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FUTURE PERFECT: EFFECTS BASED OPERATIONS, COMPLEXITY AND THE HUMAN ENVIRONMENT

By

Mr. Robert Vermaas

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OTTAWA, ONTARIO JANUARY 2004

ABSTRACT

This study is the first in a series of monographs on the Effects Based Approach. It introduces the concept of Effects Based Operations (EBO) as an alternative means to pursue foreign and defence policy objectives. This concept relies heavily on the injection and fusion of specific inter-agency, academic, corporate, diplomatic, economic and coalition intelligence knowledge for the formulation of an Operational Net Assessment (ONA), as well as a recognition of the need for technological means to assist the decision maker in ascertaining the complexity of desired tactical end-states, or, 'effects', required for the attainment of a strategic objective. It is suggested that a dramatic shift in the traditional mind-set of decision makers is needed in order to plan for, assess, analyze, and task, future strategic operations. It is also suggested that Canada pursue the development of this concept. The concluding section will outline recommendations for the DND/CF and will posit questions for further exploration.

The Effects Based Approach is outcome based. The concept relies heavily on a shift in the psychological mind-set of the decision maker, as well as a suitable application of technology to the overall planning, decision making, and analysis phases of an operation. Indeed, the effective management and manipulation of large quantities of diverse data is necessary to maintain a shared situational awareness both within and outside of an area of operations as well as to achieve an understanding of what effects may be achieved and how; what the potential unwanted or undesired effects may be; and, what the potential secondary and tertiary effects may be. If EBO are to gain acceptance and function with an appropriate level of accuracy and speed, there is a requirement of governments and armed forces for alternative thought processes to assist operational planners in recognizing where challenges and uncertainty may exist. In Canada, this may require a series of marked shifts that include:

a. More inter-agency cooperation *and* coordination of planning and operations;
b. Greater inclusion of academia, IGOs and NGOs, and private industry in planning for crises, mitigating threats, planning for 'effects', and developing a robust ONA;
c. Further exploration, both nationally and with international partners, of the complex nature of warfare generally and EBO specifically;
d. Study of the requirements needed to operationalize EBO;
e. Most importantly, a cross-government appreciation of the advantages of adopting an Effects Based Approach as a major operating concept of the future.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENTS

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FUTURE PERFECT: EFFECTS BASED OPERATIONS, COMPLEXITY AND THE HUMAN ENVIRONMENT

INTRODUCTION

1. An epigraph in a recent article in the *Economist* opens: 'Problems, problems' and then describes in depth the litany of problems that have developed following the Coalition intervention into Iraq:

> Patchy public services, continuing guerrilla attacks on coalition troops, widespread criminality, confusion over oil revenues and the financing of reconstruction, and still no sign of a home-grown government—just some of the problems facing Iraq's interim leaders.[1]

2. The article continues, 'did the Bush administration spend too much time thinking about how to secure military victory, and too little working out what to do with the country once Saddam Hussein had been removed?'[2] Edward Luttwak amplifies this sentiment, calling the Coalition strategy in Iraq a 'childish deception' with 'hugely ambitious aims' and 'unwinnable goals'.[3] Further, former US Secretary of State Madeline Albright has claimed in a recent article in *Foreign Affairs* that the Bush Administration has, with its expanded war in Iraq, alienated many potential allies and has, in turn, made the global fight against terrorism all the more difficult to win.[4] At their core, these articles question a traditional, and decidedly Western 'military', approach to warfare and its immediate aftermath. This traditional approach is incapable of accurately perceiving, or forecasting, the results of such a chosen strategy. It is an approach incapable of delivering what should ultimately appear to the decision maker the desired strategic end-states, or, 'effects', on selected political, military, economic, and social systems.[5]

3. This Research Note is the first in a planned series of monographs on the Effects Based Approach. It explores the developing theory of the Effects Based Approach, introduces Effects Based Operations (EBO) as a concept of strategic and operational

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[1] The Economist Global Agenda, *Economist,* Web edition, www.economist.com, 2 July 2003, p. 1. Accessed, 2 July 2003.
[2] *Ibid.*
[3] Edward Luttwak, 'Digging out from disaster', *The Globe and Mail*, 21 August 2003, p. A17.
[4] Madeline K. Albright, 'Bridges, Bombs, or Bluster?', *Foreign Affairs*, Volume 82, Number 5, pp. 2-20.
[5] The 'traditional' method of warfare and its pursuit in Iraq has been analyzed further in several newspaper editorials see, 'Comment and Analysis' section of *Financial Times*, 30 June 2003, p. 13; R.W. Apple, 'A New Way of Warfare Leaves Behind an Abundance of Loose Ends', *New York Times*, p. B1, B14; BBC News, 'US Plans for Iraq 'Flawed'', Web Edition, www.bbc.co.uk, 26 June 2003. Accessed, 26 June 2003; Jim Hoagland, 'The War Isn't Over', *Washington Post,* 22 May 2003, p. A35; Thomas E. Ricks, 'U.S. Alters Tactics in Baghdad Occupation', *Washington Post,* 25 May 2003, p. A1, A18.

planning and implementation and proposes possible applications of this concept in the human and virtual environments of the future. More specifically, it introduces EBO to the Canadian Forces and the wider Operational Research communities and explores the implications for the Canadian government in adopting such a concept. The Note has three sections, each of which will be explored more fully in subsequent OR publications:

a. The first section provides an introduction to the concept of Effects Based Operations and Operational Net Assessment;

b. The second section analyzes the concept's foundations in complexity theory, complex adaptive systems theory and networking theory. The reasons for the inclusion of this section are two-fold. First, it is essential that one is able to conceptualize the logic (and at times illogic) behind Effects Based Planning before one attempts to operationalize it. Second, EBO require a rigourous understanding of complexity, causality theory and the complexity of actions over time and space. Thus, the operationalization of EBO has, as a *functional* requirement, compelling need to codify that which is traditionally non-linear, i.e., war. This is a daunting task;

c. The third section of the Note expands the second's logical stream. EBO are complex in nature. There is, however, a desire for operators to quantify that which is unquantifiable in order to act (and react) in sufficient time to produce the desired effects. This being the case, the Note explores technological requirements that may, in future, enable EBO to be conducted more efficiently through time and space.

4. In summary, the advantages that the Effects Based Approach offers rely heavily on a shift in the psychological mind-set of the decision maker, as well as a suitable application of technology to the overall planning, decision making, and analysis phases of an operation. Indeed, the effective management and manipulation of large quantities of irregular data is necessary to maintain a shared situational awareness both within and outside of an area of operations as well as to gain an understanding of what effects may be achieved and how; what the potential unwanted or undesired effects may be; and, what the potential secondary and tertiary effects may be. If EBO are to gain acceptance and function with the appropriate level of accuracy and speed, there is a requirement for governments and armed forces to adopt alternative thought processes to assist operational planners in recognizing where challenges and uncertainty may exist.[6] In Canada, this may require a series of marked shifts that include:

a. Greater inter-agency cooperation *and* coordination of planning and operations;

[6] Roger Lewin, *Complexity: Life at the Edge of Chaos* (New York, Macmillan, 1992).

b. Greater inclusion of academia, IGOs and NGOs, and private industry in planning for crises, mitigating threats, planning for 'effects', and developing a robust ONA;

c. Further exploration, both nationally and with international partners, of the complex nature of warfare generally and EBO specifically;

d. Further studies of the requirements needed to operationalize EBO over the long-term;

e. Most importantly, a cross-government appreciation of the advantages of adopting an Effects Based Approach as a major operating concept of the future.

