The Return of Friction and the Transformation of US Naval Forces in the 21st Century

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ABSTRACT

In the decades which have followed the end of the Cold War, the US military has hesitantly explored the transformation of its forces. Uncertain as to what it should transform into, it is equally unsure as to how it should go about the process of transformation, let alone why it should transform in the first place. Fiscal constraints have driven some transformation, a commonsensical realization that the perceived enemy has changed has introduced more, and technological discoveries have prompted still more transformation; yet the military of the 21st century is set to be only incrementally evolved from its late 20th century parent. In no other service is this *début-de-siècle* structural uncertainty as apparent as in the US Navy- lashed as it is to the concept of the super-carrier until well into the mid-21st century. This paper explores the transformation of a segment of the US Navy not purely as a reaction to newly available technology and the like, but as a response to a new appreciation of the maritime battlespace: an appreciation driven by the still-unfolding theoretical fruits of the Revolution in Military Affairs. This transformed force, a naval swarm, will not only be a viable option for both 'blue' and 'green/brown' water battlespace dominance, but will also be a first step in learning how to operate within a chaotic battlespace rich in what Carl von Clausewitz termed "friction."

INTRODUCTION

The US military is in the midst of a Revolution in Military Affairs (RMA) and it is a revolution that will ultimately deliver unheard of precision, firepower and command and control capabilities. Understandably, few have disputed the advances that the RMA promises. However it is possible that the RMA has also done the US military a great disservice, for in the same motion with which it swept up that community in a wave of brilliant munitions, cool carbon composites and cooperative engagement systems, it has also blinded it to what used to be – or so it seemed — a guiding principle of war. Carl von Clausewitz, in his opus *On War* wrote that "everything in war is very simple, but the simplest thing is difficult." Put another way, our lost dictum is this: *things fall apart*. Entropy rules. Plans fail; technology does not deliver when called upon; at the crucial moment people do not act as they should. Sometimes we realize that we cannot penetrate the "fog" [1] of our enemy's intentions; we do not know what the enemy is planning or we cannot understand what the enemy's goal is; sometimes we do not even know who the enemy is.[2] The very environment breeds entropy, and, borrowing Clausewitz's term, it exerts a frictional force upon both the corporeal: our forces, and the incorporeal: our plans and intentions.

The importance of uncertainty, friction, and disorder are well noted in the literature of the US military,[3] but for all the attention paid to these phenomena the advent of the RMA seems to be persuading many that friction and disorder are merely obstacles to be hurdled with technology and then disregarded. It has, for example, become unfashionable in contemporary military thought to write of the Clausewitzian notions of the "fog and friction of war,"[4] as constant companions to even the most digitized troops and the most networked fleets. Indeed, some advocates of the RMA have discarded Clausewitz's cautions as anachronisms and have embraced the RMA's promises of improved situational awareness and theater domination with a near-theological fervor, stating:

> as computers, communications, and associated sensor technologies improve in power, speed and acuity, the ability to see everything within a given area will continue to improve, in some cases, at very fast rates. If it improves enough, even perfect situational awareness may *understate* what U.S. forces can see.[5]

Without any disrespect intended to the warfighters, however, it is a truism that "2500 years of history confirms that ambiguity, miscalculation, incompetence, and above all, chance, will continue to dominate the conduct of war."[6] Indeed, whether we look at the relatively recent mistaken bombing of Canadian forces in Afghanistan by the US Air Force, the failure in

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[1] Carl von Clausewitz, *On War*, Michael Howard, and Peter Paret, eds., trans., Princeton University Press, Princeton (NJ): 1976, p. 119
[2] *See*, Capt. Harold R. Van Opdorp, Jr., "Technology Alone Cannot Win," *US Naval Institute Proceedings*, November, 1997, pp. 32-34
[3] *See*, *FMFM-1: Warfighting*, United States Marine Corps, 1989
[4] Barry D. Watts, *Clausewitzian Friction and Future War*, McNair Paper 52, Institute for National Strategic Studies, National Defense University, Washington D.C.: 1996, p. 3
[5] Martin C. Libicki, "DBK and its Consequences," *Dominant Battlespace Knowledge*, Stuart E. Johnson and Martin C. Libicki, eds., National Defense University, Washington D.C: April 1996, p. 24, emphasis in original.
[6] Maj. Gen. Robert H. Scales, *Future War*, US Army War College, Carlisle Barracks, PA: 1999, pp. 25-26

intelligence that led to the US strike on the Chinese Embassy during Operation Deliberate Force, or the firing on the USS *Missouri* by the USS *Jarrett* during the Gulf War,[7] it is clear that Clausewitzian fog and friction still beset the modern-day warrior even while he is in the throes of a revolutionary increase in military sophistication. As US Marine Colonel T. X. Hammes wrote in the July 1998 issue of *Proceedings*, "fog and friction are forever."[8]

This fact raises unavoidable questions: if, almost seemingly regardless of our efforts to the contrary, friction appears to penetrate every major military endeavor, then are we mis-characterizing the concept of warfare as a whole? How does this affect our determination to impose total control or rationality over the battlespace? What changes in doctrine or organization would an altogether different characterization of war prompt?

This paper addresses the issue of force transformation by examining these questions with a specific user in mind: the United States Navy (USN). For the purposes of this discussion I use the term "force transformation" interchangeably with the concept of creating a novel force structure where previously a legacy force may have attempted to fulfill the same capability. I offer that the creation of this novel, or new, force structure will occur when there is a wholesale acceptance of a new formulation of the *nature* of warfare. Such a paradigmatical or even tropological shift will occur as a result of the inclusion of the non-technological fruits of the RMA: concepts of non-linearity, chaos and complexity theory, and

[7] 4 Canadian soldiers of the 3rd Battalion, Princess Patricia's Canadian Light Infantry (3 PPCLI) Battle Group were killed and 8 wounded on April 17th, 2002, when 2 US F-16's mistakenly engaged the troops during night-time training exercises near Kandahar, Afghanistan. On May 7th, 1999, US bombers struck at what they thought was the Yugoslav Federal Directorate for Supply and Procurement (FDSP) in Belgrade, but was actually the Embassy of the People's Republic of China (PRC) to the former Yugoslavia. 3 civilians were killed and 27 injured in the attack. Lastly, on February 25, 1991, the USS *Jarrett's* Phalanx point-defense system mistakenly fired on a cloud of distraction chaff employed by the USS *Missouri*. The depleted uranium shells struck the *Missouri*, but there were no reported casualties. *See*, (respectively) General Maurice Baril (ret.), *et. al.*, *Tarnak Farm Board of Inquiry- Final Report*, Department of National Defense, Ottawa: June 19, 2002, p. 4; DCI George J. Tenet, "Statement on the Belgrade Chinese Embassy Bombing Before the House Permanent Select Committee on Intelligence," US Central Intelligence Agency, July 22, 1999, available at: www.cia.gov/cia/public_affairs/speeches/archives/1999/dci_speech_072299.html, accessed July 12, 2002; "Lead Sheet 14246: Interview of USS *Missouri* Executive Officer, January 23, 1998," End Note 187 to Tab H of "Friendly Fire Incident Descriptions," *Environmental Exposure Report II*, Office of the Special Assistant for Gulf War Illnesses, Washington DC: December, 2000, available at: www.gulflink.osd.mil/du_ii/du_ii_tabh.htm#TAB H_Friendly-fire Incidents, accessed July 16th, 2002

discussions of language, semiotics, and heuristics, into evaluations of military theory.[9] By applying the differing lexicons and modalities of thought and process that these fields offer, we find that our characterization of war moves from that of a linear, deterministic phenomenon, to a non-linear one. This shift in appreciation will drive naval force transformation.

The present discussion begins with a recapitulation, recombination, and reinterpretation of writings on Clausewitz's notion of friction and how friction's behavior demonstrates the non-linear qualities of war. The following is then posited: that based on war's non-linear and chaotic character, much of present day military analysis and the expectations of the RMA (based as they are on outmoded and fundamentally incorrect appreciations of a linear and deterministic type of war) are faulty, and restrict the efficiency of the very forces upon whom they are to bestow "full spectrum dominance."[10] This conclusion requires us to consider a radical transformation of our forces to suit the true nature of the non-linear battlespace. I propose that for the USN, this transformation should manifest in the creation of a maritime swarm force which will not only act as a proving ground for evolutionary forms of command and control, but will also fill a current capability gap in the USN's force structure: that of forces proficient in littoral, brown, and green water combat.

FRICTION

It is ironic that our point of embarkation upon a discussion of force transformation begins with the ideas of Clausewitz, who is arguably the greatest conventional classical military theorist, yet it is his notion of friction that drives the non-linearity of warfare. Friction, or *Friktion*, is the name of a concept refined rather than a concept created by

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[8] Col. T. X. Hammes, "War Isn't A Rational Business," *US Naval Institute Proceedings*, July 1998, pp. 22-25

[9] The inclusion of other fields of study into a security and defense discourse that has come about largely as a result of the RMA has been termed the "New Strategic Discourse" (NSD) by Michael Dillon. He conceives of the NSD as how mainstream US military thinkers *conceive*, *describe*, *communicate*, and *formulate* future military doctrine. *See*, Michael Dillon and Julian Reid, "Global Liberal Governance: Biopolitics, Security and War," *Millennium: Journal of International Studies*, Vol. 30 No. 1, 2001, pp. 41-66

Clausewitz in the early 1800's. Clausewitz applied Enlightenment thought and Newtonian scientific principles to a widely held (if rarely investigated) understanding of failure, chance and small variables creating disproportionally large consequences in war. It was this remachination of a general (albeit vague) abiding martial belief into a central tenet of his primary work, *On War*, that launched the concept so powerfully onto the stage of Western military thought. For Clausewitz, friction was the "only notion that more or less comprises those matters that distinguish the real war from war on paper." Friction was "countless minor incidents" that sapped a commander and his military machine of stamina and time.[11]

If the reader is beginning to think of friction as a manifestation of 'bad luck,' then he is in good company. By refining the concept of friction, Clausewitz "rendered one of the most important elements in his image of war —chance— subject to theoretical analysis."[12] Indeed, Alan Beyerchen believes that it is a possibility that Clausewitz was aware of Henri Poincaré's work on chance, and that this informed his own work on friction.[13] Whether or not Clausewitz knew of Poincaré's work, the fact remains that as a veteran and a theorist, Clausewitz was keenly aware of chance's role in war. As he wrote in Chapter Three (entitled "Military Genius") of *On War*,

