heroes and hazards are not two different groups of people. The heroes are sometimes hazards.

The division of labor between people and machines should be developed to leave human decision making unfettered by machine interference when it is likely to prove heroic, and enhance human decision making with automated decision aids, or possibly override it with automated decision making, when it is likely to be hazardous. Again, overriding human decision-making is a highly contentious suggestion. But in cases where a machine detects a violation of rules of engagement, such as the train illustration at the close of Section 4.4.1, then it should be able to at least question the order before compliance. From the authors' perspective, the appropriate balance between the exercise of intent by people and machines is something best determined empirically, rather than on the basis of *a priori* belief. This approach identifies a means of addressing the "more is not necessarily better" problem identified in Section 3.1.1.

When automated components substitute functionality that is currently provided by people in hierarchic structures, including social coordination functionality, then those automated agents must accept the authority, responsibility and competency (Pigeau and McCann in McCann, 2000) associated with that functionality. For automated agents, this should be ordered by competency, then responsibility, and then authority.

- An automated agent's *competency* will depend on the expertise embedded within it, and the agreements it forms should primarily derive from its competencies.
- An automated agent's *responsibility* will follow from the social agreements it forms, given available competencies.
- An automated agent's *authority* is not determined by *a priori* rank, but depends upon the role it assumes in social agreements, given available competencies. As noted in Section 4.3.2, in the end, authority is a matter of agreement.

4.5.2 Improved Interaction

> Fully integrating human and machine decision making also introduces human computer interaction issues … while their graphical displays are similarly handicapped as track picture displays. UC^2 systems will both exchange and present more sophisticated relationships at varying levels of abstraction (Lambert, 1999a:pp. 36).

Following on from Section 4.4.2, the integration tenet also contends that as the machines acquire an ability to reason about their environment, *id est* comprehend and project, they will also require a means of presenting information to people that goes beyond simple "dots on maps" displays and the desktop metaphor. In essence, the machines need to have a storytelling capability, as suggested in the shared situation awareness antithesis Section 3.2.1.

In our everyday lives, television news often provides our situation awareness about the world. It does this by assembling presenters, maps, diagrams and video footage to convey stories about daily events of interest. The Future Operations Centre Analysis Laboratory (FOCAL) task has embraced this approach by developing software virtual advisers, virtual battlespaces, virtual interaction mechanisms and environments, and virtual videos, as respective software counterparts to the presenters, maps, diagrams and video footage featured in news services (Lambert, 2003a). Figure 13 illustrates the correspondence. As software, it allows the machine to generate stories from its accessible information. As software it is portable, being easily replicated, adapted and distributed throughout a network. And unlike television news services, as software it is interactive[7], allowing the user to access the information of interest to them.

[7] In FOCAL the interaction mechanisms include speech recognition, natural language processing, speech synthesis, stereoscopic displays, open hand gesture recognition and gaze tracking.

