Information Technology, Friend or Foe of Command and Control?

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Abstract

The growth in the number of digitisation initiatives and the recently announced Defence Capability Initiative, under which the US will attempt to level up the capabilities of its NATO allies, makes it worth revisiting the topic of how beneficial information technology (IT) is when used to support the exercise of command and control (C2). Whilst IT is essentially value-free, its implementation and use within an organisation are not; it can be deployed either as a control mechanism or as a tool. In the context of command and control, digitisation exposes a tension between those two roles of information technology that is mirrored in the tension between the needs of command, arguably a social activity, and the exercise of control, a more mechanistic activity. The paper tries to examine the issues, benefits and potential problems, based on a definition of command and control. An extended definition of C2 is offered that could refocus the use of IT to support C2 but this time in such a way as to maintain effectiveness and flexibility. However, it is recognised that a debate is needed to define a value set to be applied in the design of information systems for C2.

1. Introduction

'No commander is less fortunate than he who operates with a telegraph wire stuck in his back.'
Field Marshal Helmut von Moltke

In order to deal with shrinking defence budgets, many countries are increasingly prepared to purchase commercial-off-the-shelf (COTS) information Technology (IT) – both hardware and software – in order to meet defence-related computing needs that would previously have been fulfilled by using bespoke components. That trend, together with recent dramatic improvements in the potential, and a rapid fall in the cost of COTS IT, has created a situation in which armed forces, especially land forces, have begun to contemplate applying IT at force levels that could scarcely have been imagined ten years ago. The resulting programmes have acquired the label of 'digitisation'. In the US there is Joint Vision 2010 (JV2010) and in the UK there is the Joint Battlespace Digitisation Initiative (JBD) together with corresponding domain-specific initiatives.

Whilst IT is essentially value-free, its implementation and use within an organisation are not. Eason [Eason, 1988], a member of the socio-technical school of writing on the implementation of information systems (IS), makes the point that IT can be deployed either as a control mechanism or as a tool. In the context of command and control (C2), digitisation exposes a tension between those two roles of IT that is mirrored in the tension between the needs of command, arguably a social activity, and the exercise of control, a more mechanistic activity.

2. Aim

The aim of this paper is to contribute to the debate about the application of IT to military C2 – a debate that is an enduring feature of C2. Certainly in the UK with JBD recently begun and the initial research programmes taking shape, the time is ripe for a debate.

3. Scope

In order to meet the aim, the paper seeks out a definition of C2 that allows some of the benefits of the application of IT to C2 to be explored. The risks inherent in the use of IT are then explored, both at a macro level and in the context of the definition used to highlight the benefits. An extended definition of C2 is offered that allows a further examination of the ways in which IT might be applied to the benefit of those involved in the exercise of C2.

4. Definitions of Command and Control

In order to talk about the impact of IT on the exercise of C2 we need a definition of C2 that expresses some sense of the role and/or value of information to that activity. Doctrinal definitions of C2 such as those offered in publications like 'British Defence Doctrine' [HMSO,1997] are somewhat sterile in this regard they provide little indication of the nature of command or the activities it must embrace. For example, consider the two definitions given below:

> **Command**: 'The authority vested in an individual of the armed forces for the direction, co-ordination and control of military forces.'
>
> **Control**: 'That authority vested in a commander over part of the activities of a subordinate organisation, or other organisations not normally under his command, which encompasses the responsibility for implementing orders or directions. All or part of this authority may be transferred or delegated.'

Coakley [Coakley, 1992] and van Creveld [van Creveld, 1985] also offer comparatively simple definitions that make some mention of information but do not make its use or value explicit. Fortunately, van Creveld [van Creveld, 1985] offers a further definition that meets our needs:

> '…the *gathering of information* on the state of one's own forces…on the enemy and such external factors as the weather and the terrain. The information having been gathered, means must be found to *store, retrieve, filter, classify, distribute and display* it. On the basis of the information thus processed, an *estimate of the situation must be formed. Objectives must be laid down and alternative methods for attaining them worked out. A decision must be made*. *Detailed planning* must be got underway. *Orders must be drafted and transmitted*, their arrival and proper understanding by the recipients verified. *Execution must be monitored* by means of a feedback cycle at which point the process repeats itself.'

