Uncertainty Engineering

A Genealogy of the Fog of War

Kim Wheatley

A thesis submitted in fulfilment of the requirements for the degree of
Ph.D in Media, Film and Television, the University of Auckland, 2022.

Abstract

This thesis consists of a genealogy of the emergence and entrenchment of the "fog of war" (FOW) within the spaces of martial and strategic thought. Though the term is most commonly attributed to Carl von Clausewitz's *On War* (1832), and often employed in tandem with his general theory of friction, it is argued that the FOW itself never quite attains the status of *concept*, and instead functions as an empty signifier that mirrors war's own indeterminate nature. Nonetheless, by using the FOW as a point of departure, a more general inquiry into attendant efforts to conceptualise uncertainty in war is pursued via a transdisciplinary approach grounded in media studies and martial empiricism. In doing so, a general progression in the martial conception of uncertainty is traced, spanning the epistemic view of probability held by the Ancients; the emergence of an aleatory conception of probability in the 18th century; the pursuit of negentropic control during the Cold War; and concluding with a contemporary understanding informed by the science of complex systems. In conducting this survey, a prevailing tendency in the Western martial and strategic traditions to view uncertainty as a problem to be alleviated is found to have its origins in the Aristotelian schema of theory and practice. However, it is also argued that the emergence of a rival methodology, rooted in the Greek notion of *mêtis*—cunning intelligence—and the Chinese approach to war as deception, necessitates an expanded view of the FOW, as it seeks to exploit, and even *engineer* war's 'atmosphere of uncertainty' to its own ends.

Acknowledgements

This thesis emerged out of a course that I should not have taught, but did. Had I not been reading Steve Goodman's *Sonic Warfare* over the summer of 2013-14 I would never have embarked upon the study of war. I am also grateful to Jo Smith for taking a chance, and giving me the freedom to design a course on *Media War and Crisis* shortly thereafter. I cannot thank enough all of the students who joined me in that course over the next four years, as well as those who enrolled in its final form, *Media, War and Weapons,* in 2019. I didn't really know what I was doing, but your enthusiasm, creativity, and patience carried me through. Some other people from my time at VUW whose support and encouragement helped me on my way include Thierry Jutel, Anita Brady, Geoff Stahl, Minette Hillyer, Angi Buettner, Michael Daubs, Peter Thompson, and Cherie Lacie.

To my supervisors, Nabeel Zuberi and Neal Curtis, thank you both for your support, guidance, and supreme patience. Many thanks also to Antoine Bousquet for his generosity and insight, and for giving me an education in polemology during my time in London. Further hat-tips to Sam Forsythe, Dan Öberg, Richard Hames, Reza Negarestani, and Eric Meier, each of whom made suggestions or gave me a word of advice that informed this project in a meaningful way.

A special shoutout goes to my dear friend Gregory Kan, who collaborated with me on a speculative paper on the FOW that never quite came to fruition, but whose influence on this thesis has been indelible nonetheless.

Finally, thanks to my family, Ann, Chris, and Claire; to my angels, Alex and Laura; and to Linh, for everything.

Table of Contents

Introduction: The Kiesling Intervention	1
1.0 The Prehistory of Martial Uncertainty	19
1836: The Waving Fog of War	73
2.0 A Fog of Greater or Lesser Uncertainty	79
1896: The State of Ignorance	112
3.0 When War Becomes a Game	116
1942: Western Approaches Tactical Unit	156
4.0 Atmospheres of War	171
1943: Fog Investigation and Dispersal Operation	201
1961: Operation Ranch Hand	206
5.0 Negentropy and the Fantasy of Omniscience	219
2008: Body of Lies	261
6.0 Entropy as Opportunity	267
2017: ZeroS	308
Conclusion: War's Unknown Unknown	314
Works Cited	320

Introduction: The Kiesling Intervention

0.1 Object, Context, Contribution

War has long been thought of as a phenomenon that bedevils the efforts of its practitioners to operate on the basis of certainty. The "fog of war" (FOW) has become one of the most memorable expressions of this difficulty, but it is also an enigma, and not just in the sense of what it purports to describe. Within martial thought, it is often employed alongside Carl von Clausewitz's general theory of friction in order to convey the complex and uncertain nature of war. But despite the tendency to conceptually twin the two terms, as in the phrase "fog and friction"—where "friction [refers] to physical impediments to military action, [and] fog to the commander's lack of clear information" (Kiesling 85)—the degree to which they have received attention in martial and strategic thought is quite disparate.

Where there has been no shortage of effort expended to clarify, revise, and elaborate upon the general theory of friction since its conception by Clausewitz in the early 19th century,[1] the FOW has remained one of those terms that is often invoked, but rarely defined. And where friction is afforded a central place in Clausewitz's writings, the phrase "fog of war" is never used explicitly in the Prussian general's opus, *On War;* an omission that Eugenia Kiesling stresses in a short article published for *Military Review,* entitled "On War Without the Fog" in 2001. There, Kiesling points out that while references to friction appear "at least thirteen times" in *On War*, the specific phrase "fog of war" is never used by Clausewitz (85). Nonetheless, she goes on to highlight the key passage—one of only a handful of instances where the word "fog" appears in the text of *On War*—from which she suggests

[1] See, for instance, Handel (1986), Beyerchen (1992), Cimbala (2001), or Watts (2004).

the concept of the FOW is most often assumed to have originated: "War is the realm of uncertainty; three quarters of the factors on which action is based are wrapped *in a fog of greater or lesser uncertainty"* (Clausewitz, Chapter 3, Book 1 115; my emphasis).

For Kiesling, the relatively brief treatment given to the metaphor of the fog as a shorthand for uncertainty here does "not give fog the weight necessary to justify the fog and friction scheme commonly ascribed to [Clausewitz]" (86). As such, she argues against the separation or dichotomisation that occurs through the use of the designation "fog and friction," for she is concerned that rather than conceptualising uncertainty as one of the components of intelligence, which, alongside physical exertion, danger, and friction,[2] makes up Clausewitz's general theory of friction, the "fog and friction" schema encourages a distinction between friction as "purely physical hindrances to military action and fog the confusion that arises from misleading or contradictory intelligence" (86). As a result of this oversight, she suggests that military institutions have become overly preoccupied with resolving the problems of uncertainty and intelligence through technological solutions, and consequently have neglected the wider interplay of other potential sources of stress on military command that are outlined under the rubric of general friction, which she seeks to restore to prominence (87).

In doing so, Kiesling draws attention to the broader problematic of uncertainty that the FOW, and the attendant Clausewitzian general theory of friction, can be seen as attempts to theorise, while

[2] Because Clausewitz died while he was still revising the original manuscript of *On War* there are some internal discrepancies within the text pertaining to the precise factors that comprise his general theory of friction. Kiesling refers to a typology for the sources of friction provided in Chapter Eight of the first book of *On War*. However, in chapter three of book one, a different typology (comprising danger, exertion, uncertainty, and chance) is provided by Clausewitz. For an attempt to clarify and reconcile these conceptual discrepancies in the general theory of friction refer to Barry D. Watts' *Clausewitzian Friction and Future War* (2004).

also throwing into question the extent to which the actual meaning of these concepts has been sufficiently articulated or defined in martial thought:

> How fog came to insinuate itself into standard military interpretation of the text is worth some reflection. So is the resistance among teachers of *On War* to the suggestion that Clausewitz wrote a chapter on friction rather than one called "fog and friction." Also troubling is that we insist on reading fog into Clausewitz's discussion of the friction of war. In what other key passages are we making similar mistakes? (87).

Examples of the term's employment along the lines Kiesling describes is widespread in much martial literature, as well as beyond it. Indeed, as Kiesling observes, the FOW has attained the status of "one of the most pervasive and natural metaphors in the English language" because it more elegantly conveyed the uncertain and contingent nature of war than comparable concepts from the martial lexicon, such as "VUCA" (Volatility, Uncertainty, Complexity, and Ambiguity) (85). In particular, references to the FOW have become a mainstay of the doctrinal documents of many Western armed forces. For instance, the Marine Corps' capstone doctrinal document, *MCDP-1: Warfighting* observes that:

> All actions in war take place in an atmosphere of uncertainty, or "the fog of war." This uncertainty pervades battle in the form of unknowns about the enemy, about the environment, and even about the friendly situation. While we try to reduce these unknowns by gathering information, we must realize that we cannot eliminate them—or even come close. The very

nature of war makes certainty impossible; all actions in war will be based on incomplete, inaccurate, or even contradictory information (7).

Similarly, The New Zealand Defence Force's capstone doctrinal document *NZDDP-D,* makes the claim that "the 'fog of war' is real and pervasive, generating anxiety and often restricting effective decision making" (22). The British Army's *ADP: Land Operations* also invokes the FOW, framing it as a problem to be negotiated, but also as a space of possibility that might be exploited: "No matter how much information there is in conflict, a 'fog of war' that can lead to uncertainty and chaos will always descend. Chaos might be deliberately used by enemies, and presents opportunities for the bold to seize" (1-2). Together, these doctrinal treatments collectively establish the FOW as an onto-epistemic principle that describes the limits and conditions of information, knowledge, and intelligence in war under the rubric of uncertainty. However, in each instance, the FOW is invoked either as if the reader is already familiar with the concept,[3] or with only a brief attendant clarification of its meaning—typically through reference to other terms, such as uncertainty, and complexity which are themselves scarcely clarified or defined.

The FOW is therefore subject to a peculiar irony: its dual status as a fecund yet opaque metaphor for the uncertainty of war means that we do not know precisely what a FOW is, or could be, despite its persistence both within (and without) martial thought. Since its publication, Kiesling's attempted intervention has been cited occasionally in martial accounts of uncertainty, but in the two decades that have followed there have been few subsequent attempts to substantively elucidate the

[3] Kiesling makes a similar point, which she illustrates by observing that the FOW is treated by Roger Beaumont in his book, *War, Chaos, and History*, "as if it has an accepted definition" (87).

term's origins and usage. Taking these provocations seriously, this thesis takes up the gauntlet laid down by Kiesling, and sets out to trace a genealogy of the term's emergence and subsequent entrenchment within the space of martial and strategic thought. In doing so, it is argued that although the FOW is often thought of as posing a significant barrier to the 'smooth' functioning of military operations that must be alleviated, an expanded view of its function is required in order to account for attempts that seek to exploit, and even *engineer* war's 'atmosphere of uncertainty' to their own ends. Along the way, the FOW is used as a point of departure for a more general inquiry into attendant efforts to conceptualise uncertainty in war, and in doing so grapples with the vagaries of related concepts, such as contingency, chance, chaos, and complexity, and other such expressions for phenomena that do not straightforwardly disclose or unfold themselves.

Given the deep intertwining of media technologies with contemporary forms of conflict and political violence, this thesis views the field of media studies as already deeply implicated within the continual emergence and proliferation of FOWs. Following Friedrich Kittler, for whom war was the motor driving the development of media, Jeremy Packer and Joshua Reeves observe that "the production of military knowledge . . . is foremost a media problem, as warfare is organized, studied, prepared for, and conducted according to communicative capacities" (9). And so, in order to properly make sense of what Derek Gregory has termed the "everywhere war" of the 21st century (238), it would be a grave oversight for this field to ignore or overlook the history of martial uncertainty, especially since the problematics (and opportunities) implied by the FOW are invariably those for which a vast arsenal of martial media—from maps, to wargames, to radios, to radar and sonar, to satellites, to UAVs (Unmanned Aerial Vehicles), to augmented reality battlegear—have been developed in response for centuries. This study is not intended to be an exhaustive or definitive assessment into this set of histories and relations, but it at least hopes to outline the tentative beginnings of an approach to the relationship between media, uncertainty, and the martial condition so that we can better grasp the impetus behind the persistent innovation of martial media and the wider technocultural assemblages within which they are enmeshed.

0.2 Scope and Method

Any attempt to produce such a genealogy of the FOW needs to address the multiple contexts that have at once influenced and informed the FOW, and through which it has been articulated, and subsequently circulated and mutated. Though its origins can be found in martial theory and doctrine, attention must also be paid to epistemological inquiries into the limits and conditions of knowledge and prediction, including scientific, mathematical, and informational theories of uncertainty, chaos, complexity, and contingency; and the wider space that James Der Derian terms the Military-Industrial-Media-Entertainment Network (MIME-Net)—"The feedback loop between military and civilian technology" which "seamlessly [merges] the production, representation, and execution of war" (xxxvi). For Kittler, so many of our everyday media technologies are "byproducts or waste products of pure military research" (*Optical Media* 74), and the same is true for the FOW, as the term is now subject to widespread use in gaming and game design circles, where it describes a commonplace mechanic in strategy games that imposes an opaque "fog" to obscure portions of the map or gamespace which have yet to be explored by the player. In order to account for this tradition, attention is given to the early history of professional wargaming, which is understood as a practice that is fundamentally concerned with simulating the conditions of uncertainty, and as a consequence has played a significant role in both shaping and disseminating a distinctive treatment of the FOW.

Given the wide range of developments and materials which must be covered within this genealogy, a discontinuous and transdisciplinary approach is required in order to sufficiently engage with the variety of ways in which the FOW traverses and mutates through each of the aforementioned arenas. A vital inspiration for this approach is the one elaborated by Steve Goodman in his book *Sonic Warfare* (2009). Though Goodman is concerned with a different (if not entirely unrelated) phenomenon to the FOW—namely, the application of acoustic force—his acknowledgement that "we don't yet know what a sonic body can do" (xvi), leads him to employing a probing, unfolding approach to sonic warfare that "oscillates between dense theorization, the clarification of positions and differentiation of concepts, on the one hand, and descriptive, exemplary episodes drawn from fact and fiction, on the other" (xvii), and which is sufficiently malleable that it can be emulated in this study. Along the way, Goodman highlights a variety of "vibrational, conceptual, musical, military, social, or technological [events]" that are dated, but not ordered chronologically, and subsequently addressed through a succession of short, semi-autonomous modular sections, rather than in the more traditional style of longform book chapters. These sections can be read from start to finish as linearly connected blocks within the text of his book, with a clear progression of ideas being threaded between them, but can also be accessed in a non-linear fashion, with each section providing a stand-alone account of a particular moment or event that exemplifies, illustrates, and/or articulates the possible ways in which sound becomes war, and war becomes sound.

Underpinning this choice of structure is another concept employed by Goodman in *Sonic Warfare,* and which has it roots in Warwick University's infamous Cybernetic Culture Research Unit (CCRU), of which Goodman himself was at one time a member: the hyperstition, which refers to "fictions that make themselves real" (CCRU 25), or the "element of effective culture that makes itself real" (CCRU 330). It is the CCRU's contention that fictions are not to be opposed to the real. Rather, they view reality as being itself composed of and structured by fictions, functioning as "consistent semiotic terrains that condition perceptual, affective and behavioural responses" (CCRU 25). For former CCRU member Nick Land, hyperstitions function as:

> A positive feedback circuit including culture as a component. It can be defined as the experimental (techno-)science of self-fulfilling prophecies. Superstitions are merely false beliefs, but hyperstitions—by their very existence as ideas—function causally to bring about their own reality (qtd. in Land and Carstens).

In his account of the concept in an interview with Delphi Carstens, Land gives the example of capitalist economics, and also of William Gibson's coining of the term "cyberspace" in his 1984 science fiction classic, *Neuromancer*, both of which involve the emergence of fictional entities whose actualisation is accompanied by intensive hyperbolic acts of confidence and speculation that nonetheless shape, warp, and restructure the spaces, contexts, and institutions that they come into contact with.

Approached through this lens, the FOW can be thought of as a particularly unusual form of hyperstition, in that it is a fiction that at once makes itself both real and *unreal*. The act of invoking the uncertain, the contingent and the finite nature of knowledge and information in war tends to be accompanied by attendant investments in particular theorisations, practices, pedagogies, doctrines, and technics that, it is hoped, might alleviate the problematic of the FOW, but perhaps also (as we shall see) have first and second order effects that might also further propagate it. In this sense, the FOW functions as an inversion of the cinematic account of war developed by Paul Virilio in *War and Cinema*. In this text, Virilio describes war as a spectacular sensory event, where "the bombs dropped on Hiroshima and Nagasaki were *light-weapons,*" (101) and the key to victory is determined by the side that can do a better job of "appropriating the 'immateriality' of perceptual fields" (10). In contrast to Virilio's martial cinematics of illumination, the FOW has an obscuring effect, for it is concerned with the countervailing tendencies by which war *evades* capture by the technologies of representation. That said, these two tendencies need not be absolutely opposed, as war's spectacular mode can be folded into the ambit of the FOW in the moments where an excess, glut, or overload of information pose just as much difficulty to a perceptual or representational apparatus as do those phenomena that are opaque, shrouded, hidden, or obscured.

In recognising the FOW's status as a peculiar sort of hyperstition, as Goodman does with his object of sonic warfare, the structure of this thesis is partly informed by the one articulated in his book. It establishes a non-linear genealogy of the FOW consisting of six core chapters each bookended by a shorter complimentary section that highlights a significant moment, technology, or event that resonates with or exemplifies aspects of its longer counterpart. As in *Sonic Warfare*, the longer chapters of this thesis are connected by an overarching thread or thematic drift tracing the origins, proliferations and subsequent mutations of the FOW as both metaphor and theoretical formation, while also outlining its own distinctive approaches and perspectives to its history, theoretical limits, possibilities, and disjunctures.

Though these chapters do broadly progress in loose a chronological order, tracing the prehistory of martial conceptions of uncertainty back to the Ancient Greeks and Chinese before proceeding forward in time until it arrives at our present moment, there are nonetheless numerous instances where the exigencies of the FOW necessitates some divergence from the linear progression of time. Each of the shorter sections interspersed between the longer chapters can also function as a self-contained piece of exposition, and invite being accessed as distinct entities or semi-autonomous modules that compliment the more detailed examinations located in the core chapters. This semi-modular structure is informed by the FOW's own status as both an account of a particular set of conditions in the world (uncertainty, contingency, chance etc.), but also as a hyperstitional theory-fiction whose parameters, plots, and potentialities have been in constant flux since its purported emergence during the late 19th and early 20th centuries.

Indeed, in recognising a distinction between the FOW's etymological origins and the history of the wider conception of martial uncertainty that both precedes and exceeds them, this thesis maintains that the FOW is not simply an idea that emerged in X text at Y time, but rather has manifested through a variety of ruptures, breakthroughs, simulations, and theorisations that have occurred in numerous contexts, spanning professional war-games, political press conferences, epic poems, doctrinal documents, treatises on military theory, and so on. Imposing a strict linear chronology onto such a conceptually and temporally diffuse phenomenon would not only be impossible, but also profoundly counterproductive precisely because it would obfuscate the FOW's distinctive indeterminacy. Instead, this text prefers to embrace the fog, and proceeds to wander gleefully within its atmospheric shroud.

A word of caution, however: it is crucial to stress that such an exercise does not obviate the need for methodological order, rigour, method, or care. Indeed, this thesis contends that there is a significant issue with the FOW's (un)articulation stemming from a persistent tendency in martial theory and doctrine to rely on assumed but rarely defined meanings for it, and (to some extent) the Clausewitzian general theory of friction with which it is so often twinned. Just as complexity or unpredictability should not be equated with absolute randomness, so too must it be stressed that a non-linear approach to genealogy can nonetheless be organised in accordance with a particular internal coherence, structure, and logic that will provide some amount of explanation as to how FOWs have been thought, and (perhaps more importantly) what they have and can do.

In order to achieve this, the project draws on a second source of inspiration: the work of the self-described martial empiricists, Antoine Bousquet, Nisha Shah, and Jairus Grove, whose recent publications in *Security Dialogue* contend—in a pointed shot across the bows of conventional approaches to the study of war found in security studies, international relations, critical military studies, and other related fields—that instead of grounding martial research in "primary definitions or foundational ontologies of war" an unbounded investigation into the "emergent and generative character of war," where what war *does* and *becomes* is paramount (Bousquet et al. 99-100).

Central to their project is a desire to treat war as an ever unfolding mystery that cannot straightforwardly be reduced to a fundamental set of theoretical treatments because, as Clausewitz himself once noted, its conduct "branches out in almost all directions and has no definite limits; while any system, any model, has the finite nature of a synthesis" (Book 2, Chapter 1 154-155). For the martial empiricists, war is at once persistent in its tendency to recur, but also ceaseless in its efforts to continually reinvent itself in ways that are both perplexing and captivating. Rather than narrowing their account of war to a focus upon the military, as either institution or, more expansively, as an industrial complex, they stress the importance of a scope that can expand outwards, grasping war as "both a thing and a process, a unity and an assembly, an event and an ecology of relations" (Bousquet et al. 104). This is very much war in the sense described by Gilles Deleuze and Félix Guattari in *A Thousand Plateaus*, where the military and its institutions are merely a captured or appropriated fragment or subset of a much more pervasive set of phenomena (417-418). With reference to both the Deleuzeoguattarian project and Michel Foucault's work, Goodman argues that war is both a "current flowing through every niche" of the social field, but also "an undercurrent that attains a cosmic transversality, cutting across all strata, human or nonhuman, with local outbreaks in every milieu, as abstract turbulence" (33). Like Goodman, the martial empiricists follow Deleuze and Guattari in seeing war as being populated by assemblages (Grove 70). This concept refers to ensembles or "heterogenous collectives of entities that cut across the organic, mechanical, and social strata of reality" (Bousquet, *Eye of War* 16). In many cases, these assemblages are held together or given a sense of coherence through their incorporation of technical objects. Consider, for example, how the scope of a rifle invites a particular set of behaviours in the soldier who wields it. Martial empiricism therefore regards the social and technical domains as inherently hybridised, and sets out to describe how their entanglement is generative of distinctive forms of material agency which both structure and constrain their surrounding environment, and any other entities which they come into contact with (Bousquet, *Eye of War* 16).

In their initial outline of the empiricist approach to negotiating such a maximalist conception of martial affairs, the Bousquet-Shah-Grove triumvirate emphasise war as a mobilising force, through which resources—whether they be human, animal, affective, material, or technical—"are conscripted, regimented and deployed into martial worlds;" but also as a practice whose means are *designed*: entailing stratagems, cunning, trickery, deception, and all the other methods that might be folded under the rubric of warfare (Bousquet et al. 105). Of course, design encompasses the weapons of war, but also implies a broader remit, spanning schematic "diagrams of operation through which bodies, implements and terrains are arranged into apparatuses of war" (Bousquet et al. 108). Finally, martial empiricism seeks to grasp the experiential dimension of war as an *encounter*. Crucially, this foregrounds war as a "sensate experience," a brutal crucible shot through with spiralling contingencies and uncertainties experienced by humans and nonhumans alike (Bousquet et al. 110). War is therefore not reducible to any of the entities, events, or assemblages that constitute it, and so the martial empiricists pursue a methodology that emphasises martial affect, embodiment and sensation, and in doing so seek to engage war as "a question that is perpetually posed" (Bousquet et al. 112).

In adopting a martial empiricist outlook, this thesis explores the emergence and entrenchment of the FOW primarily through the second and third of the modes outlined above, as both an account of what it is like to *encounter* war, but also as part of a carefully *designed* strategy for both negotiating and exploiting asymmetries of information and situational awareness under the most extreme of adversarial conditions. It must be stressed that it does not attempt to provide a total or comprehensive survey of the FOW that solely limits itself to the space of military theory, nor does it engage in a strictly representational analysis that focuses on addressing techno-cultural manifestations of the FOW—it will not, for instance, put forward yet another account of the phenomenology or visual economy of Unmanned Aerial Vehicles (UAVs)[4] that have made up an understandable, but nonetheless disproportionate amount of contemporary media studies' engagement with marital affairs in recent years.

Though the project acknowledges and maintains a distinction between the *conduct* of war as practice, and the *concept* of war as a product of theory and discourse, the FOW is seen as emerging through the interface between both of these aspects. In this respect, this thesis takes seriously both empirical examples and secondary materials spanning martial thought and practice, philosophical

[4] See, for instance, Väliaho (2014), Hussain (2013), or Cockburn (2016) for but a few examples.

reflection, ludo-mechanics (as in the space of wargaming), or martial fictions and representations, and considers them all in terms of their *generative* capacity to produce, conceptualise, reimagine, complicate, and propagate the FOW, both as a metaphor for sensory limitations and unanticipated contingencies, but also in terms of how it describes the very cognitive and conceptual frameworks that humans use to model and negotiate reality itself. Finally, in order to grapple with such a wide range of materials and cases, this project is informed by a patchwork of approaches and perspectives drawn from, but not limited to, media and communications studies; the philosophy of statistics and probability; the chaos and complexity sciences; political science; war and military studies; histories of war, science, and mathematics; and strategic and martial thought.

0.3 Argument and Structure

Chapter 1.0, "The Prehistory of Martial Uncertainty" seeks out the origins of the martial concept of uncertainty in the Greek, Roman, and Byzantine traditions whose imprint continues to inform Western approaches to war. With reference to François Jullien's writings on efficacy and strategy, it highlights a contrast in approaches between the Aristotelian fidelity to plan and action, and the alignment of ends and means; and Odyssean cunning intelligence, or *mêtis,* which contains many similarities to the ancient Chinese strategic corpus and its preference for an 'indirect approach.' It is argued that where the Aristotelian approach views uncertainty as a source of disruption to be eliminated through the application of instrumental rationality, the path of *mêtis* regards uncertainty as an opportunity to be exploited, and even a source of advantage to be propagated through the careful application of acts of uncertainty *engineering*.

Though martial uncertainty was solely understood in epistemic terms, as the Ancients lacked a conception of aleatory probability, we do nonetheless find within the writings of the Romans and the Byzantines a continuation of the Aristotelian and *mêtic* traditions, with the former embodied in a variety of references to both the importance of obtaining reliable information and imposing order on the battlefield, and the latter in the enumeration of approaches for engineering and exploiting differentials in uncertainty between one's own forces and those of the adversary. In doing so, these traditions begin to become entrenched, establishing a basic pattern which, it is argued, has underpinned how the Western martial tradition has approached the FOW ever since. The chapter then jumps forwards in time, to a crucial moment of inflection during the early Enlightenment period, when a wave of European martial innovators sought to break with the Greek and Roman traditions which had largely remained hegemonic in the annals of strategic thought up until that time, and put forward novel accounts of the nature of warfare informed by developments in geometry, mathematics, science, and technology that, in an update of the Aristotelian tradition, sought to eliminate uncertainty as an irregularity that could be resolved through the proper application of formal methods.

