Battlespace Digitization - Coping With Uncertainty In The Command Process

Anthony Alston, Patrick Beautement MSc, PGCE
Q324 / Q323, Defence Evaluation and Research Agency,
Great Malvern, Worcestershire,WR14 3PS, United Kingdom.
+44 (0)1684-895807 or 894207
AJAlston@mail.dera.gov.uk or PBeautement@mail.dera.gov.uk

Abstract

Future military Command Processes will be different from those in use today. The design of future applications and infrastructures (to support a digitised environment) must not constrain these processes and must allow them to be adaptable (both before deployment and during operation) and to evolve in the longer term. The paper deals with a method of capturing and representing the Command Process and of mapping the Command Processes to appropriate solutions such that neither flexibility nor the emergence of novelty are constrained. The approach has three inter-linked elements: a model of the command process (ie a model of domain problem area); a model of the application and infrastructure architectures (ie a model of potential solutions); and a methodology for mapping between the two. Overall, the paper will explain how the methodology works and show how it might be used.

1. Philosophy

Recent UK and US documents state the requirements for battlespace digitisation [1, 2] and lay heavy emphasis on the role of information in winning future wars. However, information is only one ingredient in the recipe for success. In our view success in war is about carrying out high-tempo, coherent, decisive actions (faster than your opponent can react) resulting in "decision dominance"[1] and through having “command agility”. Command Agility can be thought of as the ability to be flexible and adaptable so that fleeting opportunities can be grasped. This is done by the Commander issuing clear intent and then delegating the control authority to subordinates so allowing them the scope to exercise initiative [3]. It also means being innovative, creative and unpredictable in a manner that (even if low-tempo) increases the confusion in the mind of the opponent[2]. This process is “command led” meaning that human decision-making is primary and that the role of technology is secondary.

How is this process to be supported in the 21st Century? Certainly not through the ill-considered use of digitisation. Technology is an ingredient in the recipe of success, but deciding how and where to use it appropriately needs thought. The starting point should be an understanding of the Command Process, of the Operational Art used in warfighting and of the non-deterministic nature of war. In addition, the opponent must not be forgotten. It is a truism that “He who looses learns most” and Commanders, their Staffs and those involved in executing plans must, at times,

---

1 Sun Tzu, "The Art of War": III - Offensive Strategy (4) "Thus, what is of supreme importance in war is to attack the enemy's strategy".
2 UKOPSDOC (JWP 0-10): Chapter 1, Sect III, " Because it is a dynamic contest, conflict is uncertain and chaotic ... commander must exploit chaos by foisting it on his opponent, yet bringing greater order to his own schemes than his opponent can".

loose and must be exposed to novel and challenging opponents [4, 5]. Scenarios must vary from "asymmetric warfare" (where opponents may be low-tech or offer a "future-shock" to friendly forces) to all-out war and even entirely hypothetical situations which some might consider unlikely. These experiences will root out complacency, predictability and vulnerabilities in the people, their processes and their command support systems.

This paper proposes a model of the Command Process that takes account of these things. The Model allows for the fact that, simultaneously, there are a large variety of formal and informal processes being employed and that there is a need to support them. There are many types of support that can be provided, indeed, many of the solutions to digitisation problems at the higher levels of command are organisational - not technical - and hence the applications and infrastructure architectures offered must take this into account. For example, Commanders at all levels are decision-makers and each needs a visualisation of the battlespace which is relevant to the decisions they have to make. Rather then trying to automate this process (or provide a common operational picture) it is most appropriate to give decision-makers the tools to configure their "decision desktop" to their own requirements.

This process of indicating the mapping between problems (supporting the parts of the Command Process) and the appropriate solutions (applications and infrastructure) must be carried out in a manner which does not produce predictable systems. Also, as a general rule, it is best if Command Processes ARE NOT embedded in the applications and infrastructure as this would mean that novelty, flexibility and the ability to snatch the initiative will be reduced. The paper indicates how the mappings mentioned above can be achieved.