WHAT ARE EFFECTS BASED OPERATIONS?

5. During the Cold War, the dominant principle of Western military planning was the ability to mass forces at key points whilst preventing or deterring an adversary from doing the same.[7] Success in battle, then, was understood by strategists and operators alike to depend on the ability to overcome the adversary in a lengthy war of attrition. However, the nature of conflict has clearly changed since 1991. Conflict is no longer limited to attritional, linear battlefronts and mass manouevre. As clearly demonstrated during recent events in Afghanistan and Iraq, the historic focus on achieving military superiority at the strategic, operational or tactical levels should be considered perfunctory steps towards the achievement of strategic military, economic and diplomatic aims.[8] Increasingly, conflict has become akin to a complex adaptive system that operates within the complex environments of such as terrorism, peace support operations, and regime change. Moreover, the complexity of warfare has come to include cyberspace, the nano-dimension, space, and the biological and chemical environments. Operations to attend to such threats will, therefore, require an equally adaptive approach. (Figure 1.)

[7] Desmond Saunders-Newton and Aaron B. Frank, 'Effects-Based Operations: Building the Analytical Tools', *Defense Horizons,* Center for Technology and National Security Policy, National Defense University, Number 19, October 2002.

[8] The threat of asymmetric retaliation and guerrilla warfare (slowly) persuaded Coalition forces to re-assess strategic options in Iraq in the spring of 2003. See, Edmund L. Andrews and Patrick E. Tyler, 'An Iraqis' Disaffection Grows, U.S. Offers Them a Greater Political Role, *New York Times,* 7 June 2003, p. A8.

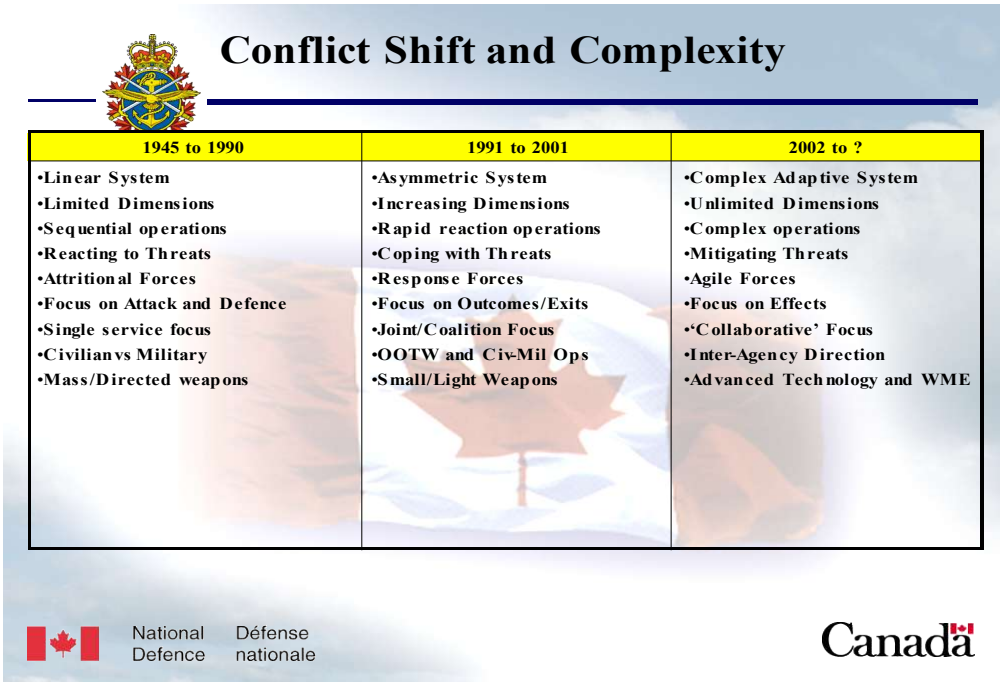

Figure 1.: Conflict Shift and Complexity.
The nature of conflict has changed dramatically since the end of the Cold War. In the future, both decision makers and operators alike are more likely to experience increased complexity (not to mention cross-over) in military, diplomatic, and economic operations.

6. The concept of Effects Based Operations (EBO) is linked to the effort to leverage a nation's (or a coalition's) strategic capabilities at the political, economic, technological, and information networking levels in order to achieve politically satisfactory outcomes for a nation or coalition. It is, at the same time, an intrinsically *psychological* concept, linking proposed actions to achieve physical *and* psychological results at the operational level. Here, psychological results may include the ability to affect an adversary's *will* to act, or, the ability to affect through dissuasion or deterrence an ability to act *in some way*.

7. Focusing merely on the degradation of an adversary's military combat power does not represent a holistic approach to future operations. These operations will likely place increasing emphasis on establishing *influence* over the *mind* of an adversary whilst keeping casualties and collateral damage to a minimum. Conceptually, EBO may enable desired aims to be achieved without the need for attritional warfare, although success is more likely to be achieved through a combination of both physical and psychological effects. Of course, a credible war-fighting capability must always buttress psychological capabilities. In Canada, for example, the defensive capability is, arguably, one component of a reductionist pillar of the three-dimensional principles of foreign affairs

that include diplomacy, defence and development. This is known as the 3-D defensive policy. Here, strategic success will rely on being able to identify the end-states, or, *effects,* that will lead to campaign success and to deploy the optimum mix of capabilities with which to achieve them. Clearly, Canadian values may dictate that operations abroad include complementary diplomatic measures such as sanction, financial incentives, and trade-offs, just as easily as the deployment of a peace keeping brigade. Alternatively, of course, such actions may also include the offer of developmental aid and reconstruction assistance at a level equal to or greater than that of the defence option.

8. Secondly, EBO seeks to control the duration and gravity of a crisis or conflict, allowing nation-states to achieve strategic objectives at a minimal cost. There is a conscious effort on the part of decision makers to achieve desired effects, which may be pursued under the primary objectives of physical and psychological effectiveness.[9] This juxtaposition of effectiveness can incorporate quantitative and qualitative measures and must consider the relative relationships between cascading, unintended, or unwanted secondary and tertiary effects. As such, it is very much rooted in theories of complexity and complex adaptive systems, as well as theoretical causality. This will be addressed below, and more fully in a subsequent ORD publication.

9. Thirdly, and perhaps most encompassing, from a derivation of a recent multinational experiment definition, EBO may be considered a process for obtaining a desired outcome or effect from an adversary, friend or neutral through the synergistic and cumulative application of military and non-military capabilities at the tactical, operational and strategic levels.[10] Other definitions consider EBO as operations conceived, planned and executed within a systems framework that considers the full range of direct, indirect and additional cascading effects that may be achieved by the application of political, military, diplomatic or psychological instruments.[11] It is worth underscoring that EBO involves a broad range of activities, of which military action is only a subset. For example, if a nation or coalition has, as one of its strategic objectives, the establishment of a democratic regime in a formerly violent totalitarian region, there may be infinite (or permutated) operational level actions and resources needed to influence desired effects. As a result, EBO may be defined as the combined direct and indirect administration of *any* means at the nation's disposal applied in a synergistic manner in order to elicit a

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[9] Desmond Saunders-Newton and Aaron B. Frank, 'Effects-Based Operations: Building the Analytical Tools', *Defense Horizons*, Number 19, October 2002, p. 1.

[10] US J9 Experimentation, US Joint Forces Command (USJFCOM), working definition, 2002. See also draft of Effects Based Planning concept for Multinational Experiment 3, a joint concept between the UK Joint Doctrine and Concepts Centre (JDCC), the Canadian Forces Experimentation Centre (CFEC), the German Bundeswehr, France, NATO ACT, Australian Defence Science and Technology Organisation (DSTO), August 2003.