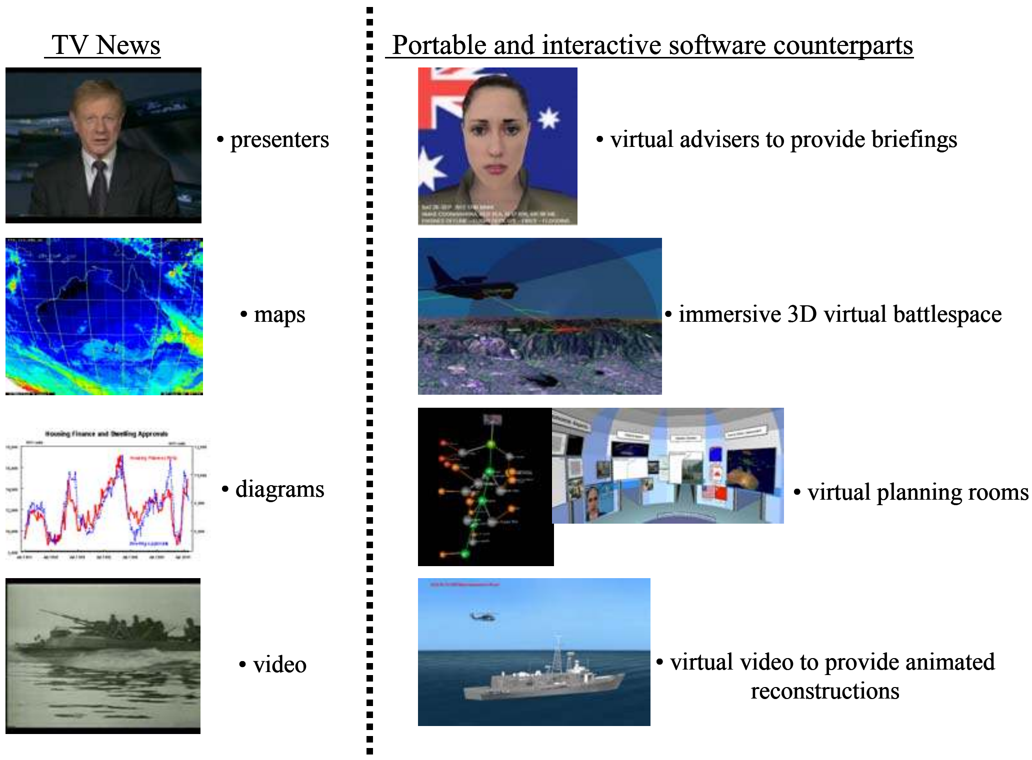


Figure 13: Storytelling Technology.

4.6 Distributed and Decentralised

> UC^2 systems primarily endorse a distributed and decentralised management structure. Each decision maker has the capacity to ask (pull knowledge), tell (push knowledge), command (push tasks) and obey (accept tasks). This potentially secures a flatter, more efficient, network structure, liberating us from a hierarchical C^2 framework whenever we choose to do so. It also introduces a command fusion problem to complement the existing information fusion problem, as each decision maker is now forced to attend to, and possibly fuse, requests for its resources from multiple sources (Lambert, 1999a:pp. 36).

UC^2 systems advocate diversity by endorsing C^2 that is distributed and decentralised.

4.6.1 Distributed UC^2

Distributed UC^2 postulates that C^2 should be distributed across location. This reflects the adaptation of location theme presented in Section 4.1.2. Current web portal technology characterises the desirable attributes.

- Awareness should be retained by members of the collective in accordance with their roles.
- Related pieces of the distributed awareness should be accessible to members of the collective from a single point of access.
- The single point of access should be location independent.
- Access to awareness should occur without members of the collective having to know the distributed locations from which it derives.

Distributed UC^2 affords location independent access (unity) while the physical distribution of information (diversity) offers protection from spatio-temporally constrained strike capabilities like missiles.

4.6.2 Decentralised UC^2

Decentralised UC^2 postulates that C^2 should support the decentralisation of intent. Each member of the collective should have the capacity to ask (pull awareness), tell (push awareness), command (push intent) and obey (accept intent). The decentralisation of intent therefore allows for agreements about intent as well as awareness. Decentralised UC^2 affords protection from strike capabilities that target centralised will (the origin and ownership of intent) like assassination and blackmail. UC^2 combines distributed UC^2 with decentralised UC^2. It accommodates a diversity of intent situated at a diversity of locations.

The shortcomings of "mission command" were noted in antithesis Section 3.3.1. In the synthesis, decentralised UC^2 gives rise to what we might term "mission agreement". Mission agreement allows for agreements that are not restricted to a hierarchical top down cascading of intent. Consequently, mission agreement supersedes mission command because it allows for intent network structures of which intent hierarchical structures are but one type. In thesis terms, intent can be introduced at "the edge" of an organisation and propagate inwards if it garners sufficient support. This introduces a "command fusion" (intent) issue to complement the "information fusion" (awareness) issue already present under mission command.

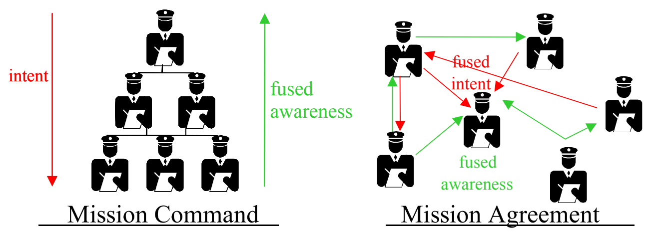


Figure 14: Mission Agreement.

The generalisation of hierarchies to networks allows for the use of hierarchies when they are appropriate, and non-hierarchical networks when they are inappropriate. Intent hierarchies assume that tasks are *decomposable* into simpler subtasks, such that each subtask may be completed independently, and thus in parallel, with others. Decomposition applied to unordered domain situations and problems, usually fails to represent the relationships between objects that make behaviours 'more than the sum of their parts'. The reason for this is that a decomposition into M tasks also requires representation of 2^M combinations of relationship groupings if a complete representation of the original problem is to be retained. It is not surprising then to find for even small values of M, that most of these relationships are discarded or trivialised to maintain tractability. A focus on the M tasks at hand is much easier than the 2^M relationships.