2. The Command Process

The real Command Process is not deterministic and cannot be found as a flowchart, fixed structure or engineering blueprint written in a book. Instead, it is a human-centred (command-led) activity which is more likely to be characterised by employing probability, complexity or chaos theory [6, 7, 8]. Indeed, an approach which tries to characterise the Command Process using the language of Command is more likely to succeed than one which uses task-based or system engineering style structures. There is considerable debate about this issue. Our view is that inappropriate methods will generate inappropriate solutions [9]. The Command Process is "fractally decomposable" in that at almost every level of command the decision-makers use a tool for thinking (called the Estimate Process) which is used to determine courses of action based on the Commanders Intent.

Hence we have adopted the DSTO Model [10] which describes the Command Process in terms of the transformation of intent. The model (see Figure 1) recognises a set of activities involving informal control (the transformation process) and another set involving formal control (the process of dissemination / monitoring of command intent). We have adapted the DSTO Model slightly to show the role of campaign visualisation and the importance of there being a shared understanding among the command team. The Formal Control processes (which can be captured in the form of a business process) are necessary to "publish orders and directives in a formal, authorised manner" and to receive reports and authentication information. Traditionally, IT systems have been designed to support these formal processes. Yet informal processes (such as brainstorming and course of action selection - not easily captured as business processes) are where the (as yet largely unexploited) benefits for digitisation can also be realised. The formal processes are often carried out in a linear or sequential manner, whereas the informal processes may involve a great deal of iteration and heuristics which may draw on creativity, intuition (experience) and "flashes of inspiration".

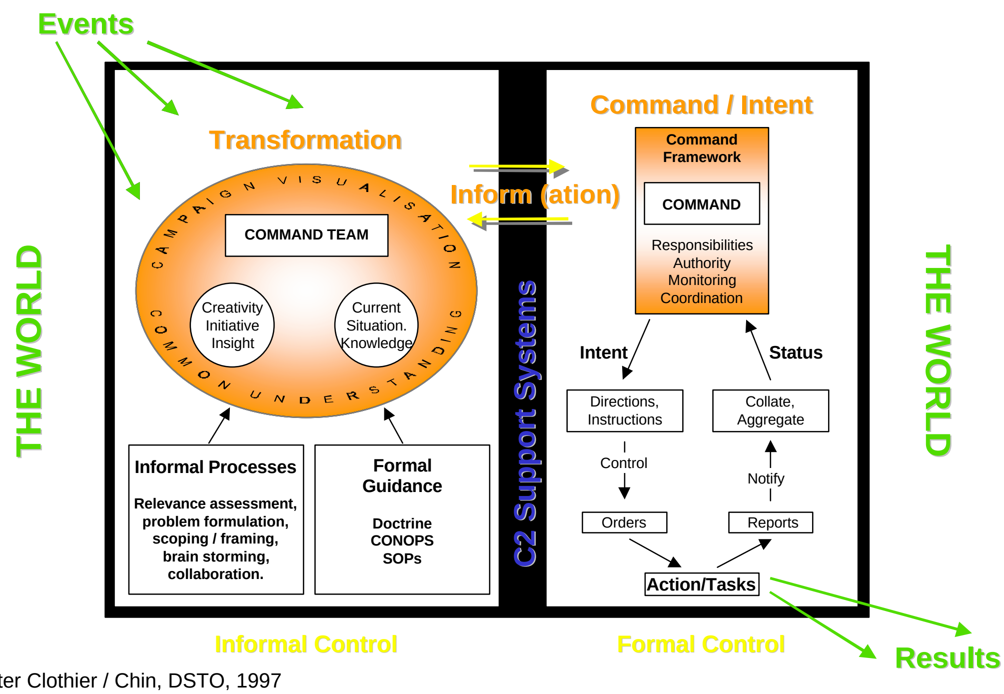

Figure 1: The Command Model

Though the Command Model shows two main axes of demarcation (formal and informal) there are others. Activities can be well-characterised or poorly-characterised; they may be stable over time or variable; specific to a location or distributed / mobile or they may be associated with a person or their functional role or may be entirely generic. When associated with specific military Tasks these issues are known as the "Operational Drivers".

For an activity to be well-characterised it has to be made up of a predictable sequence of parts threaded together in a manner which can be identified and recorded. In a well-characterised activity the people involved in the task will know what to do and will probably have been trained to follow a fairly clear set of procedures. However, in a poorly-characterised activity it will not be possible to identify threads or procedures which make up the activity (though it may be possible to identify certain repeating fragments). A poorly-characterised activity will change from event to event and moment to moment and people carrying out the task will have developed strategies to respond to these demands.