5. Current Benefits Accruing from the Use of IT in C2

Armed with Van Creveld's definition, we can take a quick look at some of the ways in which IT supports command and control in a beneficial manner.

IT is a key component of modern surveillance systems. At the front end, in the sensor equipments themselves, IT components such as signal processors enable military forces to make more effective use of more of the electromagnetic spectrum and to move the information back to those that need it or will process it for use. At the back end we use IT to manipulate the incoming information, which will have come from sources that vary both in position and in the nature of the surveillance they conduct, to produce a consolidated view of the world for the commander. Advances in IT have increased the ability of those who are tasked with this data-fusion/picture-building function to create, store and manage increasing volumes of information. Relational databases allow analysts to store information in a manner that allows them to build analogues of the real world, which in turn makes the information easier to use. New technologies such as those embodied in the Internet have allowed military forces to (begin to) create increasingly ubiquitous infrastructures over which to distribute the information.

Display technology has advanced. Green-screen, text-only terminals are increasingly being replaced by high-resolution, colour monitors that provide users with a graphical user interface to the applications that they use. Colour displays are beginning to make their way into places, such as tanks and armoured personnel carriers, that would scarcely have been conceived of fifteen to twenty years ago. One concrete benefit in this area of the move to COTS in particular is in the training of augmentees. The provision of C2 information systems and applications that use the same, or similar, graphical interfaces as common COTS packages can reduce training costs and the amount of time it takes an augmentee to become productive with an application.

Command estimates, especially those at operational and strategic headquarters can become sophisticated exercises in data management and group working. Planning teams are often under extreme time pressure; their members may not be co-located; and the teams themselves are often multi-disciplinary, which means that each member of the team must take account of the work of his or her colleagues. Without access to modern IT, it would not be possible to deliver such an approach to planning at a reasonable cost.

The testing of alternatives during planning, particularly at the operational and strategic levels, may make use of operational analysis in order to try and expose unanticipated flaws and refine the shape of those alternatives. Increases in the capability of IT have enabled the military, or its supporting scientific arm (for example the UK's Defence Evaluation and Research Agency) to develop increasingly sophisticated models of military activity. More immediately, specifications for current C2 information systems include requirements for the provision of planning aids and decision aids and even some simulation/modelling capability also. For example, the Interim Combined Air Operations Centre (CAOC) Capability software developed by the NATO Command, Control and Communications Agency includes a software component that allows planning staffs to preview an Air Tasking Order (ATO) by providing an animated display of the missions it includes. Such capabilities, which should allow planning staffs to develop more effective plans, can only be delivered to their current audience because of the dramatic advances in IT both in terms of performance compared with environmental requirements – eg space, power and environmental conditioning – and performance compared with price.

At the point at which the orders are issued, advances in technology are moving military forces away from the need to print out orders in order to transmit them to subordinate units: database-to-database exchange allows more information to be transmitted in a more timely fashion also. The same capabilities that allow orders to be delivered so rapidly will enable status reports to be delivered in an increasingly timely manner. In turn, this will allow the commander and his staff to monitor more accurately the unfolding operation; make well-informed corrections to respond to the actions of the enemy; and prosecute his campaign in the most effective and efficient manner possible.

6. Another View

Given everything that has been written so far, the key to C2 success would seem to be simply to extend the UK's philosophy for Smart Procurement from 'Faster, better, cheaper' to 'Faster, better, cheaper and everywhere we possibly can afford to'. However, another perspective on any topic does no harm; it's the aim of this paper to offer a second opinion. We'll do that by revisiting the role of IT in C2 firstly at a macro level in terms of the impact of technology and IT on warfare generally. Then, based on the macro view, we'll look at how IT might interfere with van Creveld's model by examining how it might have an adverse impact on a set of C2 system measures of performance.