Having traced the first inklings of the martial concept of uncertainty, Chapter 2.0, "A Fog of Greater or Lesser Uncertainty," is primarily focused on the work of Carl von Clausewitz. The chapter elaborates the Clausewitzian concept of uncertainty as it is laid out in the general theory of friction of *On War*, suggesting that the FOW establishes an *atmospheric* account of conflict, where war occurs within the *medium* of the battlefield, where the seemingly smooth operation of the war machine is hampered by the a multitude of unforeseen factors operating below the threshold of apprehension. This articulation encompasses both environmental and cognitive sources of uncertainty, establishing the FOW as a properly onto-epistemic theorisation of martial uncertainty. Drawing on two contemporary readings of *On War* by Alan Beyerchen and Barry D. Watts, we also find in Clausewitz a precursor to contemporary attempts to develop a complex systems analysis of war, where martial uncertainties stem from the overall pattern of adversarial interactions between opponents. The chapter concludes by outlining how Clausewitz's theorisation of chance in war constituted a major paradigm shift that broke from the extant 19th century accounts through its apprehension of aleatory probability that placed war's indeterminacy at the forefront of its concept.

Chapter 3.0, "When War Becomes a Game" highlights a series of developments occurring in parallel to those outlined in Chapter 2.0. It surveys the emergence of professional wargaming in Europe (and especially Prussia) across the 18th and 19th centuries, and finds within them a sophisticated analogous attempt to translate war into the format of the game. Where the early Enlightenment's geometric conception of war had sought to eliminate uncertainty as an irregularity, here, an aleatory form of uncertainty was placed at the heart of the modelling process via a number of innovative game mechanics. Together, these collectively constitute a paradigm shift from the relatively simplistic *representations* of war found in pre-18th century wargames to the intricate and extensive *simulations* of it in the Reisswitz *Kriegsspiel* of 1824. While a number of continuities between the uncertainty mechanics of these wargames and the Clausewitzian account of martial uncertainty outlined in Chapter 2.0 are identified, the chapter also addresses a number of key discontinuities that stem from the attempt to translate an endeavour as expansive as war into the inherently bounded parameters of a game.

Chapter 4.0, "Atmospheres of War" tugs at the threads suggested by Clausewitz's provocative evocation of an *atmosphere* of war. With reference to Peter Sloterdijk's notion of "atmoterrorism," war is understood as practice of ecological engineering that targets "the material and immaterial connective tissues of our life-worlds" (Bousquet et al. 13). This conception is complemented by an exploration of the possibility of thinking the martial environment as a *medium* that induces resistance in the form of uncertainty to hamper the effectiveness of the war machine. In order to illustrate the significant role played by war's "becoming atmospheric" along these lines, the chapter concludes with an examination of the emergent practice of martial meteorology during the Second World War (Grove 66). Here, the significance of a struggle over the power to mitigate, and potentially exploit, the uncertainties of weather systems are considered as a precursor to the arrival of an expanding contemporary battlespace that is global in scope, and which Western militaries seek to assert control over via "full-spectrum dominance" (Shalikashvili 2).

Chapter 5.0, "Negentropy and the Fantasy of Omniscience" identifies the beginnings of a tendency in the American way of war to attain martial prowess through a pursuit of technological omniscience during the 1950s and 1960s. Particular attention is given to the development of a (martial) cybernetics stemming from Norbert Wiener's World War II research into automated anti-aircraft weapons systems, which helped to inaugurate a form of warfare predicated upon negentropic control through a computerisation of the U.S. Armed forces in order to curb or negate war's many uncertainties and contingencies. Attention is also given to the role played by Operations Research in instilling an analytical approach to decision making underpinned by the cool rationality of statistical modelling, as well as to the emergence of John von Neumann's game theory which, thanks to its popularity at the increasingly influential think tank, RAND Corporation, quickly became the de-facto method for modelling nuclear strategy during the Cold War period. The chapter concludes with an evaluation of the failures of cybernetic warfare during the Vietnam war, where an overly complex American war machine floundered in the face of an excess of information, and a determined and responsive adversary well suited to exploiting its weaknesses.

Chapter 6.0, "Entropy as Opportunity" begins with an account of how a tendency to valorise uncertainty began to infiltrate the U.S. defence establishment during the mid 1990s and early 2000s via a school of thought known as Network-Centric Warfare (NCW). Drawing on developments in the nonlinear sciences of chaos and complexity, as well as the influential writings of the iconoclastic military strategist John Boyd, NCW evangelists broke from their cyberneticist predecessors by replacing the quest for negentropic control with a view of uncertainty and chaos as wellsprings of creativity and freedom, which they sought to harness through the creation of expansive and decentralised martial networks. The chapter concludes with an overview of the legacy of NCW, while also addressing the emergence of a new wave of doctrinal treatments informed by contemporary developments in information technologies and machine learning which seek to supplant it.

1.0 The Prehistory of Martial Uncertainty

Father Zeus, draw free from the mist the sons of the Achaians, make bright the air,

and give sight back to our eyes; in shining daylight destroy us, if to destroy us be now your pleasure.

—HOMER, *The Iliad*

Lay on many deceptive operations.

Be seen in the west and march out of the east; lure him in the north and strike in the south.

Drive him crazy and bewilder him so that he disperses his forces in confusion.

—MENG SHIH

In *A Treatise on Efficacy* and its predecessor, *The Propensity of Things,* François Jullien contrasts the ancient Greek and Chinese approaches to strategy, and in doing so reveals why the problematic of uncertainty is of such fundamental concern for both martial thought, and also for any field or endeavour that wishes to employ a strategic disposition as a bulwark against the vicissitudes of contingency and adversity. However, before outlining the contours of Jullien's discussion and its implications for our survey of martial uncertainty, we must begin by briefly investigating the origins and etymology of the concept of strategy itself so that we can better understand the stakes of Jullien's discussion, and the context within which the martial conception of uncertainty emerges. Then, following Jullien, the chapter traces the prehistory of the strategic tradition back to the ancient Greeks, and identifies two important branches of thought within it.

The first of these is Aristotelian, and its foundations are located in the coupling of theory and practice (planning and acting) in order to attain an alignment between intended ends and available means. The second tradition is predicated upon a capacity for "situational sensitivity" (Forsythe 36) that the Greeks termed "*mêtis,*" and associated with the cunning intelligence possessed by the Homeric hero, Odysseus, whose "practical competencies" are "perceptual, anticipatory, instrumentalising, discerning, and strategic" (Forsythe 17). Jullien finds a close analog to *mêtis* in the ancient Chinese approach to efficacy, predicated upon a patient manipulation of the potentials of a given situation or environment. Where the Aristotelian tradition maintains an antipathy towards the unexpected due to its tendency to disrupt the process by which a plan is enacted upon the world, its *mêtic* sibling is entirely "at home in a world of becoming, coping with whatever arises immediately, and without qualm or resentment" (Chia and Holt 195).

Having detailed the basic features of these two traditions, we move through the ages, examining the military manuals of the Romans and Byzantines, who both inherited the Greek strategic tradition, but also departed from it in a variety of ways that allowed for not only the management and alleviation of uncertainty, but also its cultivation and exploitation. Finally, the chapter concludes by jumping forward in time, to the Age of Enlightenment, when martial and strategic thought broke from the prevailing approaches to uncertainty which had until that point been passed down from the Ancients. In doing so, it traces the emergence of a new epistemic regime informed by advances in the field of geometry that had a profound effect on both the theory and practice of war, and which provided the backdrop for Clausewitz's remarkable intervention into the theorisation of martial uncertainty in the early 19th century.

1.1 The Etymology of Strategy

There is no commonly agreed-upon definition of strategy, either as a concept, nor as field or tradition. Part of the difficulty here is that the meaning and usage of the concept of strategy has changed considerably over time. The term has a complex etymology, and it was not until the late 19th and early 20th centuries that its usage began to become commonplace within Western martial thought. Etymologically, the term can be traced back to the ancient Greeks, who used "*strategía*" to describe the art or practice of the general, who was in turn the *strategós*, or practitioner of strategy (Heuser, *Evolution of Strategy* 4). The first century AD Roman writer Frontinus, who strove to develop a *militaris scientia* (a "science of war") in his military manual, the *Strategemata*, employed the Greek word "*strategía*" because no equivalent term existed in his native Latin. He defined the term as encapsulating "the adroit operations of generals" (3), and employed it alongside another term, the titular "*strategemata*" (which we might call "stratagems"): "for everything achieved by a commander, be it characterised by foresight, advantage, enterprise of resolution, will belong under the head of 'strategy' while those things which fall under some special type of these will be 'stratagems'" (7). *Strategemata* therefore denoted particular acts of cunning or cleverness that a commander might employ in order to obtain an advantage in battle (Wheeler 21), while *strategía* referred to generalship in a more all-encompassing sense. The scope of Frontinus' concept of stratagem was nonetheless quite broad, and could encompass any kind of military activity, including (but not necessarily limited to) acts of trickery, deception, or chicanery (Wheeler 21). Nor did stratagems necessarily have to be directed towards an enemy, but could be employed against one's own troops, for instance in the form of psychological tricks intended to boost morale.

The successors to the Roman empire, the Byzantines, would go on to refine the terminology of *strategía* further, and by the late 6th century, a distinction began to emerge in their texts between strategy; understood as the means by which a general would either defend his lands, or attack those of a rival; and tactics, which referred to the science of organising and manoeuvring bodies of men on the battlefield (Heuser, *Evolution of Strategy* 4). However, this development was largely overlooked in the martial thought that predominated throughout the Medieval period in Europe. Medieval writers tended to defer heavily to the classic Latin texts, by the likes of the Greek Aeneas Tacticus (4th century BC), or the Roman Publius Flavius Vegetius Renatus (who is often referred to simply as Vegetius, and was writing towards the end of the fourth century AD), but focused primarily on the particulars of the conduct of military affairs. As a result, their efforts tended towards composing handbooks or military manuals detailing recommended approaches concerning the use of formations, armaments, drilling, morale and so on, without addressing or invoking an explicit concept of strategy per se (van Creveld, *A History of Strategy* 29).

A helpful characterisation of the extent to which there was a strategic tradition before the Enlightenment can be found in the writings of the Prussian strategist Georg Heinrich von Berenhorst who, during the French Revolution, observed that for the most part his European predecessors had focussed on detailing lessons that had been learned empirically based on their own experiences in war, rather than attempting to provide any kind of abstract, theoretical approach to strategy that might transcend the particulars and contingencies of their historical moment (qtd. in Heuser, "Art and Science in Warfare" 186).

This state of affairs would persist until at least the mid 18th century, when the Byzantine Emperor Leo VI's *Taktiká* (written around 900 CE)*,* which contained the aforementioned hierarchical distinction between strategy and tactics, began to be translated into French, by Paul-Gédéon Joly de Maizeroy and and subsequently German, by Johann von Bourscheid (Heuser, *The Evolution of Strategy* 5). After centuries of neglect, Europe's rediscovery of the Byzantine martial tradition prompted the translation of the Latin "*strategía" and "taktiké"* directly into the Romance languages, and in doing so facilitated the proliferation of the strategy/tactics distinction as we understand it today. The translation of Leo's *Taktiká* brought about a newfound accessibility of the term strategy, which could now encapsulate the strategic discourse, and established the preconditions for subsequent European martial thinkers to attempt to define the concept of strategy in the late 19th and early 20th centuries. But despite the relative absence of an explicit or coherent *concept* of strategy before this period that could disarticulate it from the conduct of generalship (as in Frontinus), we can nonetheless identify the emergence and influence of a strategic *tradition* dating back to both the ancient Greeks and Chinese. Within these early strategic texts we find the tentative beginnings of a discourse concerned with the problematic of martial uncertainty, and so, with the help of our guide, François Jullien, it is in this direction that our attention must now turn.

1.2 Prudence, Mêtis, and the Problematic of Uncertainty

Jullien begins by observing that in the European philosophical tradition, which extends back to the ancient Greeks, there is a tendency to navigate our world by setting up an ideal form—*eîdos* —or model, which we establish as a target—*skopós*—that is to be aimed for, in the form of an end—*télos* (*Treatise on Efficacy* 1, 34). Having marked one's eyes upon such a target, one then deliberates upon the possible means that could be employed to bring about that end. Within this schema, a *plan* is therefore an "elaborated project involving a sequence of operations that constitute means designed to attain a particular goal" (Jullien *Treatise on Efficacy* 32). Jullien contends that this is also the basis of the theory-practice model, where models are determined on a theoretical basis, before subsequently being submitted to reality through the mechanism of practice (*Treatise on Efficacy* 3). Viewed through this lens, strategy functions as the process of devising plans that can subsequently be realised through action—*prâxis*.

However, Jullien observes that while this approach can work well "from a technical point of view," the management of human situations and relations is another matter entirely (*Treatise on Efficacy* 4). Invariably, our best laid plans are thwarted by unexpected events, and unforeseen circumstances:

> Our actions cannot eliminate their contingency, and their particularities cannot be covered by any general law. . . . [Inevitably] there is always a discrepancy between the planned model for our action and what we, *with our eyes fixed* on that model, manage to achieve. In short, practice always to some degree falls short of theory. The model remains out there on the horizon on which we fix our gaze. The ideal, up in the sky, is inaccessible (Jullien, *Treatise on Efficacy* 4-5).

The incursion of chance and contingency are at the heart of the problematic of uncertainty, and from its articulation in Greek philosophy through to the present, it persists as a seemingly intractable difficulty. In Aristotle's *Physics*, chance has two distinct forms: *túkhē*—luck, or fortune—which is at work in the realm of practice, and *autómatos*—the automatic, or the spontaneous—which is associated with the natural world (Allen 66). Though *túkhē* is, at times, described as indefinite (*aóristos*), unpredictable (*parálogos*), obscure (*ádēlos*), and uncertain (*avévaios*), Aristotle does not regard it as the consequence of divine interference or agency, and in this respect the mysteriousness of *túkhē* is rather a function of our inability to account for its cause (Allen 66). Aristotle also acknowledges the prevalence of uncertainty in the conduct of war. For instance, in the *Eudemian Ethics*, war is presented as an arena where success is determined through a combination of both luck and skill: "That there are some people who are fortunate is a matter of observation. For people who lack wisdom succeed in many things where luck rules; and also in areas where there is an art, but where there is also scope for luck, for instance *in the case of generalship* and steermanship" (VIII, 2, 1247a; my emphasis).

It is worth stressing that the ancient Greek conception of uncertainty was not as expansive as our own. Despite the great prevalence of games of chance, involving both marked six-sided dice, and thrown astragalus (the four-sided knucklebone of the sheep), in their society the Greeks were only capable of epistemic, rather than aleatory, evaluations of probability (Bernstein 43-44). While these two forms of probability are related, the distinction is an important one. As Hacking explains, aleatory probability refers to "the tendency, displayed by some chance devices, to produce stable relative frequencies," and describes a stochastic process, such as a coin toss, while epistemic probability is concerned with knowledge, and is "dedicated to assessing reasonable degrees of belief in propositions quite devoid of statistical background" (*The Emergence of Probability* 37-38, 50).

We find an example of epistemic probability in Aristotle's *De Caelo*, where it is observed that "to succeed in many things, or many times, is difficult; for instance, to repeat the same throw ten thousand times with the dice would be impossible, whereas to make it once or twice is comparatively easy" (qtd. in Bernstein 44). In this passage, Aristotle is able to intuit that extended sequences producing the same results are less likely than in shorter runs of dice throwing, but does not take the next logical step and attempt to calculate the precise odds of any given outcome of a throw. He can, in other words, express with a reasonable degree of certainty that an extended run of the same throw is unlikely, but he cannot provide a statistical description of the process of tossing dice in the form of a statement of mathematical probability.

Scholars have provided a few different hypotheses for why the Greeks were never quite able to develop a mathematical understanding of probability despite the popularity of games of chance and a variety of mathematical and philosophical breakthroughs which might otherwise have been conducive to its emergence. Peter L. Bernstein points out that the alphabetic numerical system employed by the ancient Greeks[5] hampered the development of breakthroughs in mathematics, potentially including systematic probability, because of how difficult it was to use for calculation, and especially mental arithmetic (XXIX). Samuel Sambursky also highlights the absence of an algebraic system for notation, but suggests that there might have been an even more fundamental explanation for the absence of a theoretical approach to probability predicated upon their broader cosmological outlook. Sambursky observes that for the Greeks, the more regular, simple, and orderly a thing is, the closer it resembles the perfection of the heavens, exemplified by the seemingly regular patterns exhibited by the stars and planets, whose motions the Greek astronomers studied obsessively (46).

In contrast, a thing that is far from a state of perfection needs to perform a great many actions, and due to its complexity and disorderliness, it is an endeavour which is much more likely to fail (Sambursky 46). This tendency is present in the aforementioned passage from *De Caelo*, where the likelihood of repeating the same cast a thousand times represents a perfection that could only exist in

[5] The Greek alphanumeric system would persist as the primary notation system for mathematics in Europe until the publication of Fibonacci's *Liber Abaci* in 1202 ushered in the gradual adoption of the Hindu-Arabic numerical system that we are familiar with today.

the heavens, whereas worldly events are marked by their tendency for irregularity and chaos. As a consequence, the idea that regular sequences of causal events might be produced by man or in the world appeared to be a contradiction in terms, and so trying to look for regularities in the frequency of an occurrence (as in the case of throwing dice) would have been an alien endeavour for the ancient Greeks (Sambursky 47). For them, heaven and earth were utterly antithetical entities and so, when attempts to predict possible future outcomes were made, the Greeks would turn not to their philosophers or mathematicians, but to the oracles and their implements of chance.

Nonetheless, uncertainty and contingency still represented a challenge for Greek philosophers. For instance, in the *Nicomachean Ethics*, Aristotle would return to the problem of uncertainty in greater detail, and sought to alleviate it by identifying the faculty of prudence—*phrónēsis*—which he hoped might mediate between theory and practice. For Aristotle, *phrónēsis* operates alongside an individual's moral virtue in facilitating efficacious actions. The role of the latter is to determine one's end or goal, while the former is limited to making a selection between possible means: "virtue makes the target correct, prudence the things conducive to that target" (Aristotle, *Nicomachean Ethics* 131). Aristotle also differentiates prudence from his conception of craft—*tékhnē* (*Nicomachean Ethics* 121). Prudence is not a technical knowledge, aimed at "making" or "production"—*poíēsis*—such as the art of the shoemaker, but rather is associated with action—*prâxis* (*Nicomachean Ethics* 119, 124). Prudence is therefore a "logistic" faculty which one employs in order to make calculations or deliberations upon the best course of action in uncertain and difficult circumstances (Jullien, *A Treatise on Efficacy* 5). In this respect, *phrónēsis* is not reducible to reason, but rather is a pragmatic disposition that works alongside it: "prudence is necessarily a characteristic accompanied by reason, in possession of the truth, and bound up with action pertaining to the human goods" (Aristotle, *Nicomachean Ethics* 121).

What is less clear in the *Nicomachean Ethics* is the precise source or basis of prudence. Jullien finds Aristotle's definitions to be overly circular, in that "he can only define prudence by whatever is prudent: the criterion of prudence, which cannot be established by science, can only be provided by a man of whom it is generally said that 'he is prudent' (*A Treatise on Efficacy* 5). For Jullien, this issue leaves the basis of prudence to be discerned solely through reference to the qualities of "remarkable individuals" such as the aforementioned Periccles (*Treatise on Efficacy* 6). That said, Aristotle does at least suggest that prudent men are those who are capable of careful deliberation upon a variety of *means* in order to achieve a given *end*. The primary example given of the process of deliberation is a mathematical one, where:

> "You start from the constructed figure and work back, through a regressive analysis of the sequence of necessary operations (so that the last term discovered by the analysis turns out to be the first from the point of view of the genesis of the sequence). In exactly the same way, you start off from the supposedly achieved goal and then work back to determine the sequence of means that lead to that achievement (and the last means discovered is thus the means which it will be necessary to begin)" (Jullien, *A Treatise on Efficacy* 33-34).

Unfortunately, there are clear limits to this approach. Where mathematics is reversible, allowing forward or backward motion along a sequence of calculations, human action can only follow the arrow of time forwards, without any possibility of reversibility (Jullien, *A Treatise on Efficacy* 34). Thus, any attempt at forecasting the reverse causality of ends-means in advance of the planned action is always fated to remain hypothetical. Furthermore, there is always the risk of unexpected, contingent events intervening, and also the possibility of means that "overshoot," or end up being disproportionate to their ends, resulting in undesirable and even unanticipated outcomes.

In addition to the aforementioned limits of the Aristotelian deliberative process, Jullien observes that the Greek philosopher is also unwilling to disarticulate the faculty of prudence from ethical considerations, because in his account of the prudent man the conditions for action must always be transcended by the ends towards which they are directed—their *télos* (*A Treatise on Efficacy* 7*).* Aristotle persistently insists that prudence is directed towards the higher good—*eudaimoníā*—, where the advantage that the prudent man pursues should not be to his own benefit, but rather for his city and people (Jullien, *A Treatise on Efficacy* 7). This constraint is most apparent when Aristotle contrasts prudence with cleverness—*deinós*. He views the two faculties as related, but where the prudent man is always guided by the good end that he works towards, cleverness entails the ability to combine whatever means are most efficacious regardless of how virtuous the desired end might be, and so it is "of such a character as to be capable of doing what is conducive to the target posited and so of hitting it" (Aristotle, *Nicomachean Ethics* 132). For Aristotle, "base" cleverness and "good" prudence are mutually exclusive categories, because the prudent man will not contemplate working towards the least moral end:

> For the syllogisms dealing with matters of action have a principle [or starting point], 'since the end, that is, what is best, is of such-and-such a character,' whatever it may be (let it be, for the sage of argument, any chance thing), this end does not appear to someone if he is not good. For corruption distorts and causes one to be mistaken about the principles bound up with action.

> As a result, it is manifest that *it is impossible for someone who is good not to be prudent* (*Nicomachean Ethics* 132; my emphasis).

But for all Aristotle's scepticism of cleverness and the desire to succeed regardless of the morality of one's approach, the Greeks did nonetheless have some fascination with *mêtis*, the cunning or wily intelligence whose name is derived from the Oceanid Titan goddess Mêtis, who was Zeus' first wife. *Mêtis* is indelibly associated with both Athena—who burst forth from Zeus' forehead after he had swallowed the pregnant Mêtis in an attempt to forestall a prophecy that she would birth powerful children who would overthrow him— and the Homeric hero Odysseus, who frequently employed acts of trickery and deception in both of Homer's epic poems, the *Iliad* and the *Odyssey*. In their pre-eminent study of *mêtis* in Greek culture, Marcel Detienne and Jules-Pierre Vernant characterise it thus:

> A type of intelligence and of thought, a way of knowing; it implies a complex but very coherent body of mental attitudes and intellectual behaviour which combine flair, wisdom, forethought, subtlety of mind, deception, resourcefulness, vigilance, opportunism, various skills, and experience acquired over the years. It is applied to situations which are transient, shifting, disconcerting and ambiguous, situations which do not lend themselves to precise measurement, exact calculation, or rigorous logic (3-4).

Mêtis is a kind of intense context sensitivity, "an intimacy so tight that the difference between the known and the knower collapses" (Chia and Holt 194). It is predominantly a practical knowledge, like the ability to ride a bike, or surf a wave, which is not particularly amenable to prior formalisation. Rather, it is attained through familiarity, observation, and worldly experience. For Singleton, *mêtis* is "the intelligence implied in the process of *eliciting improbable effects from unpromising materials*" ("Subtle Empires" 253-254). Because it is fundamentally a capacity to "use the presence of what exists," (Chia and Holt 195) to exploit the affordances inherent in the immediate moment, it shines in those uncertain situations "that are volatile, slippery, stubborn, or some combination of the three, and it finds ingenious ways to transform their current arrangement into a new one" ("Subtle Empires" 255). A prime example of *mêtis* given by Detienne and Vernant is the chariot race organised by Achilles, and depicted in Book 23 of the *Iliad*. In this scene, the young prince Antilochus is able to defeat king Menelaus, the leader of the Greeks, despite the latter being in possession of stronger and faster horses. Following the advice of his father, the wise Nestor, Antilochus' victory is won by exploiting a narrow stretch of the race track that curves around a post, which enables him to cut across the path of Menelaus, forcing his rival to rein in his horses in order to avoid a crash (Detienne & Vernant 12-13). The use of a cunning ploy by Antilochus overturns the natural order of the situation, where one might otherwise expect the man whose chariot is pulled by faster and stronger horses to succeed. From Menelaus' point of view, Antilochus has cheated him, and indeed he berates the youth both during and after the race for his actions. However, from the point of view of Antilochus, victory has been brought about not through greater strength or speed or power, but because of a superior awareness of his immediate environment, which in turn he is able to leverage into a mastery of the temporal framework of the race:

> During the struggle, the man of *mêtis*—compared with his opponent—displays at the

> same time a greater grip of the present where nothing escapes him, more awareness of the future, several aspects of which he has already manipulated, and richer experience accumulated from the past. This state of vigilant premeditation, of continuous concentration on activity that is in progress, is expressed by the Greeks in images of watchfulness, of lying in wait, when a man who is on alert keeps watch on his adversary in order to strike at the chosen moment (Detienne & Vernant 14).

Nestor's advice to Antilochus before the race is to remain alert and watchful, both of the terrain, and of his opponent, so that he can remain in control and exploit the opportunity provided by the bend in the track (Detienne & Vernant 15). By doing so, Antilochus is prepared to seize upon affordances implicit in a situation, but which can only be perceived through the cultivation of a watchful disposition.