> war is the realm of chance. No other human activity gives it greater scope: no other has such incessant and varied dealings with this intruder. Chance makes everything more uncertain and interferes with the whole course of events.[14]

As bound up in the element of chance as it is, one should begin to sense that the phenomenon of friction does not follow linear guidelines. Indeed, we find that Clausewitz

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[10] "CJCS Vision," *JFQ: Joint Force Quarterly*, Summer 2000, p. 61
[11] Clausewitz, *op cit*, p. 119
[12] Peter Paret, "The Genesis of *On War*," introductory essay to Clausewitz, *op cit*, p. 17
[13] Alan D. Beyerchen, "Clausewitz, Non-linearity and the Unpredictability of War," *International Security*, Volume 17, No. 3, Winter 1992, n.p., available at: www.dodccrp.org/copapp1.htm, accessed on 5 June 2002. Beyerchen is the definitive author on the issue of Clausewitz and non-linearity
[14] Clausewitz, *op cit*, p. 101

himself broadly hinted at the non-linear nature of war when he gave us the following example of friction plaguing an individual:

> imagine a traveler who late in the day decides to cover two more stages before nightfall. Only four or five hours more, on a paved highway with a relay of horses: it should be an easy trip. But at the next station he finds no fresh horses, or only poor ones; the country grows hilly, the road bad, night falls, and finally after many difficulties he is only too glad to reach a resting place with any kind of primitive accommodation. It is much the same in war.[15]

Here the friction (almost literally) seeps energy from the weary traveler, but the key element of this vignette is the feedback implicit in the tale. A frictional event occurs which affects the actor's (the traveler's) state of being and/or alters his options. Based on these changed conditions or options, a decision is made and the decision leads to actions which are once again affected by friction, and the process repeats itself.

Examine an updated example with more explicit feedback: imagine that on board a frigate there is a young radio operator who is unable to find the correct frequency to communicate with a fleet oiler which is steaming alongside the frigate.[16] Now let us suppose that, after a few moments of frantic searching, the erstwhile radio operator locates the reference card with the correct frequency on it (it was mistakenly placed elsewhere) and contacts the fleet oiler. The replenishment takes place, but does so a few minutes later than originally scheduled. This, in turn, affects a helicopter returning to the frigate from a rotation through a land-based maintenance section. The helicopter has had a faulty fuel line installed, and because it is required to fly the extra distance to meet up with the frigate (a result of the frigate being a few minutes off-station), the fuel line erodes that much more. Later that day, because of the extra stress placed upon it, the helicopter's line ruptures and it is rendered unairworthy, affecting the timely placement of an anti-submarine warfare (ASW) screen

[15] *Ibid.*
[16] While fictitious, this vignette is based upon events during NATO maritime exercise Strong Resolve 2002 in which the author participated and which took place in March of 2002.

ahead of the fleet. Because of this delay, a diesel submarine training with the fleet evades detection and closes with the allied ships.

Here the feedback is made much more explicit. One point of friction affects another either directly or indirectly, either slightly (making something occur later or earlier) or massively (encouraging or preventing another frictional event from occurring at all). In the current vignette, it is apparent that if the seaman had located the frequency card—in other words, if that first point of friction (F_1)—had not occurred then the erosion of the helicopter's fuel line—in other words, (F_2)—may have taken place later, which in turn may or may not have affected its status later on.

Points of friction 'feed back' into each other and are, in the end, functions of one another. This may be demonstrated thus:

Given that that reality (or R) is made up of an infinite number (or *n*) of events that may be considered friction:

$$R = \{ F_1, F_2, F_3, F_4, \ldots \}$$

⇓ and

Given that whether or not one of these events interferes with the actor is itself in part a function of another frictional event:

⇓

$$F_1 = f(F_2, F_3, F_4, \ldots)$$

$$F_2 = f(F_1, F_3, F_4, \ldots)$$

$$F_3 = f(F_1, F_2, F_4, \ldots)$$

Clausewitz enjoins his reader that "this tremendous friction… cannot be reduced to a few points, is everywhere in contact with chance… ." (*On War*, p. 120). These mathematical statements take that enjoinder into consideration, as they ultimately demonstrate the total amount of potential friction as infinite, or *n*.

$$\vdots$$

$$n = f(F_1, F_2, F_3, F_4, \ldots n\text{-}1)$$

(where $n = 8$)

Of course it is entirely possible that a multitude of completely fortuitous events occur and feedback upon each other, resulting in what could be termed a 'serendipitous' occurrence. Our sailor's mistake, for example, causes the ship to be out of position, whereupon it stumbles upon a lurking enemy submarine. Clausewitz posited that such a field of positive events, or "the positive aspects of chance" were the manifestation of the "equally pervasive" phenomenon of the *opponent's* friction.[17]

Regardless of the positive or negative nature of the events (that determination being purely subjective), such a field of interconnected changes represents a true "system" as described by systems theorists (Kenyon B. DeGreene, for example). Firstly, our model is made up of "objects," or component parts (the events: F_x); secondly, each of the frictional events have "attributes"; thirdly, each event has a definable "relationship" with its brethren ($F_w = f(F_x, F_y, F_z, \ldots)$); fourthly, all the nodes exist in an "environment", (in this case, war) which "is the set of all the objects- a change in whose attributes affects the system and also those objects whose attributes are changed by the behavior of the system."[18] We may be satisfied, therefore, that the categorization of the phenomenon of war as a system is appropriate, for,

[17] Paret, *op cit*, p. 17

> we are dealing with a system when (a) a set of units or elements are interconnected so that changes in some elements or their relations produce changes in other parts of the system, and (b) the entire system exhibits properties and behaviors that are different from those of the parts.[19]

We may further refine our characterization of our phenomenon (whether the tale of the erstwhile seaman specifically, or war in general) as an *open* system, as it interacts with the environment, actors (the warfighters), etc..[20] Indeed, as John Schmitt states, war is "an organic exchange of energy, matter, and information."[21] This is important as it gives us a further analytical toe-hold on the otherwise sheer face of the nature of the phenomenon of war. From this point, that war is a system, we can make further interesting deductions. For example, the behavior of actors such as fleets, vessels, or even individual sailors (all systems in their own right) operating within the greater system of war suggests a blurring or melting of system boundaries to create a complex adaptive system.[22]

This is a critical determination, for "it follows from the vulnerability of complex adaptive systems… that small, seemingly minor events can give rise to large outcomes," and

> that systems are sensitive at any moment in time to the conditions prevailing at that moment in time and can thus initiate processes of change that are substantial and dramatic.[23]

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[18] Kenyon B. DeGreene, "Systems and Psychology," in *Systems Behavior*, John Boshon and Geoff Peters, eds., Harper and Row Publishers, London: 1976, p. 116

[19] Robert Jervis, "Complex Systems: The Role of Interactions," in *Complexity, Global Politics, and National Security*, David S. Alberts and Thomas J. Czerwinski, eds., National Defense University, Washington DC: 1997, p. 46; *see also*, F. E. Kart and J. E. Rosenzweig, "The Modern View: A Systems Approach," in *Systems Behavior*, John Boshon and Geoff Peters, eds., pp. 8-15; C. H. Waddington, *Tools for Thought*, Jonathan Cape, London: 1977, p. 64

[20] Waddington, *op cit*, p. 64

[21] John F. Schmitt, "Command and (Out) of Control," in Alberts and Czerwinski, eds., *op cit*, cited by Andrew Ilachinski, "An Artificial Life Approach to War," *Smithsonian Lecture on Chaos and Land Warfare*, Tactical Analysis Team / Operations Evaluation Group, Center for Naval Analysis, Alexandria (VA): May 11, 2000, slide 19

[22] Christopher Bassford, "Doctrinal Complexity: Non-linearity in Marine Corps Doctrine," in F.G. Hoffman and Gary Horne, eds., *Maneuver Warfare Science*, United States Marine Corps Combat Development Command, 1998, available at: www.clausewitz.com/CWZHOME/Complex/DOCTNEW.htm, accessed on 17 July 2002

[23] James M. Rosenau, "Many Damn Things Simultaneously: Complexity Theory and World Affairs," in Alberts and Czerwinski, eds., *op cit*, p. 86; *see also*, Bassford, *op cit*, 1998

Thus, when we view friction and how it interacts with any body in this manner we see that it has become a system exhibiting elements of chaos, with each frictional event having the potential of operating along the lines of Edward Lorenz's so-called "Butterfly Effect." [24]

This evaluation of friction in war is a constant reminder that seemingly tiny events can have consequences completely out of proportion to their original, supposed, import (our radio operator's misplaced communications card, for example). But the importance of this present discussion is more than a verbose reiteration of the adage 'for want of a nail, the shoe was lost, etc…;' indeed, it goes directly to the question of how we describe the phenomenon of war. It would be a mistake to conceive of friction as:

> a statement that in war things always deviate from plan, but a sophisticated sense of why they do. The analytical world… is one of linear rules and predictable effects. The real world and real war are characterized by the unforeseeable effects generated through the non-linearity of interaction.[25]

Understanding how friction acts and reacts in war leads to an appreciation of the non-linear nature of warfare on the whole. Furthermore, when the concept of non-linearity is used for an evaluation of warfare, the analytical framework through which war is studied has effectively been changed. As Barry Watts writes in *Clausewitzian Friction and Future War*, "the role non-linearity plays is to close the door once and for all to the sort of fully predictable (at least in principle) "clockwork universe" advocated most persuasively… by the mathematical physicist Pierre Simon de Laplace."[26]

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[24] Edward Lorenz, a meteorologist by training, is noted to be the first scientist to record an instance of true chaos but is perhaps best known for his 1972 presentation of a paper entitled "Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?" The example of the flap of a butterfly's wings causing a tornado was immortalised by James Gleick in his best-seller *Chaos: Making a New Science*, in 1988, and described a system where the smallest imaginable change or action at one point can 'ripple' through the entire system and trigger phenomena that are an entire order of magnitude greater in size or power. *See*, James Gleick, *Chaos: Making a New Science*, Penguin Books, New York: 1988

[25] Alan D. Beyerchen, "Clausewitz, Non-linearity, and the Importance of Imagery," in Alberts and Czerwinski, eds., *op cit*, p. 9

WAR IS NON-LINEAR

The existence of a phenomenon which exhibits non-linear behavior (the behavior of friction) and which is embedded in the fabric of a greater phenomenon (war) suggests that war itself may behave chaotically. As Schmitt writes,

> war is fundamentally a far-from-equilibrium, open, distributed, non-linear dynamical system highly sensitive to initial conditions and characterized by entropy production/dissipation and complex, continuous feedback. [27]

Additionally, this is a characteristic of war that is divorced from numerosity. Indeed, a dynamic system does not rely on a multitude of actors (soldiers/ships/planes = variables) to exhibit chaos: "all that is needed is three or more variables and some embedded non-linearity."[28] The embedded non-linearity is, of course, the friction.