6.1 Macro Level Risks

At the macro level there are a number of pressures at work. The West has a predominantly mechanistic culture – ie one built on a faith in machines and mechanical principles – which manifests itself in Defence through a large defence industrial base that exists to manufacture and sell high technology weapon systems. Over time, driven by the experiences of warfare in the early part of this century, we in the West have become increasingly reluctant to suffer casualties in war – the 'body bag count' issue. These two factors have combined to create a situation in which we attempt to reduce the risks to military personnel by replacing them with high technology weapons. Thus begins a vicious circle of dependency, which is identified and discussed by Rochlin [Rochlin, 1997] and alluded to briefly by van Creveld also [van Creveld, 1985] when he talks about the increasing differentiation in military specialisation. To service and operate the high technology weapons, armed forces must recruit, train and retain suitable personnel, which tends to lead to the creation of professional armed forces. The personnel in these forces are valued by their nation and expensive to replace and are therefore perceived as being less expendable, which promotes a tendency to again substitute capital for labour and introduce more high technology weaponry.

6.1.1 Impact of Technology on Warfare and C2

The introduction of high technology weapons increases the differentiation between force elements and thus increases the degree of complexity in the operational environment. Keen [Keen, 1991] points to two approaches that organisations can adopt to handle increased levels of complexity in their environment; they must either simplify the task or increase their processing power. Rochlin [Rochlin, 1997] provides a number of quick snapshots over time that show how armed forces have tried to meet this challenge. Napoleon's units were able to act in battle for the most part independently, they were generally cut loose in battle to act in consonance with his well laid plans. His forces were so structured as to be 'formally decomposable': they could try to co-ordinate their actions but the state of communications once battle was joined was such that units needed to be able to function in the absence of continuous higher direction. In World War One, the artillery and the infantry may be said to have been in a sequentially dependent relationship ie the actions of one force element were contingent on the previous completion of a task assigned to another force element. This approach reflected the armies' approach to trying to get the most out of the assets that they possessed in an operational environment more complicated than that faced by Napoleon. The Great Powers tried to solve their co-ordination needs by meticulously detailed planning – for example, XIII Corps had a thirty-one page plan for the Battle of the Somme in 1916 – effectively attempting to simplify the task (cf Czerwinski's Command-by-Plan [Czerwinski, 1998]). However, the overall lack of flexibility inherent in higher command's insistence on rigid adherence to the plan destroyed the flexibility of the force elements that they were trying to wield. From the military/C2 perspective you could argue that, through extremely detailed planning, allied high commanders tried to reduce the level of uncertainty that they would face during an operation. However, in doing so they simply moved the locus of uncertainty onto the engaged forces, whose ability to act purposefully was significantly degraded when the operation could not follow the plan. The Germans developed a different approach. Their solution to simplifying the task and thus managing uncertainty was to push decision points down the organisation; they gained flexibility and improved effectiveness but paid a price in increased uncertainty for the commanders during execution. It is interesting to note that Major General Bill Robins, whilst serving as Director General Information and Communication Services for the UK's Ministry of Defence, in a keynote speech to a predecessor to ICCRTS [Robins, 1994] talked about using IS '…to move uncertainty to the point where it would do the least damage'. Which model did he have in mind? As force elements have become increasingly differentiated, the relationships between those elements have evolved to become based on reciprocal interdependence. Force elements must act together in order to achieve their task – for example, consider the co-ordinated use of attack helicopters and fast jets to mount an attack on an armoured formation or the whole ethos of joint operations. We have reached a point where, rather than simplifying the task, we rely on IT to help achieve the required level of co-ordination – ie we have increased our processing capacity. The improvement in performance that accrues from the co-ordination begins another cycle of change. Co-ordination improves performance; a given level of capability is thus available for a lower total cost than might have been the case otherwise; as defence budgets come under pressure, increased co-ordination and synchronisation of increasingly differentiated force elements is seen as the best way to maintain and improve capability; IT becomes increasingly important as the means of providing the co-ordination. However, as increased co-ordination becomes a necessity rather than a capability, the various subsystems that deliver military capability change from being simply interconnected – ie they connect because it is *beneficial* to do so – to being coupled – ie they connect because they *must* do so in order to function. As the cycle continues we are not on the verge of creating *just* a system of systems but a tightly coupled system of systems and that's the point of risk at the macro level. Furthermore, this cycle is assisted by the cycle identified by Rochlin that sees a continuing substitution of capital for labour in military forces.

