2006 CCRTS
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Title: Unintended Consequences of the Network-Centric Decision Making Model: Considering the Human Operator

Topics: Cognitive Domain Issues, Social Domain Issues, C2 Experimentation

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Unintended Consequences of the Network-Centric Decision Making Model: Considering the Human Operator

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Abstract. Although in principle network-centric warfare (NCW) has been embraced by strategic decision makers in the United States and its allies, diverse critiques have begun to appear about the soundness of the construct. Despite this multidisciplinary scrutiny, surprisingly little attention has been paid to the salient human factors questions raised by the paradigm shift. The purpose of this paper is to consider the implications of the network-centric model on individual and team decision making, reflecting in particular on the unintended consequences of network-centric decision making for the human operator.

All in war is very simple, but the simplest is difficult.[1]
- Carl von Clausewitz

Warfare is not 'network centric.' It is either 'people centric' or it has no centre at all.
- Lt Gen William Wallace, USA

Introduction. Network-centric warfare (NCW) is a concept of operations (CONOPS) spawned by rapid advances in information technology, which suggests that a dense networking of sensors and shooters will lead to unprecedented levels of situation awareness, contributing in turn to increased decision speed and self synchronization of forces. Although this vision has been embraced by strategic decision makers in the United States and its allies (Garnett, 2001; Kruzins and Scholz, 2001; Scott & Hughes, 2003; Squire. 2003), critiques have emerged from various quarters, raising questions about the validity of the concept. For example, NCW has been criticized for its basis on a flawed business model (Giffin & Reid, 2003a), its imperfect mathematics (Bolia, Nelson, & Vidulich, *in press*; Giffin & Reid, 2003a), its faulty epistemological foundations (Giffin & Reid, 2003b), its failure to consider relevant historical material (Bolia, Vidulich, Nelson, & Cook, 2006), its technological immaturity (Bolia, 2005; Talbott, 2004), and its implicit rejection of a defense acquisition system based on

[1] "*Es ist alles im Kriege sehr einfach, aber das Einfachste ist schwierig*" (Clausewitz,, 2002, p. 86). All translations, unless otherwise noted, are the author's.

validated operator requirements (Kaufman, 2005). These analyses notwithstanding, surprisingly little attention has been paid to the salient human factors questions raised by such a paradigm shift. The purpose of this paper is to consider the implications of the network-centric model on individual and team decision making, reflecting in particular on the unintended consequences of network-centric decision making for the human operator. This analysis is based on a reading of the major NCW theorists (Alberts, Garstka, & Stein, 1999; Alberts & Hayes, 2003; Cebrowski & Garstka, 1998), historical analyses on the influence of technology on command and control, and an appreciation of the relevant literature in human factors and social and organizational psychology.

The Common Operational Picture and Its Exegesis. The discrepancy between the conception of the common operational picture (COP) and its descriptor recalls Voltaire's edict on the Holy Roman Empire,[2] for it is strictly speaking neither common, nor operational, nor a picture. This incongruity is grounded in part in certain epistemological and ontological questions that are not germane to the subject of this paper.[3] What is relevant is the hermeneutical problem raised by the COP, which has been generally ignored.

The NCW thesis asserts that distribution of the COP will lead to shared situation awareness (SA), from which self-synchronization will inevitably follow (Alberts, Garstka, & Stein, 1999). This is little different than the concept of *Auftragstaktik* promulgated by Moltke in the nineteenth century (Hughes, 1993), or the practice of Nelson's captains at the Nile (Hughes, 2000; Lavery, 1998). Both relied on an inculcated shared mental model of the commander's intent, which, given a correctly apprised situation, would lead to synchronized action.

There are several difficulties with this formula in the context of NCW. The first is the idea of a shared mental model. It is easy to convince oneself that in a network-centric environment the shared mental model is the COP, but this is not the case. The COP is what is interpreted at the operational and tactical levels to build the situational assessment; the shared mental model, instilled by recurrent training, is part of the context in which the COP is interpreted. From this perspective it may be regarded as a prerequisite.