Intent hierarchies are *not robust*. When assigned tasks have inherent relationship overlap, message passing will occur between actors crossing the hierarchy in an attempt to recover that which has been lost through task decomposition. High rates or volume of such traffic will tend to overload key nodes causing *congestion*. Furthermore, a hierarchy with N nodes has a mere $N-1$ links, so there is no reserve ready if links are lost – they lack adequate *connectivity*. A breakdown near the top of a hierarchy has the effect of isolating all lower nodes from the rest of the network. If a link is lost between physically distributed commanders, the two isolated structures will have reduced mutual unity in the wake of any subsequent environmental changes. Study of some of these effects has been conducted using a variant of the game of checkers that includes network structural overlay, where actions of pieces are frozen in the event of becoming isolated (Calbert *et al*, 2003).

The traditional view of the organisation as a vertically integrated hierarchy may be critically incomplete, yet it remains a vital legacy consideration in C^2. Fortunately, there is a form of network topology that can provide dynamic robustness by augmenting hierarchies, yet remains close to optimum. Multi-scale networks (Dodds *et al*, 2003), appear to uniquely combine both congestion robustness and connectivity robustness to a wide range of environmental conditions, and retain good scalability. Multi-scale networks combine local unity (highly ordered clusters) with long-reaching diversity (random shortcut links across the network) with the long-reaching links grading from a large number at the top to a small number at the base. This means that teams function at various scales with the information burden distributed across multiple scales to avoid overloading individuals.

4.7 Social Coordination

> In general, each decision maker is concurrently confronted with ask, tell, command and obey request options. In a UC^2 system, selection between these is determined by attempting to obtain the best possible outcome for the UC^2 system in the time available. There are a number of potentially controversial elements to this standpoint:
>
> - the information fusion and decision making processes are intimately interrelated - it is not a straightforward progression from information fusion to decision making.
> - activity is decided by system utility, which need not correspond to command authority - competitive advantage can override military rank;
> - optimal utility cannot always be obtained, particularly in a tactical environment - the UC^2 system must be prepared to trade the quality of its decisions in order to make them in the time available. (Lambert, 1999a:pp. 36).

In general a UC^2 system will have a demand pool of human and machine agents offering intent, and a supply pool of human and machine agents offering capability. Moreover, the two pools will generally overlap, as any member of the collective can be a member of either pool. The challenge is to manage this level of flexibility without anarchy.

UC^2 systems can achieve social coordination by instituting social agreement protocols that coordinate collectives composed of both people and machines. The social coordination can be instituted through software, *id est*, as more sophisticated variants of existing workflow systems. In essence, eBay is a social agreement protocol implemented through software. The cost of finding information and expertise in this system is low and the agreement and monitoring mechanisms provide feedback for self-regulation. Examples of social contracting protocols, include:

1. Contract net protocol (CNP, Smith, 1980);
2. Extended contract net protocol (ECNP, Fischer, 1996);
3. Provisional agreement protocol (PAP, Perugini *et al*, 2003); and
4. Legal agreement protocol (LAP).

The above protocol ordering reflects an increase in computational complexity, and an increase in rights for the proletariat. The legal agreement protocol being introduced here, offers a facility for full contract law agreements between agents, be they human or machine. Figure 15 outlines the LAP. Anytime something is bought in everyday life, a contract exists, and so it is a familiar practice for humans. LAP formalises the agreement process, and can be embedded in software so as to hide legal complexities unless required.