Perhaps this is the true character of war: chaotic, non-linear, uncontrollable and difficult to predict. Indeed, "this is so, not because of any flaw in our understanding of such systems, but because the system's behavior is generated according to rules the system itself develops and is able to alter. In other words, a system's behavior may be *constrained* by external factors or laws, but is not *determined* by them."[29]

An inability to pre-determine the behavior of warfare is almost universally recognized (if not by the analysts, then by the users) as the rule rather than the exception.

> Soldiers and Marines instinctively recognize the limits of prediction, and increasingly, even physical scientists share that recognition from quantum physics to meteorology, science has become aware that "non-linear" interactions pervade the natural world. We call such interactions 'chaotic,' and where they predominate, confident prediction is impossible. If that is true even of the apparent regularities of nature, how much more true must it be of war? [30]

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[26] Watts, *op cit*, p. 112
[27] Schmitt, *op cit*, n.p. available at www.dodccrp.org/comch09.html, accessed July 7, 2002
[28] Andrew Ilachinski, *Land Warfare and Complexity- Part I: Mathematical Background and Technical Sourcebook*, Center for Naval Analysis, Alexandria (VA): 1996, p. 57
[29] Bassford, *op cit*, n.p., available at: www.clausewitz.com/CWZHOME/Complex/DOCTNEW.htm, accessed on 17 July 2002. Emphasis in original
[30] Scales, *op cit*, p. 23; *See also*, Rammes, *op cit*, pp. 22-25; Opdorp, *op cit*, pp. 32-34

As for Carl Von Clausewitz, it may be said with some confidence that he would have most likely been extremely comfortable with our painting of any martial exercise as a non-linear and inherently chaotic phe nomenon.[31]

Certainly Clausewitz identified and understood the importance that feedback and interaction held for the practitioner of any martial enterprise. "Clausewitz's concern for interaction," writes Beyerchen, "permeates *On War*."[32] An excellent example of this preoccupation may be found at the commencement of Chapter One. In this section Clausewitz describes war as "nothing but a duel on a larger scale. Countless duels go to make up a war, but a picture of it as a whole can be formed by imagining a pair of wrestlers."[33] This is a powerful metaphor, for it cultivates a sense of dynamism when describing warfare - the two combatants do not simply pour firepower upon each other, but bend, flex, and move as they react to the other's actions- their competition is interaction (*wechselwirkung*). Indeed, the two combatants, or wrestlers, if we return to the metaphor, make patterns and forms with their bodies that they are only able to achieve given their opponent's force or counterforce during the contest.[34] Clausewitz's choice of metaphor is crucial to this point, for he denies the reader the safety of assuming a state of 'remove' or 'stand-off' between the duelists- the image of wrestlers implies an intimacy and feedback between the contestants that the metaphor of a duel with foils or pistols would not have lent.[35] As Beyerchen writes:

> [f]or Clausewitz, the interactive nature of war produces a system driven by psychological forces and characterized by positive feedback, leading "in theory" to limitless extremes of mutual exertions and efforts… The contest is not the presence or actions of each opponent added together. It is the dynamic set of patterns made in the space between and around the contestants.[36]

[31] Where he may take issue with the current analysis is with how to go about command and control within such a chaotic environment. In *On War*, Clausewitz does not stray too far fr om the precepts of command and control that he was taught at Scharnhorst's new military college in Berlin at the turn of century: tight centralization of command, coupled with the "iron will-power" on the part of the Commander. *See*, Clausewitz, *op cit*, p. 199.
[32] Beyerchen, *op cit*, 1992, n.p., available at: www.dodccrp.org/copapp1.htm, accessed on 5 June 2002
[33] Clausewitz, *op cit*, p. 75
[34] Beyerchen, *op cit*, 1992, n.p., available at: www.dodccrp.org/copapp1.htm, accessed on 5 June 2002
[35] *Ibid.*
[36] *Ibid.*

What is, perhaps, the best metaphor for the feedback-driven phenomenon of war has been offered by Douglas H. Dearth and Charles A. Williamson, who call any martial contest akin to improvisational theater.[37] For the sake of the present discussion, this is the superior metaphor. The metaphor of improvisational dance or theater adds a degree of interaction with the environment and a further fluidity that the image of the wrestlers or the duel (literally "*zweikampf*" or "two-struggle") lacks. This is not mere word-play, nor is it a deleterious tangent to the present discussion of the nature of warfare. The choice of metaphors dictates the conception of a phenomenon and imbues it with innate qualities and governing characteristics- linearity or non-linearity, for example. "Clausewitz thus understood an essential feature of non-linearity," Beyerchen continues, "and applied its consequences in his understanding of war: the core cause of analytical unpredictability in war is the very nature of interaction itself."[38]

If it is accepted that war is non-linear and imbued with chaos, if not purely chaotic itself, then the imposition of Newtonian and Cartesian ideals upon a system whose nature is diametrically opposed to the tropological and philosophical currency that those two methodologies deal in, must be questioned. When the purpose of "Newtonian command and control is to gain certainty and impose 'order'—to be 'in control'"[39]— how can that goal be reconciled with a non-linear system which exhibits elements of chaos?

While it is true that very short term predictions about behavior in a chaotic system may be made, and "some chaotic systems can be driven in or out of chaos; that is, chaos can occasionally be controlled,"[40] the proposition that 'total control' of war is possible and that

[37] Douglas H. Dearth and Charles A. Williamson, "Information Age/Information War," in Alan D. Compen, Douglas H. Dearth and R. Thomas Goodden, eds., *Cyberwar: Security, Strategy and Conflict in the Information Age*, AFCEA International Press, Fairfax (VA): 1996, p. 25
[38] Beyerchen, *op cit*, 1992, n.p., available at: www.dodccrp.org/copapp1.htm, accessed on 5 June 2002
[39] Schmitt, *op cit*, p. 230; *See also*, Michael Dillon, "Poststructuralism, Complexity, and Poetics," *Theory, Culture and Society*, Vol. 17, No. 5, 2000, p. 8
[40] Maj. Susan E. Durham, *Chaos Theory for the Practical Military Mind*, The Research Department, Air Command and Staff College, Air University, Maxwell Air Force Base (AL): 1997, p. 2.

friction may be dispelled with MORE digitization and MORE networking is giving chase to will-o'-the-wisps on the chaotic and complex fens of warfare. Complexity and chaos theory suggest that total control of war is no more possible than a kayaker is able to control the rapids he shoots,[41] and therefore,

> the inability to accurately predict system behavior is not due to insufficient information about the system as was often assumed. Rather unpredictability is a direct and irreducible consequence of the system's sensitivity to initial conditions and the non-linear rules that govern its dynamics… …promises of a "God's eye view" of the battlefield or Admiral Owen's dream of a 200x200x200nm battlespace are thoroughly Newtonian concepts that simply do not jibe with the nature of war as a complex phenomenon. The wide-spread belief that information technology will allow us to blow away the fog of war is a dangerous delusion which fails to understand the complex nature of war.[42]

But this flies in the face of conventional military wisdom which states that,

> foreseeable advances in surveillance and information technologies will sufficiently lift "the fog of war" to enable future American commanders to "see and understand everything on a battlefield." Nor are visionary military officers alone in this speculation. In a 6 month assessment… …[analysts] concluded that "what the [Military Technical Revolution] promises, more than precision attacks or laser beams, is… to imbue the information loop with near-perfect clarity and accuracy."[43]

Those military analysts who ele vate the possibility of new C^4ISR technologies to an almost theological level sing a siren song that is eerily reminiscent of the hopes of Lloyd, von Bülow, and Lanchester. But war as it actually is, or "*eigentliche krieg*," as the great 18th and 19th century soldier and writer Gerhard von Scharnhorst called it,[44] has a tendency to deal in probabilities, rather than certainties. Clausewitz himself remarked that,

> circumstances vary so enormously in war, and are so indefinable, that a vast array of factors has to be appreciated-mostly in the light of probabilities [*wahrscheinlichkeitsgesetze*] alone. The man responsible for evaluating the whole must bring to his task the quality of intuition that perceives the truth at every point. Otherwise a chaos of opinions and considerations would arise, and

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41 Schmitt, *op cit*, p. 232
42 *__Ibid.__*, p. 237
43 Watts, *op cit*, p. 3, quoting "[Admiral William A.] Owen Says Technology May Lift 'Fog of War': Breakthroughs Could Give Forces Total Command of Future Battlefield," *Inside the Navy*, 23 January 1995, p. 3; and Mazzar, M.J., Shaffer, J. and Ederington, B., "The Military Techni cal Revolution: A Structural Framework," Center for Strategic and International Studies (CSIS), Washington D.C., final report of the CSIS study group on the MTR: March 1993, p. 58
44 Watts, *op cit*, p. 15

> fatally entangle judgment.[45]

Certainly there are those who have railed against the anticipation of perfection in battlespace awareness; Martin van Creveld notes that,

> though modern technical means undoubtedly enable present-day command systems to transmit and process more information faster than ever before, regardless of distance, movement, or weather, their ability to approach certainty has not improved to any marked extent. Nor… does there appear to be much hope of achieving it in the foreseeable future.[46]

And yet to accept that war is chaotic still demonstrates a significant step away from conventional military thought, for it breaks from classical Newtonian paradigms and Cartesian metaphors and analytical methods and moves toward a Prigoginean and stochastic vision of war. Current US naval thought, specifically and US military thought, generally, are slaved to a Newtonian trope. The two view war as a phenomenon with fixed elements (for example, nation-states) that may change as time progresses, but will always exist within a stable system. War is also seen to be deterministic in that it has rules that connect the state of the phenomenon at one moment to the next.