[11] Paul K. Davis, *Effects-Based Operations: A Grand Challenge for the Analytical Community* (Santa Monica, CA: RAND, 2001), RAND MR-1477-USJFCOM/AF, 2001

desired strategic outcome. It is imperative that planners think rigourously about the orchestration of effects and proposed actions and resources needed to achieve them, i.e., what is needed to achieve the above effect: diplomacy; military action; financial incentive?

10. EBO, then, are a coordinated set of actions (or inactions) directed at shaping the *behaviour of foes, friends and neutrals* during times of peace, crisis and war. They rely primarily on the exploitation of cognitive and kinetic weaknesses rather than simply massing traditional power against traditional power. This approach to the achievement of a long-term strategic aim necessitates planners develop a better appreciation of increasingly complex human networks. It also requires a significantly more sophisticated understanding of human values and mindsets over *time and space* as well as a multidimensional analysis of the primary and secondary 'nodes', or 'targets' to be affected during the course of EBO.[12] A 'node' may be any selected person, place, thing, or social construct, identified by a planning team and may include, for example, a national or party leader, a military base, a non-governmental organization, a power grid, a bank, a religious movement, an international fund, a population indicator.

11. Finally, the EBO concept demands from decision makers a recognition that sophisticated technological tool-suites will enable an efficient Effect-Based Planning (EBP) process. The complexity associated with the EBP process requires, by nature, a technological tool-suite capable of affording the decision maker the opportunity to compile, evaluate, assess, and analyze relevant strategic, operational and tactical data in real-time. This is a task of incredibly high order that, conceptually, integrates specific, time-sensitive, knowledge about an area of operations with data associated with proposed courses of action susceptible to an evolving strategic objective.

12. EBO is a concept still in its infancy. It has not yet advanced to a mature experimentation phase, nor has it been developed adequately enough to consider immediate implementation. Making EBO a reality will require the maturation of the appropriate theoretical and analytical frameworks, both of which consider a holistic spectrum of conflict that includes political, military, economic, social, legal and ethical, and infrastructure and information segments. This framework (or frameworks) and associated methodologies will enable decision makers to plan for activities and operations more effectively and then to adapt plans as situations evolve. Future operations that reflect the principles of EBO will, by their very nature, require political and military leadership to both *anticipate and understand* the consequences of actions. Decision

[12] R. David Smith, 'The Inapplicability of Principle: What Chaos Means for Social Science', *Behavioral Science*, Vol. 40, 1995, p. 22; Steven Guastello, *Chaos, Catastrophe, and Human Affairs: Application of Nonlinear Dynamics to Work, Organizations, and Social Evolution* Mahwah, NJ: Lawrence Erlbaum Associates, 1995.

makers will require a framework that integrates concepts such as the explicit linking of actions to resources and actions to effects. Decision makers will also require a framework that relates actions to national strategy, the continuing assessment of operational outcomes and intended and unintended consequences, the coordination and optimization of interagency efforts and the effective use of enabling operational concepts such as network-enabled capabilities and Operational Net Assessment (ONA).

13. It should be noted that while the EBO concept requires further refinement, there are a number of multinational and Canadian initiatives in place that are investigating the 'sub-concepts' involved in the Effects Based Approach. Canada has been involved in the conceptual development, analysis, technological development, experiment design, and participatory phases of Limited Objective Experiment II (LOE II) and Multinational Experiment III (MNE III). The former experiment was conducted in February 2002 and addressed multinational information sharing in 'real-time' over a secure Collaborative Information Environment (CIE) and the development of a multinational ONA database; the latter, which takes place in February 2004, explores the technological, organizational and process requirements for multinational Effects Based Planning (EBP) and coalition development of a robust ONA database. MNE 4 is scheduled for the summer of 2005 and will be an experiment on the conduct of an Effects Based Operation. Such experimentation is highly recommended and produces swathes of qualitative and quantitative data for analysis on the preparatory stages of EBO. Observations on MNE III will be analyzed and published in a subsequent ORD report.

OPERATIONAL NET ASSESSMENT (ONA)

14. A critical sub-concept, or, tool in the EBP process is the Operational Net Assessment (ONA). ONA is a continuously updated analysis of adversary, allied, or neutral capabilities during a limited number of courses of action (COA) that a state or coalition may take. Underlying it is both a process and a database that includes an assessment of *all* national or coalition assets and incorporates analytical expertise of the strategic and operational context that shapes it.[13] A functional ONA reflects a constantly refreshed national (or international) analysis of political, military, economic, social, infrastructure and informational systems relating to the proposed COA. The systems, and their interaction, are an integral component to understanding how to plan and execute EBO. (Figure 2.) This process is ideally developed through collaborative intelligence and information sharing arrangements between academia, government and treasury intelligence services, non-government organizations (NGOs), international organizations

[13] Keith P. Curtis, *Multinational Information Sharing and Collaborative Planning Limited Objective Experiments*, MITRE Corporation, 2001, p. 3.

(IGOs), corporations, and defence establishments and the use of technology accommodating geographical dispersion.

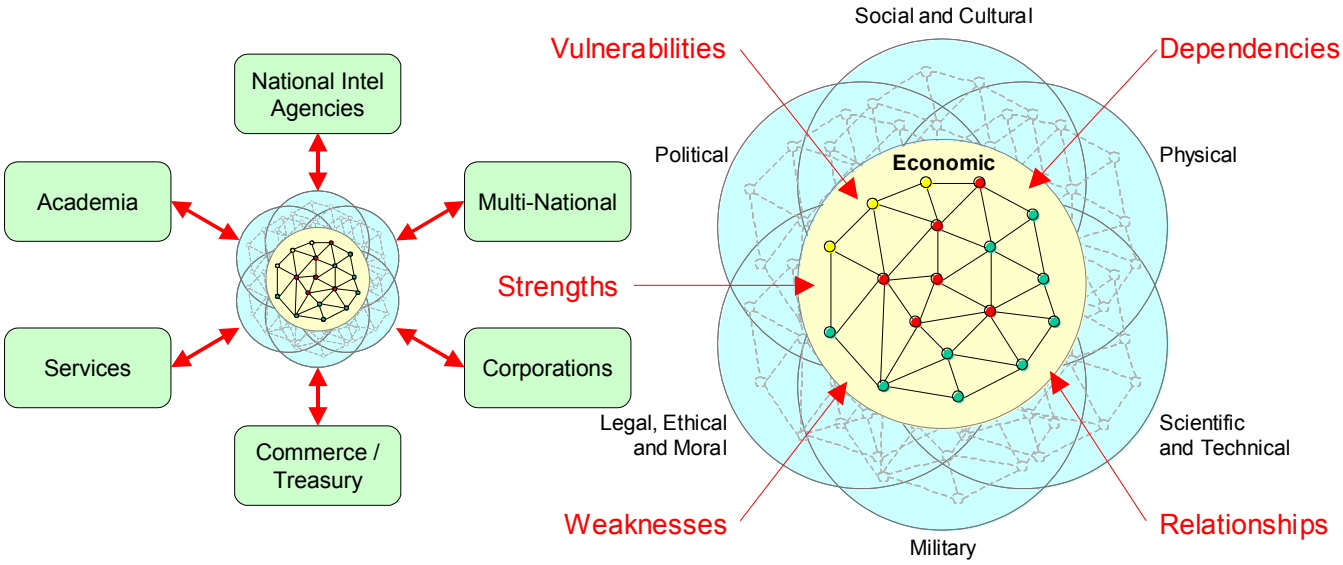

Figure 2: The ONA process requires inputs from a wide range of political, economic, social, intelligence, technological, infrastructure specialists in order to make an assessment of strengths and vulnerabilities within a 'system of systems'.