SPEECH ACT	SEND	RECEIVE
Request for Proposal (requests X α)	Contractor X uses domain knowledge to determine potential proposers $\{Y_1, \ldots, Y_n\}$ for RFP (request for proposal) goal α and sends X requests that α to each Y_i. A request can be sent at anytime.	Potential proposer Y_i receives X 's requests for α. In response, Y_i determines its best proposal β_i, and if Y_i can undertake the proposal β_i, then Y_i sends a propose speech act.
Retraction of Request (retracts X α)	Contractor X decides not to proceed with a sent RFP for a and sends this to the individuals $\{Y_1, \ldots, Y_n\}$ that the RFP goal α was initially send to. A retraction of an RFP can occur, without penalty, any time before acceptance of an offer contributing to the RFP.	Potential proposer Y_i receives a retraction for RFP goal α and deletes all proposals and offers associated with it. Damages can be sought by Y_i against X for each of Y_i's offers accepted by X.
Proposal (proposes Y_i β_i X α)	Proposer Y_i sends a proposal for β_i to X to achieve α in response to a request from X. The proposal can be sent any time before the request is retracted or a contracts for a has been let.	Contractor X receives a proposal bi to achieve a from Yi. In response, X determines whether bi is a better proposal for a than any currently received. If it is, then X sends an invitation for Y_i to offer β_i formally.
Withdrawal of Proposal (withdraw Y_i β_i X α)	Proposer Y_i sends a withdrawal to X for proposal β_i to achieve α. Y_i will do this if it becomes clear that Y_i cannot perform the proposal. A withdrawal for β_i can be sent any time before an offer for β_i is sent.	Contractor X receives a withdrawal of proposal β_i from Y_i. X removes proposal β_i and all of its dependencies.
Invitation to Offer (invites X Y_i β_i α)	Contractor X sends an invitation to proposer Y_i to formally offer proposal β_i for request α. X can send such an invitation whenever X believes Y_i's proposal β_i is the best proposal for α.	Proposer Y_i receives an invitation from X for proposal β_i to achieve α. In response, Y_i can send an offer θ_i to X for β_i, but this will be contractually binding on Y_i if X accepts that offer before Y_i revokes it.
Decline of Invitation (decline Y_i β_i X α)	Proposer Y_i sends to X a decline to offer for proposal β_i to achieve α. Y_i can do this at any time.	Contractor X receives from Y_i a decline to offer for proposal β_i to achieve α. In response, X must delete β_i and all dependent states.
Offer (offers Y_i θ_i β_i X α)	Proposer Y_i sends an offer θ_i to X for proposal β_i to achieve α. Y_i will do this if Y_i believes it is prepared to be obligated, as θ_i will be contractually binding on Y_i if X accepts that offer before Y_i revokes it.	Contractor X receives an offer θ_i for proposal β_i to achieve α. If X accepts the offer then X is contractually obligated to it. X can instead delay acceptance, but risks Y_i revoking the offer before X can accept it.
Revocation of Offer (revokes Y_i θ_i β_i X α)	Proposer Y_i sends a revocation of offer θ_i to X for proposal β_i to achieve α. Y_i will do this if Y_i believes it has a better alternative. This succeeds provided X has not already accepted the offer, in which case Y_i will be liable for damages. The revocation of the offer occurs at the time at which it is sent, not received.	Contractor X receives a revocation of offer θ_i from Y_i for proposal β_i to achieve α. In response, X must delete θ_i and all dependent states and is not entitled to damages unless θ_i has been accepted.
Acceptance of Offer (accepts X Y_i θ_i β_i α)	Contractor X sends acceptance of offer θ_i from Y_i for proposal β_i to achieve α. The effect is that both X and Yi are contractually obligated to achieve θ_i. If either party renigs, then they are liable for damages under breach of contract.	Proposer Y_i receives an acceptance of offer θ_i for proposal β_i to achieve α. At this point Y_i becomes aware of the mutual obligation.
Rejection of Offer (rejects X Y_i θ_i β_i α)	Contractor X sends a rejection of offer θ_i from Y_i for proposal β_i to achieve α. The effect is that no contractual obligation exists between X and Y_i. X will do this if X believe it has a better offer or potential offer.	Proposer Y_i receives a rejection of offer θ_i for proposal β_i to achieve α. At this point Y_i deletes offer θ_i and proposal β_i and all of their dependencies.

Figure 15: Legal Agreement Protocol.

Social protocols, such as LAP, facilitate adaptive cooperative alliances of the sort canvassed in Section 4.1.3, through the formation of contractual agreements between members of the collective. They can also generate adaptive competitive factions, as members of the collective compete for capability resource to satisfy their intent. In their primitive form, the aforementioned protocols admit a *laissez-faire* management style.

- Agents are free to contract non-linearly rather than having to adhere to a linear waterfall model, such as the JMAP of Section 3.3.3. Agents are also free to contract non-hierarchically rather than be constrained to the hierarchy of mission command of Section 3.3.1. We term this alternative to JMAP, "diverse appreciation". This is illustrated in Figure 16.

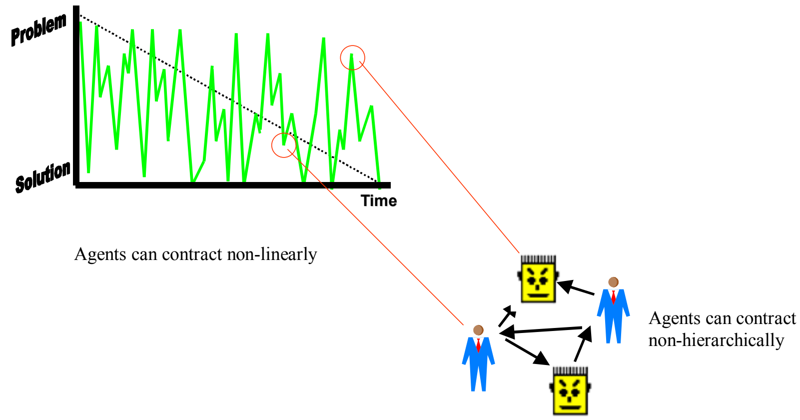


Figure 16: "Diverse Appreciation" – Agreement in UC^2.