6.1.2 Joint Vision 2010

For the US, JV2010 expresses the risk well: the UK's Joint Battlespace Digitisation Initiative has yet to be solidly defined and it is not clear whether the UK will travel the same road. Before proceeding to look further at the consequences of the risk that we have described, a quick rehearsal of the highlights of JV2010 is in order:

- Intended to deal with the US perception of the global village in 2010
  - Better armed potential adversaries
  - Technological advances outside the US
  - Information warfare/superiority by a n other + asymmetric conflict
  - Enhanced jointness
  - Increasing numbers of coalition operations

The overall aim is to dominate the opponent at all points in the spectrum of conflict – referred to as 'Full Spectrum Dominance' – and the foundation rests on using technological innovation to deliver information superiority and enable:

- Dominant manoeuvre: the multidimensional application of information, engagement, and mobility capabilities to position and employ widely dispersed joint air, land, sea, and space forces to accomplish assigned operational tasks. Dominant manoeuvre will require forces that are adept at conducting sustained and *synchronised* operations from dispersed locations. Dominant manoeuvre requires improved sensors, near real-time evaluation and simultaneous dissemination.
- Precision Engagement: a *system of systems* that enables forces to locate the objective or target, provide responsive command and control, generate the desired effect, assess the level of success, and retain the flexibility to reengage with precision when required.
- Full-Dimensional Protection: aims to protect own forces against an opponent's precision engagements. The primary prerequisite for full-dimensional protection will be control of the battlespace to ensure forces can maintain freedom of action during deployment, manoeuvre and engagement.
- Focused Logistics: the *fusion of information, logistics, and transportation* technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations.

JV2010 notes that '…dominant battlespace awareness… will not eliminate the fog of war [but] will improve situational awareness, decrease response time and make the battlespace considerably more transparent to those that achieve it.'

6.1.3 Coupling Risks

The force level risks arising from the approach described in JV2010 lie in the degree of coupling. In tightly coupled systems [Perrow, 1984] a failure in one component can lead to unintended/unexpected failures in other components. The result is a system dysfunction not anticipated by the system's designers. Organisations at risk are characterised by 'interactive complexity' as well as tight coupling. Interactive complexity is a measure of the frequency of unexpected or seemingly anomalous interactions among the system's components, including the humans (a likely feature of any military operation – just think back to the extract from JV2010 '…will not eliminate the fog of war'). Tight coupling implies:

- Parts of the system interact quickly;
- Sequences of action are invariant - there is only one right way to do things;
- Little organisational slack is available to compensate for error;
- Safety devices, including redundant checks and balances against failure, are limited to those planned for and designed into the system.

If we think back to the concepts behind JV2010, it has been designed to meet two of those criteria (first and third) and doctrine may provide a third (the second). It is interesting to note that concerns about coupling in human activity systems are not recent; Landau and Stout [Landau and Stout, 1979] rehearsed Klein and Meckling's warnings against '…efforts to integrate subsystems into a well-articulated and synchronous entity…'

By any lights an approach to the conduct of warfare that deliberately created potentially brittle systems would seem to be a risky strategy to adopt even with existing force structures; however, there are ideas floating around that would seem to raise the overall level of risk even further. As part of the thinking about the current Revolution in Military Affairs some writers are suggesting radical new force structures built on the premise that information (and thus IT) will be able to deliver the level of integration required to allow those forces to be effective. For example, Blaker [Blaker, 1997] suggests in his essay that the US Army might give up its organic air defence capability and rely on the US Air Force or the US Navy to provide it instead. From the point of view of the Land Component Commander, this approach results in an increase in force differentiation and operational complexity. Whilst the logical response might seem to be to hand off the responsibility altogether and thus simplify the task, it is more likely that he will try to exercise control over those assets, which will make the task more complex and increase the degree of coupling required between the Land Component and the Air Component.