The DSTO Model also identifies a number of levels at which different types of communication (about the same factor) takes place. At the highest level are "Knowledge Bearers" dealing with legal, financial, conceptual, process and group issues etc. Next are "Information Bearers" which address capturing, storing, processing and retrieving information. Lastly there are "Data Bearers" which carry out the transfer of electronic information as data streams. A key point revealed by this Command Model is that issues at the Knowledge Bearer level can only be solved by organisational changes [11] and, therefore, the use of technology is only appropriate at the Information and Data Bearer levels.

The mapping of these Command Process characteristics (the Operational Drivers) to the styles of decision-making (referred to above) and to the types of Command-Support Applications required is dealt with below and is the main topic of the paper.

3. Styles of Decision Making

Human beings who are “experts” make successful problems solving and decision-making look easy. Being successful is about selecting a strategy appropriate to the situation. This may involve any or all of the following: trial and error, mental mapping (manipulating an internal representation of the world – ie internal trial and error), drawing upon knowledge acquired from experience and training, “logical” analysis, insight / intuition / “hunches” (naturalistic decision-making). Different Commanders tend to favour different strategies based on their personality, experiences, beliefs and the culture (whether political, sociological or military) of which they are part. Hence, it is impossible to classify decision-makers other than to say that there are many different styles and types. Nevertheless, most decision makers are considered to be logical and rational despite the fact that it is well accepted [12, 13, 14, 15, 16] that effective military leaders have “flair”, use an intuitive style and know the power of initiative. This is illustrated in Figure 2 which is drawn from a discussion on decision-making by Professor Derek Hitchins [17].

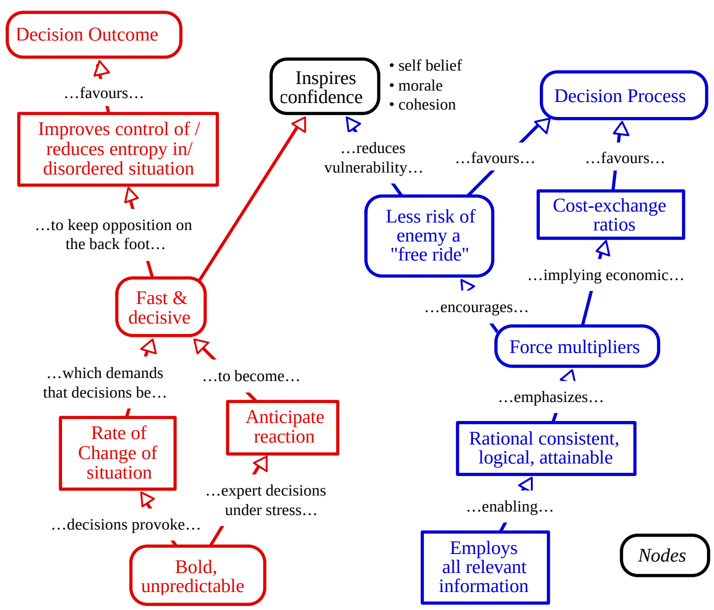

Figure 2: Styles of Decision-Making (From Reference [17])

The analysis in Figure 2 shows that different decision-making approaches have their advantages. The rational approach (on the right-hand side of the Figure) lays greater emphasis on following a set decision process and tries to reduce risk by considering all the factors. This “brute-force” approach to searching the problem space may be stalled if relevant information in unavailable and will be time-consuming and predictable. The intuitive approach (on the left-hand side of Figure 2) is fast and incisive and can be triggered based on minimum information and is best when time is at a premium. However, it is a "quick and dirty" search of the problem space which has the potential for disaster.

Decision-makers will vary their strategy as a situation unfolds. They may start to solving a problem by using strategies which worked on similar problems in the past. Subsequently, they may change to a rational approach or switch to a snap decision [18]. Hence it can be seen that supporting the wide variety of Command Process characteristics and decision-making approaches mentioned above is no trivial task. However, there is one factor which is constant and that is that any IT support provided must be able to deal with uncertainty!