Accounts such as this give us an impression of some of the features of *mêtis*, however, despite having a "meaning that remained remarkably stable over about a 1000 years from Homer to Oppian," (Singleton, "Subtle Empires" 252) there is no explicit theorisation of it as a *concept* in the way that, for instance, Aristotle attempts with prudence in the *Nicomachean Ethics*. As Michel de Certeau puts it, "it is absent from the image that Greek thought constructed of itself" (81). Because of *mêtis'* tendency towards elusiveness, polyvalency, context-dependence, and mobility,[6] Jullien speculates that it "is thus refractory to the imposition of any form set up as a model, [it] foils any attempt to stabilise its identity on the basis provided by Being or God, to which Greek thought is devoted" (*A Treatise on Efficacy* 9).

[6] Detienne and Vernant find that the Greeks most often associate acts of cunning with the octopus and the fox, the wily shapeshifters and tricksters of the animal kingdom.

Perhaps because of its proximity to action, and the local nature of its application, its *pragmatic* nature meant that the Greek theoretical and philosophical tradition, which was much more comfortable with matters of thought and being, was insufficiently capable of articulating a formal theory of efficacy predicated upon instability, mutability, and ambiguity (Jullien, *A Treatise on Efficacy* 9).

Similarly, the Romans, who would become the most influential military force in Europe for many centuries, shared the Aristotelian scepticism towards *mêtis*, and instead favoured the traits of honour, bravery, and strength embodied by the heroic figure of Achilles (L. Freedman, *Strategy* 42). And despite the profound influence of Greek culture upon them, some facets of Roman society explicitly sought to distinguish themselves from what they saw as the base trickery of their predecessors. For instance, in Livy's *History of Rome*, there is an account of an experienced group of Senators expressing their distaste towards forms of "excessively cunning wisdom" which they scorned as "Punic tricks and Greek craftiness, among whom it was more glorious to deceive an enemy than to conquer by Force" (qtd. in Wheeler 24). In a fashion not dissimilar to Aristotle circumscribing the actions of the prudent man to "the good," the Romans felt that tricks and cunning might only proffer a momentary benefit or advantage, whereas "in the long run the spirit of a man was at last conquered, who confessed that he had been overcome neither by craft not by accident, but by open hand-to-hand combat in a just and righteous war" (Wheeler 24). Whatever the reasons for the ultimate failure of the Greeks or their Roman successors to provide a philosophical account of efficacy along its lines, the conceptual possibilities afforded by *mêtis* would have to be deferred, as the term would gradually fade out of use in the Greek language, and so the aforementioned theory-praxis model of efficacy became the de-facto approach to conceiving of strategic thought in Europe, at least until the Enlightenment. Instead, we turn our attention eastward, towards China, where a parallel strategic tradition had already begun to emerge that provided a distinctive and detailed account of efficacy, but was predicated upon an entirely different model concerning the relations between thought and action.

1.3 Efficacy and Transformation

Chinese thought, argues Jullien, eschewed the predicate of the Greek philosophical tradition, where ideal forms or archetypes were at once held separate from reality while nonetheless informing accounts of it (*A Treatise on Efficacy* 15). Rather, the writings of ancient Chinese sages, scholars, and soldiers such as Sun Tzu, Lao Tzu, and Sun Bin regards the whole of reality as a "regulated and continuous process that stems purely from the interaction of the factors in play (which are at once opposed and complementary: the famous *yin* and *yang*). Order . . . is entirely contained within the course of reality, which it directs in an immanent fashion, ensuring its *viability"* (Jullien, *A Treatise on Efficacy* 15). Where the Greek model establishes, and subsequently presupposes a distinction between knowledge of the world and action upon it, the Chinese tradition *sidesteps* the theory-practice relation through its treatment of propensity and potential. Nor is there any space permitted for uncertainty or chance in the Chinese account of war, because one either accumulates propensity through a careful process of harmonisation with one's environment, surveying it for opportunities, the outcomes of which, once seized upon, will eventually appear inevitable; or waits and defers until circumstances become more favourable (Jullien, *A Treatise on Efficacy* 51).

Rather than linearly traverse between assessing, theorising, deliberating, and acting in a manner circumscribed by moral concerns, the Chinese sage is therefore wholly concerned with efficacy, and "the preparation for a future configuration of events through predetermining them as much as possible" (Goodman 38). Fundamental to this approach are two crucial dispositions. The first entails a constant assessment of one's environment and events, leading to an understanding of the *situation* or *configuration* (*xing*) (Jullien, *A Treatise on Efficacy* 17). Having done this, the sage or soldier is able to align themselves with the *potential* ("shi") implied by their situation, and which might be exploited for advantage (Jullien, *A Treatise on Efficacy* 17). It is not just that one waits for auspicious circumstances, but also that, with a good grasp of the particulars of one's conditions, one can manipulate them to better serve your will.

An example of this can be found in Sun Tzu's advice that by striving to put one's troops in a situation where their backs are against the wall, where there is no possibility of retreat or surrender, then their potential to fight without constraints can be fully unleashed, because only victory can save them from death (112-113). By this logic, circumstances are not inherently unpredictable things that can ruin any plan. Instead, they can be turned to one's advantage by the propensity that is immanent to them. Rather than bringing a model-plan to bear, "one accedes to a logic of *unfolding*: one allows for the implied effect to develop by itself, by virtue of the process that has been set off" (Jullien, *A Treatise on Efficacy* 21-22). Crucially, the potential of a situation cannot be forecasted in advance, but rather must be continually detected, since it is subject to change at any time. Thus, one evaluates the factors inherent in a situation in order to determines whether they are sufficiently favourable to exploit in the moment, as Sun Tzu explains in the memorable introduction to his *Art of War:*

> Therefore, to gauge the outcome of war we must compare the two sides by assessing their relative strengths. . . . On the basis of this comparison I know who will win and who will lose. If you heed my assessments, dispatching troops into battle would mean certain victory, and I will stay. If you do not heed them, dispatching troops would mean certain defeat, and I will

> leave. Having heard what can be gained from my assessments, shape a strategic advantage (*shi*) from them to strengthen our position. By 'strategic advantage' I mean making the most of favourable conditions (*xing*) and tilting the scales in our favour (74).

This is why Jullien wryly observes that the Chinese general only wins what appear to be 'easy' victories, for if one's evaluation of a battle determines that victory is unlikely, then wisdom dictates that it is better to simply withdraw or evade, and therefore defer confrontation until the circumstances are balanced in one's favour (*The Propensity of Things* 26).

Another fundamental point of distinction between the Western and Chinese approaches to strategy highlighted by Jullien concerns the concept of action. In the West, actions are typically viewed as their own distinct and discrete entities that can be isolated as a basic element of human behaviour, whereas the Chinese approach emphasises the importance of being open to efficacious *transformations* that are meant to harmonise with prevailing circumstances and one's environment (Jullien, *A Treatise on Efficacy* 57). Within this perspective, war itself is often understood as an action; the "act of war," a discursive gesture which, as Jullien astutely notes, works to separate or isolate war from its environment or circumstances, re-casting it as an exceptional event, rather than as an immanent occurrence that can be situated within a wider continuity. Furthermore, the relation between war and action has, in Jullien's account, taken on a mythological status in the Western tradition, particularly when it comes to actions whose effects seem somehow disproportionate to the efforts of those who conduct them. Miraculous feats of action along these lines, where the outcomes are not reducible to the efforts of those who bring them about, occur because of "inspiration" (*A Treatise on Efficacy* 52). Jullien notes that Aristotle resorts to precisely this kind of account in his *Eudemian Ethics,* when he declares that there are sometimes those who "whichever way they launch themselves, are successful without even thinking, are inhabited by a god" (qtd. in Jullien, *A Treatise on Efficacy* 53). Evidently, for the ancients, the source of inspiration was invariably divine, arriving in the form of good fortune; a gift from the gods.

Over time, a different concept of chance would emerge in the West, predicated not upon the whims of the gods, but rather stemming from the "indeterminacy of matter" (Jullien, *A Treatise on Efficacy* 53). Slowly, European thought would regard chance as an arena into which human action could insert itself in order to leverage advantage. Indeed, bold, resolute, and foundational action would often come to be regarded as the most efficacious approach to cope with the unpredictability of the world, and in doing so also emerged as the foremost criterion for evaluating the figure of archetypal Western heroes, those "inspired" figures who were able to intervene in the great events, almost as if they were destined to do so. As Jullien notes, action is therefore generally regarded as personal, a feature of the subject (*A Treatise on Efficacy* 55). Actions are also highly visible, constituting events, suggesting or implying meaning, and invariably becoming the fundamental basis of stories, myths, and legends. Actions *stand out*, intervening in the course of things, rather than blending seamlessly into them:

> Because [action] impinges from the outside, introducing a plan/project (ideal), it is always to some degree external to the world and is therefore relatively incompatible and arbitrary: both arbitrary and importunate, for, by forcing itself into the course of things, it inevitably to some degree tears at the tissue of things and upsets their coherence. In fact, by imposing itself, it inevitably provokes elements of resistance, or at least of reticence, that it cannot immediately

control and that, tacitly forming common cause, block and quietly undermine it (Jullien, *A Treatise on Efficacy* 55).

Ultimately, Jullien regards the Western model of action as being fundamentally tragic in nature, with its mythos invariably depicting a heroic figure such as Achilles or Beowulf, engaged in an epic clash or confrontation that offers no possibility of surrender or escape (*A Treatise on Efficacy* 55). Destiny cannot be avoided by the action of the hero, rather it can only be discovered *fatally*, when its cruel consequence is already too late to avoid.

In contrast, the Chinese tradition was generally sceptical of efficacy stemming solely from action. Where the Western hero works against the existing order of the world through his inspired action, which he hopes can cut through the vicissitudes of chance and fate, the Chinese tradition adopts a different approach, opting to *transform* in accordance with circumstance, rather than against it (Jullien, *A Treatise on Efficacy* 55). Such transformations are extended, rather than discrete, and it is their continuity which produces effects. Unlike actions, transformations are without locale; rather their deployment is always global in nature, and so their effects are diffuse and pervasive (Jullien, *A Treatise on Efficacy* 57). Where actions stand out, and are excessive, the gradual and incremental nature of transformations makes them difficult to notice or observe. Indeed, the more discreet a transformation is, the greater its efficacy (Jullien, *A Treatise on Efficacy* 58). In hindsight, they appear as unremarkable, inevitable, immanent features rather than as discrete products of a willful straining against the events. In contrast with his heroic, but ultimately doomed Western counterpart, the Chinese strategist knows "how to anticipate the propensity at work so that he has it at his own disposal" (Jullien, *The Propensity of Things* 35).

But for all Jullien's veneration of the Chinese approach to efficacy, there is nonetheless a fundamental feature of it that suggests an escape from the problematic of uncertainty is not so straightforward. In order to engage in strategically efficacious forms of transformation through the careful grasping and manipulating of the propensity of things, one must first have developed a reliable system for continually gathering and processing information about the world. It should come as no surprise then, that Sun Tzu devotes an extensive amount of space in his *Art of War* to the intricacies of spying, a practice which he views as being utterly fundamental to the pursuit of advantage in war:

> The reason the farsighted ruler and his superior commander conquer the enemy at every move, and achieve successes far beyond the reach of the common crowd, is foreknowledge. Such foreknowledge cannot be had from ghosts and spirits, educed by comparison with past events, or verified by astrological calculations. It must come from people—people who know the enemy's situation (123).

Sun Tzu is unequivocal here, foreknowledge stems not from any kind of mysticism, but from the considered and extensive application of the practice of spying. He goes on to enumerate a lengthy typology of all the different types of spies that a good general should employ, with particular attention given to the role of double agents, who he regards as being "the key to all intelligence," and also of expendable agents, whose role it is to have false information deliberately leaked to, so that they can pass it on to enemy agents in order to subtly manipulate or direct the opponent to act in favourable ways (125). Indeed, as the pre-eminent theorist of war as deception, Sun Tzu regards spying not just as a mechanism for garnering information about the enemy, but also for manipulating informational asymmetries between one's own forces and those of the opponent. Indeed, for the historian of deception and stratagem Barton Whaley, the writings of Chinese strategists such as Sun Tzu and Meng Shih are emblematic of a fundamental distinction between how the European and Chinese respectively conceptualised the source and function of martial forms of uncertainty:

> The fog of war can be perceived from a . . . viewpoint . . . overlooked by the Western writers, but perhaps grasped, if only dimly, by the Chinese. While Occidentals view this fog of communications as an intrinsic effect, the Orientals perceive that it is also subject to external manipulation. One can 'enforce an information blockade,' lay on 'many deception operations,' overload and confuse communications, until the enemy is driven mad. In other words, there is much that one army can do to intensify the already murky atmosphere that engulfs the enemy commanders (136).

As we have already observed, for Sun Tzu one should only engage in battle if the conditions are overwhelmingly favourable, otherwise the costs of violence are too great and alternative means are to be preferred. In this sense, the only time uncertainty should be a factor is in situations when it is being wielded against one's rival in the manner outlined by Whaley.

Nonetheless, there is an unavoidable precondition for the approach advocated by Sun Tzu: the ability to accurately assess all possible differentials in capabilities, morale, dispositions, and positioning between one's own forces and those of the enemy, as well as the wider environment, the political context, and so on. The capacity to evaluate all of these factors necessarily entails the development and maintenance of a reliable and revisable model of reality to base transformation upon. Indeed, if anything, the Chinese approach demands an even more extensive process of modelling than the Western one, given that it entails a sustained, cyclical effort of verification and adaptation between information and reality: "there is nowhere that you cannot put spies to good use. . . . It is necessary to first know the identities of the defending commander, his retainers, counsellors, gate officers, and sentries. We must direct our agents to find a way to secure this information to us" (Sun Tzu 125).

To maintain such a persistent and omnipotent perceptual apparatus there must also be costs, both financial, but also logistical.[7] Given the immense amount of data that such a network might output, it might be difficult to relay, transmit, decrypt, and make sense of the affairs with which it is concerned in a timely manner. From this perspective, Sun Tzu's chapter on spies begins to resemble the immense map described by Borges in his fragment, "On Exactitude in Science," in that it invokes an extensive, pervasive effort whose ideal form is destined to entirely overlap with the territory that is intended to surveil. For a spying network to remain functional, such omnipotence and extensivity is unlikely to be obtained, persisting only as an ideal to strive towards, rather than a realistic state of affairs that might be cultivated. And so, inevitably, chance and uncertainty reinserts itself in the margins of the spy network, even if the Chinese sages preferred approach to efficacy may have seemed to circumvent it.

Nonetheless, Jullien's treatise contrasting the Chinese and Western approaches establishes a guiding set of parameters within which we can begin to interpret subsequent developments in the treatment of strategy and its relation to martial uncertainty. It establishes the theory-practice model, and its inherent susceptibility to disruption by uncertainty, as the basis of the Western strategic tradition. Nonetheless, in the *mêtis* of Athena and Odysseus, and the writings of Sun Tzu on

---

[7] Sun Tzu insists that the most valuable spies must be treated with generosity, and unreliable spies with great violence (125).

deception, there lies the promise of an approach not just to the *alleviation* of uncertainty but also to its *exploitation* and perhaps even *engineering*. What follows is an account of the various texts, manuals, and treatises on martial affairs produced in the wake of the ancient Greeks, passing through the Medieval ages, and concluding with an important moment of inflection in the 17th and 18th centuries. This moment, which slightly precedes the emergence of Clausewitz's theorisation of war, was brought about by the endeavours of a variety of Enlightenment thinkers and soldiers who sought to break with the established and deeply entrenched approaches of the Medieval period, and in doing so attempted a novel conception of the relation between uncertainty, strategy, and martial conduct.

1.4 The Age of the Stratagem, or, Uncertainty by Design

As we have seen, the ancient Greeks had already begun to think of war as a chancy endeavour, and though the concept of *mêtis* offered up a tentative blueprint for the development of a strategic disposition suited to taking advantage of its affordances. But it would be their successors, the Romans and the Byzantines, whose writings on the art and science of war would hold sway throughout Europe throughout the coming centuries. Indeed, so pervasive was their influence that both Martin van Creveld and Lawrence Freedman gloss over the subsequent strategic contributions of the Middle Ages in their histories of strategy, giving two primary justifications. The first is predicated on the argument that strategy simply did not advance much until the Enlightenment. As Freedman observes:

> Before 1800, intelligence-gathering and communication systems were slow and unreliable. For that reason, generals had to be on the front line—or at least not too far behind—in order to adjust quickly to the changing fortunes of battle. They dared not develop plans of any

> complexity. Adopting measures such as splitting forces in order to attack the enemy from different directions or holding back reserves to reinforce success was likely to lead to command and logistical nightmares. Roads were poor and movement was bound to be slow. . . . Armies that lacked passion and commitment, whose soldiers were easily tempted to desert if food was in short supply or conditions too harsh, did not encourage confidence in sustainable campaigns. Prudence suggested concentrating on pushing enemies into positions where they would feel vulnerable or struggle to stay supplied (*Strategy* 70).

As the relative mobility of Medieval armies was at best comparable to their Greek and Roman predecessors (not everyone was as proficient as the Romans when it came to building a road!), and because combat typically consisted of pitched battles between two armies on a battlefield, or more prolonged sieges (these were especially prevalent during the Medieval period), there was, in van Creveld's view, little scope for strategic innovation during this period (*Command in War* 22-23). Certainly, some impactful technologies did emerge, such as the stirrup, and the armoured knight, while others, such as the crossbow, fell in and out use, but the effects of these on the development of novel strategic approaches in Europe were primarily felt on battlefield, rather than at higher levels (Heuser, *The Evolution of Strategy* 40). For Heuser, this time period is broadly characterised by the ebb and flow of a variety of approaches to warfare, but without any radical development, transformation, or step-change emerging to disrupt the holding pattern:

> [T]he development of military technology was thus not one-directional: both technological and organisational inventions could be forgotten or given up, and warfare in the 'Dark Ages'

> was certainly conducted in ways less sophisticated, but arguably at times no less effective, than those of the Roman Empire at its height. Over these two millennia, we observe a fluctuating pattern with different strands - disciplined infantry, agile horsemen, artillery, heavy forsemen, fortifications, siege engine and so forth - interweaving and dominating at different times, with few if any major technological innovations over the millennia for which we have archaeological evidence, until early modern times (*The Evolution of Strategy* 40).

Evidently, the conduct of Medieval war was sufficiently variable that the main task for strategists of the period was to keep up with its shifts, but not characterised by the emergence of anything so radical or novel that it required a more fundamental rethinking of its underlying logic.

The second justification that historians of strategy give for overlooking the Middle Ages is the aforementioned reliance that martial thought during this had on the guidance of the Greeks and Romans (and to a lesser extent the Byzantines), whose writings were deemed more than sufficient for an understanding of the art of war. Indeed, so deeply entrenched was Greek and Roman martial thought that commentaries on their works could be found in the time of Machiavelli whose *Art of War* (1521) contains a litany of references to Livy and Vegetius. Even Marquis De Folard's 1724 essay on tactics, *Nouvelles Decouvertes sur la Guerre*[8] ("New Discoveries About War") attempted to glean martial insights via a treatise on the Greek historian Polybius and his writings on the Macedonian Phalanx at a time when gunpowder had long since become ascendant across Europe (van Creveld, *A History of Strategy* 36-37). Nor were Machiavelli or De Folard alone in overlooking the impact that

[8] Folard's work also contains an early allusion to fog as a metaphor for uncertainty in war: "The *coup d'oeuil* is a gift of God and cannot be acquired; but if professional knowledge does not perfect it, one only sees things imperfectly and in a fog" (qtd. in Heinl 212).

gunpowder was already having on both the conduct and strategy of war. If anything, they are indicative of a significant lag between the theoretical development of strategy in response to novel technological developments on the battlefield. This delay persisted until at least the French Revolution, by which point the consequences of a variety of technological, social, and political transformations on the conduct of warfare could not be denied or overlooked by martial thought any longer (Heuser, *The Evolution of Strategy* 42). The general absence of an explicit theorisation of strategy as a concept, since the contributions of the Byzantines, largely bears out Freedman and van Creveld's dismissal of the literature produced during the Medieval period. Ultimately, we are left with the impression that thinkers during this 'Dark Age' were content with deferring to the strategic tradition inherited from the ancients because it was at least minimally sufficient, and so there was little need to overcomplicate matters by rewriting the rulebook, as it were.

Of the influential texts written by the Romans and the Byzantines, there are three whose treatment of martial uncertainty is of particular interest to us: Frontinus' *Strategemata* (dated between 84 and 96 AD), Vegetius' *Epitoma Rei Militaris* (dated between AD 383 and AD 450, and Maurice's *Strategikon* (dated between AD 575 and 628). These works constitute a distinctive genre of classical literature: the collection of stratagems (Wheeler IX). They exist in a loose continuity with each other, both in terms of structure and content. Each is presented in the form of a military manual intended for the education of officers and generals, and focuses primarily on outlining tips, maxims and examples for how to prepare and oversee the smooth functioning of a Roman (and subsequently Byzantine) army. They place varying degrees of emphasis on the importance of acts of trickery and deception in order to attain a decisive advantage. Each text is divided into several books that split up the functions of generalship into areas such as the recruiting and drilling of troops, the movement and logistics of an army, setting and avoiding ambushes, and finally preparing for and waging both pitched battles and sieges. They are worth examining despite (or perhaps precisely because of) their pragmatic approach to the practice of warfighting, because they:

1. Establish an epistemic acknowledgement of the *uncertain* and *contingent* nature of war.
2. Emphasise the importance of cultivating a variety of practices for the *negotiation, alleviation,* and *mitigation* of uncertainty.
3. Though implicit, (2) entails the creation of *mental models* of the environment of the battlefield; of the strength, capabilities, morale, and disposition of one's own forces; and of those of the opponent.
4. Actively encourage the purposive *disruption* and *manipulation* of not only the opponent's model of the unfolding situation, but also, where necessary, of the prevailing situational awareness of one's own forces. In this respect, uncertainty is not only a problem to be negotiated/alleviated/mitigated, but also a space of opportunity which can be exploited through cunning acts of what I term *uncertainty engineering*.

A brief introduction follows, describing the history, structure, and approach of each of these three works, followed by a more detailed examination of how these four themes are presented within them.

The first of these texts, Sextus Julius Frontinus' *Strategemata* consists of four books,[9] and was written as a successor to a now lost work entitled *The Art of War.* The bulk of the *Strategemata* consists of anecdotes recounting the use of various stratagems from both Greek and Roman history which are intended to provide guidance for its prospective readers. Because of its wide time span it does not provide a guide to the functioning of the Roman army during Frontinus' own historical moment, but rather is a syncretic account of how the Romans fought over several centuries. Vegetius' *Epitoma Rei Militaris* ("Epitome of Military Science") is also divided into four books, and was written at the bequest of his Emperor, Valentin, with the hope that it might provide some solutions to the Empire's decline in military might (van Creveld, *A History of Strategy* 25). Vegetius' text was profoundly influential, and was the most widely read work on military strategy in Europe before Clausewitz (Lynn 52). It does not rely as heavily on anecdotes as Frontinus' work does, but instead describes how an idealised Roman force should fight, with exhaustive detail given to various formations, weapons, drills, the composition of forces, and so on. Both texts were written in Latin, though Frontinus does occasionally employ some Greek words (including, notably, in its title). Maurice's *Strategikon* is perhaps the most distinctive of the three, being simultaneously more straightforward and eloquent. At times, it approaches putting forward a genuinely philosophical account of war and strategy, a tendency that is absent in his predecessors. It is worth noting that the authorship of this text is in dispute. Although it is attributed to Byzantine Emperor Maurice (who reigned between 582 and 602 AD), it may well have been composed in his name by other writers. Maurice's text was written in Greek, and so it was not as popular as the Latin works by the aforementioned Roman authors favoured by educated

[9] The authorship of the 4th book of the *Strategemata* has been called into question by scholars, and may have been written by a different, unknown author.

higher classes of the Medieval period. As a result, the *Strategemata* largely faded from view by the 6th century AD, only re-emerging during the humanist revival of the Renaissance, and especially following its reproduction in a printed edition during the mid 17th century.

The first feature that all three of these texts share is their acknowledgement that uncertainty and contingency pose significant problems that generals must be concerned with. It is worth stressing that none of them dwell extensively on the precise nature of the uncertainty of warfare, but rather treat the presence of chance and contingency as features of war's character as a fundamental assumption that guides their subsequent meditations on efficacious generalship. The most influential phrase in Vegetius' *Epitoma Rei Militaris,* is instructive in this respect:"[H]e who desires peace, let him prepare for war. He who wishes a successful outcome, let him fight with strategy, not at random" (63). The first line of this statement would go on to become a classic Roman paradox, *si vis pacem*, *para bellum* ("if you want peace, prepare for war"), and has since been held up as an early expression of the logic of deterrence-theory, but it is the second line that we are concerned with, for it implies that strategy is to be contrasted with the underlying randomness of war.

This association persists throughout the text, with order brought to the Roman war machine through careful observation, vigilance, drilling, practice, and the careful management and organisation of formations: "In war, he who spends more time watching in outposts and puts more effort into training soldiers, will be less subject to danger" (116). Without these things, war is regarded by Vegetius as random, chancy, disordered, and confusing, and so he places a great deal of emphasis on techniques for reducing or alleviating uncertainty through a combination of watchfulness, training, organisation, and various other efforts directed towards shaping the Roman military into a coherent fighting force. We can see these tendencies on display in a description of the ensigns and standards used by the Roman army, where Vegetius stresses how important it is that different cohorts within the legion be able to distinguish themselves from each other and their foes because without this imposed order the legion's fighting risks becoming too chaotic:

> "[T]he ancients knew that in battle once fighting commenced the ranks and lines quickly became *disordered and confused*. To avert this possibility they divided the cohorts into centuries and established individual ensigns for each century. . . . Seeing and reading this, soldiers could not stray from their comrades, whatever *the confusion of battle.*" (44-45; my emphasis).

He stresses this difficulty again in a passage emphasising the importance of a coherent system of signalling to the Roman military:

> [T]here is nothing so conducive to victory as heeding the warnings of signals. Since an army *in the confusion of battle* cannot be governed by a single voice, and many orders have to be given and carried out on the spur of the moment in view of the urgency of events, ancient practice of all nations devised a means whereby the whole army might recognize by signals and follow up what the general alone had judged useful (71, my emphasis).