15. The nature of the strategic environment mandates the Effects Based Approach adopt a global posture. This necessitates ready access to an ONA that contains information gathered from national, international and coalition sources. National information may be derived from a broad range of classified and unclassified sources and requires for successful application a strong inter-agency collaborative process. This requirement is sometimes encumbered by traditional bureaucratic structure. For example, in Canada, there are a number of departments and agencies that develop security and development policy, including, but not limited to, the Privy Council Office (PCO), the Department of Foreign Affairs and International Trade, the Solicitor General, the RCMP, Health Canada, Transport Canada, and the Department of National Defence.[14] While each of these departments may share a unified strategic aim, there may be varied interpretations of how best to achieve that aim.

16. In order to conduct EBO amongst national agencies, there is a requirement for strong inter-agency cooperation and coordination. Arguably, at present, this requirement is at best superficially implied, or at worst, simply ignored. The reasons for this are far too diverse for this paper; suffice it to say, there is a challenge ahead for the Canadian government and its agencies and departments. For example, should a severe humanitarian crisis develop abroad, one which the Canadian government pledged

[14] See Conference of Defence Association Institute, *A Nation at Risk* (Ottawa, ON: 2002).

assistance, it is generally understood that there would be a certain level of cooperation and coordination between a number of associated agencies and departments, including the Department of National Defence (DND) and the Department of Foreign Affairs and International Trade (DFAIT). It is also understood that decision making would indeed take place in some collaborative fashion. However, it is also current practice that such decision making and collaboration would be, for the most part, ad hoc and would therefore fail to provide an adequate assessment of the cascading effects of potential actions and capabilities when decisions are made. Moreover, although decisions would be made collaboratively, at least in spirit, it is unlikely that such decisions would be made based on the most holistic set of information available; nor would they be made in sufficient time. This is a challenge to overcome and one exponentially more complicated given the dynamics of a coalition environment.

17. The Effects Based Planning (EBP) process envisages inter-agency coordination and assistance in developing the ONA, creating potential 'effects'and actions linkages, and pursuing actions based on capabilities. The United States has explored the Standing Joint Forces Headquarters (SJFHQ) concept and it is, to date, now in its prototype phase. The SJFHQ concept has, at its core, a combat commander with 'reach-back' capability to knowledge and planning-specific Boards, Centres and Cells and, more importantly, to a Joint Inter-Agency Coordination Group (JIACG). This is an innovative approach to decision making, one which places an appropriate emphasis on the role of other government departments in the EBP process. As will be seen in subsequent research notes on EBO, however, alternative concepts of command and control (C2) give even greater emphasis to the inter-agency role in decision making. Research has been initiated in Canada that will explore the National Inter-Agency C2 Group concept and its position relative to ONA and EBO.

18. Once a unified strategic aim has been developed and a net assessment of desired end-states and the means to achieve them has been agreed upon, a representation of the real world is generated that allows the 'battlespace' to be considered as a complex adaptive system (CAS). From this understanding, the planning process can be properly configured to ensure that the right information gets to the right people at the right time. EBO seeks to assure decision superiority by improving one's (or one's allies) information posture, whilst manipulating another's position in order to exploit every opportunity to increase the speed and accuracy of operations.[15] Decision making will involve an assessment of the multitude of possible (and probable) outcomes or goals which 'include the assurance of "beyond first-order" effects on the agents, institutions, technologies, and

[15] Decision superiority is the application of knowledge by leaders to make the highest quality decisions directing assigned resources such that they maintain operational flexibility and agility. With its roots in the OODA loop, this concept includes psychological determinants such as will, capability and intent.

motivations that constitute an adversary's infrastructure, as well as on the global state of the socio-physical systems that comprise the adversary and international system'.[16]

19. In summary, ONA proffers an understanding of the nature, structure, and vulnerabilities of key critical nodes or targets in a 'system of systems'. ONA is continually updated to support an ongoing planning process for each selected contingency. Its utility extends from peacetime interaction with potential adversaries through the conduct of rapid decisive military operations. Given the level of understanding provided by the ONA, EBO planners, assisted by sophisticated decision support tools, can identify appropriate response mechanisms, the body and sequence of means to upset the adversary's coherency, and coerce him to actions that are favourable to national and coalition interests. The objective is to provide the decision makers with a current analysis of the adversary's capabilities and vulnerabilities (or 'nodes'), as well as an array of effects-based options that can be applied to adversary courses of action as they are identified.

COMPLEX SYSTEMS AND EBO

20. The most direct implications of EBO in the future are likely to lie in the areas of command and control (C2). That said, the Effects Based Approach relies on a firm understanding of complexity theory, causality, networking and complex adaptive systems (CAS) theory. EBO and complexity theory both deal with how a widely distributed collection of diverse autonomous agents acting individually can nonetheless behave like a single, even directed, entity.[17] Alternatively, traditional (Newtonian) science has always provided metaphors and models for isolated military concepts and, even more fundamentally, it has provided *the* general paradigm that has classified Western culture. This paradigm shapes both our interpretation of the problems we face and the solutions we generate to those problems. It is mechanistic, measurable, and reliable.[18]

21. The traditional Western way of warfare has been as heavily informed by Newtonian principles. As such, it would follow that, like other events, warfare is deterministically predictable—given knowledge of the initial conditions and having identified the universal laws of combat, one should be able to resolve specific political and military issues and predict the results. Indeed, for argument's sake, all Newtonian systems can eventually be distilled to one concept: linear *cause and effect*. In fact, such efforts to quantify cause and effect in war have been numerous, with some recent

[16] Saunders-Newton and Frank, *ibid*, p.3.
[17] Paul Davis and Brian Michael Jenkins, 'The Influence Component of Counterterrorism: A Systems Approach', *RAND Review,* Spring 2003, Web edition, www.rand.org. Accessed, 7 May 2003.
[18] See, for example, arguments presented in Murray Gell-Mann, *The Quark and the Jaguar* (London: Abacus, 1994), pp. 84-85. Note also that Gell-Mann also considers the rarity of revolutionary scientific paradigm shifts (as defined and extrapolated by Thomas Kuhn in *The Structure of Scientific Revolutions*.)

methodologies including those used in the Correlates of War (COW) Project[19]. All this to say that the more one wishes to understand war, the more willing one is to accept the use of quantifiable means to assist us in an understanding. This implies that war is altogether 'knowable' and that which we cannot directly understand, we should be able to extrapolate scientifically. Unfortunately, this paradigm is limited when applied to EBO and the complex nature of future conflict.

22. The marriage of complexity theory to international security studies should come as no surprise. Indeed, since the September 11th terrorist attacks,[20] there has been increasing focus on non-linear theories as ways to help us understand, and mitigate, unpredictable and complex adaptive systems such as terrorism.[21] Complexity theory, then, can be viewed as an innate form for investigating the properties and behaviour of the dynamics of non-linear systems, such as warfare.[22] This stands in contrast to traditional methods within the theoretical domain designed to analyze the relatively non-linear world, such as statistics.