4. Characterising the Solutions

The specification of IT support (so-called "Command-Support Applications") to the Command Process can be characterised as being either Process-Neutral (general purpose tools written with no knowledge of the operational process) or Process-Specific (where the operational process is built into the IT Support tool). Somewhere between these two extremes lies a state where IT Support is provided for well understood fragments of the overall process, termed Process Fragments. The characteristics of these various types of solutions are discussed below.

4.1 Process-Neutral

Process-Neutral Applications are the easiest to deploy because they are common across many tasks and rely upon the intelligence of the users to fit them into the process. They are commercial off-the-shelf-based tools (COTS) that require little customisation (excluding the problems of security) precisely because they are Process-Neutral. These applications are typically used where the environment is highly dynamic and requires close, flexible, collaboration between many people (especially if they are physically separated) with a need for a shared context and understanding of objectives (especially if the information is changing rapidly or is physically distributed.

4.2 ***Process-Specific***

If a process is well defined and stable (i.e. its detailed process flow is unlikely to change over time and the details of the process are always followed the same way) it is a strong candidate for automation support by a Process-Specific Application. These applications are tailored specifically to the needs of a particular process. This mixing of the process into the application structure gives the benefit of a well automated and closely matched tool at the expense of constraining the users ability to change the process. A Process-Specific Application may be built by (or on behalf of) a decision-maker by aggregating Process-Neutral elements together in such a manner that they appear to be a single bespoke application.

4.3 Process Fragments

If a process has well defined parts to it (process fragments) but the way these parts are invoked is required to be completely flexible, then Task-Customised Support Applications may be the best approach to providing support to the process. These applications concentrate on supporting the process fragments that are stable and well understood within a larger process that is not (and the inverse - supporting the process fragments that are unstable and not well understood within a larger process which is). Process fragments can be automated without the whole processes being fixed.

4.4 Applications and Infrastructure

One further aspect of the solution must be considered. What is the relationship between the so-called "Command Support Applications", the decision-makers (users) and the supporting infrastructure? A Technical Reference Model (Figure 3) has been devised which shows this relationship.