In each of these instances, Vegetius assumes that confusion will be a feature of any given battle, and even stresses the time-sensitive nature of decision making within its crucible. For him, disorder is presented as the inherent or natural state on the battlefield, and it is precisely the ability to ward against the threat of a descent into confusion through an overarching training regimen that the Roman fighting force is able to sustain its efficacy under adverse conditions: "[I]n camp, on the march, in every field exercise, every soldier should learn to follow and understand. For continual practice is obviously necessary in peacetime of a procedure which is to be maintained in the confusion of battle" (Vegetius 72-73).

Vegetius' concern with order extends towards obtaining some degree of familiarity with both the enemy and the environment. He writes extensively on the best practices for scouting ahead in order to gauge the terrain and also the location and state of the enemy forces, and is an advocate of cultivating an extensive store of information concerning the environments in which the Roman army might find itself fighting in:

> [The General] should have itineraries of all regions in which war is being waged written out in the fullest detail, so that he may learn the distances between places in terms of the number of miles and the quality of roads, and examine short-cuts, by-ways, mountains and rivers, accurately described. Indeed, the more conscientious generals reportedly had itineraries of the provinces in which the emergency occurred not just annotated but illustrated as well, so that they could choose their route when setting out by the visual aspect as well as by mental calculation (73).

Central to Vegetius' approach here is an effort to at once enhance the amount of up to date information he has at his disposal concerning the enemy, while also shrouding the present state of his own forces and intentions. Vegetius views a well informed opponent as being particularly dangerous—"[it] is difficult to beat someone who can form a true estimate of his own and the enemy's forces" (116)—and so he is quite concerned about the prospect of deserters and spies within his own ranks disclosing his plans. Accepting that he cannot necessarily eliminate the possibility of such adverse occurrence, he instead advocates maintaining and normalising a state of secrecy throughout his ranks so that such figures are unlikely to have access to critical time-sensitive information regarding the general's plans and intentions:

> But the most important thing to be careful about is to preserve secrecy concerning the places and routes by which the army is to proceed. The safest policy on expeditions is deemed to be keeping people ignorant of what one is going to do. It is for this reason that the ancients had the standard of the Minotaur in the legions. Just as he is said to have been hidden away in the innermost and most secret labyrinth, so the general's plan should always be kept secret. A safe march is that which the enemy least expect to be made. (74)

Indeed, Vegetius subscribes to the idea that widespread knowledge of the actual state of affairs is potentially a *dangerous* thing, because he views the morale of his own forces as something that is quite susceptible to being crippled by exposure to bad news. So greatly is he preoccupied by this that at one point elsewhere in the text he even details an elaborate stratagem for executing a manoeuvre that will enable his forces to retreat without realising that a retreat is occurring so that his own men do not panic and fall into disorder (Vegetius 108-109).

For all of Vegetius' conviction in establishing and maintaining an orderly system that ensures the efficacy of the Roman war machine, he is not above employing subterfuge, trickery, and deception in order to achieve his desired ends in war. Despite expounding such a great effort in advocating for a systematised approach for the Roman way of war, it is precisely because he acknowledges the disorderly nature of battle that Vegetius is fundamentally sceptical that pitched battles can provide a reliable path to victory. And so, when he sets out his general rules of war at the conclusion of Book III he expresses a preference for finding alternative solutions to defeating one's enemies: "It is preferable to subdue an enemy by famine, raids and terror, than in battle where fortune tends to have more influence than bravery" (116).

Frontinus' *Strategemata* is much more limited in its scope, as it is composed almost entirely of lists detailing various military stratagems and the situations in which they might be employed, and so there are scant opportunities to develop any kind of coherent or explicit account of martial uncertainty. Nonetheless, the criteria by which Frontinus classifies his stratagems does at least reveal a persistent preoccupation with the struggle to, on the one hand, obtain reliable information, and on the other, to hamper the opponent's ability to do the same. For instance, he proposes stratagems for both concealing one's own plans and uncovering those of the enemy; for concealing one's strengths and weaknesses; for distracting the enemy with feints and ruses, and for determining the character of the war—by this Frontinus means whether, depending on the relative strengths and composition of rival forces, it is better to engage in sieges, pitched battles, skirmishes, and so on.

Together, these concerns create the impression that Frontinus is extremely preoccupied with a game of appearances that encompasses not only the enemy, but also his own forces. We find in his work several lines of continuity with his successor Vegetius, including a stratagem for concealing a retreat from both the enemy and his own forces: "Lucius Furius, having led his army into an unfavourable position, determined to conceal his anxiety, lest the others take alarm. By gradually changing his course, as though planning to attack the enemy after a wider circuit, he finally reversed his line of march, and led his army safely back, without its knowing what was going on" (17).

That uncertainty is present in many facets of war, and that it can be manipulated, appears to be a crucial dimension for ensuring the efficacy of Frontinus' various stratagems. In this respect, he is very much an advocate of acts of deception that interfere with the enemy's plans or mental model of the situation. He describes several stratagems of this nature, but one carried out by Gaius Caesar stands out:

> Gaius Caesar on one occasion caught a soldier who had gone to procure water, and learned from him that Afranius and Petreius planned to break camp that night. In order to hamper the plans of the enemy, and yet not cause alarm to his own troops, Caesar early in the evening gave orders to sound the signal for breaking camp, and commanded mules to be driven past the camp of the enemy with noise and shouting. Thinking that Caesar was breaking camp, his adversaries stayed where they were, precisely as Caesar desired (63).

In this stratagem, Frontinus stresses the importance of information that can be garnered from the enemy's forces, and also describes a clever act of sonic trickery employed in an attempt to mimic an action which Caesar's forces were not in fact intent on carrying out. As van Creveld has noted, Frontinus makes no explicit effort to draw connections between the various stratagems which he outlines in the *Strategemata* , but despite the lack of any overarching framework within which to situate the text, we are at least left with an impression that efforts to both alleviate and manipulate uncertainty were of central concern to the commanders of both the Roman empire and their regional rivals throughout the ancient world (*A History of Strategy* 28).

Maurice's *Strategikon* is closer to Vegetius in its approach, and indeed goes beyond him in its attempts to instruct its reader in the fundamental nature of war and conflict. In the preface of the *Strategikon*'s seventh book, Maurice puts forward a cynegetic[10] theory of war:

> Warfare is like hunting. Wild animals are taken by scouting, by nets, by lying in wait, by stalking, by circling around, and by other such stratagems rather than by sheer force. In waging war we should proceed in the same way, whether the enemy be many or few. To try simply to overpower the enemy in the open, hand to hand and face to face, even though you might appear to win, is an enterprise which is very risky and can result in serious harm. Apart from extreme emergency, it is ridiculous to try to gain a victory which is so costly and brings only empty glory (65).

That Maurice compares war to hunting is not a metaphor whose significance should be overlooked. The hunter that Maurice favours is a figure who carefully studies their prey so as to set a trap that exploits the prey's own natural tendencies *against itself*. This is quite remarkable, particularly when we consider the general antipathy that both the Greeks and Romans had previously held towards acts of

[10] For a philosophical account of cynegetics see Grégoire Chamayou's *Manhunts: A Philosophical History* (2012), and for a martial one, his *A Theory of the Drone* (2015).

base cunning. At times, this mistrust extended to certain hunting practices. For example Plato, in *The Laws*, rails against the trapper whose contrivances "perform the toil of a lazy hunt," and compares angling with piracy and bird catching to theft, and instead favours "the hunting of four-footed prey that employs horses, dogs, and the bodies of the hunters themselves" (216-217). We have already recounted Aristotle's distrust of those who employ cleverness (*deinós*, a close cousin of *mêtis)* in their rhetoric and their actions, and we find a similar scepticism in Plato regarding hunters who eschew the pursuit of game through speed and strength alone. As Benedict Singleton has noted, Plato's prohibition against the use of traps is not due to a distrust of a technological approach to hunting, for the spear or the bow are viewed as entirely permissible (*On Craft* 100-101). Rather, these weapons function as prostheses that merely extend or amplify the capabilities of the hunter's arm, and so the use of nets, traps, and poisons is regarded as untenable because they cultivate "the wrong kind of sensibility: people's use of poisons in turn poisons their souls" (Singleton, *On Craft* 101). There is a clear parallel here to Aristotle's denouncement of cunning (*deinós*), and the general lack of favour exhibited in the Greek philosophical tradition towards *mêtis*, which was regarded as unsavoury due to its willingness to employ any means necessary.

Despite his status as an intellectual successor to the Greek tradition, Maurice is utterly unconcerned with matters of honour or an ideal form of "the good," while also being highly sceptical of an unalloyed reliance on force. His favoured approach is instead predicated around the metaphor of the trap which, as the anthropologist Alfred Gell argues, has encoded within it a number of ominous intentions: "We read in it the mind of its author" but also a "model of its victim" which "subtly and abstractly represent[s] parameters of the animal's natural behaviour, subverted in order to entrap it" (200-201). Implicit in the trap is this cruel inversion, predicated upon the careful study of an animal and the cultivation of an approach to *design* that entangles the natural tendencies of its victim into an apparatus that twists it against itself.

Maurice's cynegetic way of war therefore espouses a very particular onto-epistemic outlook. First, war is seen as a fundamentally uncertain endeavour, where two armies fighting in an untrammelled fashion is viewed as a perilous state of affairs that is to be avoided at all cost: "The best leader is one who does not willingly engage in a *hazardous* and *highly uncertain* battle and refrains from emulating those who carry out operations recklessly and are admired for their brilliant success, but one who, while keeping the enemy on the move, remains secure and always *in circumstances of his own choosing"* (Maurice 87-88; my emphasis). Where Frontinus primarily establishes a contrast between order and disorder, Maurice is concerned with the elimination of *risk*. He is unequivocal in his preference for pursuing victory through the judicious application of strategy rather than by what he views as the blind pursuit of overwhelming force:

> A ship cannot cross the sea without a helmsman, nor can one defeat an enemy without tactics and strategy. With these and the aid of God it is possible to overcome not only an enemy force of equal strength but even one greatly superior in numbers. For it is not true, as some inexperienced people believe, that wars are decided by courage and numbers of troops, but, along with God's favour, by tactics and generalship, and our concern should be with these rather than wasting our time mobilizing large numbers of men. The former provide security and advantage to men who know how to use them well, *whereas the other brings trouble and financial ruin* (64; my emphasis).

Secondly, from the viewpoint of Byzantine thought, war is to be countenanced only once a sufficiently detailed model of the opponent is available as the basis for a strategy that functions like a trap; as a wicked or cruel subversion of that model. In Maurice's estimation, it should be possible to anticipate every potential action that the enemy might countenance; twice in the text he invokes a saying attributed to the Greek historian, Polybius, that a general should never have to say "I did not expect it" (81, 86). In these respects, we find that Maurice's approach shares a lot of similarities with Sun Tzu's, and many of his passages eerily echo descriptions from *The Art of War* on how to exploit the distinctive characteristics of the enemy:

> That general is wise who before entering into war carefully studies the enemy, and can guard against his strong points and take advantage of his weaknesses. For example, the enemy is superior in cavalry; he should destroy his forage. He is superior in number of troops; cut off their supplies. His army is composed of diverse peoples; corrupt them with gifts, favors, promises. There is dissension among them; deal with their leaders. This people relies on the spear; lead them into difficult terrain. This people relies on the bow; line up in the open and force them into close, hand-to-hand fighting. (Maurice 64-65).

That Maurice's approach entailed the construction of carefully cultivated representational models of his foes is especially borne out by the penultimate book of the *Strategikon*, which consists of a series of anthropological commentaries on the characteristics and tactics of the various peoples and cultures the Byzantines viewed as threats, such as the Persians, Slavs, Avars, and Scythians. Evidently, Maurice abjured fighting against an unfamiliar enemy, and demanded extensive surveillance before any combat took place: "[c]ontact should not be made with the enemy's main body, nor should they be allowed to observe our own formation clearly, before reconnoitring their lines and finding out whether they are planning any ambushes (69). Like his Roman predecessors, he was also keen to both maintain secrecy about his actual plans, and to manipulate the enemy's impressions of them, in the form of acts of uncertainty engineering: "It is very important to spread rumours among the enemy that you are planning one thing; then go and do something else. Your plans about major operations should not be made known to many, but to just a few and those very close to you" (80).

Maurice also exhibits an awareness that the enemy is cultivating a mental model of his forces and their behaviours, and as a result he advocates introducing variety into his methods in order to avoid becoming overly predictable: "One must not always use the same modes of operation against the enemy, even though they seem to be working out successfully. Often enough the enemy will become used to them, adapt to them, and inflict disaster upon us" (80). Like a skilled poker player in our own time, presenting a high degree of variation in the range of possible actions one might take has the effect of injecting greater uncertainty into the mental model of the opponent, scrambling their ability to reliably make inferences about what subsequent actions you will take based on previous ones you have exhibited.

As with Vegetius and Frontinus, Maurice is quite happy to manipulate the impression his own troops have of the situation. Not only does he propose sending false deserters to the enemy so as to disclose fake reports to them, but "[courage] should be roused in our troops by fabricating a report of a victory over the enemy won by our men someplace else" while "[news] about reverses suffered by us should be kept secret, and reports stating just the opposite should be circulated about" (80). Maurice is also an advocate of engaging in acts of subterfuge that threaten to turn the enemy forces against each other by creating the impression that some of their number might be traitors, even if they are not: "A way of arousing discord and suspicion among the enemy is to refrain from burning or plundering the estates of certain prominent men on their side and of them alone" (81).

Indeed, so extensive must the general's collection of stratagems be in order to manipulate every facet of the representational models held by both his forces and those of the enemy that Maurice warns of the potential for informational overload to stymy a commander's ability to act. He cautions against overburdening the general on the day of the battle, and insists that he must not take on too many tasks so that he can spare his mental faculties in order to properly direct his troops (79). Evidently, the expectations Maurice sets for the general are impossibly high. He must become an quasi-omnipotent figure, prepared for all contingencies—"The general must correctly manage not only matters of immediate concern, but must also take thought for the future"—and equipped with an exhaustive repertoire of stratagems that he can pluck from at will in response to whatever particularities the circumstances demand (Maurice 87). There is a sense in reading the *Strategikon* that it is precisely *because* the limits of the human mind loom large when held in comparison to the image of such a perfectly malleable and cunning strategic ideal that war is presented as an *excessively* risky and uncertain endeavour. If you can get what you want through acts of diplomacy, politics, subterfuge, or rhetoric, why would you bother with so chancy and costly an endeavour as war, especially when it demands such a high standard of mental and strategic perfection from its practitioners?

The military manuals of the Romans and Byzantines surveyed here leave us with a remarkably detailed impression of how sophisticated the ancients could be when it came to their understanding of the uncertain and contingent nature of war. Though none of them could move beyond providing an epistemic account of uncertainty, they nonetheless worked towards developing a variety of different approaches to it, even if they were not always fully realised or widely adopted during either their own time or by their predecessors in Medieval Europe. Although they represent only a fraction of the extent of writing on military strategy, their contributions were influential, and their authority largely unchallenged until the Age of Enlightenment brought with it a torrent of fresh thinking that would entirely reimagine the problematic of martial uncertainty.

1.5 Geometric Irregularity

In the wake of a plethora of advances in the physical sciences, the 17th and 18th centuries brought about a major transformation in the conception of strategic thought. A number of scientific breakthroughs, from Copernicus, to Galileo, to Newton, heralded the potential for a newfound understanding of the universe as a fundamentally intelligible place whose underlying logics were predictable, and could be described accurately through the language of mathematics and geometry (Bousquet, *Scientific Way* 44-45). The principles of Newtonian mechanics provided an explanation of the movement of all physical bodies, whether on earth, or in the heavens, and presented a view of the world as constituted by "matter in motion according to fixed laws that could be expressed mathematically" (Bousquet, *Scientific Way* 45). Furthermore, this groundbreaking discovery implied the promise that it might, at least theoretically, be possible to predict accurately and completely the future and past events and behaviours of all physical systems. The Newtonian image of the world was therefore a profoundly deterministic one, where all events could be understood straightforwardly as the direct products of a sequence of discernible causes, and whose original state and conditions could be disclosed by tracing the path of its causal chain backwards through time (Bousquet, *Scientific Way* 45). This development had profound consequences for many facets of human society and affairs, and war was not exempt from them. Indeed, the challenges posed by specifically military problems, particularly in the field of ballistics, had already provided a major impetus for a number of foundational developments in physics, as Henry Guerlac explains:

> Biringuccio's *De La Pirotechnia* (1540), now recognized as one of the classics in the history of chemistry, was for long the authoritative handbook of military pyrotechnics, the preparation of gunpowder, and the metallurgy of cannon. The theory of exterior ballistics similarly was worked out by two of the founders of modern dynamics, Tartaglia and Galileo. Perhaps it would not be too much to assert that the foundations of modern physics were a by-product of solving the fundamental ballistical problem. Tartaglia was led to his criticisms of Aristotelian dynamics by experiments—perhaps the earliest dynamical experiments ever performed—on the relation between the angle of fire and the range of a projectile. . . . But to Galileo is due the fundamental discovery that the trajectory of a projectile, for the ideal case that neglects such disturbing factors as air resistance, must be parabolic. This was made possible only by his three chief dynamical discoveries, the principle of inertia, the law of freely falling bodies, and the principle of the composition of velocities. Upon these discoveries, worked out as steps in his ballistic investigation, later hands erected the structure of classical physics (70-71).

Following the synthesis of many of these discoveries into an expansive account of the physical world, the publication of Newton's *Principia Mathematica* in 1687 arrived at the perfect moment, when a new wave of military thinkers sought to translate the scientific ideas and approaches of the

Enlightenment that the *Principia* embodied back into the study and conduct of war. As Azar Gat observes, "the ideal of Newtonian science excited the military thinkers of the Enlightenment and gave rise to an ever-present yearning to infuse the study of war with the maximum mathematical precision and certainty possible" (30). Antoine Bousquet describes this period as the "mechanistic" age of warfare, whereby the metaphor of the clockwork mechanism came to embody both "the unveiled order of the physical world and a prescribed ideal in human affairs" (*Scientific Way* 30). Chaos, chance, and uncertainty, were viewed as anathema in this time, as the prevailing image of a divine clockwork apparatus proffered an alluring promise of absolute predictability and control over all human endeavours (Bousquet *Scientific Way* 31).

Bousquet proposes that the martial epitome of these ideals could be found in Frederick the Great's intensively drilled Prussian Army of the late 18th century, which at its apex resembled: "a giant clockwork mechanism in which bodies and technologies were combined to produce a 'war machine' that embodied all the virtues of its model: precision, predictability and order" (Bousquet *Scientific Way* 61). Like Vegetius before him, Frederick sought to minimise uncertainty through a combination of strict discipline and repetitive training exercises, but the degree to which he intensified and regulated this process reduced his troops to something approaching the status of subservient automata whose every action was carefully predefined and heavily systematised via the drill. As Manuel DeLanda observes:

> When Frederick the Great assembled his armies in the eighteenth century, he did not have the technology to eliminate human bodies from the space of combat, but he did manage to eliminate the human will. He put together his armies as a well-oiled clockwork mechanism

> whose components were robot-like warriors. No individual initiative was allowed to Frederick's soldiers; their only role was to cooperate in the creation of walls of projectiles through synchronized firepower (127).

The combination of extensive drilling and the denial of individual initiative results, for DeLanda, in the inability of the clockwork army to produce new information, "that is, to use data from an ongoing battle to take advantage of fleeting tactical opportunities," (66). This issue was exacerbated by the relatively limited communications technologies available at that time, as commanders remained restricted to the use of drums, "the bugle, the standard, and early optical semaphores as acoustic and visual forms of transmitting commands across the troops" (DeLanda 65).

The influence of the prevailing scientific outlook of the Enlightenment could also be found in the strategic literature of the age, and the desire for a comprehensive and universal formalisation of war was at its heart. As Michael Howard notes:

> Military thinkers sought for rational principles based on hard, quantifiable data that might reduce the conduct of war to a branch of the natural sciences, a rational activity from which the play of chance and uncertainty had been eliminated. For some this data was provided by topographical and geographical measurements, for some by calculations of supply needs and march-tables, for some by the geometrical relationship of supply lines to fighting fronts or of armies to their bases (6).

The first significant effort to shift the theory and conduct of war in this direction via the imposition of an overarchingly scientific approach was made by the Italian soldier Raimondo Montecuccoli (1609-80). A peculiar figure, Montecuccoli fought for the Imperial Army during the Thirty Years War, where he rose to the rank of general. He wrote sporadically throughout his military career, producing three major works, the *Treatise on War* (*Trattato Della Guerra*), the *Zibaldone* (an extensive reference work), and *On the Art of War* (*Del Arte Militare*), a more concise revision of his original *Treatise.* All three works were published posthumously, and were subject to widespread circulation and attention throughout mainland Europe from the beginning of the seventeenth century. In his account of Montecuccoli's strategic contributions, Gat identifies a persistent continuity spanning the entirety of the Italian soldier's theoretical ouvre that combined the humanist outlook on war and politics propounded by Justus Lipsius with an extensive and eccentric array of references to occultism, Paracelisan alchemy and medicine, and magical natural philosophy (17-21).

Following Lipsius (and to some extent also Bacon and Machiavelli), Montecuccoli sought to situate war within a political framework governed by and directed towards political motives and aims respectively (Gat 18). As for the occultists and Paracelsians, the Italian soldier's writings took from them a fascination with the potential to harmonise the microcosmic and macrocosmic scales, albeit in a martial context:

> Many ancients and moderns have written on war. Most of them, however, have not crossed the boundaries of theory. When some, such as Basta, Melzi, Rohan, la Noue, etc. have combined theory with its application, they have either undertaken to cultivate only one part of this vast field, or have restricted themselves to generalities, without getting down to the details of the

> supporting sciences . . . which make the perfect military general. It is impossible to understand the whole fully, if one is not familiar with its constitutive parts (Montecuccoli qtd. in Gat 22).

As part of his effort to think of war in this holistic fashion, Montecuccoli pioneered the attempt to advance a martial science that would aim "to reduce experience to universal and fundamental rules . . . [which could] then be applied to particular times and circumstances by means of skilful judgement" (Gat 22). His approach was greatly informed by the Aristotelian method, which Montecuccoli explained thus: "the innate force of reason, while comprehending the objects, also turns them into concepts which it stores in the memory. From several combined recollections, experience emerges, and from many experiences there springs general understanding, which is the beginning of all sciences and arts" (qtd. in Gat 22-23). Implicit in this approach is a move from the particular towards the general via increasing degrees of abstraction. In this way, Montecuccoli sought to grasp war's fundamental, universal principles and then apply them as circumstances demanded (Gat 23). However, despite laying the groundwork for a scientific way of thinking about war, while also attempting an expansive treatment of many of its facets, spanning training, logistics, fortifications, marching, and fighting, Montecuccoli was ultimately unable to present a theory of war that could transcend his own historical moment. Instead "his universal science of war, was . . . simply a reflection of the warfare of his day between the campaigns of Gustavus Adolphus and the early wars of Louis XIV" (Gat 24).

Though his work may not have lived up to its lofty ambitions, Montecuccoli's attempts to put forward a science of fortifications, drawing on the work of Lorini, an Italian contemporary and expert in that particular field, did at least point the way towards a union that would become increasingly popular and influential in attempts to systematise war during the following century: martial geometry

(Gat 25). The rising centrality of geometry in martial thought during the Enlightenment period was prompted in large part by pragmatic concerns on the battlefield. With the growing importance of gunpowder, and especially of cannons and subsequent forms of heavy artillery, stretching back to at least the early 15th century, the conventional architectural form of the high stone wall, which had been so effective a bulwark against the arrow, the trebuchet, and the ballistae, was rapidly becoming a liability (Engberg-Pedersen 11). The need to replace vertical walls that were difficult to scale, and could shelter the defenders of a keep from the missile bombardments of besiegers with layered and nested horizontal bastions, necessitated the emergence of a new architectural science (Engberg-Pedersen 11). From the beginning, this development was understood in terms of the management of chance and uncertainty, as an excerpt from an early 16th century treatise on fortifications by the Hungarian artist and mathematician Albrecht Dürer makes clear:

> Since today in our time many unheard-of things happen, it seems to me imperative to consider how a fortification should be built in which kings, princes, lords and cities can defend themselves. . . . Therefore I have undertaken to show how such a structure is to be built. The intrusion of the *unheard* and *unexpected* is met with a building that transforms brute acts of violence into a geometrical design. The development of new architectural forms *domesticates* and *brings under control the contingencies of warfare* (qtd. in Engberg Pedersen 11-12; my emphasis).

For Dürer, war and violence are intrusive and uncertain, while geometry and the architectural form heralds the promise of control. Nor was the promise and potential of a martial geometry to abate war's blind contingencies unique to the Hungarian.

Sébastien Le Prestre, Marquis de Vauban (1633-1707), perhaps the most influential and well-known of all the Enlightenment's military engineers, outlined a comprehensive system for the geometry of fortifications from the ground up. His *Nouveau Traité de Géométrie et Fortification* (1695) begins with a detailed examination of the fundamental geometric shapes and figures—triangles, circles, and squares—and how to progressively complexify them (for instance, by rendering them in three dimensions), before going on to explain how these fundamental forms might serve as the basis for a science of fortification (Pedersen 12). As the basic shape of a fortress gradually takes form out of these more simple shapes, Vauban delimits the space of war into one where order can be constructed first on the symbolic plane of the page, before being realised on the actual terrain (Pedersen 12). Vauban's warfare, argues Anders Engberg-Pedersen, "is thus concerned with the production and management of symbolic forms," where "the contingencies of warfare are transformed into the security of a symmetrical drawing" (12-13). Indeed, the terrain itself is regarded as a contingency, and though the construction of "irregular fortifications" is deemed to be permissible, the preferred approach is to regularise the topology of the site of the fortification itself through levelling or raising the earth so as to better approximate the desired geometric form rendered on the page (Pedersen 13). Nor did Vauban solely limit the application of geometry to the construction of fortifications. He was equally renowned for his systematic approach to besieging them, through the construction of a zigzagging series of trenches, which were dug in a parallel fashion that limited exposure to fire from the defender's fort (Gat 37). Before the implementation of this approach, attacks on well defended fortifications were almost guaranteed to incur substantial losses on the side of the attackers, but Vauban's system, which he perfected during the late 17th century in almost fifty sieges fought for the benefit of his King, Louis XIV, and described at length in his *Traité des Siéges* (1705), was heavily formalised, and for a time at least seemed endlessly and straightforwardly repeatable (Guerlac 75-79).