6.2 Micro Level Risks

At the micro level ie within the command and control process itself, the original rosy picture of the benefits of IT also begins to shade to grey.

6.2.1 Measures of Performance

Together with the definition of C2 that we used earlier, Van Creveld also offers a number of measures of performance (MOP) for the exercise of command and control which provide a suitable framework against which to re-examine the possible value of IT in the exercise of C2.

- Information gathering should be accurate, continuous, comprehensive, selective, fast.
- Reliable means to separate truth from falsehood, relevant from irrelevant, material from immaterial.
- Matrix of analysis must correspond to the real world.

- Objectives should be feasible and desirable.
- Alternatives should be real.
- Orders should be clear and unambiguous.
- Monitoring should only be close enough to secure reliable execution.

6.2.2 Information Management

At the management point in van Creveld's C2 process there are system level issues that need to be addressed with particular emphasis on compiling recognised pictures for display to commanders (which will strongly influence performance against the second two bullets in the list above). There is a variety of ways in which such pictures can be compiled and used. At the most 'open' extreme, the picture is compiled by having relevant staffs make their own picture available for general use – eg the logistics element of a joint operational picture would be provided by the logistics cell – and the resulting, complete picture is simply one of a number of sources of information that is available to the command team to inform decision-making. At the most 'closed' extreme, the picture is compiled by a dedicated picture compilation cell and the resulting picture is the only source of information that is used by the command team to support decision-making. Integrated pictures are becoming popular, especially at the higher levels of command: for example, the United Kingdom's Joint Operational Command System will have a Joint Operational Picture (although its precise nature is not necessarily undetermined yet). Whilst the distinction between the two states may not seem particularly important, it should be borne in mind that the virtues of the integrated pictures include such things as:

- Increased consistency in the data being made available to command teams [Anderson, 1999] – ie a reduction in the level of uncertainty facing the command team.
- An improved ability to build shared understanding of the state of an operation within the command team [Hiniker, 1998].

The purpose of these pictures is to feed the estimating and decision-making elements of van Creveld's model. Those activities will be strongly conditioned by any picture's ability to satisfy the first two MOPs listed on the previous page, which will in turn strongly influence performance of the command system against the third. The risk here is that given an increasingly 'can do' technology and a culture that likes technology and abhors uncertainty, the operational community will find itself moving towards closed picture compilation models. That could produce a situation where the third, fourth and fifth MOPs are undermined by a failure in the picture compilation component; however, in the closed picture model there will be little information to hand to allow a member of the command team to challenge a possibly flawed view/plan. At this point, what price the value of being inside the enemy's decision-cycle, especially if the picture is the result of an effective strategic deception operation?

6.2.3 Planning

Planning can benefit from modelling support and so the introduction of a wider and more detailed modelling capability to support the commander would seem to be 'a good thing'. There is a lot of work going on in this area as can be seen by reviewing the proceedings of previous CCRTS and ICCRTS. However, there are risks associated with culture and thinking that distort the way we use information. Rochlin [Rochlin, 1997], summarising Landau and Stout [Landau and Stout, 1979] states that '…the organization's search for control [is] a search for knowledge - empirically verified observations, theories based on them, and predictive models not only of organizational behaviour, but of the organization's environment. The key word is "predictive". With a predictive model, and a verified theory an organization can exercise "control"; it can make precise corrections by comparing feedback from its actions with the predictions of the model. If the organization's knowledge is sufficiently comprehensive, there will be very few unanticipated events around which it has to organize.' Arguably, too much modelling, or perhaps an over reliance on modelling, threatens the third MOP; as van Creveld [van Creveld, 1985] notes, 'the enemy's independent will is not entirely governed by the means at his disposal' (issues of reflection and rationality) – a point being borne out by the unfortunate events unfolding in the Balkans. The risks here should be clear.