The language that conventional military thought uses to describe warfare betrays its adherence to Newtonian thinking. It describes military actions as 'operations,' and says that missions 'go like clockwork.' The metaphorical palette is a mechanical one, and affects our very understanding of war.[47] This thinking is deeply ingrained. Indeed US naval planners in the 20th and the beginning of the 21st century have an extraordinary amount in common with their brethren in the 17th and 18th centuries, in that they see perfection and economy in order and simplicity- in lines of 52-gun ships or concentric circles of guided missile destroyers designed to protect an aircraft carrier. USN experimental doctrine and planning has largely remained embedded in the classical tropes and paradigms of Mahanian (and therefore

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[45] Clausewitz, *op cit*, p. 112
[46] Martin Van Creveld, *Command in War* , Harvard University Press, 1987, pp. 265-266 quoted in Van Opdorp, *op cit*, p. 33

Newtonian and Cartesian) thought, resulting in the incremental betterment of tactics and doctrine that, for the most part, have not changed much since the 1950s.[48] Beyerchen suggests that the traditional military propensity for such formations is due to more than strategic and tactical inertia, and is in fact symptomatic of being "deeply rooted in a cultural heritage that stems from the classical Greeks. The underlying notion in that "truth" resides in the simple (and thus the stable, regular, and consistent) rather than in the complex (and therefore the unstable, irregular, and inconsistent)."[49]

The present discussion advocates a break with Newtonian, deterministic, ordered thinking. It rejects the notion that complete prediction in –or control of— war is possible, for to successfully achieve these things within a chaotic system is impossible. So can there be a balance between chaos and control? Does one necessarily negate the other? Julian Birkinshau of the London Business School says that a balance *is* possible: "there's some sort of balance, at the edge of chaos, when you have enough structure to keep control of what's going on, but individuals and groups self-organize spontaneously…"[50]

So perhaps describing war as an inherently chaotic phenomenon is not an *a priori* rebuff of general command and control after all: military history proves that effective command and control of a force has been (sometimes quite adroitly) achieved. For example, the digitization of communication links and the networking of the battlespace that was evident as early as the Persian Gulf War has greatly reduced the US military's decision making cycle and has increased its capacity for precision strikes and quick deployment, and the Navy's "network-centric warfare"[51] seems likely to increase that service's capabilities

[47] Schmitt, *op cit*, in Alberts and Czerwinski, *op cit*, p. 221
[48] VAdm Arthur K. Cebrowski, "A Focus on Fundamental Principles," *Seapower Magazine*, February 1999, p. 53
[49] Beyerchen, *op cit*, 1992, n.p., available at: www.dodccrp.org/copapp1.htm, accessed on 5 June 2002; *see also* Alan Beyerchen, "Non-linear Science and the Unfolding of a New Intellectual Vision," Papers in Comparative Studies, Vol. 6, 1988-89
[50] James Meek, "Spaghetti Organisation," *The Guardian*, 18 October 2001, Section G2
[51] VAdm Arthur K. Cebrowski and John Garstka, "Network-centric Warfare: It's Origins and Future," *US Naval Institute Proceedings*, January, 1998, pp. 28-35. "The Navy has embraced an RMA concept called network-

further. However, none of these leaps forward in military thought and technology breaks from the classically rooted military mind-frame that has been the focus of this discussion. As a result, attempts to minimize friction in a battalion, a corps, or a fleet, encounter an upper limit of effectiveness hindered by the very fact that they are based upon a philosophy and a dialectic incompatible with war's true nature.

SWARMS

The question, therefore, is what kind of naval force is least susceptible to the deleterious affects of the non-linear and chaotic character of war? One answer is a swarm. The concept of naval vessels operating in a swarm is not a new one. Indeed, one can trace its employment back to the Athenian fleet's victory over the Persian fleet in 480 BC at Salamis, the action between the Christians and the Turkish fleets at Lepanto in 1571, the Royal Navy's global strategy against the Spanish in the 16th century, and the German U-Boats' "Wolf Pack" tactics during the Battle for the North Atlantic in the Second World War.[52] A review of these historical examples suggests, as RAND's John Arquilla and David Ronfeldt undertake, that "the progression towards more complex, better organized and more effective fighting formations has gone hand in hand with advances in information management systems."[53] If this is the case, as it certainly seems to be, then what does this digital age hold in store for swarming?

While 'swarming' has "never been systematically and explicitly developed as a major doctrine,"[54] advances in technology now make such a strategy and force structuring possible:

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centric warfare. It involves the use of widely dispersed but robustly networked sensors, command centers, and forces to produce significantly enhanced massed effects." US Secretary of Defense's 1998 Report to Congress, Chapter 13: "The Revolution in Military Affairs and Joint Vision 2010," Government Printing Office (GPO), Washington D.C.: 1998, n.p., available at: www.dtic.mil/execsec/adr98/chap13.html#top, accessed on May 20, 2002

[52] John Arquilla and David Ronfeldt, *Swarming & The Future of Conflict*, DB-311-OSD, RAND, Santa Monica (CA): 2000, p. 11; s*ee also*, Correlli Barnett, *Engage the Enemy More Closely: The Royal Navy in the Second World War*, W. W. Norton & Co., New York: 1991, pp. 195-6

[53] John Arquilla and David Ronfeldt, "Looking Ahead: Preparing for Information Age Conflict," in *In Athena's Camp*, John Arquilla and David Ronfeldt, eds., MR-880-OSD/RC, RAND, Santa Monica (CA): 1997, p. 469

[54] Arquilla and Ronfeldt, *op cit*, 2000, p. 41

> The information revolution is the key to the development of new designs and capabilities for sustainable swarming— from the establishment of an initial posture of dispersed forces, to the coalescing of those forces for an attack, to their dissevering return to the safety of wide dispersion, and their preparation for a new pulse. Only a new generation of robust information gathering and distribution systems can support such pulsing.[55]

Within the last decade, US military exercises such as the USN's "Fleet Experiment Bravo," the US Army's "Army After Next" (AAN) and, most notably, the US Marine Corps' "Hunter Warrior," and "Urban Swarm,"[56] have involved some non-linear aspects, and have demonstrated results that serve to advance the argument for a swarm doctrine.[57] None, however (and this is especially true for the USN's "Fleet Experiment Bravo") embodies the characteristics of a true swarm. This is equally true for recent combat operations as the Navy, "whose air elements played no small part in the swarming air campaign in the Persian Gulf, has to think through a variety of issues… the organizational impulse to keep large amounts of firepower on a few large platforms should be seen as something of a violation of the principles of swarming."[58]

A review of current naval literature reveals that the idea of a swarm of naval vessels has only been offered briefly as a solution for US naval operations in littoral waters, but that short article published by a mid-grade officer in *US Naval Institute Proceedings* in March 2001 did not evaluate the swarm doctrinally, nor with an eye to its capabilities beyond a very narrow interpretation of its littoral role.[59] One of the foremost writers and experts of US naval

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[55] Arquilla and Ronfeldt, *op cit*, 1997, p.468

[56] Arquilla and Ronfeldt, *op cit*, 2000, p. 80; Maj. Lawrence Roberts, "Flying in Hunter-Warrior," *US Naval Institute Proceedings*, September 1997, pp. 46-50; Scales, *op cit*, p. 145

[57] It should be noted that although swarm doctrine is being discussed in the US, the USN's embracing "Network-centric Warfare" is not tantamount to a *general* acceptance of swarm theory as the next stage of US military evolution. Indeed, many aspects of current, and future, US naval policy fly in the face of the most elementary theories of swarm warfare. Arquilla and Ronfeldt, *op cit*, 1997, p. 470

[58] Arquilla and Ronfeldt, "Looking Ahead…," in Arquilla and Ronfeldt, *op cit*, 1997, pp. 469-470

[59] Cmdr. Joseph Skinner, "Swarm the Littorals," *United States Naval Institute Proceedings*, March 2001, pp. 88-91

theory, Capt. Wayne P. Hughes, makes mention of a type of "streetfighting"[60] warship in his updated *Fleet Tactics and Coastal Combat*, as does the ex-US Naval War College President (now the Director of the Office of the Secretary of Defense's Office of Transformation) Vice Admiral Arthur Cebrowski, but these ships and tactics fall short of true swarm behavior and characteristics.[61] The USN's future Littoral Combat Ships are a sign that the Service is choosing to utilize smaller platforms in the littoral combat environment, but there is no sign that anything but advanced conventional maritime doctrine will inform their usage.[62] The doctrine required for a true swarm, as well as the physical characteristics and behavior of a swarm, has been extensively mapped out by RAND's John Arquilla and David Ronfeldt, but while this same material speaks volumes on information warfare and land-based swarming, it stops short of investigating a swarm's potentiality *vis à vis* naval or maritime warfare, beyond the notion that it may "enliven" the current USN doctrine of network-centric warfare.[63]

For the purposes of this discussion, a swarm is made up of many (50+) corvette-or-smaller sized, fast, stealthy, lightly crewed,[64] identical vessels, intensively digitized and completely interlinked with each other, with one or two key weapon systems and without extensive magazines. As shall be detailed later, a surprising percentage of the swarm's constituents may be destroyed without undue degradation of the entire fleet's capabilities. The swarm would be schooled in a "battleswarm doctrine"[65] that is "endlessly mutable,

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[60] *See*, Scott C. Truver, "Tomorrow's U.S. Fleet," *United States Naval Institute Proceedings*, March 2001, pp. 102-111; *see also*, Capt. Wayne P. Hughes, Jr., "Take the Small Boat Threat Seriously," *United States Naval Institute Proceedings*, October 2000, pp. 104-107

[61] Capt. Wayne P. Hughes, Jr., *Fleet Tactics and Coastal Combat*, 2nd ed., Naval Institute Press, Annapolis (MD): 2000, pp. 321-346. "Streetfighting" is most often discussed as a way to combat low-tech, primitive swarms. *See* Scott C. Truver, "The Big Question," *Jane's Defence Weekly*, 24 April 2002, p. 22-26

[62] *See*, Andrew Koch, "Sea Power 21 to Change Face of US Navy," in *Jane's Defence Weekly*, Vol. 37, Issue 25, 19 July 2002, p. 3; *see also*, Andrew Koch, "DD(X) Moves Ahead," in *Jane's Defence Weekly*, Vol 37, Issue 19, 8 May 2002, p. 2

[63] Arquilla and Ronfeldt, *op cit*, 2000, p. 84.