The successes of Vauban's formalisation of fortification and siege tactics did not go unnoticed, and so it did not take long for other military minds to attempt to extend his geometry of war from the more limited context of the siege to the much greater chaos of the pitched battle. As Gat puts it, "Once conceived, the methods of fortifications and siegecraft provided a clear and exact—almost fully geometrical—guide for action, requiring only mathematical application. And if siege warfare was subject to a priori and precise reasoning, why could not the same be achieved in all branches of war?" (37). Such efforts were commonplace during the first half of the 18th century, starting with Jacques-François de Chastenet, Marquis de Puységur (1655-1743), who, like Vauban, fought in the wars of Louis XIV, and wrote an extensive treatise, *Art of War by Principles and Rules* (published posthumously in 1748) which, like Montecuccoli before him, advocated for a new systematic general theory of war. Puységur was convinced that a universal approach to war was possible, and sought to find its basis in "the full scope of historical experience" stretching back to the ancient Greeks and Romans (Gat 36). Despite his expressed fidelity to the likes of Homer, Herodotus, Socrates, and Xenophon, as well as his insistence that the advent of firearms had not fundamentally changed the character of war, Puységur was excited by the potential he found in the aforementioned writings of Vauban (Gat 36). But where Vauban limited his approach to the siege, Puységur suggested that a wider application of geometric principles to war was possible: "armies operated in space, and while geography offered concrete knowledge of this space, geometry was to provide a precise instrument for analysing and regulating the movements of armies within it" (Gat 37-38). However, Puységur did not take this thought to its seemingly logical conclusion, and so it would be up to another, later figure, to take on the challenge of constructing a total martial geometry.

Adam Heinrich Dietrich von Bülow (1757-1807) took the themes of the prevailing Enlightenment spirit favouring rationality that characterised the period and intensified them to their greatest extreme. After almost two decades spent in the service of the Prussian service, where he rose to the rank of lieutenant, Bülow left the military and began to travel across Europe, and eventually the United States. During this time he also became a prolific writer, focusing primarily on military operations. He was greatly influenced by the Welsh military theorist Henry Lloyd (1718-83), and especially his concept of the line of operations, which described the chain of logistics and communications between a travelling army and its bases of supply. Unlike Puységur, Bülow was also a firm believer in the idea of a prevailing revolution in military affairs brought about by firearms, and was obsessed with articulating a novel theory of war which could account for the transformations which he felt they were prompting, not only in European warfare, but also in the wider arenas of politics and economics (Gat 81-82). At the core of his strategic outlook, Bülow was particularly attentive to the logics of supply systems, which by his time had become increasingly important in order to maintain a steady flow of ammunition so as to sustain the ongoing operations of riflemen and artillery at the frontlines. For him, the intricacies of manoeuvring armies in the field and especially those which might threaten to disrupt the enemy's own lines of operations were of vital importance, even superseding the primacy of pitched battles as the key to success in modern warfare (Gat 81-82).

In order to explain their significance, Bülow developed an elaborate geometric diagramming system, which conceived of an offensive military action in terms of a triangle, with the object of an operation situated at the apex, and the "home" fortifications from which the supplies would be sent as points along the base (18-20). The sides of the triangle denoted the boundaries of the supply routes themselves. Finally, a straight line from the centre of the base would be drawn towards the object/apex, which Bülow referred to as the attacker's line of operations (18-20). The attacking army would progress along this line towards its objective, but could be disrupted if a defending army was able to penetrate the triangle from its sides, and in doing so threaten to cut off the attacking army from its supply lines. In Bülow's analysis, the shorter the base of the triangle, and the deeper the attacking army has to penetrate to reach its object (creating a longer line of operations), the shorter the distance a defending army has to penetrate in order to threaten cutting off the attacker (Gat 82-83). Having developed this model, Bülow could then analyse it using geometrical principles, and determined that an "object angle" of 90 degrees (from the corner of the base to the apex) created a critical point of inflection, where any narrower angle would not allow an attacker to adequately cover their line of operations, resulting in an insecure advance (Bülow 36-38). On the other hand, an angle of greater than 90 degrees promised absolute security, and would result in a state of affairs where any attempt by the defender to bisect the line of operations would in turn expose them being cut off from their own base of operations following a penetrative manoeuver by the attacking army (Bülow 36-38). With this system, Bülow felt he had stumbled upon a fundamental mathematical formalisation of the science of martial strategy. So decisive was his breakthrough that battles themselves were deemed to be obsolete, because if an attacker's base was insufficiently robust the defender could force a retreat simply by threatening the line with the correct geometrical manoeuvre (Gat 84). From this observation, Bülow proceeded to make a larger set of geopolitical claims, noting that modern war would increasingly favour large nation states with long borders which could provide sufficiently large bases of operations (Gat 84). This geopolitical science was further justified with references to Newtonian mechanics:

> The agency of military energies, like the other effects of nature, becomes weaker . . . in an inverse ratio of the square of the distance; that is to say, in this particular, of the length of the line of operations. Why should not this law, which governs all natural effects, be applicable to war, which now consists of little more than the impulsion and repulsion of physical masses? If, which I do not doubt, it is admissible in the theory of lines of operations, we may in future easily calculate the utmost extent to which military success may be carried (Bülow 199-200).

And so, just as the philosopher mathematician Blaise Pascal's geometric system, outlined in *De l'esprit Géométrique* (1655), advanced a method of reasoning that was capable of eliminating contingency and producing certainty through the careful application of geometry, so too had Bülow found what appeared to be a robust system for making a priori determinations regarding the outcome of strategic, and even geopolitical situations. As Engberg-Pedersen puts it, from the treatises of Vauban onwards a new martial epistemology had emerged where: "the state of war appears as a calculable product of a series of graphic operations, as the function of a fundamentally knowable and immutable geometric order. Obviously, unpredictable events and chance occurrences would arise immediately in an actual siege, but they would appear as deviations from the theoretical foundation, not as an integral part of it" (19).

The age of the martial engineers had fundamentally transformed the conception of war, whose outcome, they believed, was not to be determined on the battlefield, nor even in an analysis of the relative disposition of forces, but rather through the proper understanding and application of the symbolic and geometric principles which undergirded their subsequent interplay. As war was absorbed into the prevailing *esprit géométrique* it had become spatialized, but also regularised, with contingency either eliminated, or at worst regarded as a temporary *irregularity* which could straightforwardly be eliminated following the proper adherence to the initial set of calculations. For practitioners of the Aristotelian strategic tradition, this must have seemed an ideal state of affairs, for it permitted plans to be drawn up in advance of battle and then enacted without fear of their interdiction by chance events. However, as we shall see, this approach soon proved disastrous, and instead, rather than omitting uncertainty, those who sought to plan and model war would seek it incorporate chance *within* the model itself in the hope that this might minimise the possibility of a fatal mismatch upon the eventual commencement of battle.

1836: The Waving Fog of War

The year is 1775, and British forces are hunkered down in the city of Boston following a pair of defeats to American revolutionaries at the battles of Lexington and Concord. On the night of June 16, General Thomas Gage, the commander of the British army, receives a reconnaissance report indicating that the provincial American forces have advanced, and are fortifying Breed's Hill, a key strategic vantage point overlooking Charlestown on the Boston peninsula (Brooks 126-127).[11] Aside from ordering a relatively ineffective naval bombardment of the freshly erected redoubt, Gage is slow to react, handing the 1,200 Americans led by Colonel William Prescott additional time to entrench their position by shoring up the eastern flank of Breed's Hill, which would otherwise have been exposed to a rapid assault.

After further delays, the British prepare to launch their attack in the early afternoon, having shuttled 2,300 men, who had been stationed in Boston, across the Charles river in longboats. However, upon observing that the Americans have reinforcements positioned on the nearby Bunker Hill, the British force halts, awaiting the arrival of their own reinforcements (Brooks 145). When this compliment finally arrives, the British use incendiary ammunition to set fire to Charlestown, located at the foot of Breed's Hill, in an attempt to clear out a detachment of American snipers who had already begun inflicting casualties on the newly landed troops, and then press their assault on the hill, charging up its slopes into an onslaught of American rifle fire (Brooks 157-158). The ensuing battle is fierce and chaotic, with the rising smoke from the burning Charlestown only adding to the confusion. One

[11] Though the events of the day are referred to as the "Battle of Bunker Hill," this title is something of a misnomer, as the bulk of the fighting took place at the nearby Breed's hill.

onlooker, watching the battle unfold from Boston observed: "the eye was filled with the blaze of the burning town, fire coursing through whole streets or curling up the spires of public edifices, the air above filled with clouds of dense, black smoke" (qtd. in Brooks 158). After two failed attempts to assault the redoubt, the American troops finally run out of ammunition, and are overwhelmed during the ensuing hand-to-hand combat as the British breach their fortifications. By 5pm the surviving American forces have withdrawn, leaving the British in control of the peninsula (Brooks 177). Nonetheless, the British victory is at best pyrrhic, yielding the highest casualty count of any single encounter in the revolutionary war, and serving up a chastening lesson regarding the resolve and capabilities of their colonial adversaries.

Sixty years later, in 1836, Mcdonald Clarke (sometimes stylized as M'Donald or MacDonald), a New York based poet of some minor infamy published a collection entitled *Poems of M'Donald Clarke.* One of its entries, "The Battle of Bunker Hill," memorialises the events of the eponymous battle on June 16 and 17, 1775. Both the poem and its author have largely been forgotten in the annals of history, aside perhaps from Clarke's acknowledgement as a formative influence on Walt Whitman, and for his distinctive nickname, "The Mad Poet of Broadway."[12] However, there is one passage, appearing in the second half of the poem, where Clarke describes the revolutionary soldiers steeling themselves for a potential third assault by the British, whose significance merits a reappraisal:

[12] Clarke was known as an eccentric figure in New York's literary circles who styled himself (or at least, his fashion sense) on Lord Byron.

Will they dare a third attack?

Is a question seen in every eye;

Old Put[13] across the neck and back,

Rides slowly, their vengeance to defy—

Wildy, in that deadly hour,

The Ramparts shove their bolted shower,

While mid the waving fog of war,

Thunders the Yankee's loud hurrah (188).

This passage, which describes a crucial moment in the battle where American soldiers are desperately fighting to hold out against successive British assaults on the Breed's Hill redoubt, is striking because it marks the first usage of phrase "fog of war" in the English language. But what exactly was Clarke attempting to convey through his choice of metaphor here? He was no soldier, so Clarke's account of the battle and its chaotic conditions would have been entirely reliant on written histories and testimonies of the event in question.

Since the Yankee's "loud hurrah" appears to emanate from the "waving fog of war," one possible interpretation would be to treat Clarke's usage of the phrase literally, as a description of an actual fog shrouding the American redoubt. But historical accounts of the battle give no indication that the hillsides of the Charlestown Peninsula were wrapped in fog: "[T]he engagement now known as the Battle of Bunker Hill was fought . . . under rather optimum conditions for a mid-June day—the

[13] The moniker "Old Put" refers to Israel Putnam, one of the American commanders who was present at the redoubt during the battle.

ground was dry, the sky was clear, the temperature was warm but not excessively so, and the air was still relatively dry, though growing more humid hourly" (Ludlum 33).

If Clarke's "waving fog of war" does not refer to meteorological conditions, there are two other possible interpretations that merit consideration. Firstly, there is some evidence to suggest that large volumes of smoke billowed up from the burning buildings of Charlestown after they had been set aflame by the British. If Clarke was aware of this, he may have been attempting to convey the limited vision that might have been experienced by the colonial revolutionary soldiers as they attempted to fight while smoke and flames wafted up from the town. The second possibility is that Clarke's "waving fog of war" may have been referring to yet another form of visual occlusion: the smoke produced by the firearms employed by both sides during the battle. Until the development of smokeless gunpowder in the late 19th century, battlefields would rapidly be shrouded in an opaque, smoky haze expelled as a byproduct from the discharge of firearms, and so it is likely that this phenomenon played some part during the Battle of Bunker Hill. As Major-General B. P. Hughes observes in his extensive study of 17th, 18th, and 19th century firearms:

> "One of the most significant obstructions to fire on all battlefields of the smooth-bore period was undoubtedly the dense clouds of white smoke that gunpowder produced when it exploded. An entire line of infantry would be obscured after a volley, and batteries of guns firing continuously would be enveloped in the smoke of their own discharges" (64).

Given this, it is certainly possible that the FOW described by Clarke was an attempt to convey the effects of the massed firing of weapons upon battlefield visibility that was a distinctive feature of warfare in the 17th and 18th centuries.

Clarke's evocation of the FOW may allude to one or both of these possible explanations, but precisely why he opted to employ the metaphor we cannot know for sure. Nonetheless, the suggestion remains that Clarke's usage of the FOW in the poem emphasises the difficulties that arise when the limited human sensory apparatus is faced with the hostile atmosphere of the battlefield. Nor can the timing of this coinage go unnoticed, for it was made during a moment of great historical inflection, not only in terms of martial epistemology and strategic thought, but also in the wider arenas of philosophy and science. The Copernican revolution in philosophy brought about by the publication of Immanuel Kant's *Critique of Pure Reason* in 1781, together with the inklings of a dynamical approach to the study of physical systems , and a growing understanding of the explanatory potential of statistics and aleatory probability, were all beginning to poke holes in the prevailing Enlightenment confidence regarding the absolute primacy of reason and the deterministic nature of the universe's physical laws.

Whether Clarke was familiar with any of these developments is unclear, but the martial imagery that he produced certainly resonates with the wider transformations that were underway during his particular historical moment. And so, by exhuming Clarke's 'Battle of Bunker Hill', we can properly attribute the coining of one of the most evocative metaphors in the English language, while also acknowledging that its momentary evocation in 1836 indexes a much longer ontogenesis encompassing a variety of technological and epistemic transformations which had already been underway for some time before Clarke put pen to paper in an attempt to convey what it might have been like to experience them on the battlefield. After all, Clarke was not describing a battle that took place during his own lifetime, but rather was engaging in an act of historicisation and memorialisation, a move which further complicates the possibility of establishing a definitive point of origin for the FOW as metaphor. Indeed, the phrase did not catch on immediately, and would require further interventions in both 19th century Prussia and Britain before the FOW would find a place within the martial lexicon.

2.0 A Fog of Greater or Lesser Uncertainty

Doubt is not a pleasant condition, but certainty is absurd.

—VOLTAIRE

A general never knows anything with certainty, never sees his enemy clearly and never knows positively where he is. When armies meet, the least accident of the terrain, the smallest wood, hides a portion of the army. The most experienced eye cannot state whether he sees the entire enemy army or only three quarters of it. . . . The general never knows the field of battle on which he may operate. His understanding is that of inspiration; he has no positive information; data to reach a knowledge of localities are so contingent on events that almost nothing is learned by experience.

—NAPOLEON BONAPARTE

The Age of Enlightenment heralded a sharp break that would separate its martial thought from the prevailing approaches to strategy and uncertainty that held sway during the Medieval period. Reason itself maintained primacy, but it was also supplemented, as we have seen, by the promise of geometry and especially its potential to imbue martial practitioners with a comprehensive, repeatable, and formal system for both conceptualising and waging war. As Manabrata Guha argues, this led to a "general orientation to try to account for war and its conduct as a science in terms of a set of universal principles that would explain not only the conduct of war, but also the *concept of war*" (37). However, the newfound confidence in this approach would quickly begin to crumble, both because of developments in science and philosophy, but also as a result of changes on the battlefields of Europe.

The Napoleonic wars were particularly influential in this regard because they shattered many of the speculative conclusions derived from the application of formal systems developed in the preceding two centuries. Bülow's work in particular quickly fell into disrepute, as Napoleon's penchant for the decisive battle, focusing on the absolute destruction of the enemy's army, stood in sharp distinction to Bülow's emphasis on achieving a strategic advantage through manoeuvres against the line of operations that obviated the need for battle at all (Gat 88). Though Bülow did attempt to provide retroactive justifications for his approach in light of Napoleon's campaigns, particularly because manoeuvre and the line of operations remained important features of Napoleonic warfare, his critics were quick to point out the difficulties his absolutist approach had when there was such an immediate and overwhelming amount of empirical evidence to complicate it. Indeed, a young Clausewitz, who had initially found himself enamoured with Bülow's desire for a rational and scientific conception of war, was quick to point out the flaws inherent in his decision to omit the play of chance and uncertainty from his martial geometry in an anonymously published review of one of his fellow Prussian's later works. Here is Gat's summary of this critique:

> Bülow's own examples refuted his principles. All this was the unavoidable result of the attempt to force a priori mathematical categories on the diversity of historical experience; Bülow lacked a critical historical approach. Not only was history adapted by Bülow to fit his theory but everything that was not consistent with his desire to systematize was ignored. . . . War was a map game for him. A true study of war must take into account the full diversity and complexity of the conditions involved. Bülow's system was but one abstraction on top of the other; a single concept was generalized to create a false science" (92).

Despite the evident limits of the systems developed during the 17th and 18th centuries by figures such as Bülow, Montecuccoli, and Puységur, the quest for a universal theory of war, filtered through the dual lenses of science and reason retained its appeal. Indeed, "the ambition now was to develop a framework of war so flexible that it would be able to account for not only chaos, chance, and uncertainty, but also provide a Reason-able basis on which the question regarding war would and could be contained" (Guha 42). The Prussian major, Georg Heinrich von Berenhorst (1733-1814), was perhaps the first to grapple with the challenge of developing a theory of war which could be empirical in method and universal in scope, as he explicitly set out to advance "a kind of Kantian critique [of the military sciences]" (qtd. in Engberg-Pedersen 39).

Where prior thinkers had focused on outlining war's fundamental features or principles, searching for continuity between their historical moment and those of the revered ancients, Berenhorst's starting point was instead to identify the *limits* of what martial thought could justifiably say about war (Engberg-Pedersen 39). He did this by combining a historical survey of events from the advent of the geometrification of war around 1700 with a theoretical conception of war that viewed it as "a human activity that forms a world unto itself insofar as it is governed by specific operative rules, [a world that was understood] as a historical phenomenon that changes over time" (qtd. in Engberg Pedersen 39). In particular, Berenhorst objected to treatments of war's concept and conduct that sought to shackle the accidental and the contingent with the promise of mechanical order and geometric formalisation. Instead, he proposed a new epistemic model which would transform the preceding vision of war as science or geometry into "*l'empire du hazar,*"—the empire of chance (qtd. in Engberg-Pedersen 51). For Berenhorst, the presence of chance in war was utterly pervasive and absolute, such that it could even be identified as perturbing even the campaigns of Frederick the Great, perhaps the general who abjured chance more than any other.

For all the necessity of Berenhorst's intervention, his conclusions had tilted too far in the opposite direction for the comfort of many of his peers, and so it was that Clausewitz emerged as the figure who sought to strike a conciliatory path that could both affirm the presence of chance, while also searching for an epistemic framework within which to both *describe* it in the form of war's *concept*, but also negotiate it for war's *conduct*. What follows is a detailed examination of Clausewitz's unfinished opus, *On War*, with particular attention to its treatment of uncertainty and chance as a vital inspiration for the concept of FOW.

In order to establish a wider context within which to situate its account of Clausewitzian uncertainty, the chapter begins by outlining the overarching objectives of Clausewitz's project, which sought to balance a rationalist account of the nature of war with the pragmatism of an experienced soldier who was well aware of the highly contingent nature of his chosen object of analysis. This overview is followed by an extended examination of the general theory of friction, which is approached through a lens provided by two contemporary commentators, Alan Beyerchen and Barry D. Watts, both of whom attempt to make sense of Clausewitz's theorisation of uncertainty by drawing on scientific theories of chaos, complexity, and non-linearity. Along the way, attention is given to a number of passages where Clausewitz uses the word "fog" metaphorically in a fashion that establishes an association with uncertainty. Finally, the chapter concludes by considering Clausewitz's treatment of chance and probability, and an evaluation of the extent to which the Prussian general was able to advance a novel aleatory treatment capable of breaking from the prevailing epistemological accounts which had hitherto been the exclusive frame through which martial uncertainty had been conceptualised.

2.1 The Concept of War

Much like Berenhorst, Clausewitz valued the importance of a historical and contextual analysis of war, but sought to combine it with a universal theory of war "which would be valid despite and within the great diversity of historical experience" (Gat 191). Significantly, this theory was not intended to be prescriptive or provide a doctrinal guide for how to conduct war, but rather was conceived as a philosophical enquiry into war's nature, which he nonetheless intended to outline in a sufficiently flexible manner such that it could accommodate the distinctive contingencies and peculiarities of any given war. For this reason, Clausewitz generally sidesteps addressing the "lower level" theorisations that address the arena of tactics, and which tend to be articulated as collections of practical rules and principles of the sort examined at length in the first chapter. For Clausewitz, a universal theory of war can never be found here, because particular tactical formulations or guidelines are difficult to apply outside of any particular historical, cultural, geographical and technological context. Instead, military theory needed to be used to "analyse the constituent elements of war" (Book 2, Chapter 2 163) which "cannot be inferred merely from the individual instances under study" (Book 2, Chapter 5 182).

It was precisely this preoccupation, spurred on in part by the demands placed on Clausewitz between 1810 and 1812 as an instructor at the Prussian military academy, and as the military tutor to Crown Prince Friedrich Wilhelm, that would eventually lead to the writing of *On War.* Starting from the minimal, universal definition of war as an "*act of force to compel our enemy to do our will*," Clausewitz goes on to theorise a distinction between what he terms Absolute War and Real War in order to capture the essence of war's limits, conditions, and tendencies (Book 1, Chapter 1 83). These two terms emerged out of a significant shift in Clausewitz's thinking about the nature of war that informed the writing of Books VI and Book VII, and his revisions of Book I of *On War*. Where Clausewitz's earlier thinking had privileged the "war of destruction" that would come to be described by the theory of Absolute War, and which Clausewitz believed had been realised (at least to some extent) during the Napoleonic Wars, the newer sections acknowledged that most wars tended to be more limited in nature. Gat's account of how Clausewitz reconciled these two positions is worth quoting in full:

> [Clausewitz] recognises the existence of two types of war, *but* claims that the war of destruction expresses the nature of war and thus takes priority; against half-hearted war, an all-out one would always gain the upper hand. A new concept now becomes necessary: 'the urge for decision' is 'true war, or absolute war if we may call it that.' Limited wars are not a genuine form of war but the results of various factors which exercise counter-influences on the real, absolute nature of war and modify it (221).

Ultimately, Clausewitz sees Absolute War as tending towards the utter annihilation of at least one of its participants. It encapsulates his minimal definition of war as an act of force, where "there is no logical limit to the application of that force. Each side therefore compels its opponent to follow suit; a reciprocal action is started which must lead, in theory, to extremes" (Clausewitz, Book 1, Chapter 1 85). Absolute War is therefore Clausewitz's way of establishing the logical conclusion or culmination of war as a dynamic where each side attempts to utterly destroy the other. Indeed, for Guha, this form of war is characterised by a *non-human* logic that is "marked by *its desire* for the annihilation/absolute defeat of the enemy and thus was dangerous and destructive" (52). The possibility or spectre of Absolute War was necessary for Clausewitz's account of war because it expresses the nature or essence of war in its most fundamental terms, where the capacity to muster an excessive and overwhelming application of force trumps all else.

Wanting to distinguish war as it might be conceptualised in theory from the actualities of its practice, Clausewitz used the lessons of history to guide his account. He repeatedly stresses that surveys of military history demonstrate that the significant majority of wars are more limited in nature, and rarely adopted or ascended to the logic of Absolute War (Gat 220-221).[14] Rather, Real War was characterised by "natural inertia, for all the friction of its parts, for all the inconsistency, imprecision, and timidity of man; and finally we must face the fact that war and its forms results from ideas, emotions, and conditions prevailing at the time" (Clausewitz, Book 8, Chapter 2 702). For Gat, the "natural inertia" that Clausewitz refers to here involves a variety of "internal factors"—seen as being intrinsic to the framework of Real War— theorised under the rubric of the general theory of friction, and working in concert with a variety of other "external factors," that function as a kind of brake or regulator which prevents war from sliding towards the unchecked bloodshed that was characteristic of its absolute form (222). Perhaps the most notable of these "external factors" is the influence of politics on war, as articulated in Clausewitz's famous maxim that "war is merely the continuation of policy by other means" (Book 1, Chapter 1 99). Both of these sets of factors—the "internal" effects of friction,

[14]The main exception in *On War* was Napoleon, who Clausewitz regarded as having come the closest to approximating Absolute War: "War, in his hands, was waged without respite until the enemy succumbed, and the counterblows were struck with almost equal energy" (701).

and the “external” influence of politics—will be of significance in this account of Clausewitz’s work, but for the moment let us focus on the role played by the general theory of friction.

2.2 The General Theory of Friction

The general theory of friction is one of Clausewitz’s most enduring contributions to martial thought. Despite its centrality to Clausewitz’s wider project, the treatment of the general theory of friction within the text of *On War* is somewhat fragmentary and, at times, even contradictory. This issue can, at least in part, be attributed to the incomplete nature of *On War*, which Clausewitz was in the process of revising at the time of his death. Clausewitz only invokes the “single concept of general friction” once, as part of the concluding observations in the first book of *On War*: “We have identified danger, physical exertion, intelligence, and friction as the elements that coalesce to form the *atmosphere* of war, and turn it into a *medium* that impedes activity. In their restrictive effects they can be grouped into a *single concept of general friction*” (Book 1, Chapter 8, 141; my emphasis). Here, Clausewitz presents war in environmental terms, with the concept of general friction corresponding to the notions of *atmosphere* and *medium*, within which the war machine is encapsulated. In this way, Clausewitz presents these features as being fundamentally inescapable. Just as one cannot swim without the medium of water, neither can one conduct war outside of the medium of friction. The full significance of this distinctive set of relations shall be developed further in Chapter 4.0, but for now we shall proceed to detail the particulars of the constituent elements of the general concept of friction, and in doing so highlight how he conceptualises the problematic of martial uncertainty.