The problem is how to indoctrinate the shared mental model. Moltke's field commanders at Königgrätz, via explicit training and tours on the Prussian General Staff, had been infused with the mental model of their chief (Van Creveld, 1985; Wawro, 1996). It could thus be said that they had a shared mental model – his. Such a transmission, however, would be more difficult to effect across services, and especially across nations, due to the infrequency of joint and coalition training. The fact that most modern military operations are conducted by coalitions – often *ad hoc* coalitions – suggests that soldiers, sailors, and airmen fighting together may not possess a shared model.

[2] Voltaire noted, correctly, that the Holy Roman Empire was neither holy, nor Roman, nor an empire : "*Ce corps qui s'appelait et qui s'appelle encore le saint empire romain n'était en aucune manière ni saint, ni romain, ni empire*" (Voltaire, 1990).
[3] Some of these are addressed in Giffin & Reid, 2003b; and Lambert & Scholz, 2005.

This is not to say, however, that shared situation awareness is precluded by the failure to develop a shared mental model; only that the precondition considered essential by Moltke may not be met. It is entirely conceivable, for example, that individuals with different mental models may derive the same interpretation of the COP. Does this imply that they have shared SA?

Unfortunately, this question is not an easy one, since an accepted definition of shared SA is lacking. Endsley (1995), for example, defines *team SA* as the degree to which all of the team members develop sufficient individual SA to perform their required tasks. However, this does not necessarily imply a *sharing* of SA (Klein, 2000; Salas, Prince, Baker, & Shrestha, 1995). If two geographically separated brigade commanders, looking at their portion of the COP, decide to attack the enemy simultaneously, this represents synchronized action but not necessarily shared SA. Indeed, it does not even suggest collaboration, since one brigadier may not even be aware that the other is attacking.

Of course, this does not rule out shared SA as a possibility. If the same two brigade commanders held adjacent commands but were prevented from communicating, one might decide to attack given a COP comprising both brigade areas and the knowledge that his colleague, trained to the same mental model, would surely also do so. In this case the shared mental model provides the hermeneutical context for both the commander's vision of the situation and his understanding of his colleague's interpretation thereof. It is this variety of SA that is viewed as desirable not only by SA theorists, in conflict with Endsley's view of "team SA" (Salmon, Stanton, Walker, & Green, 2006), but also by the advocates of NCW.

The problem is that this conception makes two tacit assumptions that are not guaranteed to be met. The first is that a shared mental model will lead to a shared interpretation of the COP. The second is that the shared interpretation of the COP will lead to a shared interpretation of *the* correct course of action. Regrettably, military history is replete with situations in which one or both of these conjectures proved false.[4] What is difficult to prove in these cases is whether the failure was due to fallacious reasoning, or to the lack of a shared mental model.[5] Regardless, this may present a major human factors challenge for the implementation of the network-centric CONOPS, which will only be exacerbated by adversary-induced uncertainty and information overload.

Information, Uncertainty, and their Display. One of the key assertions made by NCW theorists is that advances in technology will afford the provision of more information to

[4] At both the Battle of the Dogger Bank (1915) and the Battle of Jutland (1916), captains in Beatty's battle cruiser squadrons misinterpreted both command intent and the situational picture, resulting in a failure in collaborative engagement. In both cases, the British ships were to engage the Germans one-for-one in line of battle, but ended up doubling up one of the German vessels, leaving one ship free to fire unmolested.

[5] For example, it is likely that Montgomery and Patton had a shared awareness of the operational situation in the autumn of 1944 (Hastings, 2004), yet promoted different avenues of attack. Is this because they lacked a shared mental model? Or is it because each wanted to be the first to drive into Germany? Can these two options even be disentangled?

operators at every level of the sensor-to-shooter chain, leading to an almost complete elimination of uncertainty, resulting in higher levels of situation awareness and improved mission execution (Alberts & Hayes, 2003). There are at least two problems with this position.

The first is the idea, current among technophiles (see, for example, Owens, 2000), that uncertainty is an artifact that can be somehow excised from warfare, and that the way to achieve its removal is by adding more information (i.e., more sensors). Although it is impossible to demonstrate the truth or falsity of this proposition either logically or empirically, it should certainly not be assumed as given. Indeed, the prevailing view has been contrary. Clausewitz, for example, has noted that "War is the territory of chance. No other human activity gives this stranger so much room to maneuver, because no other has on all sides such constant contact with him. Chance multiplies the uncertainty of all circumstances and interferes with the course of events" (Clausewitz, 2002, p. 64).[6] Moreover, current theories of science regard uncertainty as a property not only of warfare, but of the physical world (Heisenberg, 1973; Margenau, 1950).

