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"Adapting C2 to the 21st Century"
"Operational Command and Control in the Age of Entropy"
(Track 1; Track 5)

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ABSTRACT

"Operational Command and Control in Age of Entropy"
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Operational leaders face a myriad of command and control challenges in 21st Century warfare. These challenges all have a common denominator: the increasing macro-effects of entropy. Entropy effects are far more than Clausewitzian friction on and in the battlespace; they are intrinsic to the very command and control supra-system, its information and succeeding actions. This paper discusses the more important entropic effects as they affect operational art and operational science. It concludes that militaries face significantly different problem-solving and decision-making challenges than in the past: instead of planning to maximize one's maximum benefit in operations (overwhelming force), one will be forced to plan on minimizing one's maximum regret (lowering expectations.) Militaries must realize that there is no way to avoid these effects, and that they must expect and plan for the increasing appearance of them in all operations.

PAPER OUTLINE (Tentative)

"Operational Command and Control in the Age of Entropy"
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Introduction:

a. The Problem: non-linear, non-deterministic, quantum (micro) effects and behavior is now beginning to appear in the macro-world. These effects are beginning to appear in large scale physical world and societal behavior. They are appearing because (a) the world is fast becoming a closed system because of its interconnectivity and (b) because human societies are becoming closed systems due to globalization of information, economies, and culture.

b. Entropy, or "lost energy and information," is one salient indicator of the reality of these effects. Entropy is technically defined in the Second Law of Thermodynamics and in Shannon's Law of Information Entropy. Both laws are mathematically interchangeable and address then same phenomenon only in different guises. Simply put, entropy means that anything that one does always will result in lost energy and information; no action or operation's benefits ever can meet, let alone exceed, its costs. In the past, because the world and human societies appeared large and open systems, humans appeared to be able to produce local "negative entropic" actions and behaviors, like the construction of industry and cities. With the decreased openness of the world and human societies (the small world or six degrees phenomenon), the illusions of those actions and behaviors have become increasingly apparent (for example, global warming.)

c. Militaries, because of their relative large size within their specific societies, are prone to entropic effects. One can witness this through an application of Augustine's Laws; the increasing unit cost of military equipment is precisely one indicator of information entropy. Carl von Clausewitz was the first strategist to systemically address entropy in military operations through his use of friction, a classical physics term that captures the idea of energy entropy. Even in Operation Iraqi Freedom, although the human resources of the U.S. led Coalition were small, the material and information resources were extremely large, so large that they even dwarfed the comparable (in speed and Area of Operations size) operation, Fall Gelb, the German invasion of France in 1940.

Body:

a. Operational command and control is a function of operational leadership; it is also a necessary function for any military operation to succeed. Military operations as currently practiced depend on excellent application of operational art and operational science (the term is adapted from J.F.C. Fuller.) There are entropic effects now affecting both the art and the science.

b. Entropic effects on Operational Art as related to Command and Control

1. Affecting Operational Factors (Force, Space, Time): the trade-offs among these factors no longer is an equivalence relationship. Space and Time now are inextricably related to each other, and Force, a measure of Mass, can be shown to shape Space and Time as much as Space and Time defines necessary Forces. However, the relationships are probabilistic and result in more complex and vulnerable C2 informational bandwidths and channel capacities to make the trade-offs work.

2. Affecting Operational Elements: culminating points become more difficult to predict and less stable when they occur; center of gravity loses its relevance as a planning concept because it requires too much information and channel capacity to overcome the Heisenberg Uncertainty associated with trying to pin down such centers; decisive points become both more numerous and less decisive due to indeterminacy, a characteristic of information entropy.

3. Affecting Operational Geometry: dimensions of operations (sea, land, air, virtuality, space) become highly mixed and complex; operations addressing these mixes require increased coordination which in turn requires increased information bandwidth and channel capacity which in turn leads to overload, and eventual loss of information or knowledge or situation awareness. Lines of convergence/divergence, interior/exterior lines, lines of communication and operations in the various dimensions become much complex and sometime irrelevant as the geometry defining them becomes more multi-dimensional Riemannian as opposed to the linear Euclidean concepts that now describe Theater Geometry.

4. Affecting Operational Functions: the six necessary and sufficient operational functions now require more energy (including forms of mass) and more information to integrate and work towards operational success. The challenge becomes more one of minimizing mistakes and minimizing stovepipes as opposed to maximizing integration and interagency effort.

5. Affecting Operational Planning: the concepts associated with operational planning are already extraordinarily complex; the challenges associated with such planning are overcome through collaborative planning techniques and software that enable increased efficiency of information use among a very large planning community. However, the planning concepts are now frozen in products like OpPlans and OpOrds. OIF demonstrated entropic effects through radical and constant revisions to the OpPlan (over 20 major changes vice 2 major changes in DESERT STORM) that can now be expected to be the norm due to the expanded bandwidth and channel capacity associated with collaborative planning. Energy entropic effects can expect to hem in planners because of relative scarcity of manpower, equipment and logistics (especially fuel, food and ammunition.)

6. Affecting Operational Leadership: existing operational leadership concepts still focus on the leadership as an individual. The entropic effects on the already complex and non-linear operational planning efforts will force a revision of this concept; operational leadership will become organizational leadership, or more

specifically for the military, battle staff integration. Perhaps even the very idea of command and control will have to evolve to an alternative concept.

c. Entropic Effects on Operational Science

1. Affecting Operational Science concepts: there are five operational science concepts: space, energy, mass, information and time. Each has found expression in operational planning, using Newtonian physics as the baseline for their definition. While this has worked in the past, increasing globalization among human societies and interconnectivity of the world has changed the way humans act and has changed the world as an ecological system. The result is that rather than appearing as an open and deterministic system, upon which Newtonian science depends, the world and human societies now appear closed and indeterminate. In other words, the world and human society is beginning to exhibit Quantum science traits. This means that different design characteristics for complex indeterminate systems and processes will be needed; no longer will optimization be a sufficient design characteristic, but rather robustness, resiliency, and redundancy will have to become the system and planning parameters of choice. New ideas like coherence/decoherence and superpositioning will have to modify ideas about these operational science concepts; most especially, uncertainty will have to be accounted for in any application of the concepts. Separation of operational concepts in application no longer will be possible; all the concepts now are intrinsically interconnected and mutually affected in what physicists now call "strange ways."

2. Affecting Operational Science conceptual relationships: current operational planning doctrine implies the equivalence of the relationship among space, energy, mass, information and time. Military leaders and planners routinely substitute one for the other: for example, shock and awe (maximum use of energy and information) is meant to replace mass (overwhelming force.) Entropic effects affect this relationship by destroying the equivalence and replacing it with limits and probabilities of near equivalence. Operational leaders and planners will have to become very comfortable with ideas involving probability and the calculus to be able to achieve some semblance of operational success.

Conclusions:

a. Summary of argument.
b. Command and Control morphs into Coordination and Tracking?
c. Changes are inevitable and unavoidable. Entropy is irreversible.
d. Basic mindsets must change, not hardware and software.
e. "People fight wars, not machines. And people use their minds!" John Boyd, 1987.