Returning to the aforementioned passage outlining the concept of general friction, note how Clausewitz uses the term “friction” to refer to both the general concept, and also to one of general friction's "components or sources" (Watts, *Clausewitzian Friction* 17). Elsewhere, in the third chapter of book one, Clausewitz makes a reference to the "climate of war," which he says is composed of another four "impeding elements" (Book 1, Chapter 3 120). Confusingly, these are "danger, exertion, uncertainty, and chance" (Book 1, Chapter 3 120). Following Watts, we can lay out these two lists into a table so as to more clearly parse their discrepancies:

Book One: Chapter Three	*Book One: Chapter Eight*
Danger	Danger
Exertion	Physical Exertion
Uncertainty	Intelligence
Chance	Friction

As Clausewitz explicitly links the atmosphere of war to the concept of general friction in Chapter 8 of Book 1 in *On War*, Watts argues that the items outlined in these two lists need to be accounted for in order to properly articulate its constituent elements.

How does Watts reconcile the discrepancies between the two lists? He begins by pointing out that the respective concepts of *danger* and *exertion/physical exertion* parallel each other fairly neatly, and taken together broadly refer to, in the case of *danger*: "the debilitating effects that the imminent threat of death or mutilation in battle has on the ability of combatants to think and act effectively" (*Clausewitzian Friction* 18); and for *exertion/physical exertion*: "the extraordinary physical demands that combat so often makes on participants can quickly begin to impede clear thought or effective action" (Watts, *Clausewitzian Friction* 18). Thus, he is able to equate them, and move on to providing accounts of *intelligence/uncertainty* and *chance/friction* which shall occupy our attention for the remainder of this chapter.

In the case of the former pairing, encapsulating *intelligence/uncertainty,* Watts observes that Clausewitz's account of the different forms that intelligence can take in war "turns quickly to the uncertainties and imperfections that pervade the information on which action in war is unavoidably based" (*Clausewitzian Friction* 18). As the two accounts ultimately revolve around how Clausewitz deals with the underlying issue of uncertainty, they can be safely conflated, with Watts preferring the latter term because "the fundamental role uncertainty plays in [contemporary] fields like quantum mechanics and information theory [renders] uncertainty [as] the deeper, more pervasive concept of the two" (*Clausewitzian Friction* 18). Unfortunately, Watts believes that the discrepancy between *chance* and *friction* cannot be resolved quite so neatly. The passages which refer to *friction* in the narrower sense as a constituent element of the "general concept" focus primarily on the "internal resistance to effective action stemming from the interactions between the many men and machines making up one's own forces" (Watts, *Clausewitzian Friction* 19). This definition of *friction* focuses primarily on internal workings of the war machine, and the effects of stochastic (random) processes upon it, where "countless minor incidents—the kind you can never really foresee—combine to lower the general level of performance, so that one always falls far short of the intended goal" (Clausewitz, Book 1, Chapter 7 138). On the other hand, for Watts, Clausewitz's treatment of *chance* seems to address a larger scale, and refers to "unforeseeable accidents, the play of good luck and bad, that runs throughout the tapestry of war" (*Clausewitzian Friction* 19). Having made these distinctions, Watts proposes an expanded list, positing five definitive sources of general friction identified in Book I of *On War*:

1. Danger

2. Physical Exertion
3. Uncertainty
4. Friction (in the narrow sense of resistance within one's own forces)
5. Chance

However, Watts still regards this new list as being insufficient, because at other points in *On War* Clausewitz goes on to identify further concepts that might help to explain why "the actual conduct of war falls so far short of the maximum possible application of violence implicit in war's pure concept" (*Clausewitzian Friction* 19), and which therefore might also be understood as fitting within the ambit of the general concept of friction. Foremost among these concepts are the material, spatial and temporal limits governing the application of military force (Watts, *Clausewitzian Friction* 19-20), which, during the Napoleonic era, led Clausewitz to conclude that "war does not consist of a single short blow" (Book 1, Chapter 1 87). Watts observes that while the age of nuclear war and intercontinental ballistic missiles has enabled war to be conducted with a speed, range, and force that would have been unimaginable during Clausewitz's time, these (and other) weapons are still subject to meaningful physical constraints that limit the scale and violence that war can attain (*Clausewitzian Friction* 20).

Yet another check on war's natural tendency towards violent extremes is found in the guiding role played by politics. Because the reasons for war's occurrence are always tied to some political situation, "it is natural that the prime cause of its existence will remain the supreme consideration in conducting it" (Book 1, Chapter 1 98). This is why Clausewitz points out that if war truly were an expression of absolute and "untrammelled" violence it would quickly exceed the limits of the political and "drive policy out of office and rule by the laws of its own nature" (Book 1, Chapter 1 98). However, this does not happen, because policy continually permeates military operations, guiding and influencing its course until either its goals are achieved, or a substantial defeat is at hand (Book 1, Chapter 1 99).

Having grouped together the human, material, spatio-temporal and political limits as further sources of friction, Watts argues that two final elements also need to be acknowledged. The first of these is derived from Clausewitz's discussion of unpredictability stemming from interaction in his theorisation of war in the third chapter of Book Two of *On War*. There, Clausewitz argues that "war is not an exercise of the will directed at inanimate matter, as is the case with the mechanical arts, or at matter which is animate but passive and yielding, as is the case with the human mind and emotions in the fine arts. In war, the will is directed at an animate object that *reacts*" (173-174). Elsewhere, Clausewitz explicitly links unpredictability to interaction, arguing that: "the very nature of interaction is bound to make [war] unpredictable" (Chapter 2, Book 2 161). Thus, Watts adds unpredictability stemming from the interactive nature of war as a further source of friction.

The final source of friction in *On War* that Watts identifies stems from a claim Clausewitz makes in Book Eight, where he posits that the means of war must be suited to its ends (707). As Michael Howard has noted, Clausewitz's fascination with the dialectic between ends and means had been a consistent theme running throughout much of his work (30). There are ends and means operating at various scales, both within the conduct of war, but especially between the political objectives governing the end of a war (its desired outcome on the part of a participant) and the military means used to attain it (Howard 30-33). For Watts, disconnects between ends and military means in war can also be sources of friction, with the case study of Vietnam, where American's "firepower intensive" approach did not prove itself a "suitable means for building a viable South Vietnamese nation that would be capable of defending itself" being a case in point (*Clausewitzian Friction* 20).

Thus, Watts emerges with a list of eight elements, which together constitute his taxonomy of a unified concept of general friction:

1. Danger
2. Physical Exertion
3. Uncertainty
4. Friction (in the narrow sense of resistance within one's own forces)
5. Chance
6. Physical and political limits to the use of military force
7. Unpredictability stemming from the interactive nature of war
8. Disconnects between ends and means in war (*Clausewitzian Friction* 20-21).

Because Clausewitz does not discuss items (6) and (8) on this list during the portions of the book which explicitly outline the factors comprising the general concept of friction there is reason to be hesitant about including them in this list. Such a debate would be beyond the scope of this project however, so instead, let us direct our attention to what Watts' reconstruction does helpfully highlight. Watts identifies four distinct treatments of martial uncertainty present in the Clausewitzian project: *uncertainty*, *friction*, *chance*, and unpredictability stemming from the *interactive* nature of war. A careful examination follows of how Clausewitz handles each element, and the extent to which he was able to combine them in order to generate an account of martial uncertainty that could bridge the divide between both its epistemic and aleatory dimensions. Along the way, we shall be attentive to the moments where Clausewitz invoked the metaphor of fog, which, although falling short of an explicit concept of FOW, nonetheless established a vital association that would go on to inform subsequent attempts to account for the intricacies of martial uncertainty by his predecessors.

2.3 Uncertainty

In one of *On War*'s most memorable passages, Clausewitz declares that "war is the realm of uncertainty; three quarters of the factors on which action in war is based *are wrapped in a fog of greater or lesser uncertainty*" (Book 1, Chapter 3 117). Note how his phrasing is not that of "fog of war" but rather of war as wrapped in a "fog of uncertainty." In this way, Clausewitz establishes uncertainty as a pervasive feature of war, and conveys it through the metaphor of the fog. But what does he mean by uncertainty? While a precise definition is not provided in *On War,* its first chapter does contain some rumination on the subject, which associates the pursuit of clarity and certainty with the human intellect, whereas "our *nature* finds uncertainty fascinating" (Book 1, Chapter 1 97; my emphasis). Elaborating, Clausewitz muses that human nature "prefers to day-dream in the realms of chance and luck" where ""unconfined by narrow necessity, it can revel in a wealth of possibilities; which inspire courage to take wing and dive into the element of daring and danger like a fearless swimmer into the current" (Book 1, Chapter 1 97). Here, we find Clausewitz determining that courage and self-confidence are necessary qualities for actors in war because decisions have to be made and actions taken under adverse conditions where the outcome is not certain. Indeed, it is precisely this association between moral forces and uncertainty that prompts Clausewitz to declare that war is not wholly amenable to a theoretical approach predicated upon "absolute conclusions and prescriptions" (Book 1, Chapter 1 97). Rather, he affirms that:

> It must also take the human factor into account, and find room for courage, boldness, even foolhardiness. The art of war deals with living and with moral forces. Consequently, it cannot

> attain the absolute, or certainty; it must always leave a margin for uncertainty, in the greatest things as much as in the smallest. With uncertainty in one scale, courage and self-confidence must be thrown into the other to correct the balance (Book 1, Chapter 1 97).

Thus, we can say that for Clausewitz uncertainty is, at least to some extent, a product of war's "human factor," encompassing that which cannot straightforwardly be decomposed through the rigorous application of reason or logic, and must instead be confronted through a combination of moral fortitude, training, experience (a quality which Clausewitz viewed as invaluable) and the commander's *coup d'œil*—his ability to rapidly appraise a situation and make vital determinations about what is to be done:

> If the mind is to emerge unscathed from this relentless struggle with the unforeseen, two qualities are indispensable: *first, an intellect that, even in the darkest hour, retains some glimmerings of the inner light which leads to truth; and second, the courage to follow this faint light wherever it may lead.* The first of these qualities is described by the French term, *coup d'œil;* the second is *determination* (Book 1 Chapter 3 102).

Although, as Samuel Forsythe observes, Clausewitz did not hold "the Odyssean tradition of stratagem in high regard," and was dismissive of the possibility of achieving victory through means of manoeuvre and deception as advocated for by Sun Tzu, "his description of the perceptual and inferential ability of the military genius has distinct resemblances to the Confucian commanders situational sensitivity" (36). For Clausewitz, this "situational sensitivity," is expressed in terms of a faculty for grasping topography, combined with sufficient imagination to combine limited fragments and impressions of the situation into a picture of the whole: "Things are perceived, of course, partly by the naked eye and partly by the mind, which fills the gaps with guesswork based on learning and experience, and thus constructs a whole out of the fragments that the eye can see . . . imprinted like a picture, like a map, upon the brain, without fading or blurring in detail, *it can only be achieved by the mental gift that we call imagination*" (Book 1, Chapter 3 127). Clausewitz calls this figure, who is possessed of *coup d'œil,* and has the intellect, presence of mind, courage, and experience to apply it in order to forge new plans in the face of the unexpected, the genius.

The other passage in *On War* which contains an extensive discussion of uncertainty can be found in the chapter on intelligence mentioned by Watts. Here, Clausewitz defines intelligence as "every sort of information about the enemy and his country—the basis, in short, of our own plans and operations" (Book 1, Chapter 6, 136). The other distinctive feature of intelligence, which Clausewitz goes to great pains to stress, is how "unreliable and transient it is. . . . Many intelligence reports in war are contradictory; even more are false, and most are uncertain" (Book 1, Chapter 6, 136). Later in *On War*, he reiterates this point in a passage that is often attributed as the source of the metaphor of the FOW: "the general unreliability of all information presents a special problem in war: all action takes place, so to speak, in a kind of twilight, which, like fog or moonlight, often tends to make things seem grotesque and larger than they really are" (Book 2, Chapter 2 161). The reasons the unreliability of intelligence are twofold. First, there is the "difficulty of *accurate recognition*" which stems from the unreliability of the "senses [which] make a more vivid impression on the mind than systematic thought" (Book 1, Chapter 6, 137). Secondly, Clausewitz highlights how the failures of the senses can then be compounded by psychological factors: "most intelligence is false, and the effect of fear is to multiply lies and inaccuracies. As a rule most men would rather believe bad news than good, and rather tend to exaggerate the bad news. The dangers that are reported may soon, like waves, subside; but like waves they keep recurring, without apparent reason" (Book 1, Chapter 6, 136).

Here, Clausewitz suggests that the failures of intelligence stem from the constraints imposed by human sensory and cognitive limits, which are in turn amplified by the intense stresses, dangers, and demands of the battlefield (Watts, *Clausewitzian Friction* 76-77). In this way, Clausewitz's account of martial uncertainty encompasses not only the unpredictable nature of the human condition, but also the role played by our limited sensory and cognitive capacities. Consequently, there exists a seemingly irreducible limit to the relationship between the chain of sensing/thinking/acting that is further exacerbated by the psychological stresses that participating in battle imposes. Clausewitz highlights the potential fragility of the human psyche to prolonged exposure to the brutality of war throughout the text. For instance, in one such passage he describes how a mind exposed to suffering and danger can result in emotion overriding reason through the production of a "psychological fog" where "it is so hard to form clear and complete insights" (Chapter 3, Book 1 125). It is important to stress that these sorts of claims stand aside from accounts of the dynamics of war in general, or about the environment or conditions (geographical, historical, cultural, etc) in which war is fought in particular, and instead places at the centre of the general theory of friction the figure of the human, understood fundamentally as a limited, and finite being.

In fact, this definition can and should be widened slightly to include not only the human, but any actor, agent, or entity engaged in the act of warmaking. Though one should not discount instances where the scent of dogs, the vision of horses, or the echolocation of dolphins has played an important factor in the history of warfare,[15] of particular salience here is the role played by technological extensions to the human sensory apparatuses, such as satellite images, thermal imaging devices, or motion sensors. This is worth stressing because, as Bousquet has observed, perception has progressively "[relocated] from an exclusive residence within its native biological substrates to myriad technical apparatuses. The human senses, which originally inspired the search for their artificial replication, are increasingly demoted or even altogether displaced by devices to which they are often unfavourably compared" (*The Eye of War* 11). Of course, these various technological extensions to the human sensory system are themselves subject to particular limits and constraints, so the underlying observation that Watts makes regarding Clausewitz's account of the limits of the human remains pertinent.

2.4 Friction

It is somewhat difficult to distinguish the limited case of friction as a constituent element from Clausewitz's overarching general concept of friction. Though its placement within the collection of chapters detailing the other elemental factors (danger, physical effort, and intelligence) that together coalesce to produce what Clausewitz refers to as "war's atmosphere" in the first book of *On War* seems to indicate that the account is intended to pertain to its more minor form, the scope which this brief chapter covers is nonetheless quite substantial. Clausewitz begins by stressing that without personal experience of war one cannot properly comprehend the multitude of minor, unforeseen difficulties which can hamper one's plans and operations:

[15] See Ryan Hediger's edited collection of essays on *Animals and War* for a wide range of such accounts, as well as Kittler's "Animals of War: A Historical Bestiary."

> Everything in war is very simple, but the simplest thing is difficult. The difficulties accumulate and end by producing a kind of friction that is inconceivable unless one has experienced war. . . . Countless minor incidents—the kind you can never really foresee—combine to lower the general level of performance, so that one always falls far short of the intended goal. . . . Friction is the only concept that more or less corresponds to the factors that distinguish real war from war on paper. The military machine—the army and everything related to it—is basically very simple and therefore seems easy to manage. But we should bear in mind that none of its components is of one piece: each part is composed of individuals, everyone one of whom retains his potential of friction (Book 1, Chapter 7, 138).

In this description of friction Clausewitz highlights minor incidents that take place *within* the components of the war machine, and which can hamper its overall progress towards its objectives. For Alan Beyerchen, this particular conception of friction is one of the aspects of Clausewitz's work which he sees as eerily presaging the nonlinear sciences of chaos and complexity which would emerge during the second half of the twentieth century, and which have gone on to become one of the defining conceptual paradigms through which war is theorised by Western military institutions and thinkers today. In order to explain what is meant by non-linearity, Beyerchen begins by outlining some basic precepts of *linear* systems, which must obey two simple conditions. The first of these is *proportionality*; where changes in system output must be directly proportional to changes in system input; and the second is *additivity*, which avers that a whole be equal to the sum of its parts, allowing problems to be broken into constituent pieces that, once solved, can be added back together to obtain a solution to the original problem (62). After noting that the mechanistic, Aristotelian military theorists, including

Antoine-Henri de Jomini and Bülow, who Clausewitz explicitly sought to distinguish himself from, had a preference for "idealized linearizations" (64) Beyerchen goes on to define nonlinear systems as those that *disobey* the conditions of proportionality and additivity. These qualities make nonlinear problems much more challenging to model, especially when they also involve features such as feedback loops, delays and "trigger effects" that take place dynamically (63).

The initial example that Beyerchen gives of nonlinear science is the field of chaos theory. Here Beyerchen is particularly interested in the tendency of chaotic systems to exhibit sensitivity to perturbations in their initial conditions. He also notes that "the very nature" of chaotic nonlinear systems makes them prone to abrupt changes, with transitions that depend upon the "*parameters of* the system more than on the *variables within* the system" (65). The challenge of accurately predicting the behaviour within such a system—Beyerchen refers to Edward Lorenz's 1960s meteorological studies as an example—is not simply a function of its massive scale, but instead arises primarily from the degree of precision required to identify and trace the initial input data. Because of the nature of dynamic interaction, "the system's variables cannot be effectively isolated from each other or from their context," rendering any attempt at linearisation impossible (Beyerchen 66). It is worth noting that the behaviour of chaotic nonlinear systems can still be predicted to some degree, but the robustness of predictions decays the further one gets from their initial conditions. This is something we experience frequently, for instance, it explains why weather forecasts tend to be fairly reliable in the short term, as the initial conditions are visible to and measurable by meteorologists, but become increasingly inaccurate the further into the future they attempt to venture.

Following his account of the problems that chaotic systems pose for linear sciences, Beyerchen turns his attention to *On War* in order to establish how Clausewitz's treatment of war might be understood in terms of nonlinearity. He begins by highlighting some of the similarities between Clausewitz's account of friction and the sensitivity of nonlinear systems to perturbations in their initial conditions. As Clausewitz explains, "success is not due simply to general causes. Particular factors can often be decisive—details only known to those who were on the spot . . . while issues can be decided by chances and incidents so minute as to figure in histories simply as anecdotes (Book 8, Chapter 4 720). Similarly, in nonlinear systems, seemingly minute shifts at one scale or level can produce significant effects at another or, as Bousquet puts it, "local causes can have global effects" (*Scientific Way* 197). In this way, Clausewitz's account of friction highlights the causal effects of minor events occurring at scales above or below human perception or apprehension that can accumulate to hamper the smooth operation of the war machine. In effect, this account dissolves the naive spatial distinction implicit in accounts of the known and the unknown in military theory up until his intervention. Instead, Clausewitz acknowledged that the seemingly simple military machine contained its own internal layers of contingent outsideness, whose effects might be felt, as if by chance, at any moment, even within the ostensible ambit of the known.

For this reason, Beyerchen notes that friction should ultimately be understood as that which is neither extrinsic nor abnormal to the course of any given war, and explains its operation via the analogy of thermodynamic entropy. Beyerchen points out that by Clausewitz's time the notion of friction as physical resistance was already being related to heat "in ways that would ultimately lead to the Second Law of Thermodynamics and the concept of entropy" (76). Clausewitz clearly had some familiarity with this literature, as he explicitly invokes physical mechanics in the following passage:

> This tremendous friction, which cannot, as in mechanics, be reduced to merely a few points, is everywhere in contact with chance, and brings about effects that cannot be measured, just because they are largely due to chance. One, for example, is the weather. Fog can prevent the enemy from being seen in time, a gun from firing when it should, a report from reaching the commanding officer (Book 1, Chapter 7 139).

Here, fog is invoked in a literal sense to illustrate the theoretical principle of friction as it is described in classical physics. In thermodynamics, "friction is a nonlinear feedback effect that leads to the heat dissipation of energy in a system. The dissipation is a form of increasing degradation toward randomness, the essence of entropy" (Beyerchen 76). Similarly, in Clausewitz's account of friction, there is a general tendency towards a decline in performance, and efforts to counteract degradation, such as training, discipline and the "iron will" of the commander which "pulverizes every obstacle, but of course . . . wears down the machine as well" (Book 1, Chapter 7 138).

The second understanding of friction that Beyerchen describes is explained with reference to information theory, and especially its particular understanding of the concept of noise:

> The second meaning of "friction" is the information theory sense of what we have recently come to call "noise" in the system. . . . Clausewitz understands that plans and commands are signals that inevitably get garbled amid noise in the process of communicating them down and through the ranks. . . . His well-known discussion of the difficulty in obtaining accurate intelligence presents the problem from the inverse perspective, as noise permeates the generation and transmission of information rising through the ranks. From this perspective,

> his famous metaphor of the "fog" of war is not so much about a dearth of information, as how distortion and overload of information produce uncertainty as to the actual state of affairs. Clausewitz's basic intuition here is that organisations are always slower and more inflexible than the natural events they are intended to control. Seen in this light, training, regulations, procedures and so on are redundancies that enhance the probability of signal recognition through the noise (76-77).

With this account, Beyerchen highlights the difficulties of reconciling reality as it is perceived by the war machine in its intelligence reports and internal communications from actual events as they unfold in real-time on the battlefield in a fashion that is analogous to how information theory attempts to grapple with the problem of isolating a signal from the noise within a channel. This treatment of the general theory of friction starts to move beyond making claims about what is and is not known, because it now also subsumes the processes by which actors in war negotiate the problems posed by the limits of senses. The spatio-temporal dimension is critical here, because where the first source of friction stems in large part from the sensory and cognitive limits of war's participants, in this second treatment Beyerchen is acknowledging that acting and thinking as limited beings in time and space necessarily leads to the generation of lossy internal models of reality that can never "fully add up" to the things which they attempt to apprehend.

2.5 Interactivity

Though it is not explicitly articulated as part of the general theory of friction, Clausewitz nonetheless accords a great deal of significance to the interactive nature of war in a fashion that establishes an important connection to his account of martial uncertainty. Perhaps the example which best illustrates this point can be found in Clausewitz's interpretation of war as a *Zweikampf* ("two struggle"), expressed through the metaphor of a duel between two grappling wrestlers (Book 1, Chapter 175). In such a struggle, Clausewitz suggests that the bodily contortions of each opponent are contingent upon the counterforce and counterweight of the other. Similarly, in war, it is imperative to account for the presence of an active and reactive opponent, as well as for the interplay of force upon force which will ensue from an engagement between adversaries: "[One] must expect positive reactions, and the process of interaction that results. Here we are not concerned with the problem of calculating such reactions . . . but rather with the fact that the very nature of interaction is bound to make [war] unpredictable" (Clausewitz, Book 2 Chapter 2 161).

Beyerchen views this metaphor of the wrestling match as significant because it suggests that interactivity is a key feature of warfare. In this definition, the war-system consists not simply of a sequence of interactions from each opponent, but instead describes the overall "pattern or shape generated by the mutually hostile intentions and simultaneously consequential actions" (Beyerchen 67). These patterns are dynamic, and feature positive feedback loops that can in turn generate further extremes of mutual exertion (Beyerchen 67). Indeed, it is precisely this recognition of war's tendency towards such a spiral of violence which led to Clausewitz's formulation of the concept of Absolute War which we discussed earlier.

As we have already seen, Clausewitz is careful to point out that the escalatory tendency of the clash of wills will in reality be throttled by a number of other factors, with politics being first and foremost among them. As Beyerchen puts it, politics provides the context which "bounds the system constituted by a given war" (68). However, Beyerchen also observes that Clausewitz does not see war's relationship to politics as being static or unidirectional, a point the Prussian clarifies in *On War*'s first book: "War moves on its goal with varying speeds; but it always lasts long enough for the influence to be exerted on the goal and for its own course to be changed in one way or another. . . . That, however, does not imply that the political aim is a tyrant. It must adapt itself to its chosen means, a process that can radically change it; yet the political aim remains the first consideration" (Chapter 1, 98-99). This framing acknowledges that as war unfolds its character may shift, with fresh developments feeding back into the political ends that guide its conduct.

Clausewitz concludes the first chapter of *On War* with the claim that war "is a remarkable trinity" consisting of a tripartite interaction between "primordial violence, hatred and enmity, which are to be regarded as blind natural force; of the play of chance and probability within which the creative spirit is free to roam; and of its element of subordination, as an instrument of policy, which makes it subject to reason alone" (Book 1, Chapter 1 101). Contemporary interpretations of the trinity tend to abstractly describe these three tendencies as *emotion* (as a kind of general will to violence), *chance*, and *reason*. Clausewitz also provides further clarification by pairing each aspect of the trinity with the institutions that are seen as dealing with (or in) it: the violent nature of the *people*, the friction faced by the *army*, and the political machinations of the *state* (Book 1, Chapter 1 101).