The second problem is with the implicit assumption that more information is necessarily better. This suggests that poor decisions have historically been the result of a dearth of information, which has not always been the case. In the 1973 Yom Kippur War, for example, the failure of Israeli intelligence to anticipate the Egyptian and Syrian attacks was not due to a lack of information, but to the interpretation of the information available in the context of an inappropriate shared mental model of Arab intentions (Bolia, 2004).

This assumption also evokes the idea of quantity over quality, but the quality of the data must also be taken into account. Clausewitz, writing in the early nineteenth century, observed that "a greater part of intelligence reports that one receives in war are contradictory; a still greater part are false, and nearly all are subject to uncertainty" (Clausewitz, 2002, p. 84).[7] While these proportions may have altered over the course of two centuries, the core assertion remains valid.

In addition, an increase in the quantity of data offers no advantages if the quality of that data has been compromised. For example, data may be inaccurate due to faulty sensors or to an imperfection in the software by which it is processed. The latter is a concern in data fusion and tracking systems, since spurious or dropped tracks could result in a loss of SA. Data may also become compromised by an enemy-mounted deception campaign, filling the network with illusory tracks or misleading intelligence. Finally, there is the problem of knowing what is missing. The continuous availability of vast amounts of information imparts an illusion of completeness. This is a problem because the operator may know what he knows, but will not always know what he does *not* know. The COP provides few if any clues as to what is *not known* about allied and enemy force elements.

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[6] "*Der Krieg ist das Gebiet des Zufalls. In keiner menschlichen Tätigkeit muß diesem Fremdling ein solcher Spielraum gelassen werden, weil keine so nach allen Seiten hin in beständigen Kontakt mit ihm ist. Er vermehrt die Ungewißheit aller Umstände und stört den Gang der Ereignisse*."

[7] "*Ein großer Teil der Nachrichten, die man im Kriege bekommt, ist widersprechend, ein noch größerer ist falsch und bei weitem der größte einer ziemlichen Ungewißheit unterworfen*."

If an object is not displayed, it may be that it does not exist in the battlespace, but it may also be that it has eluded sensors or that its transponder is malfunctioning. If an operator does not recognize that available information is incomplete, he likely knows neither that he needs it nor where to look for it.

The quantity of information accessible by operators also needs to be considered, especially with respect to the human operator's limited capability to process it. Although the network-centric CONOPS may lead to a substantial increase in the amount of information available, it is not likely to engender a concomitant increase in the operator's attentional capacity. If too much information is presented at once, the operator will not be able to completely assimilate or analyze it, and there is no guarantee that the information lost will have been the least critical.

Automation and its Accidental Consequences. One means of averting information overload is to automate much of the processing that might otherwise encumber the human. Automation supporting warfare may vary from assisting operators (e.g., automated data fusion, entity tracking, and automated decision support) to replacing them (e.g., fully autonomous combat vehicles) (Parasuraman, Sheridan, & Wickens, 2000). Lamentably, any automation may engender grave, yet inadvertent consequences.

There is an extensive literature on the performance effects on humans interacting with automated systems (for a recent review in the context of aviation, see Parasuraman & Byrne, 2003). Studies suggest that the automation of a task or set of tasks can change the perceptual and cognitive demands of the operator, and may lead to skill degradation as the operator receives little or no practice in the manual completion of a task (Parasuraman & Riley, 1999). Worse yet, skill degeneration may not be noticed previous to a critical automation failure – for example, a network outage – during which humans are compelled to perform previously automated tasks manually (or cognitively).

Another major human factors issue associated with the use of automated systems revolves around the question of trust in the automation. On the one hand, if users do not trust an automated system, either because it is novel or because it is unreliable, they will not use it. On the other hand, users of highly reliable automated systems quickly build trust in them, to the point at which, if the systems fail in way that is not manifested overtly, the users will not notice. This is symptomatic of a phenomenon known as automation-induced complacency (Parasuraman & Riley, 1999). The failure of a highly reliable tracker, for example, could engender a loss of track continuity, which may lead to a failure to engage the enemy, or even the accidental engagement of one's own forces.