[64] *See*, Scott C. Truver, "Thinking Smart: Better Ships and Smaller Crews," *Jane's Navy International*, Vol. 103, No. 10, December 1998, pp. 12-19

[65] Arquilla and Ronfeldt, *op cit*, 2000, p. 49

developing strategic vulnerability… according to any and every eventuality."[66] Indeed, "swarming may be a way to actualize the potential of the [US] Navy's emerging doctrine of "network-centric warfare."[67] This swarm would operate by,

> converg[ing] on [its] target from multiple directions. The overall aim is sustainable pulsing- swarm networks must be able to coalesce rapidly and stealthily on a target, then dissever and redisperse, immediately ready to recombine for a new pulse.[68]

The force would seem almost biological in its movements: flowing towards and then swarming around its targets in a highly effective mode of attack. Placed on the defensive, the swarm would not provide any 'seams' or gaps in capabilities from one platform to the next that an enemy may exploit. Moreover, such a force "def[ies] counterleadership targeting."[69]

The swarm is ideally suited to the chaotic battlespace in two main ways: doctrinally, in that its doctrine (when coupled with the swarm's unique structure) can maintain an increased decision making cycle tempo (its *agility*) in the face of frictional events; and structurally, in that the very decentralized, duplicative nature of the swarm force may (when combined with the proper doctrine) absorb the elimination of one or many vessels from action (its *robustness*). The swarm's structure and its doctrine are mutually dependent. A naval force that is decentralized but operates along the lines of a conventional command and control system is not a swarm, nor is a conventionally arrayed carrier battle-group that utilizes a novel and *avante garde* command and control system. Neither of the fleets in these two examples is able to reap the rewards of a doctrine and force structure designed for the non-linear battlespace.

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[66] Michael Dillon, "The Military Body," *Body and Society*, John Armitage, ed., Special Issue, Forthcoming: 2002, p. 7
[67] Arquilla and Ronfeldt, *op cit*, 2000, p. 64
[68] David Ronfeldt, John Arquilla, Graham E. Fuller, and Melissa Fuller, *The Zapatista "Social Netwar" in Mexico*, MR-994-A, RAND, Santa Monica (CA): 1998, p. 15

A SWARM IS AGILE

As noted above, one of the most striking characteristics of a swarm is its ferocious agility. Swarming draws from its relatively non-hierarchical structure to deliver an extremely high tempo decision-making cycle in the face of friction: there is no lengthy chain of command to ponder decisions and then relay commands down a command 'stove-pipe.' The force, therefore, can perform the constant set of iterative actions described by Colonel John Boyd: the force can observe its environment; it can orient itself and its adversary(ies) within that frictional environment; it can decide on a course of action; it can ultimately act on that decision; and it can do all of these (known as the "OODA Loop" functions) *more quickly* than its conventional or primitive opponent.[70] This manifests in an agility which allows a swarm to account for and respond to friction, transition from decision to action, from one action to another, from attack to defense, maneuver to maneuver, *faster* than its opponent.[71] The shorter the cycle (or smaller the "loop"), the faster the force seems to operate, forcing the slower combatant to act on observations, orientations, and decisions rendered obsolete by the swarm's faster cycles.[72]

While the swarm's very structure helps speed such a cycle, the nature of the "battleswarm" doctrine it fights with provides much of the agility as well. This doctrine draws from elements of maneuver warfare and is predicated on the fact that the swarm vessels' commanders would be provided with the focus of the entire effort, or *schwerpunkt*,

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[69] *Ibid.*

[70] William S. Lind, *Maneuver Warfare Handbook*, Westview Press, Boulder (CO): 1985, p. 5; for an interesting glimpse of how the current staff officer cadre of John Boyd's home service (the US Air Force) process his theories of air combat maneuvers (ACM) and warfighting, *see* Maj. J.L. Cowan, *From Air Force Fighter Pilot to Marine Corps Warfighting: Colonel John Boyd, His Theories on War, and Their Unexpected Legacy*, (unpublished MA thesis), United States Marine Corps Command and Staff College, United States Marine Corps University, United States Marine Corps Combat Development Command, Quantico (VA): 2000. For more on the iterative nature of warfare *vis a vis* John Boyd decision-making theories, *see* Linda P. Beckerman, "The Non-Linear Dynamics of War," Science Applications International Corporation (SAIC), ASSET GROUP, April 20, 1999

[71] For an excellent discussion of the nature of 'agility' as used in this context *see*, Robert Leonhard, *The Art of Maneuver: Maneuver-Warfare Theory and AirLand Battle*, Presidio Press, Novato (CA): 1991, pp. 183-186

and with mission tactics (orders that deal with the furtherance of the mission - not the minutiae of minute-to-minute operations) or *auftragstaktik*.[73]

Schwerpunkt and *auftragstaktik* create a tactical, operational, and strategic environment that allows for 'reconnaissance pull' tactics: commanders allow their subordinate units to probe an enemy's formation for weakness, and then pour through wherever the reconnaissance elements find an opportunity. As William Lind, one of the foremost authors on maneuver warfare theory, writes:

> the idea behind recon pull is to use reconnaissance assets to find the gaps and surfaces of the enemy and to pull the main body towards the gap for penetration. It implies flexibility and adaptability by higher headquarters with the acceptance that reconnaissance units and not higher headquarters determine the point of penetration.[74]

'Reconnaissance pull' is a crucial, foundational tenet of maneuver warfare, but seems to run counter to a more conservative warfighter's conventional wisdom; indeed, "with true 'recon pull' implementation, a higher headquarters never knows exactly the time and place of the penetration before operations commence… Decentralized decision-making and action to exploit the gaps allows friendly units then to drive operational tempo."[75] In other words, decentralized decision-making and action to exploit gaps in an enemy's formation allows for the increase of the OODA cycle of the friendly force.

The *Wehrmacht* was the most adroit practitioner of maneuver warfare of its time, and in many cases was able to 'out-tempo' its opponents by using the more relaxed command and

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[72] The "OODA Loop" has also surfaced in British defence doctrine; *see*, Joint Warfare Publication 0-01, *British Defence Doctrine*, 2nd Edition , Joint Doctrine and Concepts Centre, Ministry of Defence, Shrivenham: October, 2001

[73] *See*, Richard Simpkin, *Race for the Swift*, Brassey's Defence Publishers, London, 1985; *see also*, Lind, *Maneuver Warfare…*; Lind is heavily cited by Robert B. Polk in his excellent essay on Boyd's theories as they apply to modern land warfare: "A Critique of The Boyd Theory - Is it Relevant to the Army," *Defence Analysis*, Martin Edmonds, ed., Centre for Defence and International Security Studies, Lancaster University: Vol. 16, No. 3, December 2000, pp. 257-276. For the best descriptions of the origins and original implementation *auftragstaktik* and *schwerpunkt*, see the memoirs of General Guderian and Field Marshall Rommell, respectively: Heinz Guderian, *Panzer Leader*, trans. by Constantine Fitzgibbon, Penguin Books, London: 1952; Erwin Rommell, *The Rommell Papers*, B. H. Liddell Hart, , ed. , trans. by Paul Findley, Collins, London: 1953

[74] Lind, *op cit*, 1985, p. 10 as cited in Polk, *op cit*, p. 274

[75] Polk, *op cit*, p. 267

control structure inherent in such a warfighting doctrine.[76] This is not to say that their lines of command, control, and communication were lax - indeed, nothing could be further from the truth. Instead, a more organic system of command and control arose, which relied more on *implicit* understandings rather than *explicit* instructions. This implicit understanding between a subordinate and a superior reaches its purest form in *auftragstaktik.* Robert Polk describes this as a contract between the superior and the troops he commands.

> The superior pledges to make his desired result crystal clear and then leave his subordinate maximum latitude attaining that result. The leader also pledges to back him up when he makes mistakes, so long as they are mistaken initiatives and not the result of passivity. The contract of course includes subordinate responsibilities as well. The subordinate pledges to pursue the superior's goals vigorously in order to achieve the operational aim. He will discipline himself so that his initiative serves his higher commander's intent. [77]

This trust is, according to Boyd, the "Common Shared Understanding" (or CSU)[78] that is vital within the context of maneuver and maneuverist warfare; Richard Simpkin, author of *Race to the Swift*, concurs:

> …if there is one assertion in [*Race to the Swift*] that my whole experience, research and reason tells me is beyond dispute, it is that maneuver theory can only be exploited to the full by the practice of directive control (*Auftragstaktik*) in the full German meaning of the word. [79]

Once CSU is cultivated, the seeds of maneuver warfare are sown, and a decentralized and up-tempo command and control network may be established that is able to turn within its opponent's OODA cycle, and allow the naval swarm to operate within a non-linear environment steeped in friction.

[76] It should be noted, however, that while the *Wehrmacht* was the most advanced practitioner of maneuver warfare, Soviet military strategists were also generating extremely advanced maneuver-based warfighting doctrine. *See*, Vladimir Kiriakovich Triandafillov, *Kharakter Operatsli Sovremenmykh Armil (Character of Modern Army Operations)*, original publication in Moscow, 1948. *See*, Martin Edmonds and Robert C. Gray, eds., *Landmarks in Defence Literature*, Bailrigg Study No. 5, Centre for Defence and International Security Studies (CDISS), Lancaster University, Lancaster (UK): 2001, p. 109

[77] *Ibid.* pp. 263, 267

[78] Polk, *op cit,* p. 263

[79] Simpkin, *op cit*, p. 53

Auftragstaktik and CSU (albeit by different names) are not unknown to naval warfare. Indeed, Nelson's instructions and the drills he gave his Captains leading up to his victory at the Nile demonstrate aspects of *auftragstaktik* and "common shared understanding." Nelson drilled his Captains and their crews mercilessly for months prior to his battle with the French fleet in August 1798, and the result was that although each was given precise instructions on his ship's role in the forthcoming mêlée, each captain was also told Nelson's 'grand plan,' so they knew exactly what he wanted in the event that the unexpected did occur. And occur it did; as Capt. Wayne Hughes, Jr., writes:

> …Nelson always had a plan of action, a comprehensive one. He always transmitted it to his Captains and practiced it so they were of one mind about what was wanted…. So although in one sense the Battle of the Nile did not go as planned at all, in a deeper sense it is the epitome of a sound plan executed flawlessly in spirit.[80]