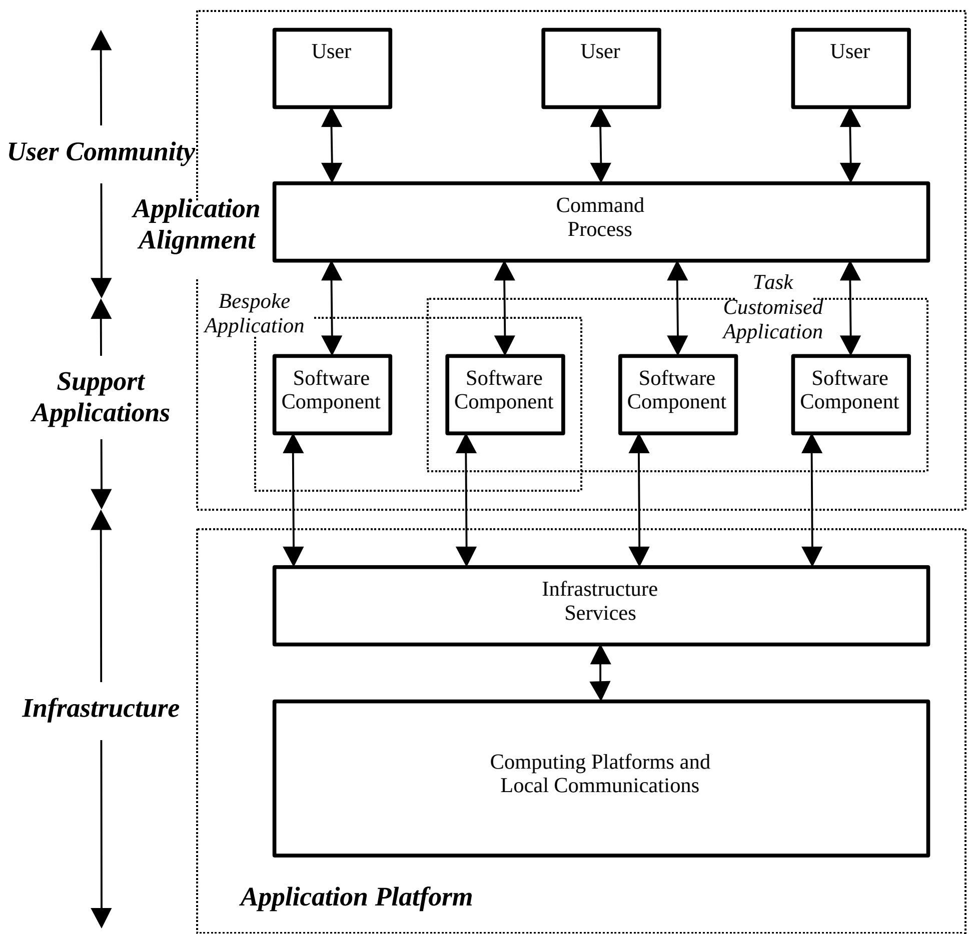

Figure 3: Technical Reference Model

This Model shows that the decision-maker (user), the Command Process and the Support Applications are closely bound together (aligned). This “entity” is separate to the infrastructure. The infrastructure provides a service – information provision – which exploits a trader-broker architecture (outside the scope of the paper) to make information available when and where it is required. This Technical Reference Model supports the Command Model described above as it would allow decision-makers (who know what information they need to have to solve their problems and how they want it displayed) to carry with them their own self-customised Command-Support Application and plug it into the infrastructure as required.

5. Optimising the Solutions to Process and Style

The Operational Drivers mentioned at the start of the paper identified that the Command Process can be categorised as being either well or poorly characterised. Similarly, the Technical Reference Model has stated that software components can either be grouped in a bespoke manner, for well characterised processes, or Task-Customised when poorly characterised. By making a mapping between Process Characterisation and IT Support characteristics, it is possible to make some statements about the type of compatible Command-Support Applications which would be required. The mapping is shown in Figure 4 below.

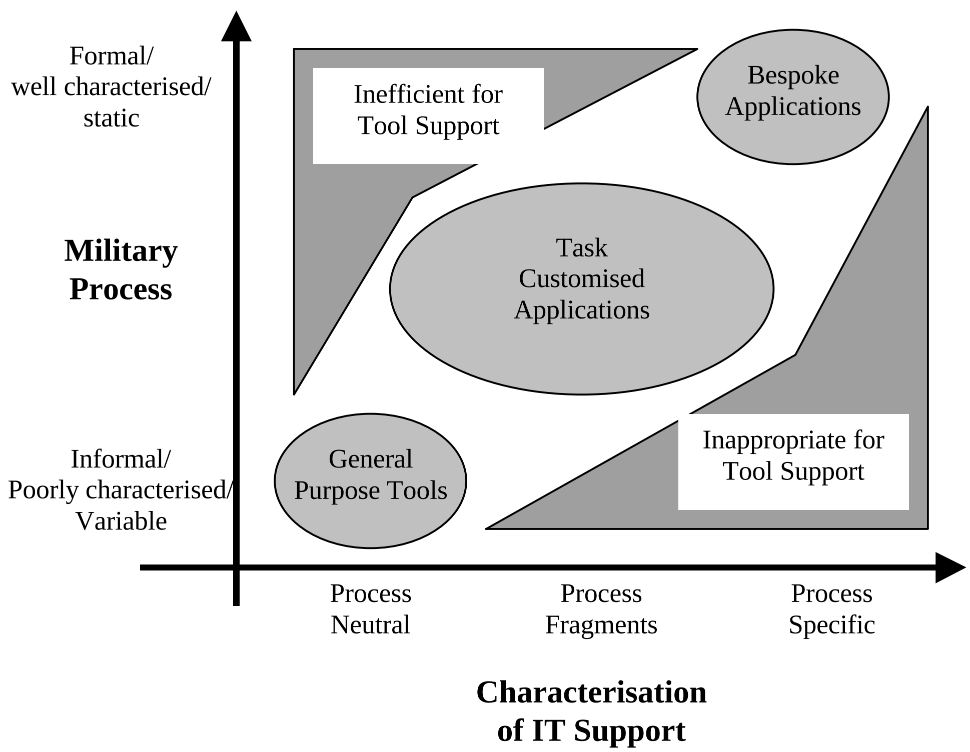

Figure 4: Mapping of Military Process to IT Support

The outcome of mapping Military Processes to IT Support in this way results in the identification of three ‘domains’ where IT Support is applicable and two ‘domains’ where it is not.