- Section 3.3.2 noted that the self-synchronisation of capability to achieve mission intent is not always possible because the level of awareness of the environment may preclude it. Under the more advanced protocols, intent can instead be adapted to match the awareness of the contracted capability available. This allows behaviour to occur to match the level of awareness of the situation, where the adapted intent can precipitate action.
- Finally, in the spirit of Section 4.3.2, under the more advanced protocols, agents are also free to maintain public and private intent, so that competing intents within a UC^2 system can be managed rather than discarded, just in case they subsequently prove to be valuable.

Additional social policies will be required if individuals are to trade self-benefit for the benefit of a collective. This could involve, for example, a multi-scale networking constraint to ensure efficiency within a collective. It could involve a prioritising of intent according to the rank of the members of the collective. It could have social constraints that govern how to trade membership and the quality of decisions with the time available. These issues will vary with the nature of the collective.

From the perspective of UC^2, the concept of multidimensional manoeuvre referred to in Section 2.2.2 has two parts, the multiple dimensions are the categories of the semantic primitives from Figure 11 and manoeuvre refers to adaptability as outlined in Section 4.1.

4.8 Management Levels

Each UC^2 system is understood and managed at four levels.

- the Individual Level, which is concerned with each individual decision maker, automated or otherwise, in the UC^2 system;
- the Platform Level, which is concerned with the collection of individuals resident on a single asset platform;
- the Team Level, which is concerned with a system of assets dedicated toward achieving the same mission within the UC^2 system; and
- the Sociological Level, which is concerned with the multi-mission interaction between systems of system assets. (Lambert, 1999a:pp.36)

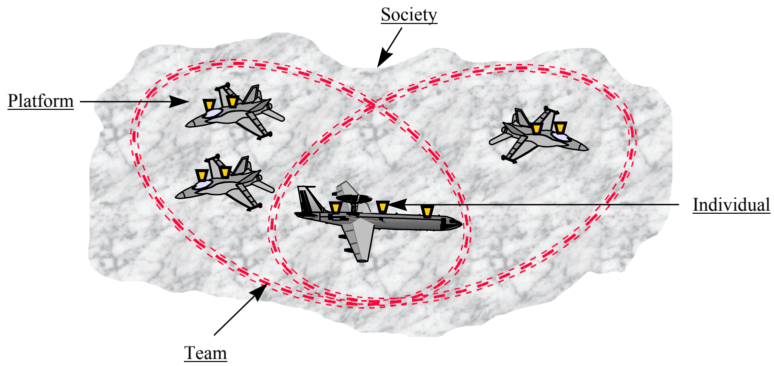


Figure 17: Levels of Management.

The UC^2 framework identifies at least four management levels, characterised by diminishing proximity and increasingly flexible options for social coordination. Figure 17 identifies an instance of the four levels of management pictorially. The four levels of management identify natural and social constraints that will necessarily be imposed on what might otherwise be the *laissez-faire* management style alluded to in Section 4.7.

- Individuals are the smallest unit of management. Whether human or machine, the individual practises self-management by relying on cognitive capabilities.
- Platforms provide the second unit of management. Despite the advances in virtual presence noted in Section 4.1.2, some individuals will be collocated on platforms that must be socially coordinated.
- Teams constitute the third unit of management. Teams are formed on the basis of a commonality of intent, rather than a commonality of location and intent. This allows for a more flexible approach to social coordination.
- Societies form the fourth unit of management. Societies form on the basis of interaction, be it physical or virtual. Societies accommodate the mix of collaborative and competitive ingredients noted in Section 4.1.3.

A UC^2 system is perhaps best understood as a society of societies. The social agreement protocols and constraints have to contend with both dynamic intra and inter social group consequences. Individuals will generally belong to multiple social groups concurrently. Societies are dynamic, often with membership changes according to the mission. Any UC^2 coalition to achieve a specific mission intent will comprise agents with varying degrees of synergy (unity) and antagonism (diversity) towards that intent. A key question is "who is going to help you, and who is likely to hinder", and how do you best manage their behaviour? The Sociodynamics model (Caples, 1999) based on work of Jean-Christian Fauvet, classifies societies into inter-related groupings to bring deep insight for their management to achieve intent.