With a swarm utilizing highly advanced forms of *auftragstaktik*, reconnaissance pull, and *schwerpunkt*, an almost collaborative tactical combat system is born which is able to respond immediately to changing factors in the battlespace. "Battleswarm doctrine" is, therefore, the first really plausible response to a central problem of command: complexities of information in war present extreme logistical problems for the warfighters.[81] A swarm's riposte to this problem lies in this collaborative quality and typifies what Thomas Czerwinski terms "Command-by-Influence,"[82] insofar that,

> [c]ontrol is provided by feedback-the continuous flow of information about the unfolding situation [or better, the changed situation based on subordinate initiative], returning to the commander-which allows the commander to adjust and modify command action as needed... Control is not strictly something which seniors impose on subordinates; rather, the entire system gains control... based on feedback about the changing situation. The result is a

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[80] Hughes, *op cit*, 2000, p. 25
[81] Michael Dillon, *Information, Communication and Non-Linearity*, Department of Politics and International Relations, Lancaster University. Report pursuant to contract CU0005-0000001776 - DERA, Ministry of Defence, 2000, p. 29
[82] Thomas J. Czerwinski, "Command and Control at the Crossroads," *Parameters*, US Army War College, Autumn 1996 , n.d., available at http://carlisle-www.army.mil/usawc/Parameters/96autumn/czerwins.htm, accessed on January 2002

> mutually supporting system of give and take in which complementary commanding and controlling forces interact to ensure that the force as a whole can adapt continuously to changing requirements.[83]

This, then, is the core of "battleswarm doctrine": a swarm does not follow classical notions of command and control and eschews the 'top-down' command and control paradigm that typifies 'legacy' Western military thought. Instead, swarming demands *schwerpunkt* and *auftragstaktik* from all the constituents of a swarm. A vast decentralization of command takes place, with no "master voice controlling the actions of the individual vessels." The swarm is totally self-sufficient but receives supplemental intelligence and weapons-free/weapons-tight authority from its commander (either embarked and standing off from the swarm, or ashore). The commander's brief is an *operational one only*, and once the swarm is deployed the commander exists primarily to grant weapons-free or weapons-tight status to the swarm and give it operational and theatre-wide guidelines; he or she has a "global, and therefore imprecise view of the combat arena."[84]

The swarm allows its command element to unleash the force against truly non-linear threats that conventional forces cannot easily handle (such as irregular littoral forces), and if unleashed against a conventionally arrayed linear foe the swarm will appear to possess almost instantaneous decision-making cycles, as its constituents' electronic and biological sensoriums sample the ether of the battlespace, relay the information to their brethren, and react to the stimuli, all via a seemingly collaborative command and control structure.

A SWARM IS ROBUST

As noted previously, a swarm also derives its ability to withstand friction and maintain its agility from its decentralized structure. Conventional (and out-of-date) naval communication systems are "centralized" systems (*See* Figure 4 (A)), where a central node

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[83] Marine Corps Concept Paper (MCCP) 6, *Command and Control* (draft), Headquarters, United States Marine Corps, Washington, DC: 12 December 1995, pp. 43-46, cited in *Ibid.*
[84] Andrew Ilachinski, *Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook*, Center for Naval Analysis, Alexandria (VA): 1997, p. 17

(such as a Flag Ship) instructed the constituents of the battle-group and disseminated information amongst them. Communications and therefore dataflow operated strictly between the constituents and the commander.

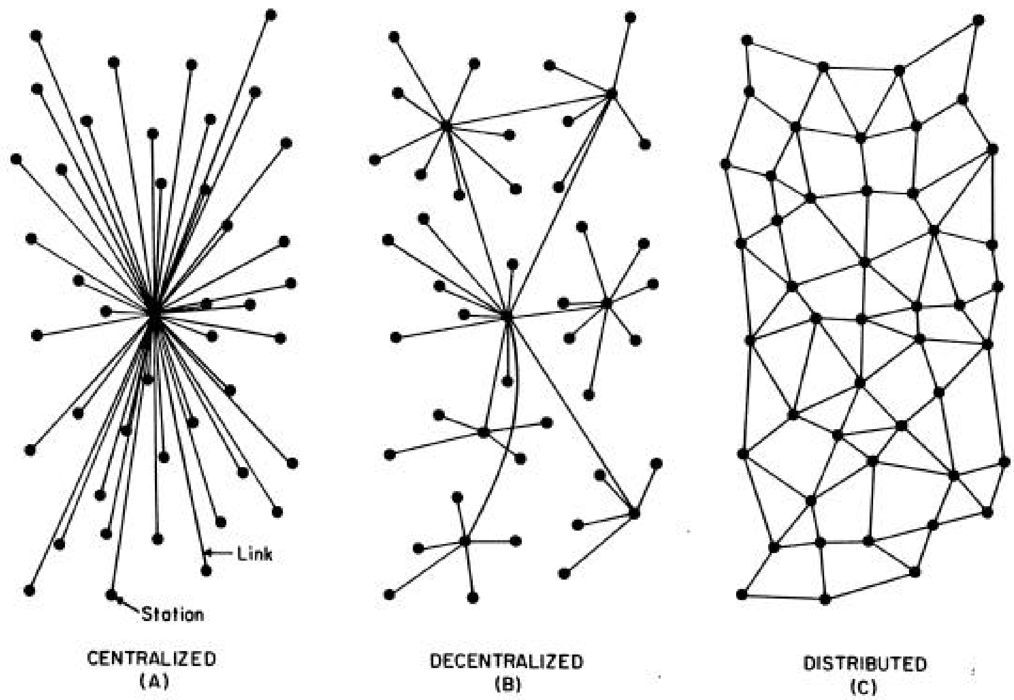

Fig. 1: Centralised, Decentralised, and Distributed Networks

Source: Paul Baran, *Introduction to Distributed Communications Networks*, RM-3420-PR, RAND, Santa Monica (CA): August 1964, Introduction

“Decentralized” (B) force structures utilize some shared information amongst the constituents, but the primary recipient of the tactical data is still the command and control node. A distributed plan (C), however, does not share this vulnerability, and indeed the acuity of the sensor network is remarkably resilient, operating at peak efficiency even after the destruction of many of its nodes. Paul Baran’s pioneering work at RAND in the 1960s, on the survivability of the US telecommunications infrastructure against a nuclear strike, reveals just how robust such a distributed communications system (the swarm's, for example) may be. His work suggests that if each node (or vessel) can interconnect with any or every other vessel, then even in the face of a mass missile attack with follow-on salvoes, the network can lose a significant number of its constituents and still maintain a near-perfect sensorium.[85] As weapon systems become more and more reliant on data-streams and as anti-radiation weaponry becomes increasingly advanced, the robustness of a communications network becomes of even greater importance.

Baran's work at RAND in the 1960s on dispersion and networking laid the foundation for the modern internet and is the basis of modern command, control, and communications theory; a true swarm force will utilize his work on networks and their resiliency, to introduce a decentralized info-mesh with startling survivability characteristics.

The swarm vessels will also utilize a distributed sensor network and will therefore be able to rely on cheaper, smaller, individual sensor systems and combine their search and detection efforts; this in turn, means that members of the swarm can cycle their individual radiating sensors and therefore confuse an opponent's passive detection systems. Organic over-the-horizon (OTH) systems, such as embarked airborne early-warning (AEW) aircraft, may be replaced with links to satellite systems, as the large number of inter-linked radiating vessels will expand the standard radar search area.

Additionally, the fluid movement and dispersal of the swarm force made possible by technological (digital communications)[86] and doctrinal (*auftragstaktik* and *schwerpunkt*)

[85] *See*, Paul Baran, *On Distributed Communications: History, Alternative Approaches, and Comparisons*, RM-3097-PR, RAND, Santa Monica (CA): August 1964. *See also*, US Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407, Government Printing Office, Washington DC: January 1990

[86] For an interesting model of swarm behavior *see* the Center for Naval Analyses' *ISAAC/EINSTEIN* (Irreducible Semi-Autonomous Adaptive Combat/Enhanced ISAAC Neural Simulation Toolkit) computer program. The program is downloadable and is available at: www.cna.org/isaac/ ; *see also*, Andrew Ilachinkski, *Irreducible Semi-Autonomous Adaptive Combat (ISAAC):* An Artificial-Life *Approach to Land Combat*, Center for Naval Analyses, Alexandria (VA): 1999

networking is itself an advantage; it denies easy targeting solutions to the enemy and offers protection against area-weapons.

Offensively, the burden of investment in communication systems that a swarm force would require is balanced by the relative light weapons load-out with which each individual member of the swarm must be equipped.[87] Instead of one vessel being equipped with numerous very precise weapons systems to guarantee a hard or soft kill, many networked vessels with fewer warshot may operate synergistically for the same effect. For example, a lower cost weapon system using guns that have a 50% probability of kill would be inadequate protection for a carrier battle-group. Three such gun systems, however, would provide an 87.5% probability of kill (traditional weapon systems have a design goal of 85%) and eight would provide a combined 99.8% probability of a kill.[88]

There are advantages to be found in such a small weapons load-out. Small magazines of very expensive next-generation guided munitions which are emptied in the first few moments of an engagement reduce the possibility of hard-to-protect unused ordnance detonating when the vessel comes under attack. Additionally, such a weapons load-out which is expended quickly, defeats the problem of unused ordnance going down with the ship.[89]

In terms of land-attack capability, each of the swarm's constituents could further adhere to the standard of small weapons loads and be equipped with a pack of two next-generation tactical ballistic missiles (TBMs): a load-out that would not be excessively burdensome. Taken individually, such a load-out would prove only marginally effective against an inland foe; taken as a swarm, however, a pulsed attack from the entire swarm

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[87] A recent USN "streetfighter" concept vessel, the hypothetical *Sea Lance*, is equipped with a 4-cell Harpoon/SLAM launcher, a small VLS surface-to-surface/air missile system, and a 30-mm gun. Truver, *op cit*, 2002, p. 25. This load-out is equivalent to our swarm craft in the discussion above.
[88] Skinner, *op cit*, p. 89
[89] *See*, Hughes, *op cit*, 2000, p. 262

could cripple an entire national infrastructure.[90] Against cruise missile attack, sea-skimming surface-to-surface missiles (SSM) or air-to-surface missiles (ASM) a swarm force's interwoven point-defense systems would provide an excellent hard-kill self-defense capability.[91]