Perturbing the Levels of War. At least since the time of Moltke, military theorists have distinguished three levels of war – the strategic, the operational, and the tactical – corresponding to three stages of military decision making (Hughes, 1993). Because the consequences of decisions made at each level differ vastly in magnitude, decision authority is conferred based on military rank, which is expected to vary directly – due to training as well as selection – with expertise at these levels.

These stages also have different time courses, which allow for different decision-making methodologies. Decision making at the strategic level is typically construed as a rational process involving the detailed analysis of a series of courses of action (COA). The decision then corresponds to the selection of the optimal COA (Bryant, Webb, & McCann, 2003). At the tactical level, there is no time for such exhaustive examination. Here decision making is said to be "recognition-primed" (Klein, 1997), and is characterized by an intuitive response to a Gestalt recognition of the situation, analogous to the *coup d'oeil* described by Clausewitz (2002). One noteworthy characteristic of the recognition-primed decision making model is that it emphasizes decision speed over decision quality, and hence seeks a "satisficing" rather than an optimizing decision. A model for operational decision making has not been as well described, but may be imagined as a hybrid of the two (Bryant, Webb, & McCann, 2003).

Under the NCW thesis, the divisions between the three levels of war become obscured. As decision quality information is made available to all echelons of the command chain, decision authority will be pushed down to lower levels in order to expedite prosecution of an increasing quantity of time-critical targets, a concept known in network-centric parlance as "power to the edge" (Alberts & Hayes, 2003). But the conferral of authority upon the "edge" of a military organization is meaningless unless the level of expertise is there. It is not enough to argue that, since more decisions will be made at the tactical level, tactical decision making skills will be sufficient for the job. Tactical decision makers will also need to have a clear understanding of the operational and strategic implications of their decisions.

It has been proposed that these issues will be resolved in part by the use of automated decision support systems. There are at least two challenges to this argument. First, context-sensitive decision support is one of the most challenging problems in computer science, even for problem domains significantly less complex than combat operations (Bolia, 2005; Bolia, Nelson, Vidulich, & Taylor, 2004). A useful COA generator for tactical commanders is likely to be years, if not decades away. Second, the use of decision support systems will change the cognitive demands of the decision task in ways that are not predictable. One of the possible consequences is that tactical decision makers using these systems will sacrifice speed of decision for perceived optimality.

Authority and Responsibility. Another claim that can be made with respect to NCW is that it obfuscates the division of command. By providing access to a detailed common picture at all strata of the command chain, the network-centric model encourages decision making at inappropriate levels. For example, a corps commander may be able to "zoom in" on the situational picture at the platoon level, and, believing she has a correct view of the situation, give direct orders to the platoon leader. Not only does such micromanagement circumvent the normal command chain, potentially causing confusion at intermediate echelons, it also makes assumptions about the accuracy and legitimacy of the COP that, for reasons discussed above, may not prove tenable. It is also contrary to the doctrine of *Auftragstaktik*, which is grounded in Moltke's idea that "no plan outlives the first contact with the enemy,"[8] which suggests that the commander closest to the front is the best equipped to make the decisions.

Although likely to be less frequent, this problem may also appear at the other end of the command chain, for the same reason. A commander at the tactical level, able to "see the whole picture," may decide to modify a battle plan, not in response to enemy action, but because she believes doing so will create a desired effect in a different part of the battlespace. In this case, the subordinate officer has neither the requisite authority nor expertise for altering the plan, but has the information required to do so.

Also of concern is that the distribution of decision making – and in some cases the uncertainty about where decisions will be made – will allow commanders to distribute not authority, but responsibility. If an operation goes well, this may not be an issue, but in the event of failure it may lead to pervasive buck passing.

Teamwork and Distributed Collaboration. One of the pervasive themes found in the writings on NCW is that of distributed collaboration across the network. Connectivity allows the sharing of information, the sharing of intent, the sharing of SA, and, presumably, collaborative engagement. Significantly, NCW not only *allows* this type of sharing, it requires it. This is more than a subtle distinction.