23. Complexity has been defined as:

> The set of deterministic theories that do not necessarily lead to long-term prediction… The numerical variables are still uniquely related to each other locally in space and time. But… we cannot obtain the future values implied by the theory just as a result of compact, well-defined manipulation of the present values.[23]

24. Complexity can appear even in apparently simplistic or deterministic causal situations, such as those in the natural world.[24] The mathematician Henri Poincaré showed that the motion of three celestial bodies, although governed by scientific laws, defied exact solution: while eclipses of the moon could be predicted thousands of years in advance, they could not be predicted millions of years in advance—a very short period in astronomical terms.[25]

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[19] J. David Singer and Paul F. Diehl, (eds.), *Measuring the Correlates of War* (Ann Arbor, MI: University of Michigan Press, 1990).
[20] United States, Department of Defense, *Quadrennial Defense Review Report,* 30 September 2001, p. 14.
[21] Ironically, it is rather late to arrive when compared to its use in fields such as economics, management, ecology, biology and physics. See for example, Dana Mackenzie, 'The Science of Surprise: Can complexity theory help us understand the real consequences of a convoluted event like September 11?', *Discover*, Web edition, www.discover.com/feb_02/featsurprise.htm. Accessed 8 July 2003.
[22] Douglas A. Van Belle, 'Unexpected Innovation: Lessons from Simulating Complex Anarchical Environments Over the Internet', *Van Belle,* Volume 22, Number 2, p. 18, Web edition, http://csf.colorado.edu/isa/isn/VANBELLE.html.
[23] Alvin Saperstein, 'Chaos: A Model for the Outbreak of War', *Nature*, Volume 309, pp. 303-305.
[24] Robert Jervis, 'Complex Systems: The Role of Interactions', in David Alberts (ed.), *Complexity, Global Politics and National Security* (Washington, DC: CCRP/Institute for National Strategic Studies, 1997), p. 46.
[25] *Ibid.*

25. As we know, linear systems portray an arrangement of nature (with all of its warts and foibles) where outputs are proportional to inputs, where the whole is equal to the sum of its parts, and where cause and effect are directly (or through inductive reasoning) observable. According to David Alberts, it is a scientific environment where prediction is facilitated by planning; success is pursued by detailed monitoring; and a 'premium is placed upon reductionism, rewarding those who excel in reductionist processes', in which large swaths of data are reduced to manageable morsels.[26] By contrast, non-linear systems consider the arrangement of nature, with all of its complications (including warfare), as an environment where inputs and outputs are not proportional; where the whole is not quantitatively equal to its parts; and, where cause and effect are not immediately visible.[27] It is the world of EBO—where phenomena are not visibly predictable but are self-organizing; where unpredictability defeats conventional methods; and, where self-organization defeats traditional control.[28]

26. It is clear that social interactions within political environments constitute systems and that the many outcomes within those systems are the consequences of complex interactions. In EBO, we are dealing with a system (or system of systems) where:

a. a set of elements are inter-connected so that shifts in the system produce changes in other parts of the system and;

b. the entire system exhibits properties and behaviours that are related to but different from the sum of the parts.

27. The result of this is that the systems within EBO display non-linear (and causal) relationships that cannot be understood by adding together the units or their relation. Indeed, many of the results of actions are unpredictable, unintended or unwanted.[29] Actions produce effects, but these effects may be neither the intended results of the action, nor what was wanted to achieve the overall objective.

28. International relations are full of inter-connections and complex interactions. Ripples move through channels established by interests and strategies.[30] Therefore, when these interactions are elaborate, or multidimensional, the ramifications will be as

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[26] David Alberts, *Complexity, Global Politics and National Security* (Washington, DC: CCRP/Institute for National Strategic Studies, 1997), p. xiii.

[27] M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon and Schuster, 1992).

[28] This argument has evolved, in part, from a University of Maryland project on complex adaptive systems. See, Kiersten Blair Johnson, 'The Development of Progressive and Sustainable Human Complex Adaptive Systems: Institutions, Organizations and Communities', 1999. Web edition, www.wam.umd.edu/~nafikiri/webcomplex.htm. Accessed, 17 June 2003.

[29] Robert Pool, 'Chaos Theory: How Big an Advance?', *Science,* Vol. 245, 9 July 1989.

[30] Note a study on modelling civil violence in Joshua M. Epstein, John D. Steinbrunner, Miles T. Parker, 'Modeling Civil Violence: An Agent-Based Computational Approach', *Center on Social and Economic Dynamics,* Working Paper, Number 20, January 2001.

well.[31] Similarly, when planning EBO, one must consider, and mitigate, the wide array of potential, possible, and probable effects and cascading effects which may result from a single course of action. In a system, the chain of consequences extend over time and space and the effects of actions are always multiple. Any disturbance of a 'node' within the system, or the disturbance of a system within a system of systems, will produce several effects. Consequently, and contrary to all the hopes and aspirations of strategists, one cannot always find or develop *the* key agent which will produce *the* desired effect. For example, one cannot (nor should not) expect to link with linear methods one hundred years of scientific, economic, and cultural degrees to the events on September 11th. That is, a link from Ernest Rutherford to Albert Einstein to Robert Oppenheimer to Harry Truman to Joseph Stalin to Winston Churchill to Jawaharlal Nehru to Mohammad Ali Jinnah to Prince Mohammed Daoud to the Mujahideen to the Taliban to Osama bin Laden, although arguably causally sufficient is not causally logical in a non-linear system. Because of the prevalence of inter-connections, we cannot understand systems by simply summing-up the characteristics of the parts.[32] More precisely, actions interact to produce effects that cannot be readily comprehended by linear models.[33] Agreed, we may intuitively expect linear relationships, but this is not possible, particularly in warfare.[34] Moreover, the effect of one series of characteristics can depend heavily on what other characteristics are within the environment.[35] Interestingly, even if one were to hold true Michael Doyle's thesis that democracies do not fight each other in a world where other regimes exist, it would not hold true that an entirely democratic world would be a peaceful one.[36]

29. EBO are not linear; nor is the ONA process that feeds them. They are conducted in an open, collaboratively distributed, non-linear system sensitive to initial conditions and characterized by complex, continuous feedback. Thus, EBO are a *process* rather than an event. The environment in which EBO operate, the 'system of systems', is an open system--continuously exchanging energy and information with other systems and with the strategic environment at large. EBO are in a continuous state of flux—they operate within the perpetuity of crisis, conflict and post-conflict resolution. Planners and decision

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[31] See also, Garrett Hardin, 'The Cybernetics of Competition', *Perspectives in Biology and Medicine,* Vol. 7, Autumn 1963, p. 80.

[32] Allan Beycheren, 'Nonlinear Science and the Unfolding of a New Intellectual Vision', in Richard Bjornson and Marilyn Waldman (eds.), *Papers in Comparative Studies,* Vol. 6. (Columbus, OH: Center for Comparative Studies in the Humanities, Ohio State University Press, 1989).

[33] Kenneth Waltz, *Theory of International Politics* (Reading, MA: Addison-Wessely, 1979); Charles Perrow, *Normal Accidents* (New York: Basic Books, 1984.

[34] Roger Beaumont, *War, Chaos, and History* (Westport, CT: Praeger, 1994).

[35] These may be linkages but not necessarily logically causal ones.

[36] Michael Doyle, 'Michael Doyle on the Democratic Peace', *International Security*, Volume 19, 1995, pp. 180-184; see also Robert Jervis, *ibid,* p. 52.

makers must, therefore, be cognizant of interactions and linkages between nodes, or targets, within and between systems. (Figure 3).