In terms of constraint of scale, modern human social structures have a stratification based on primitive social norms. Hill and Dunbar (2003) confirm that "clans" of around 150 people are common on the basis of the extrapolation of group size according to brain size across primates. He notes also several other scales ranging from "tribes" of 1500-2000 through to "support cliques' of around 5. Each stratum corresponds to a different level of trust and social cohesion. Consideration of these aspects of social cohesion will be vital in situations of high uncertainty.

4.9 UC^2 Design

The design and development of UC^2 might be considered in several phases. An initial phase would be implementation of human networking support, including distributed mission agreement and social coordination protocol technologies. A second phase would be progressive implementation of agent capabilities, followed by a third phase of human-agent integration, which would necessarily revisit the first phase, and so forth.

4.9.1 Requirements – Preferential and Critical

Software agents are a key capability of the synthesis. Agents are a relatively new paradigm for adaptable information systems. They are: a means for reducing the communicative gap between human and computer systems (Lambert, 1999b); key processors to realise distributed (high-level) data fusion (Lambert, 2003a); social coordinators and at the very least a conceptual structure for the design of complex information systems. However, they will introduce new challenges to security and assurance. The design of UC^2 systems may be based on the notion of preferential and critical requirements (Lambert, 1999a).

> Much of the management of a UC^2 system is concerned with preferential trade-offs. The scope for trade-offs depends upon the level of autonomy available, and this varies as we progress through the four levels of a UC^2 system (Lambert, 1999a:pp. 38).

Preferential requirements are addressed differently at each management level of Section 4.8, according to the increasing degree of autonomy.

- Individual: routines and real-time scheduling.
- Platform: a temporal shortest path problem in which the commander must satisfy intent, given routines and beliefs.
- Team: multi-agent collaboration based upon joint mission intentions.
- Society: negotiation to share resources for collective benefit.

Preferential requirements may be achieved by coding the *appropriate strategies* into agent designs.

The satisfaction of *critical requirements*, that specify behavioral *boundary conditions* of the UC^2 system, typically by citing failsafe conditions, requires verification.

> The critical requirements for a UC^2 system identify constraints which the system *must comply with at all times*. The critical requirements specify the behavioural boundaries of the UC^2 system, typically by citing fail-safe conditions. As all of the critical requirements must be met, a measure of guarantee is inappropriate (Lambert, 1999a:pp. 39).

If verification is necessary for the deployment of a specific UC^2 mission configuration, then a formal proof of system design would be required. The UC^2 approach to design is to define adaptable capability that can be adaptively combined, while ensuring that certain boundary conditions must be met. This contrasts with the static architecture approach of Section 3.1.2.

The lack of quantitative formal design elements underpinning the architecture frameworks approach described in Section 3.1.2, is addressed by augmenting this descriptive approach with an *agreed* set of formal semantic primitives (Figure 11). These primitives allow for a mathematical logic base to underpin the behaviour of aspects of a UC^2 system. This will mean there is no "translation" between the descriptive architectural products and the design of detailed behaviour models of networked operations (where compromises and misinterpretations can sneak in). These primitives would facilitate the design and monitoring of a UC^2 system. Moreover, in the spirit of Section 4.4.2, these primitives will need to be semantically represented within the machines, so that their meaning is accessible to others, and so that alternative theoretical frameworks are comparable with it.

4.9.2 Capability Development – Partial Design Contracting

In describing the *use* of a UC^2 system, the authors have proposed an adaptive, devolved, automation integrated, distributed, decentralised, non-linear approach. In this section the authors argue that these same sentiments equally apply to the *design* of a UC^2 system. In the current military mindset, *design* and *use* are different things. Under the UC^2 conception, the distinction between design and use becomes blurred. In seeking to *use* capability, it may prove necessary to adapt intent to generate new capability, and so capability design becomes an ingredient of capability use.

The development of a UC^2 system would not follow the conventional linear waterfall model with complete, detailed (and consequently out-of-date) system requirements, but involve a non-linear development based on a model of "partial design" contracting. It is non-linear because deliverables span the spectrum of specification through to solution, without starting at specification and ending with solution, but by combining components determined by the competencies of capability developers, and the unique characteristics of the capability to be addressed. This shift in mindset brings with it a stronger ambition for adaptive capability, composable capability and shorter development times.

It is inevitable that the user will become the requirements developer, capability composer, deployer and maintainer of UC^2 systems. This inevitability follows a similar argument made by Cebrowski (2004). Web services provide an extant example of how capability development should function in the future.