Clausewitz uses the metaphor of a pendulum suspended above three magnets to illustrate the trinitarian relationship between violence, chance, and politics. Beyerchen is particularly fascinated with Clausewitz's use of this image because it exemplifies the sensitivity of nonlinear systems to changes in their initial conditions. When a pendulum is swung above three magnets its behaviour is erratic, such that its final resting position (over any one of the three poles) will vary significantly even with only very minor changes to the initial position of its release. Beyerchen notes that although this experiment does not constitute a complex system—as it is only composed of four parts (the magnets plus the pendulum), rather than many—its tripartite arrangement means that it is still able to generate nonlinear patterns of interaction. Such a system is deterministic, and conforms to Newton's laws of motion, so that with an idealised experiment (as in a frictionless pendulum), the future outcomes resulting from different points of release can be accurately predicted. However, because all physical measurements of an actual arrangement of this magnet experiment are always approximations that are limited by the accuracy of the instruments attempting to generate them, a gap emerges between the epistemic and ontological frames that prevents any absolute prediction of the pendulum's trajectory (Beyerchen 70).

Although Beyerchen does not make explicit reference to this dynamic in terms of its ontological and epistemic features, it is in these terms that Beyerchen's evaluation of Clausewitz should be considered. For Beyerchen-Clausewitz, war provides such a challenge to its practitioners precisely because of the intense demands of information gathering and processing that it requires. Knowledge of the "state of things" is vital for operational decisions to be made, but because of the shifting, interactive nature of the *Zweikampf*, coupled with the limited nature of the epistemic frames through which its practitioners attempt to react, simplicity and analytical certainty become difficult to obtain. Indeed, Beyerchen suggests that "the core cause of analytical unpredictability in war is *the very nature of interaction* itself" (73). Clausewitz sees interactivity at play between adversaries in a way that cannot be measured quantitatively because the reactions of one's opponent are unpredictable. Interaction is also at play in the processes that occur within the system comprising each fighting side. The example that Beyerchen cites to demonstrate this is Clausewitz's reflection upon the differing effects of victory or defeat, which can often be felt disproportionately:

> As we have already mentioned in Chapter Seven, the scale of victory does not increase simply at a rate commensurate with the increase in size of the defeated armies, but progressively. The outcome of a major battle has a greater psychological effect on the loser than the winner. This, in turn, gives rise to additional loss of material strength [through abandonment of weapons in a retreat or desertions from the army], which is echoed in loss of morale; the two become mutually interactive as each enhances and intensifies the other (Book 3, Chapter 9 236).

Here, Clausewitz describes an internal feedback loop that stems from the outcome of an earlier interaction (in the form of a lost battle) with the opponent. Beyerchen observes that the unpredictable consequences of such interactive exchanges can even lead to shifts in the fundamental rules by which war is fought, a dynamic which adds further structural instability to the war-system (75). The dynamics of such a system are increasingly difficult to predict, particularly as it progresses from its initial conditions. In war, even establishing what the precise nature of these initial conditions would be is likely to be impossible, which further compounds the difficulty of making accurate predictions.

2.6 Chance

At the heart of Clausewitz's general theory of friction is the notion of chance. Where Berenhorst regarded chance as utterly pervasive, to the point that the outcome of war was almost entirely random, Clausewitz's understanding of chance was more refined, and as we shall see, implied that the Prussian general had grasped a number of important advances in mathematics. It may have appeared that he shared Berenhorst's view of war as being uniquely inflected by 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" (Book 1, Chapter 3 117). However, he was careful not to treat it as ineffable, or to overextend its effects by thinking of war as a realm of pure, unbounded contingency. Instead, Clausewitz affirmed the presence of the laws of probability which governed their effects (Engberg-Pedersen 57). This is most evident in the passages where Clausewitz describes how an officer or general should best carry out the planning of operations. Rather than adopting a rigid, axiomatic approach stemming from predetermined theory, as one might find in the works of Puységur or Bülow, Clausewitz recommended that one strive to calculate, or at least approximate, the probabilities of events, actions, and outcomes, and compare them to each other in order to determine the most likely case (Engberg-Pedersen 57):

> '*Method,'* finally, or 'mode of procedure,' is a constantly recurring procedure that has been selected from several possibilities. It becomes routine when action is prescribed by method rather than by general principles or individual regulation. It must necessarily be assumed that all cases to which such a routine is applied will be essentially alike. Since this will not be entirely so, it is important that it be true of at least *as many as possible*. In other words, methodical procedure should be designed to meet the most probable cases. Routine is not based on definite individual premises, but rather on the *average probability* of analogous cases. Its aim is to postulate an average truth, which, when applied evenly and constantly, will soon acquire some of the nature of a mechanical skill, which eventually does the right thing almost automatically. based on determined, specific premises, but rather on the *average probability* of analogous cases, and the result is to produce an average truth (Book 2, Chapter 4 176).

In other words, Clausewitz advocates for decisions to be made based on their likelihood in probabilistic terms. Because of the interactive nature of war (the clash of wills), he does not believe that a foolproof, axiomatic approach is ever possible, but instead that actions should be taken on the basis of which outcomes will, on average, be most likely to occur based on the data at hand. Because one rarely, if ever, has access to perfect information, and because one also has to deal with an ever shifting tapestry of interactions in a time-sensitive fashion, the best course of action is never assured, and instead one can only hope to act like a gambler, and play the odds. It is for this reason that Clausewitz famously compares decision making in war to that of a player in a game of cards:

> If we now consider briefly the *subjective nature* of war—the means by which war has to be fought—it will look more than ever like a gamble. . . . In short, absolute, so-called mathematical factors never find a firm basis in military calculations. From the very start there is an interplay of possibilities, probabilities, good luck and bad that weaves its way throughout the length and breadth of the tapestry. In the whole range of human activities, war most closely resembles a game of cards (Book 1, Chapter 1 96-97).

That Clausewitz was attempting to approach the conduct of war in a manner comparable to that of a card player is made most explicit in an essay he wrote in 1807-08, entitled "Über die Künftigen Kriegs-Operationen Preußens gegen Frankreich" ("Concerning Prussia's Future Military Operations Against France"). In this essay, Clausewitz argues that when determining whether to conduct a military operation one must not only weigh up the odds, but also consider the relative political value of any given action. He writes that the one should not attempt "to obtain an advantageous war situation and then to calculate the absolute probability of a great success, but to choose the lesser of two evils (qtd. in Engberg-Pedersen 60). Following this logic, Clausewitz argues that even though the chances of Prussia's victory if it chooses to rebel against France are highly improbable, the value of national independence outweighs the risk of failure (qtd. in Engberg-Pedersen 60). Engberg-Pedersen notes that this logic is a variation of a similar argument made by the great statistician Blaise Pascal in his *Pensées* (published posthumously in 1670), where Pascal proposes the following hypothetical wager concerning the existence of God: Assuming that we have no way of knowing whether God truly exists, is more beneficial to act as if God exists, or to assume that he does not? In his answer, Pascal argued that if the gains of believing in God are infinite (i.e. eternal life in Heaven), and the risk is only one's finite life and the expectation of living it in a pious fashion, then even with a fifty percent chance of God's existence any astute actor will be correct to bet on God's existence, because the value of an infinite gain exceeds the modest value that would be accumulated by not having to live a pious life (154-155).

Pascal's wager is notable for being the first formal attempt to employ what we now refer to as decision theory to make an expected value calculation (Hacking, *The Emergence of Probability* 102-103). That Clausewitz was able to put forward a similar formulation indicates that he grasped the fundamentals of probability expressed in Pascal's work, which in turn enabled him to propose the possibility of making strategic judgements not only on the basis of epistemic uncertainty, but by taking into account aleatory probability also. In doing so, Clausewitz had not only found a path to strike a middle ground between the extremes represented by his predecessors Berenhorst and Bülow, but also to escape the straightjacket that Aristotle made for himself, and strategic thought and the problematic of uncertainty more broadly, in his *Nicomachean Ethics*. As Engberg-Pedersen puts it, what Clausewitz realised was that war might appear "utterly unpredictable only if one operates within an epistemic regime that demands certainty from deductions and axioms. From the point of view of probability theory, however, warfare can to some extent be managed, if only within a system of average probabilities (Engberg-Pedersen 67).

If we were to sum up Clausewitz's contributions to the understanding of martial uncertainty succinctly, we might say that he was able to describe it in four modes. First, his account of friction (in the limited sense, rather than the broader general theory) described with remarkable perspicacity the effects of stochastic processes upon the conduct of warfare. Secondly, his description of the limits of sensory and cognitive processes, coupled with the unreliability of intelligence helpfully conveys the significance of epistemic forms of uncertainty, stemming both from informational deficits, but also from overloads and the psychological stresses, all of which Clausewitz outlines in a fashion that echoes subsequent developments in thermodynamic and infotheoretic accounts of entropy. Thirdly, Clausewitz's trinitarian model provides a prescient image of how the interactive nature of a complex adaptive system renders prediction difficult, a problem which is further compounded by the challenge of determining and accurately measuring its initial conditions. Finally, Clausewitz's suggestive metaphor of the *Zweikampf* highlights the effects of an active, calculating enemy, whose desire to thwart one's efforts provides perhaps the most intractable source of uncertainty of all. Though the general theory of friction is outlined in a somewhat messy and discontinuous fashion in the text of *On War* it does nonetheless span all four of these aspects, and in doing so established the first systematic attempt at a comprehensive treatment of the problematic of uncertainty in martial or strategic thought.

2.7 Betraying the Model

Having outlined Clausewitz's general project, as well as his distinctive treatment of uncertainty, we can now attempt to situate it in relation to the Aristotelian and *mêtic* strategic approaches. As Jullien points out, Clausewitz's treatment of warfare "provides evidence of how difficult it is to theorize how to act" (*Treatise on Efficacy* 9-10). Though he too erects an ideal model in the form of Absolute War, this is done in order to highlight its limits in the face of "this nonconducting medium, this barrier that prevents a full discharge," ie. the handbrake of politics, the stultifying atmosphere of friction, and the presence of moral factors (Clausewitz, Book 8, Chapter 2). But despite clearly demonstrating "that past thinking about warfare missed the point in setting out to make a model of something that could not be modeled" Jullien argues that Clausewitz remains ensnared within the Aristotelian theory-practice notion (*Treatise on Efficacy* 11). Since he does not adopt a different framework, his only recourse is to "set those terms in opposition and think about what divides them," and in doing so becomes able to accurately perceive that the *mismatch* between Real and Absolute war "constitutes the peculiarity of warfare" (*Treatise on Efficacy* 11). As Jullien eloquently puts it: " In short, to think about warfare is to think about the extent to which it is bound to betray the ideal concept of it" (*Treatise on Efficacy* 11).

For all Clausewitz's scepticism regarding the possibility of employing a context independent abstract model of war as the basis for the conduct of war, he nonetheless insists upon the usefulness of context dependent plans devised in advance of the joining of battle:

> War plans cover every aspect of war, and weave them all into a single operation that must have a single, ultimate objective in which all particular aims are reconciled. No one starts a war . . .

> without first being clear in his mind what he intends to achieve by that war and how he intends to conduct it. The former is its political purpose; the latter its operational objective. This is the governing principle which will set its course, prescribe the scale of means and effort which is required, *and make its influence felt throughout down to the smallest operational detail* (Book 8, Chapter 2, 700; my emphasis).

And yet, Clausewitz is also aware that uncertainty and chance will inevitably intervene, and that the adversary will react in ways that are unpredictable and thereby undermine even the best plan. This returns us to the same impasse as before, and in order to negotiate it Jullien argues that Clausewitz resorts to an appeal to experience: "only by adapting through experience, in other words through practice, can one hope to improve the situation (*Treatise on Efficacy* 14). It may be that Jullien gives Clausewitz too little credit here, however, as his account of the figure of the genius is not solely predicated upon experience, but also courage, determination, presence of mind, and an "accurate and penetrating" eye that shares many similarities with the capabilities Detienne and Vernant ascribe to *mêtis* (203). Nonetheless, his scepticism of cunning, ruse, and stratagem (he devotes a short chapter to a discussion of its limitations in Book III) makes it difficult to neatly align Clausewitz with the *mêtic* tradition; while his mistrust of excessive idealisation and mindfulness of the roiling contingencies of war scarcely make him a model Aristotelian. Perhaps the ultimate lesson of Clausewitz is to demonstrate the need for a synoptic view that can unify both approaches, while also maintaining an awareness of their respective limits.

1896: The State of Ignorance

Although it has received far less attention than Clausewitz's general theory of friction, a significant contribution to the theorisation of martial uncertainty occurred in Britain in 1896, when a retired Colonel, Lonsdale Hale, attempted the first explicit attempt at a definition of the FOW during a talk given at Aldershot military academy. Perhaps unsurprisingly, Hale specialised in studying the Prussian art of war, and was known to be a devotee of Clausewitz. His talk consisted primarily of an analysis of the Battle of Kissengen, fought in 1866 between Prussia and Bavaria, in order to highlight how the decision-making by the commanders on both sides was hampered by a variety of factors, including crude and outdated maps, miscommunications, environmental obstructions, and missed rendezvous. Though it is a brief text, the degree to which Hale is preoccupied with the problematic of uncertainty is striking, and also indicative of the effect that Clausewitz's contributions were beginning to have upon martial thought even outside of Prussia by the late 19th century. Hale's key contribution, the FOW, is defined at the outset in the talk's preface, with Hale proclaiming that it should be used to describe:

> [T]he state of ignorance in which commanders frequently find themselves as regards the real strength and position, not only of their foes, but also of their friends, and also as regards the details of the ground over which the operations are actually being carried out. For obvious reasons, this fog rarely shows itself in our peace training over our well-known manoeuvre grounds (522).

In Hale's interpretation, the fog of war is understood in primarily epistemic terms as a *state* or mental condition that afflicts the commander, and can stem from environmental impediments that obscure line of sight, as well as the limits of information and intelligence more generally, including representations of the battlefield, such as maps. This emphasis is not insignificant, as it is not only suggestive of the epistemic dimension of the FOW, but also the central role played by martial media in negotiating the conduct of war in the late 19th century. Following Clausewitz's general theory of friction, it encompasses both the machinations of the "external" enemy, but also the limits and dangers of relying too heavily on second-hand, "internal" forms of knowledge.

In this respect, Hale elaborates upon Clausewitz's treatment of intelligence problems. Where the Prussian observes that "the only situation a commander can know fully is his own; his opponent's he can know only from unreliable intelligence," (Book 1, Chapter 1 95) the British Colonel's overriding concern is to stress the extent to which the fog of war dissolves any possibility of reliably and consistently being able to grasp the definitive locations and dispositions of *one's own forces* in addition to those of the enemy. Another significant point of departure between the two accounts is that with Hale, the specific connection to aleatory conceptions of uncertainty is absent, though the notion of a "state of ignorance" does at least recall Clausewitz's account of friction as an atmosphere, or condition of possibility that bounds war. By comparison, Hale's treatment is theoretically impoverished. Where Clausewitz's general theory of friction progressively elaborates a sophisticated account of the many different sources of uncertainty, exhibiting some cognisance of both its epistemic and aleatory forms, Hale's preference for the term "ignorance" carries with it an implication that the known and unknown can be more rigidly distinguished from each other, and that adherence to proper techniques of intelligence gathering and communication might alleviate the problems that the FOW poses.

Of course, Hale deserves some credit, for it is his phrasing, "the fog of war," rather than Clausewitz's metaphor of the "fog of uncertainty" which has persisted in the lexicon. His text was reprinted widely in the military journals of his time, including in the United States and Canada, which likely explains how the term began to pick up traction, as it quickly became a commonplace shorthand for the pervasive uncertainty of war. Up until the 1930s, if the concept was attributed at all, it was generally to Hale, and not Clausewitz. This passage, from A. Hilliard Atteridge's account of the Battle of Solferino published in 1913 is typical of how the FOW was invoked during that period:

> War maps and battle plans, with their definite presentment of the positions occupied by both sides over leagues of ground, are misleading, unless we remember that, whatever the aeroplane and the dirigible may do for generals of coming days, those of the past had to judge the situation and make their decisions in the midst of what Colonel Lonsdale Hale has happily described as the "fog of war" (42).

However, one notable exception is Major Stewart L. Murray's, *The Reality of War*: *A Companion to Clausewitz*, published in 1909, which is perhaps the first work in English to attribute the "fog and friction" schema to the Prussian general:

> Friction in war is one of Clausewitz's most characteristic ideas. He always looks at everything from that point of view, and as friction and the fog of war, and their influence on human

nature will always be the chief characteristic of real war as distinguished from theoretical war or war on paper, it is chiefly this habit or mode of thought which makes his writings of such great and permanent value (82).

Neither of these passages makes an explicit attempt to define the fog of war. In both instances, familiarity with the concept is to some extent presumed by the author. This is perhaps unsurprising given its complete absence as a stand-alone concept in Clausewitz, and the relatively limited theoretical treatment given by Hale, where there is no attempt to situate it within what Manabrata Guha refers to as a wider "architectonic" of war "in which allowances could be made not only for all that lay within, but also, potentially for that which lay beyond the reach of Reason" (i.e. the vicissitudes of chance, uncertainty, and contingency) as Clausewitz does with his general theory of friction (49-50). In this sense, the limitations of Hale's initial sketch of the FOW are perhaps indicative of why it would never quite go on to attain the status of concept, persisting primarily as metaphor or cypher. Indeed, the tendency to invoke the FOW's influence while simultaneously neglecting to proffer an explicit description of its features would recur again and again, perhaps most notably in 1938, when it was used in the title of the influential British military theorist B. H. Liddell Hart's analysis of the first World War, *Through the Fog of War,* but never actually referred to in the actual text of the book—a few scant references to the use of fog as a cloak or cover for attacks aside. However, as we shall see, the FOW's insubstantial conceptual status may also have been to its advantage. By becoming an empty signifier the FOW could continually be reapplied in order to describe emergent conceptions of martial uncertainty as they arose, whether through new discoveries in science and mathematics, or in response to changes in the conduct of war.3.0 When War Becomes a Game

> The idea, you see, is that [the game] is so complex, so subtle, so flexible and so demanding that it is as precise and comprehensive a model of life as it is possible to construct. Whoever succeeds at the game succeeds in life; the same qualities are required in each to ensure dominance.
>
> —IAIN M. BANKS, *The Player of Games*

> Ever since words existed for fighting and playing, men have been wont to call war a game.
>
> —JOHAN HUIZINGA, *Homo Ludens*

We have thus far traced the progressive emergence of the FOW in the martial theory of the 19th century, during a time when war's age of reason and geometry was successively giving way to Berenhorst's empire of chance, and then to Clausewitz's novel accounts of interactivity, probability, and friction. However, there is one further arena in which we can also find traces of the FOW's emergence during this period: the mechanics of professional wargames. This chapter surveys this space, and finds within it a sophisticated and entirely novel effort to translate the dynamics of war into the medium of the game during the late 18th and early 19th centuries. Where past attempts at a formalisation of war had been geometric, and were predicated upon the omission of irregularity, the game designers of this period gradually worked towards the incorporation of chance and uncertainty via a number of innovative mechanics that broke with the tendency towards determinism and abstract representationalism found in earlier wargames (notably chess and its variants). The culmination of these changes was the Reisswitz *Kriegsspiel* (literally "war game") of 1824, which was subject to mass production for use by the Prussian military, and transcended the medium of the game, amounting instead to an intricate *simulation* of war. The Reisswitz *Kriegsspiel* and its many successors would go on to inform martial pedagogy, and eventually even the conduct of war as they became integrated into both military academies within and beyond Europe, and even the day-to-day apparatus of command and control itself during the World Wars of the 20th century.

This chapter begins by considering the nature of simulation and its relation to the medium of the game. It then provides a brief sketch of the history of early wargaming, before tracing in greater detail the emergence of 18th and 19th century wargames and the novel mechanical features that enabled them to become simulations of war. In doing so, a number of continuities between the uncertainty mechanics of these 19th and 20th centuries wargames and the treatment of martial uncertainty in Clausewitz's *On War* are identified. The chapter also highlights the discontinuities between the mechanics of wargames and the features of the FOW which predominantly stem from the challenges inherent in translating the manifold complexities of war into the bounded parameters of the game.

3.1 Games as Simulations

Simulation has a complex etymology. In one sense, it is often used to refer to things which are false, or involve feigning, hypocrisy, or to pretense. It refers to something which is similar, but somehow different, to "something that appears to be what in fact it is not" (Bousquet, *Wargames* 13). Bousquet connects this definition of simulation to that of representation, in the sense that representations *appear* to be their referents, even though they are not, and are thus inherently illusory in nature (*Wargames* 13). Though they are tied to an object in the world, they nonetheless remain 'just' images, and so have a certain kind of ontological flatness to them (Bousquet, *Wargames* 13). In media theory, this account of simulation is heavily informed by the writings of Jean Baudrillard, for whom simulacra are engaged in an escalatory play that progressively detaches the image from its referent. In this "precession of simulacra," the system of referentiality undergoes a transformation that shifts the function of the image from reflection or representation towards a state of pure self-referentiality (van Hilgers 62, Baudrillard 6). Bousquet argues that "simulation" in this sense also has its correlate, the *dissimulation*, which works in opposition to the simulation (*Wargames 13*). Rather than being an act of imitation or representation, dissimulation involves making something recede from view or detection. As Baudrillard puts it, "to dissimulate is to pretend not to have what one has" (4). Such things threaten to evade regimes of representation entirely, often through techniques of masking, camouflage, or concealment. We are not to notice them at all. Where representations may have an iconic relationship to their referents, dissimulations work *upon* the object in the world itself, they seek to blend into the world, rather than separate themselves from it.

But for Bousquet there is also a second, more contemporary notion of simulation, which has yet another relation to the real, and which functions in a manner entirely distinct from that described by Baudrillard. This is the notion of the simulation as a *model*, which "suggests the dynamic representation of processes, operations, and situations through the formal description of the internal characteristics and constituent variables of a given system" (Bousquet, *Wargames* 13). In the philosophy of science, the purpose of a model is to gain an insight into the workings of a complex physical system through an understanding of a more simple, hypothetical system that stands in for its referent (Godfrey-Smith 726). Where the traces of the real are progressively effaced in Baudrillard's precession of simulacra, the model instead seeks to capture the *depth* of whatever is being simulated. Representations have iconic (or indexical, or symbolic) relations to their referents, but cannot capture the actual *functionality* of them. In contrast, models seek to both capture and replay or recreate the actual processes and functional characteristics of their referents, albeit in a limited or restricted fashion.

In a model you have "a set of interrelated propositions" which set out to capture and replicate the internal behaviour and dynamics of the system which they seek to reproduce (Bousquet, *Wargames* 14). From there, "[assumptions] are made about the system, and mathematical algorithms and relationships are derived to describe these assumptions" (Bousquet, *Wargames* 14). Thus, mathematically, the model adopts some of the functions that the referent system actually performs. This helps to reveal how the system works, particularly as the system is tested via exercises and experiments. Crucially, the model in this sense does not stand in a secondary, "flattened" relation to its referent, but instead it presents "an abstract set of operational principles whose experimentation becomes the basis for the production of the real" (Bousquet, *Wargames* 14). Indeed, by abstracting and simplifying the functional principles of its referent, a model can strip away a great deal of the noise present in the referent system, and in doing so produce a "more real" picture of its dynamics than might otherwise be available from observing it directly. From this point of view, far from representing, or effacing the real, the simulation-as-model becomes instead "an intense site of its production" (Bousquet, *Wargames* 14).

For Bousquet, the first historical moment where a simulation-as-model emerges is in the invention of the Prussian *Kriegsspiels* of the early 19th century (*Wargames* 14). In doing so, Bousquet observes a distinction between the types of games we might play primarily for entertainment, and wargames which involve performing an experiment upon a model. Where games of the former nature, such as *go* or chess only depict combat in a relatively abstract way, and at best might help to cultivate some basic strategic intuitions or principles, in *Kriegsspiel* a much more intentional effort to functionally replicate depict the dynamics of war can be found. However, it is worth stressing that the capability of a game to fully simulate war is necessarily limited. For Clausewitz, the major problem here is war's indefinite and unbounded nature:

> Efforts were therefore made to equip the conduct of war with principles, rules, or even systems. This did present a positive goal, but people failed to take adequate account of the endless complexities involved. As we have seen, the conduct of war branches out in almost all directions and has no definite limits; while any system, any model, has the finite nature of a synthesis. An irreconcilable conflict exists between this type of theory and actual Practice (Chapter 1, Book 2 154-155).

Though Clausewitz is thinking here of the mechanistic theories of war produced by Bülow and others, the point he makes is equally applicable to the problem of establishing or fixing war's limits within the inherently fixed and bounded rules of a game. Indeed, as van Creveld points out, "a game capable of simulating every aspect of war would *become war*" (*Wargames* 5). An *experience* of the existential stakes of war, and the presence of unrestricted physical violence which constitute a necessary (if insufficient) part of war's essence are difficult to capture without physically endangering participants in a game. To some extent, this problem is intractable, but it was never a fundamental barrier to the production of wargames which could at least seek to simulate with some degree of verisimilitude *some* facets of war, such as the effects of terrain, the movement of troops, the role of logistics and so on. Nor has it prevented their gradual adoption and acceptance as an invaluable tool for both pedagogy and operational planning within military institutions. Finally, it is worth noting that the birth of the wargame as a full-fledged simulation did not occur ex nihilo, but instead was the culmination of an extended and extensive process of experimentation and innovation by a variety of European game designers, who benefited from a number of major developments in fields such as cartography, statistics, and war itself during the age of reason. What follows then is a brief overview of the prehistory of wargames, and then a more detailed examination of three distinctive wargames from the late 18th and early 19th centuries. We find that each of these contributed novel mechanical features which fulfilled the necessary preconditions for the proper emergence of the wargame as simulation in the Reisswitz *Kriegsspiel* of 1824.