Taken to an extreme, a swarm may overwhelm opposition with a legion of relatively cheap constituents, confusing tactical solutions and inhibiting countermeasures. Martin C. Libicki terms this "fire-ant warfare," and writes of a swarm's constituents:

> They are cheap, they can get closer to the target, and they are collectively more robust against deliberate attack. Because they are cheap, many can be deployed; deploy enough of them, and it becomes too expensive for the enemy to kill them.[92]

Present day studies by strategic evaluation centers are recommending more and more dispersal and networking of forces in an advocacy of something approaching pre-swarm status:

> While it has been long understood that dispersing forces can enhance their survivability, recent analysis and experience also point to an opportunity for improvement in their ability to out-maneuver and destroy enemy forces. In war's logic, networked forces can be more "productive." With data networking, dispersed forces can operate as seamlessly as massed forces can. Better than massed forces, they can support one another in any combination, provided that command and control (C2) procedures keep pace. Although evolving C2 doctrine has yet to capitalize fully on the potency of networked forces, it is already clear that decentralizing tactical decision making [*sic.*] can improve the ability of forces to adjust to the threats and opportunities of a fluid battle. In the extreme, by converting distance from a drawback into an advantage, information technology can keep enemy forces in the crosshairs of violence and one's own forces far from it.[93]

[90] *See*, Hughes, *op cit*, 2000, p. 334. Hughes concludes *Fleet Tactics* with a discussion of a hypothetical maritime conflict between the US and Turkish navies. Part of the US force engaged in-theatre are "*Phantoms*;" stealthy, high-speed, 200-ton vessels which operate with a rudimentary swarm-doctrine. Each *Phantom* is equipped with two TBMs designed for deep-strike land-attack missions, although they may be re-tasked for naval use(a fact that Hughes' fictional Captain in *Fleet Tactics* makes good, and rather ingenious, use of).
[91] Skinner, *op cit*, p. 89
[92] Martin C. Libicki, "The Many and the Small," in Arquilla and Ronfeldt, *op cit*, 1997, p. 199
[93] David C. Gompert and Irving Lachow, *Transforming US Forces: Lessons from the Wider Revolution*, IP-193, RAND, Santa Monica (CA): 2000. The recommendation to disperse surface naval forces in the face of the

In *The Mesh and the Net: Speculations on Armed Conflict in the Age of Free Silicon*, Libicki suggests that the replacement of current highly complex hierarchical command and control systems with networks of dispersed computers and communication platforms introduces significant problems of command and control.[94] Indeed, the digital networking and processing requirements of such a tightly knit – yet hierarchically flattened - force are overwhelming and are only now becoming possible: massive data-links networking each constituent into the swarm and linking the swarm, in turn, to any shore-based or afloat command or intelligence element. Its collective combat system, for example, must be able to eliminate excessive redundancy in targeting and weapon allocation. However, as expensive and advanced as the swarm's communications may be, the interconnection of every constituent into a "mesh" and backing by an advanced "battleswarm doctrine" provides the most stable and robust force structure in a non-linear world.[95]

REAL-WORLD CAPABILITIES

The creation of a naval swarm, as detailed above, would not merely be an exercise in novel force structure transformation or creation. Indeed, a swarm could significantly bolster the USN's capabilities where bolstering is currently needed most: in the littoral, brown and green water battlespace. In these theaters, a swarm would be extremely effective against three main threats: shallow water/littoral anti-submarine warfare (LASW); small, high-speed surface combatants (counter-swarm); and over-the-headlands, pop-up, airborne threats.[96]

In terms of LASW, blue-water navies are currently presented with an extraordinarily difficult proposition - that of localizing and attacking extremely quiet diesel submarines in

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proliferation of 'smart' or 'brilliant' weaponry has been proffered before. The differences, however, between mere force dispersal for force-protection's sake and a swarm are extremely significant.

[94] Martin C. Libicki, *The Mesh and the Net: Speculations on Armed Conflict in an Age of Free Silicon*, McNair Paper 28, Institute for National Security Studies, National Defense University, Washington D.C., March 1994, p. 15

[95] Libicki, *op cit*, 1997, pp. 191-216

[96] *See*, Richard Scott, "Survival of the Fittest," *Jane's Defence Weekly*, January 23, 2002, pp. 22-25

the acoustically confused green and brown waters of the littoral theater. In brown water, i.e. rivers, estuaries, or navigable waters close to the surf-zone, the shallow nature of the environment introduces unique challenges to any sonar operator, as the concentration of biologicals, the effects of the wind and sun, and the proximity to the sea-bed begin to bend, reflect, refract, and distort any sound's propagation path - ultimately confusing search and attack solutions, especially those that use traditional long-range search techniques.[97]

While 'green' water sonar searches may hold fewer environmental challenges (primarily because the weather 'top-side' will hold less impact on acoustic conditions, and the bottom is not as close to the searching vessel), it is still a complex acoustic environment in which to conduct a sonar search. In green water zones

> where there "is a mixture of drifting water bodies of different temperature, salinities and velocities, with shoals of fish adding a further complication," sonar ranges are limited by shallow and turbulent water. If these difficulties were not enough, the continental shelf is "usually rough, with rocky outcrops and wrecks to generate false contacts… …Low frequency sonars lack precision and definition under such conditions and passive sonars of all frequencies are of little use. Only active sonars can make sense out of these chaotic conditions." Since the anti-submarine submarine is the chief practitioner of passive sonar, it may not be able to fulfill its expected role in littoral water conditions.[98]

The problem grows only more urgent as more and more countries accept delivery of advanced diesel propulsion submarines with the intention of using them in a littoral environment.

There has been some discussion that some current SSNs or the USN's new *Virginia*-class attack submarine can fulfill the LASW role, although this claim is highly dubious

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[97] Skinner, *op cit*, p. 89. For a discussion on emerging LSAW weapon technologies, *see* David Foxwell, "Running Into Shallow Water: Updating ASW Weapons," *Jane's Navy International*, Vol. 104, No. 5, June 1999, pp. 11-15

[98] Martin Edmonds, *ASW in Coastal Waters: A New Challenge*, Bailrigg Memorandum 41, Centre for Defence and International Security Studies, Lancaster University, 1999, p. 21, citing A. Preston, "Stealthy Submarines and ASW" *Military Technologies*, #9, 1992, p. 67; *see also*, David Foxwell and Richard Scott, "Offboard Sonar Charts a Fresh Course for ASW," *Jane's Navy International*, Vol. 104, No. 2, March 1999, pp. 18-25

indeed.[99] The *Virginia* (and by logical extension, any other SSN), as effective as she may be as a hunter-killer in the LASW role, fails the 'acid-test of littoral warfare': are there sufficient numbers of that ship so that the loss of one will not cripple a mission along a treacherous coast?[100] At $1.65 billion each (based on FY95 dollars)[101] the loss of a *Virginia* -class SSN can hardly be termed as 'affordable,' and with an envisaged fleet total of 30 *Virginia* -class SSNs (no doubt distributed amongst the world's maritime 'hot spots'), the loss of one would prove abortive to any LASW mission. This reinforces Capt. Wayne Hughes' analysis of littoral warfare in 1997:

> some coastal navies, supplemented by sensors, weapons, and command-and-control systems on land but pointed to seaward, are very proficient in adapting to their own geography, weather conditions, coastal shipping and air traffic, and generally, the clutter of their littoral environment. …They will use tactical mobility, surprise, and a rapid, violent, coordinated attack… …Proficient coastal navies expect to sacrifice their ships and aircraft in large numbers to blunt our attack in a littoral war. Such is power warfare of the enemy's choosing.[102]

One should be prepared to lose vessels in such a martial contest.

A swarm, however, may hold the answer to LASW operations. A swarm can link its constituents' active sonars, which, although they are individually limited in range,[103] when networked provide an optimal solution for the localization and sanitization of a submarine and/or mine threat in green or brown water.[104] A fleet of 50+ fast, small vessels, highly networked and sharing each other's subsurface data picture, could engage a 'brown' water submarine threat by shifting which vessels' sonars were radiating whilst the other members of the swarm repositioned themselves at high speed - thereby further 'muddying' the

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[99] The claim is set forth by Mike Parry, " *Virginia* Can be a Streetfighter," *US Naval Institute Proceedings*, June 2000, p. 31

[100] Hughes, *op cit*, 2000, p. 347

[101] United States Navy official website: http://www.chinfo.navy.mil/navpalib/factfile/ships/ship-ssn.html, accessed on June 1, 2002

[102] Capt. Wayne P. Hughes, Jr., USN (ret.), "Naval Maneuver Warfare," *Naval War College Review*, Summer 1997, n.p., available at: www.nwc.navy.mil/press/Review/1997/summer/art2su97.htm, accessed December 12, 2001

[103] Current mid-frequency (2.5-10kHz) hull-mounted active sonars have reliable detection ranges of only approximately 5nm. Brian Longworth, "New Currents Pull Undersea Warfare," *Jane's Navy International*, Vol. 100, No. 3, June 1995, p. 17

submarine's tactical picture. Such a prosecution of this submarine threat would be the epitome of what one naval analyst labels the "fundamental tactic [of future ASW] will be… *attack, attack, attack*, while aggressively applying the complementary tactic of *run, run, run*."[105] Last, but by no means least, a swarm constituent passes the littoral theater acid test that the *Virginia* so patently fails. Indeed, "small, stealthy, high-speed warships look to be valuable for close-in operations in which we would not want to risk a larger warship."[106] The loss of one vessel of a 50+ vessel swarm may even be considered worth the destruction of a nearby diesel/AIP submarine.[107]

The swarm is also extremely proficient against both unconventional and conventional littoral surface threats. As more nations begin to employ large numbers of small, fast, surface combatants, a high-tech swarm may be the best way to engage a multitude of very fast combatants simultaneously (themselves forming a primitive swarm of sorts) - disrupting their ability to converge on a single target and initiate a 'pulse.' Conventional navies are not the only threat when it comes to surging a large number of small, fast, surface vessels. Indeed, the Liberation Tigers of Tamil Eelam (LTTE) engage not only in primitive swarm tactics, but a branch of their naval arm, the Black Sea Tigers, engage in suicide attacks using a swarm of stealthy, high-speed power-boats (with weapons procured from North Korea) to disrupt shipping and destroy Sri Lankan naval vessels.[108] A high-technology naval swarm may be best able to engage these primitive swarms in what US naval planners term 'streetfighting' or the ability to engage surface threats (most often in an enemy's littoral water-ways) at short-range and with almost no advanced early warning.