- General Purpose Tools. Where the Command Process is poorly characterised and / or informal then the best that IT Support can provide will be general purpose tools like white-boarding and word processors and generic visualisation tools,

- Bespoke. Where the Command Process is well characterised and there is a requirement for a high level of formality (non-repudiation of message receipt etc) then bespoke IT Support systems may be employed that mirror the Military Process. In this area care must be taken not to compromise Flexibility of Command by keeping too rigidly to a single process,

- Task-Customised. Where fragments of the Command Process can be characterised then IT Support can provide specific tools for those fragments. These tools will not be 'linked' by an understood Military Process but will be invoked by the user when required. IT Support in this category covers analytical tools and specific database query tools,

- Inappropriate for Tool Support. Where the Command Process is poorly characterised and / or is almost unique to each decision-maker (for example in creating each decision-maker's situation awareness) it is inappropriate to attempt to build a bespoke IT Support system. Similarly, where the Military Process requires very formalised procedures it is inefficient to provide generalised IT Support.

This approach is designed cope with uncertainty and to enable the optimum and appropriate Command-Support Applications to be acquired in the light of the Operational Drivers described in above. This is counter to most "cybernetic" approaches [19, 20] to Command Support Systems which attempt to digitise the whole process, reducing command agility and compromising decision dominance. It is a fundamental principle of the Model described in this paper that there are certain situations where the use of computer-based IT is **not appropriate** and would actually be damaging to the Command Process.

6. Future Developments

In the continuing debate about how to model command and control there is still much to discuss. However, we maintain that there needs to be greater acceptance of the view that the Command Process is not deterministic and cannot be analysed using a "traditional" reductionist approach. A Command and Control system is not like a central heating system and must be analysed using the appropriate tools. Those tools are still under construction but it is clear that they must be made from components which can deal with complexity, emergence, non-linearity and uncertainty as well as coping with entirely novel forms of warfare [21].

To realise the potentials and achieve Command Agility there are there main issues to consider which are illustrated in Figure 5. Firstly, it is necessary to have a clear vision or concept of what is trying to be achieved. It may be possible to make some progress by a clever use of existing capabilities. Next, as has been indicated above, it is important to select, research and develop appropriate technology to support the concept. In doing this (for example in mapping Command Support Applications to the process) further work needs to be done to characterise the styles of decision-making which humans use and in understanding how to provide users with an appropriate set of tools from which they can select the ones they want to use. Where possible it is important not to embed the process in the application as this reduces flexibility and agility.

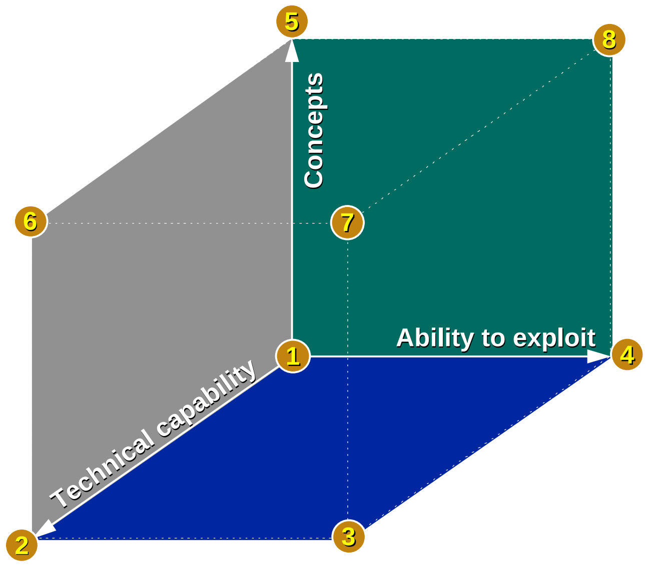

Figure 5: Realising the Potential

Finally, even with these problems solved it is still essential to demonstrate the ability to exploit these capabilities by exercising and training so that Commanders and their staffs can evolve and experiment with and adapt their processes through facing a variety of ruthless, agile opponents. This means providing synthetic environments which allow this agility and investigation of novelty. This is not possible with current synthetic environments as current processes and procedures have been embedded in the software [22, 23].