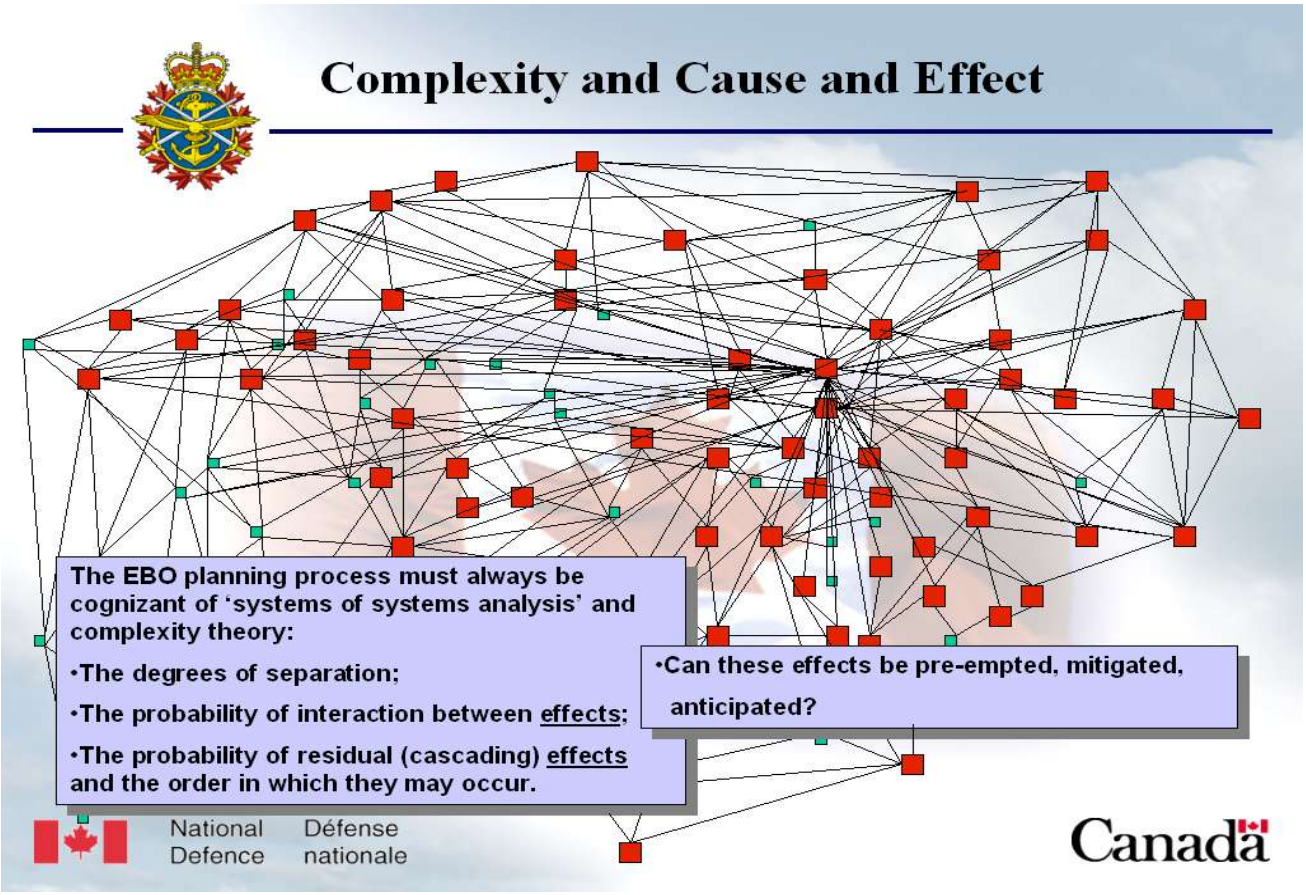

Figure 3: Complexity and Cause and Effect.

30. Complexity theory and causality theory, then, provides a fundamental theoretical background to the complex nature of conflict generally and EBO specifically. The challenge is to apply this understanding to the operational planning levels.

EBO IN A VIRTUAL ENVIRONMENT

31. If we are to treat war as a non-linear system, two premises emerge:

a. War, as we traditionally understand it, is uncertain;

b. War, as we traditionally understand it, is uncontrollable, given our linear understanding of command and control.

32. Uncertainty is a natural and unavoidable product of a dynamic endeavour such as war. Complex systems cannot be manipulated to suit our current understanding of the so-called 'battlespace'. On the other hand, decision makers can adapt to complex systems and produce technology enablers to help mitigate uncertainty. Thus, if EBO are uncertain and uncontrollable, one might consider technological enablers as means of

achieving at least *relative* certainty and *relative* control. In the end, it is not a question of whether we will ever have the technology to gather enough information to understand the complexities involved in EBO, but once we have the capability, how can we best use it to best shape events?[37]

33. The quest to remove uncertainty from strategic and operational planning has always dominated warfare. Indeed, recent US and coalition political/military experiments have been specifically designed to help mitigate uncertainty.[38] US-led experiments on 'collaborative information environments'; 'dominant effects'; 'network-enabled capabilities'; and, 'rapid-decisive operations', have all placed an emphasis on technological enablers to help achieve certainty.[39] Interestingly, this reliance on technology to mitigate uncertainty reflects the reality of a technologically advanced US military unsure of its future role in global affairs,[40] not to mention a very conscious defence decision to transform that was initiated under Secretary of Defence Donald Rumsfeld.[41] As mentioned above, the MNE III experiment is designed to test the processes, organizations and technologies required to conduct Effects Based Planning. Once the experiment is concluded and analysis completed, recommendations will be forwarded to DND through ORD.

34. According to some military theorists, 'to date, most warfare has taken place within what Robert J. Bunker terms the "human space", meaning the traditional four-dimensional battlespace that is discernible to the human senses'.[42] This traditional space has taken place with human beings doing their best to hit with projectiles other human beings who are, in turn, doing their best to hit with projectiles other human beings. Advances are being made, however, that propose placing humans 'on' the periphery of battle.[43] There is a progression being made of ever more capable machines taking the

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[37] Jeffrey Cooper, 'Diplomacy in the Information Age: Implications for Content and Conduct', *iMP Magazine*, Web edition, www.cisp.org/imp/july_2001/07_02cooper.htm, July 2001. Accessed, 17 June 2003.

[38] Recent exercises have included USJFCOM-sponsored multinational experiments such as Limited Objective Experiment 2 and the forthcoming Multinational Experiment 3.

[39] William M. Arkin, 'A New Mindset for Warfare', *Washington Post*, Web edition, www.washingtonpost.com/ac2/, 22 September 2001, p. 3. Accessed, 17 June 2003.

[40] David C. Gompert and Irving Lachow, 'Transforming US Forces: Lessons from the wider revolution', *Issue Paper,* RAND/National Defense Research Institute, 2002, Web edition, www.randf.org/publications/IP/IP193/. Accessed, 22 October 2002.

[41] United States, Department of Defense, *Quadrennial Defense Review Report,* 30 September 2001.

[42] Thomas K. Adams, 'Future Warfare and the Decline of Human Decisionmaking', *Parameters,* Winter 2001-02, pp. 57-71; also Robert J. Bunker, *Five-Dimensional (Cyber) Warfighting* (Carlisle, PA: US Army War College, Strategic Studies Institute, 10 March 1998, pp. 7-8.