6.2.4 Monitoring

Technology also begins to threaten the ability of a command system to satisfy the needs of the last MOP. The author has anecdotal evidence of higher command elements trying to affect the detailed action of units well down the chain of command simply because the technology made it possible to do so. Specifically, in the face of over centralisation McCann and Pigeau [McCann and Pigeau, 1996] point to resignation/abdication because of lack of trust and a failure to learn through investing in action and seeing a result. Such behaviour is less than ideal during a single operation but what about the longer-term impact of such an environment on an armed force's ability to develop its future high commanders? Again, the views of the US are interesting. We can draw on the words of US Army Chief of Staff General Gordon Sullivan [Demchak, 1996] '…the digitalization of the battlefield - the electronic linking of every system in the Battlespace - will allow the commander to synchronise all the elements of combat power.' JV2010 notes that 'Commanders will be expected to reduce the costs and adverse effects of military operations…Risks and expenditures will be even more closely scrutinised than they are at present.' What price mission command or *Aufstragtaktik* in an environment such as this?

6.2.5 Application of IT

There are two, more general points also worth considering, which lie outside the framework provided by van Creveld. The first revolves around the balance between the amount of intelligence and process invested in the human component of an IS vs that invested in the IT. Rochlin [Rochlin, 1997] has as one of his themes the risks inherent in investing too much intelligence in the IT such that the people become critically dependent on it. This would seem to be less than ideal if the underlying IS has not been well implemented; Eason [Eason, 1988] highlights risks in this case such as poor task support and, more importantly, formalisation of procedures. It remains a cornerstone of Defence procurement that you procure for war (ie high intensity conflict) and then adapt for peace but in the new world order the line between these two states has been replaced by a spectrum of operational activity. There is little point in deploying a system if the embedded process actually hampers the exercise of C2 because its scale is wrong or its content is inappropriate. The can recall observing an exercise in which the primary purpose of the C2 IS, to support the cyclic production of an ATO, drove most of the activity within a CAOC, whilst there was no need for such an ATO. The IS was designed to produce an ATO and the process in the CAOC was designed to service the IS. This created a situation where the planning staffs would invest 100-150 man hours worth of effort producing a plan and entering it into the IS only to have that bulk of that effort discarded by the operations staffs for whom the planned missions were of limited relevance.

Simple displays are also problematic. At a trivial level, a 21 inch or 19 inch monitor is big, comparatively expensive, consumes valuable air transport space en route, and then consumes energy and gives off heat in use, both of which may be highly undesirable. CRT/LCD displays possess limited display resolution that makes the use of map data very awkward (extent of coverage vs detail). Given the number of command and control systems that display picture in a map form this places a limitation on information transfer from the technical system into the wider socio-technical system. Furthermore existing displays / applications provide poor support to group interaction – each member of the command team works at their own workstation or all simply share a projected image of 'poor' quality – which can threaten the cohesion of the command team and its ability to plan effectively.

7. A Way Forward

So, what of a way forward? The underlying theme behind this paper is that C2 should be viewed as more of a social activity, within which information is processed and decisions are made, rather than as a mechanical method where all that is required is that the participants follow a set of programmed steps and success will be guaranteed. There is already a body of work that appears to take this perspective but its disciples are in the minority in the wider C2 community. McCann and Pigeau [McCann and Pigeau, 1996] define C2 as '…the establishment of common intent and the subsequent transformation of that intent into co-ordinated action' – others (eg Hitchins [Hitchins, 1994]) offer similar ideas also. We can use such a definition to add something to van Creveld's model (or to make it explicit): the exercise of C2 must include integration activities that support the development of common intent and shared understanding. Such a definition would tend to lead to a focus on those information technologies that support team building and integration rather than simple group working. The objectives of such a focus would be to promote flexibility and adaptability in the C2 process; to assist commanders to adapt to working with uncertainty – rather than trying to suppress it; and to try and overcome the disintegrating effects of current IT. This would seem to be an ideal opportunity to examine the utility of synthetic environments (SE) in C2 and the Swedish project, ROLF 21, with its aquarium appears to be doing this (see also Hitchins' work [Hitchins, 1998]). It's interesting to note that whilst the Swedes are pressing forward in this area, the US and the UK appear relatively uninterested in the use of SE in C2; the Nordic countries have frequently taken a less mechanistic view of IS as evidenced by the work of people such as Lytinnen.