4.9.3 UC^2 Compliance

When is a capability element UC^2 compliant? In responding it is important to recall from Section 2.1, that,

> A capability option is viewed as anything that has a capacity to change one's awareness of the world, typically by changing the world. This is a much broader sense of the term 'capability' than is commonly applied in military contexts, which often restrict the focus to military equipment.

On this account, force elements like frigates are capabilities, but so too is a standard operating procedure, and potentially, so is this document.

- A *capability element* includes anything that we might use to transform the world. A capability element is analogous to a tool in a toolbox.
- A capability element becomes a *capability option* if its functionality can deliver desired intent from the envisaged situation. A capability option is analogous to a tool that we select from the toolbox to achieve some intent, given the current situation.
- *Action* results from the use of a capability option. Action is analogous to the activity performed when using the selected tool.

So capability elements become capability options *circumstantially*, depending: (i) on the intent under consideration; (ii) on awareness of the situation; and (iii) on the function the capability can perform. For example:

i. A patrol boat and a financial management system are both capability elements. A patrol boat might be an appropriate capability option when the intent is to warn off prospective illegal fishing boats. A financial management system might be an appropriate capability option when the intent is to monitor the financial cost of a military operation.
ii. A patrol boat and P-3C in tandem might be an appropriate capability option when there is awareness of an illegal fishing boat and a foreign submarine is in particular area.
iii. In the two previous examples, the choice of capability elements is based on the functionality offered by the respective capability element.

However, capability options should not be limited to intended design functions. A shoe or a rock might serve as a hammer if needs be. Neither the shoe, nor the rock, is designed to act as a hammer, but the rigidity, hardness and strength of the shoe and rock might, in some circumstances, enable either to perform the function of a hammer, when a designed hammer is unavailable. Analogously, military capability options should be understood in terms of the functions they can perform, not just the functions that they were designed to perform.

UC^2 compliance for a capability element therefore involves specifying functionality and doing so in a way that accords with the UC^2 design principles.

The specification of capability element functionality involves all five tiers of the framework of Figure 11.

- Capability element functionality should be specified *metaphysically* in terms of where and when it will exist, together with the identity of its component systems. This includes the commission date of the capability element, when it is scheduled for obsolescence, when component equipment maintenance, refits and upgrades are scheduled, *et cetera*.
- Capability element functionality should be specified in terms of its *designed function*. For force elements, this includes the ability of both the capability element and its component capability elements, to sense, move, strike, carry, protect and communicate. Defining force element capability in terms of these functions facilitates effects-based operations in which intent is matched with appropriate functionally defined capability, whether or not that capability was necessarily designed with that intent in mind. This approach fosters adaptive capability elements.
- Capability element functionality should be specified in terms of its *environmental* operating conditions for its designed functions. For example, an FA-18 operates airborne, and to some extent ground based, and has, *inter alia*, an environmentally constrained radius of action, speed range, strike envelope and radar range.
- Capability element functionality should be specified *socially*. This includes social operating conditions, such as crewing requirements, dependencies on parts from other nations, combat comparisons with foreign nation force elements, *et cetera*. It also concerns the socialisation of capability. Air Strike And Interdiction is a capability element, essentially a social coordination plan for conducting a particular type of operation. It can be conceived as comprising a combination of Maritime Air Strike, Air Interdiction, Air Ground Attack or Armed Reconnaissance capability elements, each of which are also social coordination plans. When Air Strike And Interdiction becomes a capability option for some intent, a selection of Maritime Air Strike, Air Interdiction, Air Ground Attack or Armed Reconnaissance capability options is assembled, which in turn select from force elements that can deliver sufficient strike, move and sense functionalities. The more abstract social coordination capability elements accommodate the adaptive assembly of capability options.
- Capability element functionality should be specified in terms of *cognitive* capacities, be they implemented by human or mechanised means. This includes an Airborne Early Warning (AEW) aircraft's ability to assemble awareness of its environment through the dynamic control of its phased array radar(s). It equally includes the knowledge of a fighter pilot, or an automated UAV, to perform a role within a social coordination plan such as Armed Reconnaissance.

The specified capability should then accord with the following UC^2 design principles.

- Capability elements should be able to *adaptively* operate interoperably, independently of the location, broader function, structure or process in which they are contextually situated.
- Capability elements should accommodate *devolution* by not being reliant on centralised command and control.
- Capability elements should be systemically *ubiquitous*. There should be no single point of failure in design, and functionality should degrade gracefully under failure.