[43] There are numerous sources on this topic. Some of the more applicable to this article include, Dan Hunter and F. Gregory Lastowka, 'To Kill an Avatar', *Legal Affairs,* May/June 2003, Web edition, www.legalaffairs.org/issues/July-August-2003/feature_hunter_julaug03.html. Accessed 3 July 2003; Matthew Brzezinski, 'Autopilot: Can the Next War be Fought with no Soldiers at All?', *New York Times Magazine,* 20 April 2003, pp. 38-40, 80.

place of humans in the battlespace. More significantly, these progressions include, most notably, 1) computer-driven information gathering and synthesis systems; and, 2) the proliferation of autonomous tactical weapons systems, i.e., robotic systems. More and more elements of warfare are evolving beyond the realm of the human senses, and, more importantly, crossing outside the limits of human reaction and assessment times.[44] Logically, then, military systems, once integrated, will eventually be 'too fast, too small, too numerous, and will create an environment too complex for humans to direct'.[45]

35. None of this is accidental. As mentioned, emerging technologies are well within the mandate of the two most recent US QDRs and have been explored by most Western armed forces.[46] Secondly, these enablers have been actively pursued by the military despite post-Cold War Western defence expense reductions. Knowledge is seen as the key to the successful achievement of an objective; speed and accuracy are seen as the keys to exploiting that knowledge, and, computer-assisted decision making tools are an inevitable evolution of this process. Consequently, it is all the more simple to envisage a steadily altered role for humans in decision making and operations as the century progresses.[47]

36. A fundamental development underlying the evolution (or devolution) of human control is that of automated information and networking systems. A recent US TRADOC paper has claimed:

> Advances in computer architecture and machine intelligence will have reached the point where intelligent agents can analyze the environment and current battle situation, search likely target areas, detect and analyze targets, assist in attack decisions, select and dispense munitions, and report results.[48]

37. Indeed, the difference between a machine that can do all of these things and actually make key decisions may only be a matter of programming. The above is a description of computers that can function autonomously to conduct asymmetric warfare

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[44] Thomas K. Adams, *ibid.,* p. 58.

[45] *Ibid.* Examples include the emergence of directed energy weapons (DEWs) with capacities for engagement at the speed of light; developments in nano-, bio-, and quantum-technology; 'digital army' initiatives such as the Land Warrior system; semi- and fully autonomous robotic systems; the first operational light-speed weapon, the US Air Force's Yal-la Attack Laser; microwave systems; and tiny MEMS (Micro-Electro-Mechanical Systems).

[46] Kip N. Nygren, 'Emerging Technologies and Exponential Change', *Parameters*, Summer 2002, pp. 86-99, Web edition, http://carlisle-www.army.mil/usawc/Parameters/02summer/nygren.htm

[47] This is a major philosophical issue unable to be explored further in this article. See Michael Ignatieff's excellent study on this topic, *Virtual War* (London: Vintage, 2000); John Leech, *Asymmetries of Conflict* (London: Frank Cass, 2002); Batya Friedman and Lynette Millett, '"It's the computer's fault": Reasoning about computers as moral agents', Department of Mathematics and Computer Science, Colby College, 1995, Web edition, www.acm.org/sigchi/chi95/Electronic/documnts/shortppr/bf2_bdy.htm. Accessed, 17 June 2003.

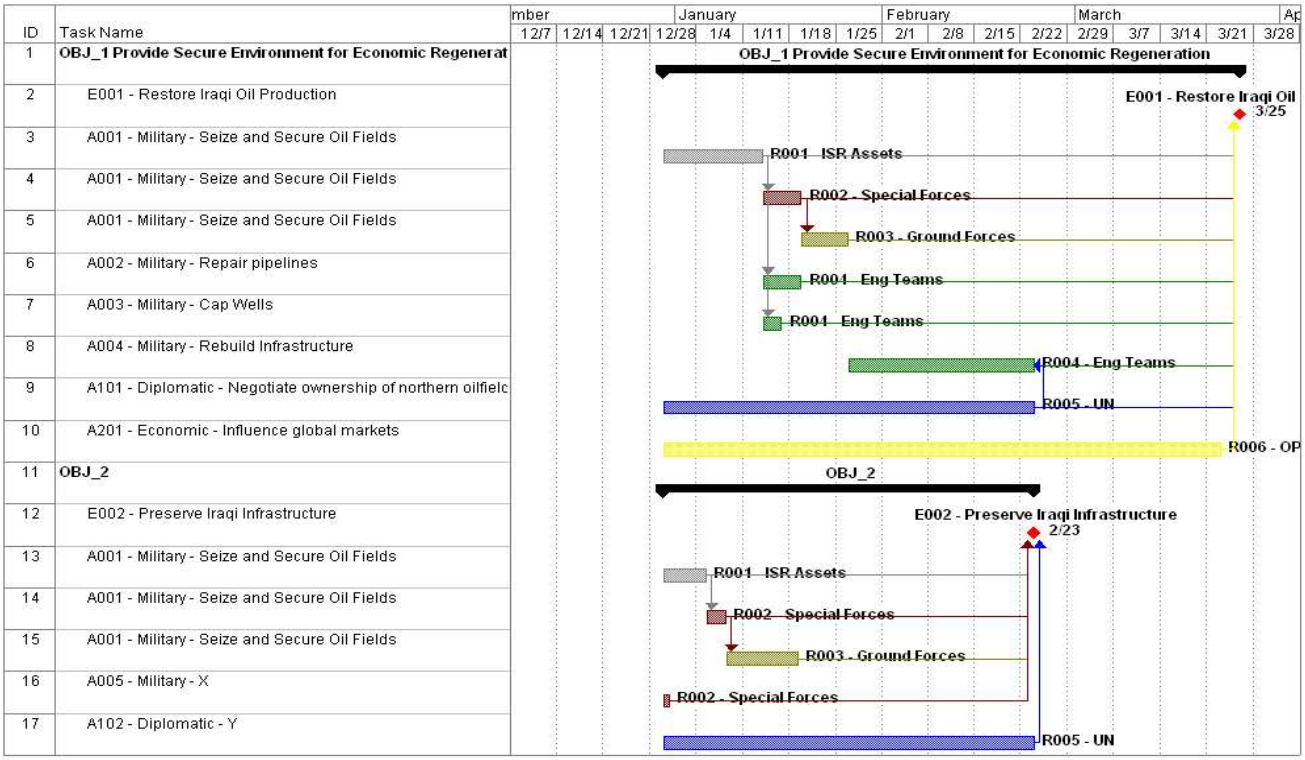
[48] US Army Training and Doctrine Command, 'Concept of Employment for Unmanned Systems (Draft)', 24 August 1999, p. 4.

at the tactical level. If anything, the description is an understatement. This author suggests that within our lifetimes, computers may be capable of planning, tasking, and assessing events at the operational level. During MNE III, the coalition planners for the EBP process will test a number of different software packages during each of the planning steps. Canada, in particular, has taken the lead for both the conceptual development and design of a technological tool that would enable planners to synchronize desired operational effects across time and space. This tool, to be tested in MNE III and subsequently analyzed by ORD, is expected to adapt proposed effects to actions to available capabilities in order to provide planners with a visualization of what the 'best' course of action would be based on probabilities of success, resource constraints, action usage and required predecessors. (Figure 4). Subject to experimentation and analysis, this tool may be worthy of further development for DND and OGD crisis management and EBO.

38. There have been several recent defence science investigations into the marriage of technology to complex thinking and complex adaptive systems such as EBO. The TTCP JSA AG10 'Technologies for Effects Based Operations', in which Canada has participated, focussed on modelling and analysis concepts and tools and techniques that would bring both analytical rigour and assistance to decision making in the complex environment of EBO.[49] Included in the exploration were physical models (such as the Canadian GEOPOL model), in which physical networks are characterized by nodes and links with sources and sinks, plus material stocks and flows; virtual network models, (including the Australian Analytica Model and the Danish Hugin model), in which networks of relationships can be listed hierarchically and assigned relative value, or, which may bring an ability to build interactive causal networks for strategic indicators and warnings that aid operational planning. The US SIAM (Situational Influence Assessments Module) software application purports to streamline complex decision making by facilitating the construction and analysis of an influence net model. The net model depicts events and their causal relationships.