Lastly, in procuring systems for Command Agility there will need to be a different approach to specifying functionality, security, assurance and accountability. To reflect the Command Model there will be different styles of specification for the different types of solutions. A Process-Neutral Application can neither be specified nor evaluated in the same way as a Process-Specific one. Developing "viewpoints" relevant to the Command-Support Application or Infrastructure under examination will be essential as will being able to reconcile that an item being procured is, simultaneously, not fully testable without the system it supports nor fully testable with it.

7. Conclusions

This Model (and its associated view of issues such as the need for Command Agility and Decision Dominance) has recently been used in the UK and has been well accepted by the military community as a useful way to think about the Command Process. The Model sees the Commanders (at each level) as human agents interacting directly among themselves and, where appropriate, (using their own self-customised "user-interface" Command-Support Applications connected to a software-agent enabled architecture) via the infrastructure described above. The Model is a starting point for thinking about the future as it neither pre-supposes any individual Command Process nor is it specific to any particular technology. Nevertheless, it is realistic about the kind of dynamic and uncertain environment in which Command-Support Applications and their related infrastructures must operate in the future.

8. References

1. Chairman of the Joint Chiefs of Staffs. *Joint Vision 2010*. 1997.
2. UK Secretary of State for Defence. *United Kingdom Strategic Defence Review (Essay 3).* Jul 1998.
3. Leser (Lt Col, US Army) J W S. Initiative: *The Power Behind Intent.* September – October 1997. Military Review
4. Michael R. Lwin. *General Tzu's Army: Opfor of the Future*. Joint Force Quarterly, Spring 1997.
5. House J M (Col). *The Enemy After Next*. Military Review 1998.
6. Echevarria (Maj, US Army) A J. *Optimising Chaos on the Nonlinear Battlefield.* September – October 1997. Military Review
7. Scheider (Prof) J J. *Black Lights: Chaos, Complexity and the Promise of Information Warfare*. 1997. Joint Force Quarterly, Spring 1997.
8. Woodcock A E R. *Medial Surfaces of Rational Expected Utility Maximising Decision Making (REDM)*. IEEE. 1992.
9. Kirsch G. *Unpredictability – Another Word for Freedom. "Computers showing a certain degree of complexity turned out to be more or less unpredictable; and: trying to build predictable computer systems caused these systems to be more or less unable to react to unpredictability"*. In Artificial Life and Virtual Reality, Wiley and Sons Ltd. 1994.
10. Chin M, Clothier J, Carthigaser M. *Command and Control Capability Assessment and the Criticality Issue*. DSTO. Presented at the 1997 ICCRT Conference. 1997.
11. Roman (Lt Col) G A. Airforce 2025 Research Paper *The Command or Control Dilemma: When Technology and Organisational Orientation Collide*. Air University, Maxwell AFB. http://www.au.af.mil/au/2025/monographs/E-s/e-s.htm - April 1996.
12. Walker (Air Marshall) Sir John. *Battlestaff Organisation and Training.* No source reference. Sept 1993.
13. Kammerer (Maj, US Army) J. *Preserving Mission-Focused Command and Control.* Military Review. September – October 1997.
14. Reisweber (Maj, US Army) D. *Battle Command: Will We Have It When We Need It ?.* Military Review. September – October 1997.
15. Lesser J W S (Lt Col). *Initiative: The Power behind Intent*. Miltary Review. September – October 1997.
16. Gumbert J (Maj). *Leadership in the Digitized Force*. Military Review. Jan – Feb 1998.
17 Hitchins D K (Prof). *Effective Decisions in Emerging Conflicts.* CCRP Conference. Sep 1998.
18. Brander G N and Scard N. *Models of Human Decision Making*. DRA/CIS/CSS5/CR94024/1.0. Defence Research Agency. Oct 94.
19. Vincent (Lt, USAF) G A. *A New Approach to C2 – The Cybernetic Design.* Airpower Journal, Summer 1993.
20. Serfaty D. *Adaptive Architectures for Command and Control.* Second International Symposium on C2 Research and Technology. Presentation Paper. 1996.
21. Emmett P. *Software Warfare – The Militarisation of Logic*. Joint Force Quarterly. Summer 1994.

22. Belknap M. *The Force-on-Force Model: An Anachronism in the Information Age*. Joint Force Quarterly, Spring 1997.
23. Beautement P. *Cost-effective Simulation of Enemy Forces Through Effects-based Wargaming.* Best paper I/ITSEC 98.