- Capability functionality that is error prone, tedious, mechanical, time consuming and/or voluminous for people to perform should be obtained through *automated* capability elements.
- Capability elements should engender and support human centred creativity, with *integration* to automated capability elements appropriately interfaced.
- Capability elements should support the virtual integration of the functionality of *distributed* capability elements and accommodate the *decentralisation* of intent across different capability elements.
- Capability elements should be *socially coordinated*, while supporting naturally forming *management levels*.
- Capability element *design* and use should be considered holistically, noting both preferences and critical conditions.

5. Conclusion

> You cannot long sustain a contradiction. We know that if you're living a contradiction, after some period of time, there will be a policy change.
>
> Art Cebrowski, Transformational Trends Nov-04.

In some respects UC^2 promotes a radical departure from the conventional approach to military operations. For example, it challenges *a priori* defence architectures, *a priori* authority structures, and *a priori* machine subordination. By contrast, the conduct of military operations has a rich, long and established history, which by *argumentum ad verecundiam*, may cause some to immediately dismiss UC^2 thinking as erroneous or impractical. For those entrenched in the current ways of doing business, it will be difficult to appreciate that the current conceptualisation of military operations has, *ipso facto*, become a legacy system, which fails to take advantage of emerging technology and evolving commercial business practice. So as a purely academic exercise to free the reader from legacy thinking, for the remainder of this section, the authors ask the reader not to consider UC^2 in the context of conventional military operations. Pretend instead, that we are designing a system for offensive terrorist units and defensive counter-terrorist units, a contest for which we have no established capability and so no preconceived approach. Then ask yourself which system you would adopt – the conventional military approach or UC^2?

This paper began with support for the *thesis* of NCW, followed by an *antithesis* that aimed to open up the key contradictions and shortcomings in the NCW thesis. It then presented a *synthesis* of the thesis and antithesis. The synthesis contends that NCW correctly asserts value to awareness, intent and capability in the use of networks, but has been naïve in its conception of the collective. Our synthesis, UC^2, is aimed at "achievable intent", through "unity with diversity".

In brief form, the UC^2 framework has the following tenets.

0: **Adaptations** in transport and telecommunications are adapting the influence distance has on presence, which is adapting organisational function toward strategic alliances, which is adapting organisational structure toward networks, which is adapting both the impact on localised events and the pace of change.
1: **Decision Devolution** enables the social collective to decide, rather than governing individuals, in order to benefit from the diversity of expertise.
2: **Ubiquity** of C^2 offers extreme robustness through agreements between similar, rather than identical, C^2 capabilities on every platform.
3: **Automation** provides the basis for ubiquity by extending intrinsic human capabilities with automated semantic and cognitive decision makers and aids.
4: **Integration** between people and machines is managed through mixed initiative strategies and by equipping cognitive machines with storytelling technologies.

5: **Distributed** locations allow seamless virtual integration with the robustness of physical diversity **and Decentralised** intent provides unity through mission agreements with robustness through a diversity of underlying intent.
6: **Social Coordination** among people and machines in a collective can be flexibly achieved through automated social agreement protocols and social policies.
7: **Management levels** naturally arise from commonalities of location and intent.
8: **UC^2 Design** attends to preferential and critical requirements while embracing capability design as an integrated part of capability use.

The following table exposes the transformation from thesis and antithesis concepts to synthesis concepts.

Thesis	**Refinement**	**Synthesis**
power to the edge (S 2.4)	is achieved by	decision devolution (S 4.2)
professional mastery (S 2.2.2)	is extended by	augmented soft. expertise (S 4.4.2)
mission command (S 2.2.2)	is subsumed by	mission agreement (S 4.6.2)
improved networks (S 2.1)	is replaced by	adaptable networks (S 4.1)
shared awareness (S 2.1)	is understood as	unity with diversity (S 4.3.2)
self-synchronised capability (S 2.1)	is refined by	social coordination protocols (S 4.7)
mission effectiveness (S 2.1)	is refined by	degree of mission intent (S 4.7)
Antithesis	**Refinement**	**Synthesis**
more isn't necess. better (S 3.1.1)	is addressed by	mixed initiative decisions (S 4.5.1)
architecture views (S 3.1.2)	are augmented by	UC^2 design (S 4.9)
information content (S 3.2.1)	is extended by	augmented soft. expertise (S 4.4.2)
information presentation (S 3.2.1)	is achieved by	storytelling technology (S 4.5.2)
common as consistency (S 3.2.2)	is replaced by	common as agreement (S 4.3.2)
mission command (S 3.3.1)	is subsumed by	mission agreement (S 4.6.2)
levels of awareness (S 3.3.2)	are replaced by	adaptive intent (S 4.7)
JMAP (S 3.3.3)	is replaced by	social coordination protocols (S 4.7)

So in developing your new C^2 system, which would you choose? Hopefully, you see too!

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