Figure 4: Effect Synchronization Example. Effects can be synchronized over time and space based on resource constraints, predecessors, action doubling and usage.

[49] 'DRAFT Final Report of TTCP JSA AG10 "Technologies for Effects Based Operations"', Unclassified, December 2003.



39. Current computer technology has not yet begun to approach its theoretical limits. In 1998 (a long time ago in computer terms), scientists at Los Alamos National Laboratory announced that they had been able to consistently manipulate subatomic particles, thus opening the way for computation systems an order of magnitude smaller and faster than anything in existence.[50] In 1999, researchers at UCLA began work on a molecular computer with a processing power of 100 personal computers. In October 2001, American company ASI revealed the development of its KARNAC suite, a software package that uses human 'profiling' and data mining techniques to sift through seemingly unrelated pieces of information in order to pre-empt terrorist attacks before they happen.[51] More recently, Professor Wilpen Gorr and researchers at Carnegie Mellon's Heinz School have created a computer programme that forecasts 'criminal' activity before it occurs. Gorr's programme is based on a sophisticated trend analysis of criminal activity combined with an ability to predict with some degree of probability

[50] 'Breakthrough Made in Subatomic Manipulation', Scripps-Howard Newspapers, 8 November 1998. Web edition, www.nandotimes.com.

[51] Duncan Graham-Rowe, 'Intelligence Analysis Software Could Predict Attacks' *New Scientist.com,* Web edition, www.newscientist.com/news/print.jsp., 2 October 2001. Accessed, 17 June 2003. See also ASI Website, www.asinc.com for information on their PreAct® Libraries.

future criminal activity.[52] The implications of such advances are almost unimaginable: inexpensive, ubiquitous supercomputing in minute machines so advanced that they can gather, assess, and analyze thousands of strands of complex information. This is not to suggest that there will ever be a conscious decision to remove humans from battlefield decision making; rather, in the future, soldiers might retain less control, whilst gradually leaning towards advanced systems whose logic dictates that human control become more obscure.[53] The implications for complex analyzes such as Effects Based Planning (EBP) are equally fantastic. How can one effectively and efficiently plan for tasks in order to achieve a stated strategic objective?

40. As technology advances, one might expect the clarity of EBO computer models to improve exponentially. Of course, linear algorithms may never be able to replicate the non-linear and often unquantifiable logic of war. Indeed, the history of human conflict is littered with examples of how armed forces achieved results that no algorithm would have predicted.[54] EBO, however, might be executed completely outside of the human space. The concept of 'net-war' assumes that conflict will eventually be waged virtually within and amongst computer systems attacking the full spectrum of opposing military and civilian information systems. By its very nature, then, the speed and accuracy of EBO may be limited only to the speed of the electronic circuit boards in which it develops. EBO is complex and adaptive, with operational moves often too pervasive for human intervention. In the end, both offence and defence might be completely automated, simply because humans will be far too slow and linear to participate. As a caveat, one might also assume that the panacea of technology may not appear as sufficient as one might expect. Indeed, there are several mathematical, engineering, technological, and temporal/spatial, not to mention ethical, issues that require attention before such an advance be considered an appropriate enabler of EBO. Nonetheless, one suspects that the future of EBO requires further investigation of the technological potentials.

CONCLUSION

41. This paper has been deliberately suggestive: future conflict is uncertain and complex and Canada must understand it. The paper has introduced the concept of EBO and argued that its planning and execution rely on an understanding of the complex

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[52] Wilpen Gorr, 'Cloudy, with a chance of theft', *Wired*, September 2003, pp. 79-80.

[53] One should also note the development of 'computerized knowledge assessment' (CKA), or brain fingerprinting, which analyses brainwaves to predict terrorist attack. See Steve Kirsh, 'Identifying terrorists before they strike by using computerized knowledge assessment (CKA)', www.skirsh.com, 7 October 2001, Accessed, 17 June 2003.

[54] Charles J. Dunlap, Jr., 'Technology: Recomplicating Moral Life for the Nation's Defenders', *Parameters*, Autumn 1999, Web edition, http://carlisle-www.army.mil/usa/Parameters/99autumn/dunlap.htm. Accessed, 2 May 2003.

nature of conflict and on theories of complex adaptive systems and causality. An acceptance of EBO demands a shift in mind-set, as well as the application of sophisticated technologies to the overall planning, decision making, execution, and assessment phases of an operation. The effective management and manipulation of large quantities of evolving data is essential in order to achieve and maintain shared situational awareness both within and outside of an area of operations (or system of systems) and to gain an understanding of what effects may, or may not be, achieved with the available resources. If EBO are to function efficiently and with the appropriate level of accuracy and speed required in the future security environment, there is a need for alternative methods to assist leaders and planners in recognizing where, and why, uncertainty exists.[55] Traditional linear methods of warfare are no longer suitable; neither are the traditional means of operational planning, decision making and command and control. As Charles Darwin stated, 'Nature is prodigal in variety, but niggard in innovation'.[56]

42. As noted, this study is the first in a series of monographs on the Effects Based Approach. It has introduced EBO as a concept that relies heavily on the injection of specific inter-agency, academic, corporate, diplomatic, economic and coalition intelligence knowledge for the formulation of an Operational Net Assessment (ONA), as well as a recognition of the technological means needed to assist the decision maker in ascertaining the complexity of desired tactical end-states, or, 'effects', required for the attainment of a strategic objective. It is suggested that Canada pursue the exploration of this concept.

43. The advantages that the Effects Based Approach may offer rely heavily on a shift in the psychological mind-set of the decision maker, as well as a suitable application of technology to the overall planning, decision making, and analysis phases of an operation, be it humanitarian, developmental, defence or a combination thereof. If EBO are to function efficiently and with the appropriate level of accuracy and speed, there is a requirement of governments and armed forces for alternative thought processes to assist operational planners in recognizing where challenges and uncertainty may exist. As mentioned, in Canada, this may require a series of shifts that include:

a. Greater inter-agency cooperation *and* coordination of planning and operations;

b. Greater inclusion of academia, IGOs and NGOs, and private industry in planning for crises, mitigating threats, planning for 'effects', and developing a robust ONA;

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[55] Roger Lewin, *Complexity: Life at the Edge of Chaos* (New York, Macmillan, 1992).
[56] Charles Darwin, *Origin of Species* (New York: Modern Library Edition, 1936), p. 143.

c. Further exploration, both nationally and with international partners, of the complex nature of warfare generally and EBO specifically;

d. Further exploration of the requirements needed to operationalize EBO;

e. A cross-government appreciation of the advantages of adopting an Effects Based Approach as a major operating concept of the future.

44. Taking the above into account, the following recommendations should be considered:

a. Continued Canadian involvement in the development of the EBO concept within a multinational environment, i.e., specifically in terms of conceptual refinement, what can Canada provide the international community, or, what can the international community provide Canada?

b. Continued Canadian involvement in the development of analytical tools and techniques that assist in the refinement, collation and visualization of complex systems;

c. An investigation into a suitable organizational framework for a Canadian headquarters structure and Effects Based Inter-Agency C2 structure;

d. An exploration into the relative merits of Canada adopting the Effects Based Approach. Is it feasible? Does it merit substantial organizational, functional, operational re-evaluation of the CF? Does it merit financial allocation?

e. An assessment of the Effects Based Approach and its inclusion into a major Canadian defence paper, or, strategic concept.

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