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[104] *Ibid.*; Skinner, *op cit*, p. 89; Edmonds, *op cit*, pp. 20-24
[105] Capt. Walt Stephenson, USN, letter to *U.S. Naval Institute Proceedings*, December 1998, p. 10
[106] Truver, *op cit*, 2002, p. 24
[107] *See*, David Foxwell and Richard Scott, "Diesel Subs Depart from Convention," *Jane's Navy International*, Vol. 104, No. 3, April 1999, pp. 16-24
[108] Roger Davies, "Sea Tigers, Stealth Technology and the North Korean Connection," *Jane's Defence Weekly*, 7 March 2001, n.p., available at www.janes.com/security/regional_security/news/jir/jir010307_2_n.shtml, accessed on July 4, 2002

While this ability to streetfight is highly effective against primitive swarms launched by state or even non-state actors, it is devastating against more conventional, conservative threats (e.g. a few larger vessels). In this regard, a naval swarm behaves very similarly to guerrilla fighters operating in urbanized areas, and the existence of profound similarities between general guerrilla warfare, urban warfare and maritime combat in a littoral environment make that comparison an apt one. In the Battle for Grozny in 1994-1995, for example, Chechen fighters utilized highly sophisticated swarm tactics, when

> combat operations broke down into small unit firefights because of the non-linear nature of urban terrain…. If a Russian unit advanced too far (or adjacent units fell back), it was cut off, surrounded, and attacked by Chechens like "wasps on a ripe pear."[109]

With its unique attributes (interlinking and dispersal, for example) a swarm force can be a naval streetfighter *par excellence*, surrounding and destroying much larger, theoretically more able aggressors with a speed, ferocity, and impunity that a flotilla of capital ships can not muster.[110]

In terms of pop-up over the headlands attacks, where attacking aircraft fly nap-of-the-earth terrain following profiles until they emerge over the surf-zone and strike, the swarm allows those members of the fleet who are 'tucked in' against the shore to make use of the sensors of those constituents of the swarm that are standing off.

Additionally, having a small draft and low observability characteristics makes the swarm craft an excellent special operations force delivery system, allowing for multiple rigid inflatable boats per swarm constituent to be inserted close to and along a length of coastline in a manner that can not be duplicated by current (and even envisaged) special operations submarines.

[109] Sean J. A. Edwards, *Mars Unmasked: The Changing Face of Urban Operations*, MR-1173-A, RAND, Santa Monica, 2000, p. 26; *see also*, Olya Oliker, *Russia's Chechen Wars 1994-2000: Lessons from Urban Combat*, MR-1289-A, RAND, Santa Monica, 2001

A SWARM IS VERSATILE

A swarm can operate in most of the world's maritime theatres and, almost without exception, all the world's current maritime 'hot-spots.' The size of the swarm's constituents would make operations possible in the Mediterranean Sea, the Persian Gulf, the South China Sea, the Indian Ocean, and, judging by the performance of similarly sized vessels in this year's NATO maritime exercise Strong Resolve 2002, the Baltic Sea, in very rough conditions.[111]

The main disadvantage that the swarm will face is its inability to perform long-distance sustained steaming and extended operations in some of the most extreme sea-states. This is not to say that the swarm will be unable to engage in endurance operations, but long distance transits in smaller vessels are not as comfortable for the crews and may unduly punish the platforms themselves. It is possible, however, to envisage a system of 'mother ships' that can themselves engage in long-range steaming and, once in-theater, disgorge the swarm. Current research into multi-hull technology and 'lifting bodies' is providing clues into the possible application of such platforms to the role of swarm 'carriers.'[112] Additionally, existing bulk carriers and very large cargo carriers may also be fitted to serve in such a role. Such measures would allow a swarm to transit from one theater of operations to another.

Once in 'blue water,' (i.e. outside the continental shelf) the swarm is as effective as it is when streetfighting. For example, if needed to conduct open-ocean ASW operations, a few of the swarm could be fitted with passive towed array sonar systems, and trade off 'sprint'

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[110] For an excellent analysis of the performance of light ground troops vs. a 'heavy' aggressor, *see*, John Matsumura, Randy Steeb, *et. al.*, *Lightning Over Water: Sharpening America's Light Forces for Rapid Reaction*, MR-1196-A/OSD, RAND, Santa Monica (CA): 2000, pp. 15-32

[111] During that exercise (4 March 2002 – 18 March 2002) small vessels, such as the Polish warship *Kaszub* (*Grisha* class, 1,200 tons displacement at full load, 233.6 ft. long), weathered gales but were still able to participate in all the exercise's scheduled serials. Specifications from Keith Faulkner, *Jane's Warship Recognition Guide 2000*, 2nd ed., Robert Hutchinson, ed., Harper Collins, London: 2000, pp. 216-17

[112] Andrew Koch, "US Navy Plans Futuristic Experimental Ship," *Janes Defence Weekly*, 20 March 2002, p. 6

and ‘drift’ duties with its brethren. As regards AAW and anti-surface warfare (ASuW), a swarm loses none of its effectiveness in open waters.

Additionally, a swarm’s unique characteristics *vis á vis* its stealthiness, extreme networking and surveillance capacity, coupled with sheer numbers, may also extend its utility to operations-other-than-war (OOTW), for example maritime interdiction operations (MIOPS). In MIOPS, a swarm’s pattern of dispersal would prove invaluable in conducting boardings from one constituent whilst simultaneously surveilling the interdiction area. Indeed, the comparatively cheap swarm constituent may be the perfect platform with which to conduct low-intensity OOTW. As an unnamed USN surface warfare flag officer stated in a recent *Jane’s Defence Weekly* article,

> we already know, for example, that a multi-mission warship like the *Arleigh Burke* (DDG-51) AEGIS guided-missile destroyer can carry out ‘other than war’ tasks like maritime interdiction operations… what we need to do is to ask ourselves whether this is an appropriate and cost-effective task for the DDG-51 with their crews of 359 sailors, and, if the answer is ‘not really,’ what are the alternatives? What are the ‘opportunity costs’ of devoting a DDG-51 to this type of operation? And, are there operational constraints attendant with using a Burke to do a smaller warship’s job? For example, the Burke’s 31ft. (9.4m) draft clearly limits our ability to carry out certain tasks in certain near shore regions.[113]

CONCLUSION

While notions of fluidity, non-linearity, fog and friction are paid lip service in US military service manuals, such references have not, to date, manifested or found resonance in US force structures. Newtonian paradigms of command and control retain their iron-grip upon the US military, as does Enlightenment thinking upon modern day western mainstream military thought in general. Ironically it is the RMA, which is almost always mischaracterized as a purely technological revolution, that can begin to affect some fundamental change.

[113] Truver, *op cit*, 2002, p. 24

Perhaps the most important aspect of the RMA is that it has brought non-traditional modes of analysis to the fore of military and defense thought. Areas of intellectual inquiry like the complexity sciences, chaos theory, the philosophy of language and semiotics, are now being utilized by more and more mainstream Western military institutions, and fields like heuristics, cybernetics, and artificial intelligence are now becoming established as pathways to greater operational efficiency in future force structures and doctrine. [114] The true prescription of this new mode of military thought is that war must be reconceptualized *en toto*, and forces created to operate within this newly appreciated phenomenon. In other words, the United States Navy must move further away from appraisals of new concept weapons and platforms, to an RMA-driven exploration of new concepts *of* weapons and platforms and how they are used.[115] The result is a naval force transformed.

This paper has returned to one of the conceptual pillars of classical military theory, Carl Von Clausewitz, and has demonstrated that the inherent non-linearity of warfare may be deduced through an analytical examination of the nature of friction. From that starting point it has been offered that such an understanding of war necessarily means that the utilization of conventional force structures and theory hinder the efficiency of any military endeavor.

What is proposed herein, a naval swarm, has never been suggested as an *explicit* response to this new understanding of war in general, and naval or maritime war in particular. As discussed, a naval swarm draws its ability to thrive in a non-linear battlespace because of its two main defining characteristics: its structure and its doctrine, which give the force its extreme robustness and agility.

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[114] *See*, Michael Dillon, *Complexity and Semiotics: A Pilot Report on the Security Problematics of New Knowledge,* Department of Politics and International Relations, Lancaster University. Report pursuant to contract CHS7227- Defence Evaluation Research Agency (DERA), Ministry of Defence, January 1998. *See also,* Michael Dillon, *Information…, op cit*, 2000

[115] Qiao Liang and Wang Xiangui, *Unrestricted Warfare*, PLA Literature and Arts Publishing House, Beijing (People's Republic of China): February 1999, p. 10

Irrespective of the fact that the large surface combatant is set to remain the mainstay and center-piece of maritime warfare in the West for some time, the USN is confronting multiple simultaneous challenges:

- how to counter a growing threat in green and brown water environments, littoral anti-submarine warfare, counter-swarm, and conventional littoral anti-surface unit warfare. *and*;
- how to deal with the proliferation of smart to brilliant weaponry and cruise-missiles that require hyper-layered defensive systems to protect the largest surface platforms (i.e. super-carriers, etc.) from this threat, *and*;
- how to create a maritime force that is flexible enough to handle these threats and be able to perform functions that have been the traditional domain of those vessels (like the super-carrier) that may be forced out well beyond the continental shelf by the proliferation of cheap, off-the-shelf guided next-generation weaponry.

Although the concept of streetfighting is beginning to find some resonance within western naval communities, it is the next evolutionary step along the doctrinal continuum, the naval swarm, that may hold the answer to these problems. By capitalizing on new digital technology, materials, and construction techniques, as well as revisiting and re-tooling older notions of command and control doctrine (*auftragstaktik* and *schwerpunkt*), a naval swarm would combine robustness, versatility, agility and devastating firepower with an ability to take casualties and remain mission-effective to create a fighting force that would confuse, out-perform, and ultimately defeat any opposition.

The naval swarm has the advantage of filling a current capability gap which exists within the US Navy (specifically in littoral, brown and green water operations) and draws heavily on some of the most critical fruits of the RMA (both conceptually and technologically); yet its very existence is testament to the non-linear and chaotic nature of the maritime battlespace that the advocates of the RMA often times ignore.