The other issue that drops out of a social approach to C2 and, by implication, a more interpretative approach to the development of C2 IS concerns the location and flexibility of the C2 process. There is no one kind of operation – more likely there are no kinds of operation at all, each will be unique in its own way – and therefore there can be no one way to exercise C2 and thus C2 processes must be flexible and adaptable. People can have such qualities instilled within them, IS can be designed to handle a number of scenarios but that is not necessarily quite the same thing as being flexible and adaptable. A C2 system in which much of the process is vested in the individuals rather than the IT would be less likely to face these problems compared to one where the technological component of the wider system defines the process.

Ultimately, the way that the IS/IT is deployed and used in support of any activity is strongly influenced by the values that surround the activity itself; therefore, it is important that those values have been made explicit in some way. In other cases the values invested in the technology will default to those held by those that procure the equipment and those that develop it and supply it. In the context of the military and the exercise of C2, it could be argued that either of Eason's points of view about the role of IT is valid, the key point being that there should have been some argument rather than a simple acceptance of technological determinism. The question that follows acceptance of the need for a debate revolves around the level at which it should be held. Ideally, such a process would be top-down. Unfortunately, the logical first debate would revolve around the way in which governments employ military force: when military force is acceptable; what kinds of military force can be applied; who should be accountable etc. All of these are topics about which most governments understandably wish to maintain a degree of ambiguity in their dealings with other parties. Given that, we are left with a 'middle-out' approach and here there are two options: to debate the nature of C2 and thus fix the role of IT, or simply debate the role of IT. The better of the two would be to debate the nature of C2 in order to decide the values we wish to invest in the process: for example, Czerwinski [Czerwinski, 1998] offers three philosophies for the exercise of C2:

- Command-by-Direction in which the commander, provided with all the information he could possibly require, directs the actions of all of the forces under command. This paper has highlighted the risks in such a philosophy, as does Czerwinski also, in terms of the possible brittleness of the resulting system.
- Command-by-Plan in which the commander produces a plan that attempts to cater for every eventuality. Allusion has been made to the efforts of the British Army in World War One to adopt this approach as a means of reducing the level of uncertainty that commanders had to face.
- Command-by-Influence which is the term Czerwinski uses to describe the use of *Auftragstaktik* and which he appears to believe is the most effective and flexible form of command. However, for command-by-influence to work it is necessary to acknowledge and then account for the social nature of command as expressed by writers such as McCann and Pigeau.

The results of the debate can be used to influence doctrine, either to mitigate the risks inherent in the tightly coupled approaches to exercising C2 that are emerging or to ensure that, not withstanding a move towards increasing centralisation of command, the C2 IS that are procured are genuinely flexible and scalable. The former issue might be addressed through force packaging, the latter through reflection on and then action concerning the balance between the amount of process/intelligence vested in the people in a C2 system and the IT in the same. Modelling and exercises that investigated the issue of brittle C2 systems and exposed commanders and staffs to the effects of a break down would also be helpful. Among other things such efforts could help commanders to work with and accept uncertainty, which might reduce the incessant demand for status reports and the tendency to micro-manage the conduct of their subordinates.

8. Conclusion

C2 is not a technical matter. However, we would seem to be culturally predisposed to apply such solutions to support the exercise of C2 and in doing so we are creating potentially brittle systems because of the emphasis on coupling subsystems. Technical solutions to C2 problems are not appropriate by themselves. Technical solutions to problems caused by technology in C2 are even less appropriate. As was said at the start, IT, of itself, is value-free. An aim such as 'the right information to the right place at the right time' also makes no judgements about the values that may be invested in the implementation of the IT needed to deliver the aim. Selection of the right set of values could lead to the creation of flexible and adaptable C2 systems. Thus one of the key decisions that should inform the nature of programmes such as JBD concerns that values that should be contained in the C2 system.

9. Acknowledgements

The author is grateful to Dr Ron Matthews, Cranfield University for creating the circumstances that made it possible to write this paper and to Professor Derek Hitchins for his comments on an earlier draft.

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