One of the most significant challenges in the study of team decision making and distributed collaboration is the problem of what to measure. There are serious philosophical issues with the extension of individual measures – e.g., SA and workload – to the team domain (Bolia & Nelson, *in press*). This is especially awkward when considering the measurement of purported cognitive processes or the results thereof, such as decision making (Nelson & Bolia, *in press*).

Recent reviews have begun to address the hypothetical impact of NCW doctrine on team performance and the measurement thereof (Best & Skinner, *in press*; Nelson, Bolia, & Vidulich, *in press*). They are not exhaustive, however, and fail to remark on two potentially serious topics which may be impacted by NCW: trust and leadership.

Trust is an important component of effective teamwork (Geber, 1995; Salas, Sims, & Burke, 2005). If team members do not trust one another, the team will not function smoothly. The question is then whether *ad hoc* distributed teams, whose members retain a high level of anonymity due to lack of socialization, will be able to build a degree of trust similar to that achieved by teams operating in a face-to-face environment. The same question arises with respect to leadership, which will continue to play a critical role in military operations, despite calls for "power to the edge." Not only is leadership dependent on trust, it is also accepted that good military leaders build trust by personal interaction with their troops (Puryear, 2003). Needless to say, a willingness to risk one's

[8] "*Kein Plan überlebt die erste Feindberührung*."

life for a commander is less likely to be inculcated by an instant messaging session than by personal dealings.

An unintended consequence of distributed collaboration is that it may facilitate irrelevant communication. For example, technologies such as instant messaging may provide opportunities for unsupervised communication between users on topics that are unrelated to mission goals. This phenomenon has been observed previously in laboratory simulations (Funke, Galster, Nelson, & Dukes, 2006). While opportunities for off-mission conversation were certainly available through face-to-face and radio communication before the introduction of instant messaging, such communications were closely scrutinized and regulated by supervisors, thereby minimizing their frequency and impact. Instant messaging, on the other hand, enables discreet and anonymous communication between users, making it difficult to monitor and control. The primary concern here is that unregulated social communication may be distracting, driving visual attention as well as working memory away from mission relevant tasks.

Training and Selection. The lack of novelty of many of the foundations and postulates of NCW should not lead to the hasty conclusion that it is not an entirely different form of warfare. If taken to its logical conclusion, NCW would revolutionize the way wars are fought, beginning with a de-emphasis of the command chain, requiring substantial changes in military structure. However, little has appeared in the literature concerning the organization, selection, and training of network-centric soldiers, sailors, and airmen.

With respect to training, Best & Skinner (*in press*) have done an admirable job of discussing traditional training issues in the context of the network-centric CONOPS. Still, questions remain. For example, how does one train the shared mental model required by the revision of *Auftragstaktik*; or train lieutenants to make decisions previously made by lieutenant generals? In addition, can soldiers be trained to trust people they have only met online?

Selection may prove to be at least as important an issue. The doctrine of “power to the edge” highlights the “strategic corporal” as a player in network-centric operations (Alberts & Hayes, 2003). The idea of personnel without even the equivalent of a high school diploma making decisions with strategic consequences suggests that much more consideration needs to be given to the problem of who will be fighting the wars of the future.

Conclusion. Nearly a decade has passed since the late Admiral Cebrowski proclaimed the virtues of NCW to the world. In that time, the doctrine has continued to grow, to the point at which its adherents declare that its attainment of fruition is only limited by appropriate investments in the technology. Yet such claims fail to recognize that warfare is *human*-centric. Unless and until the relevant human factors questions are addressed, NCW will continue to be little more than a utopian dream.

Acknowledgments. The authors would like to thank Bob Foster and Greg Funke for their helpful comments on an earlier draft of this paper. The germ of this essay was an address given at a meeting on "Cognitive Performance: Force Multiplication Through Human-in-the-Loop Augmentation," sponsored by the US Army Medical Research and Materiel Command, and the authors gratefully acknowledge Colonel Mike Russo (USA), the conference organizer, and all of the participants for discussions that helped to formulate or solidify the ideas presented herein.

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