3.2 A Prehistory of the Wargame

Wargames are at least as old as recorded history itself. Among the earliest archaeological traces of ancient cultures are miniature toy versions of tools and weapons. These were some of the first representational models, fashioned as a means for the transmission of knowledge that would enable "the first simulations of adult tasks to help each generation pass on survival skills to the next" (Caffrey 11). The use of these figures was quite variable, encompassing religious and cultural functions as well as martial ones (Peterson 205). Figurines were also used by generals to create schematic diagrams of the respective compositions of friendly and enemy forces, such that their potential positions, manoeuvres, and tactical opportunities could be experimented with. It is also known that the first boardgames extended back into prehistory, with archaeological evidence suggesting that the Ancient Egyptians played games as far back as 2000 BC, and the Ancient Chinese perhaps even further, with the earliest estimate being 2300 BC (Caffrey 12). Whether these early board games were games of war is less clear, but we do know that many fundamental principles and mechanics that would subsequently become mainstays of war games as we now recognise them emerged during this time; including the board, and its division into spaces—an act of spatialisation which delineates the world of the game from its outside; the addition of pieces which could move across the squares of the board; and implements of chance, such as lots, bones, and dice, which could be used determine the distance a piece might move across when traversing the board, while also introducing an element of uncertainty to the gameplay.

One of the earliest games that we can with some degree of confidence refer to as a wargame, in the sense that it allowed its players to play a game that explicitly attempted to represent some aspects of war, is *chaturanga*, an Indian game that was the predecessor of contemporary chess. The game has been traced back to around the time of the Gupta empire in 7th century CE, and incorporated pieces standing in for various elements of its military during that period, including chariots, footsoldiers, and the elephant (Peterson 207). The presence of these representational figurines distinguished *chaturanga* from other ancient wargames, such as the Greek *petteia*, Roman *latrunculi*, or Chinese *weiqi* (better known by its Japanese name: *go*), which were all relatively abstract in their depiction of war—though in *weiqi* it is notable that the win condition is the encirclement or outflanking of the opposing player's pieces, which was perhaps indicative of an overall preference for an early form of manoeuvre warfare rather than one of attrition in the martial tradition of ancient China (Peterson 207, Wilson 15). In contrast, as Peterson notes, "[among] the great innovations introduced by *chaturanga* [are] the different style of movements allowed to each unit in the system, which approximated the forces they represent" (207). The chariot (*ratha*) moved in a straight line, much like the rook in chess, while cavalry (*turaga*) had a crooked hook-like move similar to that of the knight (Peterson 207). *Chaturanga* was gradually exported via trade, reaching the Middle East, before eventually spreading to southern Europe by 900 CE (Peterson 208). In Persia, the game was called *shatranj*, as its players would declare "shah" when referring to the king piece, which established the early phonetics for the contemporary word "check." Other pieces also received their names and functions from this version of chess. For instance, the chariot, with its straight vertical movement became known as the "rukh," a word which the Europeans eventually transliterated in order to refer to their castle piece, or "rook" (Peterson 208). By the 16th and 17th century chess was being played in European courts, where Spanish and Italian players made a variety of theoretical contributions to the game, establishing many of what we now recognise as its contemporary ruleset (Peterson 208).

However, the emergence of what we would now recognise as the modern rules did not prevent chess from continuing to evolve. Along the way, chess has had a profound influence on European wargaming efforts, with most wargames emerging since the Medieval period being variations of chess in one fashion or another. Indeed, its widespread popularity led to the initial entrenchment of some fairly limiting conventions, most notably the persistence of abstract tiled boards (even if they were sometimes arranged in different shapes or configurations), and the presence of perfect information, as all participants in chess can see where all of the pieces are located on the board at all times. Combat in European chess-like wargames was typically deterministic, with displacement tending to be the main combat system, where one piece would "capture" and then "remove" another once it came to occupy the same square. In these respects, chess and its progeny reflected the prevailing mechanistic outlook that prevailed in Europe during the 16th and 17th centuries, including in warfare. However, as Andrew Wilson notes, the "belief that war was an exact science and the quest for 'true principles' to guide its conduct, soon led to the design of more complicated games" (16). And so, just as the emergence of statistics and probability would contribute to the unravelling of the clockwork image of the world and its physical mechanics, so too would the deterministic gameplay of the earlier chess variants be dissolved as aspiring game designers began to pursue a more realistic model of war within the parameters of their medium.

3.3 Towards Simulation: Hellwig, Venturini, Opiz

Among the earliest European wargames to make a significant break from chess was *Das Kriegsspiel* developed in Brunswick by the mathematician Johann Christian Ludwig Hellwig (1743-1831). Hellwig released his first version of this game in 1780, and claimed that with it he wished to achieve two objectives, which were themselves quite instructive. The first of these was to "bring to life the rules of the art of war and thus serve to provide the students of this art" (qtd. in Peterson 213-214). Secondly, he wished to "provide a pleasant entertainment through a game where nothing depends on chance, but rather all depends on the skill of the player" (qtd. in Peterson 214). For Hellwig, war was a phenomenon bounded by particular rules which could be grasped and transcribed into the medium of the game. We also find in his proclamations a view that chance was still understood as an enemy, a thing to be removed from the game for it could not be co-terminus with the simulation of war, which Hellwig viewed as being an endeavour whose outcomes were solely determined by the respective capabilities of the combatants, which should in turn be governed by a recourse to war's universal rules and axioms. Nonetheless, with these two statements, Hellwig may well have been the first person who definitively and explicitly attempted to *simulate* war, and to do so in such a fashion that its fundamental principles could be potentially be grasped, and also passed on through instruction.

So how did Hellwig attempt to realise his two objectives for the game? His major innovation was to massively expand the grid of chess, while also utterly transforming it. Rather than having play occur on an abstract grid of alternating black and white tiles as in chess, Hellwig wanted the terrain in his game to reflect the types of terrain that armies would actually encounter. This was achieved by colour-coding all of the various tiles that would make up the board (Peterson 214). For instance, white tiles signified ordinary ground, but the game also included tiles representing mountains (red), swamps (green), and water (blue). Each of these types of terrain could impose restrictions to the movements of units passing across them, while also potentially conferring advantages or disadvantages to combat. Mountain tiles were impassable, while crossing a river required the use of a special pontoon unit. At the start of the game, the board was divided down the middle. Players could position their pieces anywhere on their half, provided they were greater than one turn's march away from the borderline. In another major departure from chess, Hellwig's board was entirely modular, and did not come in one prescribed size or shape. Instead, he encouraged his players to experiment with the side of the board, and for one of the later editions of the game (released in 1803) he produced a fully configurable "board" comprised of six-sided cubes, each side of which depicted a different type of terrain, that could each be rotated and then ordered into a grid to form a fully customisable battlefield (Peterson 214).

In addition to developing a more realistic model of the battlefield, Hellwig also attempted to introduce greater variety into both the appearance and function of his game pieces. Setting out to depict the makeup of forces one might expect to find on a European battlefield of his time Hellwig divided the game pieces into three types: infantry, cavalry, and artillery (Peterson 215). Peterson notes that the two main editions of Hellwig's game handled the modelling of infantry and cavalry quite differently, and in a fashion that progressively unshackled their mechanical functions from the types of movements one would expect to find in chess. In his earlier 1780 version of the game a large variety of infantry and cavalry pieces were included, and although they each exhibited a variety of different movements (for instance, with some pieces being able to move a larger number of squares than others), they broadly retained a chess-like system of movement, and still captured opposing pieces through the familiar deterministic displacement system. This would change in the 1803 version, which included a greater variety of units, and also some novel mechanical developments. Artillery pieces now required infantry pieces to "man" them, and they could only fire in the direction that they were facing. In this respect, Hellwig's figurines broke with the symmetrical abstractions of chess pieces, and instead incorporated a higher degree of iconic representation (Peterson 216). These changes also involved the introduction of ranged fire. For instance, infantry and artillery could fire upon units instead of advancing to replace them. The effectiveness of infantry was dependent on the respective orientation of one's own and the enemy's pieces. Infantry units facing each other are immune to each other's ranged fire, but if an infantry unit were to fire upon another from its flank it is destroyed, but unlike in chess the infantry unit does not move to occupy the space vacated by the defeated unit. Along with these breaks from the combat mechanics of chess Hellwig further complexified his game through the introduction of mechanics intended to simulate the construction of bridges, the importance of logistics, and the establishment of lines of communication which could be intercepted by one's opponent (Peterson 216).

Hellwig's game became somewhat popular across mainland Europe, and was played by officers in training in his native Brunswick, as well as in Denmark and even Britain (Wintjes, "Europe's Earliest Kriegsspiel?" 20). Indeed, such was its influence that it quickly became subject to further modification, adaptation, and iteration by other game designers. The most notable of these came from another Brunswick native, the geographer Johan Georg Julius Venturini (1772-1802), who in 1796 developed what came to be known as "Venturini's Game." Venturini was a student of military history, who encountered Hellwig's game under the tutelage of Jakob Mauvillon, a professor of military history at

Brunswick Collegium Carolinum (Peterson 217). Venturini set out to improve on Hellwig's game, and did so with a further adjustment to the board.

Rather than persisting with the tiled, modular board developed by Hellwig, Venturini favoured playing upon a scale cartographic map, as his profession as a military geographer dictated that he was well aware of the importance of terrain in shaping the dynamics of conflict. His *Lehrbuch der Militair-Geographie der östlichen Länder am Niederrhein* ("Textbook on the Military Geography of the Eastern Territories by the Lower Rhine"), published in 1804, provided a detailed description of the terrain on the contested border between France and Belgium from the perspective of the tactical opportunities which it proffered. Indeed, the work defines the art of war as "the superior use of terrain advantages" (qtd. in Engberg-Pedersen 127). Given the centrality of terrain in Venturini's conception of war, Hellwig's modular tiles were deemed insufficiently detailed to make terrain play a meaningful role in the strategic decision making of his game.

Solving this problem was not straightforward, as cartography was a relatively recent development in Venturini's time, for in the late 16th century, scale maps were uncommon. Instead, most maps were cadastral, depicting cities, political divisions, roads, geographical features and so on, but not at topographical scale. The first scale topographical map of France was commissioned in 1670, and only completed by its originator's grandson more than a century later, in 1789, just before the French revolution (Peterson 218-219). Nonetheless, Venturini sought to incorporate topographical maps, but in order to make his game playable by conventional chess-like figurines a compromise was still needed, so Venturini imposed a one-inch grid over the map. Each square represented 2,000 paces, or roughly one mile per square. His game would often be played on two maps, one at a larger scale for movement and strategy, and a second, smaller scale map for tactical engagements, where battles would play out (Peterson 219-220).

With the shift to a scale map play could now occur at units of distance that mirrored that of the physical world. Thanks to this innovation, Venturini was then able to mechanically connect the movement of units to the actual *time* it would take to cover an equivalent distance in the physical world. Thus, time could be implemented mechanically within the model of the game alongside space, with the movement that each unit would travel in one turn being connected to the comparable amount of time its referent would require to traverse that distance in the physical world. In addition to this substantial accomplishment, Venturini's game also made a number of other refinements to the template provided by Hellwig, as it "increases the variety of terrain, takes into account seasons and weather, vastly increases the sorts of entrenchment and fortifications that combatants might construct, and adds significant, but not necessarily exciting, detail to the feeding, equipping, and support of forces in the field" (Peterson 218). However, aside from the game's seasonal weather system, Venturini's game, much like Hellwig's, did not introduce any features which could disrupt the causal chain of action and effect for its pieces. Movement and combat remained deterministic, and so as in chess experienced players were never in doubt as to the outcome of any of their decisions. Indeed, the disparity between the clockwork determinism of the wargame and the contingent nature of war did not go unnoticed by Venturini's contemporaries. For instance, Engberg-Pedersen draws attention to a review of Venturini's game written by an anonymous self-proclaimed "retired wargamer" who declared that although the game was sophisticated and enjoyable, it was nonetheless unable to sufficiently capture the complexity of war completely "since so often in war unrepresentable accidents decide" (127).

Despite these growing pains, it would not be long before the emergence of a new wargame that could incorporate some elements of chance into its model. In fact, the first attempt in this direction was already underway during Venturini's lifetime, by his contemporary, the Bohemian bank official Johann Ferdinand Opiz (1741-1812). Born in Prague, Opiz developed his elaborate game, which made use of modular boards that were similar to Hellwig's, in 1760 (Schuurman, "Models of War" 453). However, the game would remain in relative obscurity until 1806, when it was given a formal release by his son, the painter Giacomo Opiz Jr (1775-1841) (Wintjes, "Europe's Earliest Kriegsspiel?" 21). In the introduction to his father's game Opiz Jr included a letter which he had received from a young Austrian officer that commended its novelty. The letter begins by lauding Opiz's incorporation of realistic terrain, but is primarily concerned with highlighting the significance of its simulation of chance:

> What gives your game the greatest resemblance to war operation is this: that the result of the players' dispositions does not always turn out according to their will, but often according to the less advantageous chance of the *roll of the dice*.—This *singular feature of your game* is a wonderful first-rate *original thought*, which lends your game a certain degree of perfection in the really useful way.—For this is how it is in real war. The dispositions of even the most experienced and daring commander are not always carried out to the letter, rather the effects of mutual fire and a thousand other chance occurrences often impact the dispositions and lead to a wrong or even disastrous end (qtd. in Engberg-Pedersen 128).

In order to introduce the element of chance Opiz's *Kriegsspiel* is played with a pair of dice, which are used to help determine the outcome of a variety of different events, including "the impact of firepower, the capture of prisoners, desertion, and the success or failure to advance in mountainous terrain" (Engberg-Pedersen 128). Although their implementation was relatively simplistic compared to that of subsequent wargames, the experience of playing the game was altered dramatically by their presence. With the abolition of chess's deterministic combat mechanics a player could no longer straightforwardly survey the balance of power across two rival forces and be assured of the outcome of their impending engagement. As in the general theory of friction, which Clausewitz would later advance, in the Opiz game "[not] only is chance inserted as an operational principle; it also makes necessary a probabilistic analysis that weighs the probabilities of multiple future contingents and seeks to take the effects of chance into account" (Engberg-Pedersen 129). For Engberg-Pedersen, the ability of the Opiz game to train its players in the intricacies of "contingency management," combined with incorporation of the third dimension in the form of terrain representation represents a tipping point where "the war game had reached a degree of complexity that transformed it from a mere game into a simulation that could serve as an important instrument in the preparation for war" (132). Certainly, by 1809 wargames were becoming part of the official curriculum of the Prussian War College in Berlin at the behest of the Prussian Chief of Staff (and Clausewitz's instructor) Gerhard Johann David von Scharnhorst, indicating that what would soon become the pre-eminent military institution of its age was beginning to recognise their pedagogical potential. For Engberg-Pedersen, this development could not have occurred had the *Kriegsspiels* not themselves undergone the necessary transformations so as to reflect the shifting scientific understanding of the epistemic regime of war (131-132).

Nonetheless, there is one limitation which Engberg-Pedersen overlooked in his account of the shift from game to simulation during this era: the persistent presence of perfect information in the European wargames which had been produced up to that moment. By 1809, none of the various editions of the Hellwig, Venturini, or Opiz wargames had devised a system which could fully immerse its players in what Clausewitz would later refer to as the "atmosphere of war" by constraining their ability to access information about the entire situation at any moment during gameplay (141). Though the Opiz game did introduce an element of contingency through dice rolling, many other variables which would otherwise have remained hidden in war as a consequence of the limited sensory capabilities of the combatants are revealed to the players of his game. It is for this reason that Engberg-Pedersen's anointing of the Opiz *Kriegsspiel* as the first simulation of war seems premature. Though its limited introduction of contingency was remarkable and was certainly unprecedented in its time, it did not integrate other extant developments, such as Venturini's adoption of a topographical map, which in turn ushered in the promise of emulating not only war's spatial dynamics, but also its temporal ones. Nevertheless, further breakthroughs were to come, with the most significant of these stemming from the innovations of a father and son who hailed from Brunswick's nearest regional power, Prussia.

3.4 The Reisswitz Kriegsspiel

Georg Leopold von Reiswitz,[16]was born in 1760 in the city of Wroclaw, in what is now modern day Poland. Reiswitz was a student of military history, and had hoped to be a soldier, but suffered an arm injury that forced him into the civil service.[17] He developed a great passion for wargaming while completing his university studies, but because the Hellwig game was quite expensive Reiswitz and his friends could not afford to purchase it. Undeterred, they bootlegged the game, and were quickly able to develop their own replica of it. By 1807, Reisswitz could be found teaching his recreation of Hellwig's game to his then thirteen year-old son, Georg Heinrich. Then, in 1809, Reiswitz encountered a Prussian journal which contained a text that critiqued the Opiz wargame, highlighting its unrealistic representations of terrain. The author of the critique, one Rector Günther of Oleśnica, was particularly aggrieved that the figurines representing troops on the board would occupy the space of an entire square mile (the size of each terrain tile on the board), when in reality "as Freidrich [the Great] said in his lessons to his generals, on a single square mile there are a hundred possible positions" (qtd. in Peterson 223). Reiswitz was quite struck by this observation and, seized with inspiration, decided that rather than play a replica of an imperfect game he might attempt to develop his own more refined version.

[16] The absence of the second "s" in the name of Georg Leopold von Reiswitz is not a mistake. As Jorit Wintjes notes, the publication of the 1812 *Kriegsspiel* attributed the game to a "von Reiswitz" ("A School of War" 57). His son, Georg Heinrich von Reisswitz adopted the second "s" in the spelling of his surname with the publication of an updated version of the father's game in 1824. It is this latter edition of the game which is the most well known and historically influential, which is why I default to spelling "Reisswitz" with a second "s" unless I am specifically referring to the father, in which case I shall refer to him and his game as "Reiswitz."

[17] This account of the development of the Reisswitz game closely follows that provided by Jon Peterson in his magisterial history of games of simulation, *Playing at the World* (2012). For further historical detail see also Wintjes "A School of War," and von Hilgers *War Games* (2012).

Reiswitz' first major design decision was to banish the mainstay of all chess-like wargame variants[18] to date: the grid. By 1810, Reiswitz had begun experimenting with the use of a box filled with damp sand, which could be sculpted into any desired topography. Later that year, he travelled to Berlin, presenting and demonstrating his game to various civil servants. Word of his game began to spread, and eventually Reiswitz was summoned to demonstrate his game to the Prussian princes at the Berlin castle. We know that this game took place at a much more granular scale than Venturini or Hellwig, focusing instead on emulating the dynamics of combat at the tactical level. The pieces in his game were not iconographic miniatures, but rather small wooden cubes or rectangles that Reiswitz colour-coded in order to denote their different roles or functions (artillery, infantry, cavalry etc.).

The exhibition was a great success, with the German princes, and particularly Prince Wilhelm, being so taken with the game that they promptly petitioned Reiswitz to present it to their father, Freidrich Wilhelm III (the grandson of Frederick the Great). Reiswitz informed the princes that he did not dare to bring a box of sand before his king. Instead, he promised them that he would return to the palace once he had developed something more appropriate for the King's edification. After spending an entire year refining the game, and upon returning to the palace, its residents are said to have been astonished by what was brought. Here is a first hand account, most likely written by Prince Wilhelm himself:

> It was in the shape of a large table open at the top for the terrain pieces to fit into. These terrain pieces were 3 to 4 inches square, and the overall area was at least six feet square. The small squares could be re-arranged so that a multiplicity of landscape was possible. The

[18] Hellwig, Venturini, and Opiz all made use of rectangular grids in their games.

> terrain was made of plaster and was colored to show roads, villages, swamps, rivers etc. In addition there were dividers for measuring distances, rulers, small boxes for placing over areas so that troops who were unobserved might make surprise attacks, and written rules which were at this stage not yet in their fuller form. The pieces to represent the troops were made of porcelain. The whole thing was extremely well painted (qtd. in Peterson 224).

In some ways the first edition of the Reiswitz *Kriegsspiel* (see Figure 1) represented a rolling back of earlier advances. Though it explicitly references Opiz's game as an influence in its "Vorrede" ("forward"), Reiswitz's game omits the use of dice, and instead reinstated a chess-like system where strictly deterministic actions would determine the outcome of combat (Wintjes, "A School of War" 61-62). Furthermore, unlike the original sandbox version, the modular tiles—each of which depicted a distinctive terrain feature such as a hill, segment of river, forest, and so on—were flat, so properly vertical terrain was no longer a feature. Nonetheless, the game was played to scale, with the grid of chess-based games dismissed in favour of rulers, which were used to determine distance. By introducing a consistent scaling system across the tiles and playing pieces, Reiswitz was finally able to free movement in the game from the rigidly prescribed verticals, horizontals, and diagonals of chess. Now "there was no question of whether troops could move forward, or diagonally, or in the manner of chess knights—troops could move in any direction across the terrain that a ruler might be pointed from their starting position" (Peterson 226). In a further departure from his predecessors, the importance of scale extended to the pieces, which were designed to take up the same amount of space on the board as they would on real terrain. Rector Günther, would have been delighted!

Figure 1: Reiswitz *Kriegsspiel* (1812). Reproduced from Peterson, *Playing at the World*.

Of even greater significance was the rudimentary use of large wooden boxes to obscure portions of the board from one's opponent, making this the first attempt at incorporating limited and asymmetrical information into the gameplay and mechanics of a wargame (Wintjes, "A School of War" 61-62). The rules also outlined a series of mechanics for placing and moving hidden units, suggesting that Reiswitz was attempting to create an entire system of play where opponents in the game were not constantly able to see each other's pieces. As von Hilgers puts it:

> Reiswitz's "mechanical device" regulates the representation of visibilities, information flows, movements, strikes, and losses of troops during a battle. His rule system is thereby *open to the contingencies* that different tactical manoeuvres can produce. . . . Earlier war games essentially only reproduced the rehearsal of specific formations. Reiswitz's tactical war game, on the other hand, is a system that confronts its players with incalculabilities that can no longer be rehearsed, but can only be played through (47; my emphasis).

At long last, the player of the wargame would not be omnipotent, but rather would be plunged into the fog of battle. It is worth noting that von Hilgers mistakenly assumes that Reiswitz Sr's *Kriegsspiel* retained the use of dice from Opiz in his description of the game's mechanics, and so his emphasis on the degree to which the game was able to present its players with "incalculabilities" is exaggerated. While there was some variability in the damage dealt by gunfire in the Reiswitz *Kriegsspiel* it scaled in a linear fashion depending on the distance from and size of the target: the farther away, and the smaller the unit, the less the damage dealt (Peterson 230). Under this system, the way combat unfolds becomes dependent on the context in which units are engaged, albeit in a fashion that does not introduce any aleatory uncertainty regarding the specific outcome of any given action. In other words, combat was now subject to a greater range of *possible* outcomes, but these outcomes were still governed by a deterministic system that maintained a clear and discernible relationship between cause and effect. As such, players could freely consult the relevant rules determining gunfire, and straightforwardly glean how much damage they could expect to deal before committing to an action. Nonetheless, the introduction of limited and imperfect information in a game setting that could simulate the adversarial interaction of war preempted some of the vital components of the Clausewitzian account of war as a dynamic struggle ("Zweikampf") or duel taking place under conditions of uncertainty, with the central difference being that one did not have to rely upon any sort of probability calculus to make informed decisions once combat was joined on the board of Reiswitz's game.

Altogether, these advances clearly made for a novel and engaging experience for the Princes, but unfortunately, the ruleset of the updated Reiswitz *Kriegsspiel* was not fully finished. In the meantime, the table was left at the palace while Reisswitz departed to work on the rules, which were subsequently published a year later, in 1812. However, by April of that year the French army subjugated Prussia while on its way to invade Russia. Reiswitz was posted to Kwidzyn (a city in Western Prussia) and though he had by that time completed and published two hundred copies of a formal account of his wargame, his work was put on hold until the cessation of fighting following Napoleon's defeat at Waterloo in 1815. Upon the conclusion of the war, Reiswitz attempted to finalise the ruleset of his version of *Kriegsspiel*, but upon further playtesting found that a fresh start was required due to the large number of further modifications that he hoped to implement. The game he had produced for the Prussian royals, replete with its hand-painted modular tiles and lavish wooden cabinet, was simply not feasible to produce en-mass in its existing form. And so, it would not be the elder Reiswitz, but rather his younger son, Georg Heinrich Rudolf Johann von Reisswitz (1794-1827) who would carry out this task.

Unlike his father, the younger Reisswitz was an experienced soldier who, having fought in the Napoleonic wars, earned an Iron Cross in 1813, and eventually served in the Prussian artillery. After the war, he spent a period stationed in Stetin, from 1816 to 1819, where he took up his father's dreams of producing a more refined and realistic wargame in earnest. A subsequent posting to Berlin enabled Reisswitz to further test and refine the game's ruleset while working in collaboration with a company of other junior officers from the Prussian army. The culmination of these efforts came in 1824, with the formal publication of *Kriegsspiel*, which, as Jon Peterson notes, "would serve as the basis for a century of military wargaming in Germany and around the world" (227). Like Hellwig before him, Reisswitz outlined the method underpinning his design choices. He wished only to "convey a realistic picture of the events" on the battlefield (qtd. in Peterson 227). Indeed, he was reluctant to call his creation a game at all, but eventually entitled it *Kriegsspiel* because he felt he could not come up with anything better. What is certain is that where the games of Hellwig, Venturini, Opiz, and Reiswitz Sr had all been produced by civilians, and to varying degrees were still beholden to the mechanics of chess and the impetus to provide an engaging and entertaining playing experience, Reisswitz Jr's game was "aimed exclusively at his fellow officers and was, after its official introduction to the Prussian army, soon used for instruction and planning purposes" (Wintjes, "When a Spiel is Not a Game" 9).

The greatly redesigned *Kiregsspiel* contained a number of distinguishing features. First, like Venturini's game, it was to be played on topographical maps. By the 1820s, cartography had improved by leaps and bounds, with lithographic maps of Europe being readily available for the Prussian general staff, and so Reisswitz decided that the game would be played on the very same standard issue military maps that soldiers would themselves use for their actual operations. Thanks to the tutelage of his father, Reisswitz Jr was intimately familiar with the limits of the efforts of his predecessors such as Hellwig and Venturini, whose failings he partially attributed to the less developed state of cartography in their time. His father's game was also deemed not up to scratch, as "the landscape had been forced into squares . . . with rivers, seas, villages, mountains, valleys, etc., pushed out of their natural shapes and into straight lines" (qtd. in Peterson 228). Instead, by having his game play out on Prussian military maps, Reisswitz not only reaped the rewards of the recent advances in the field of cartography, but also took advantage of a resource which his intended audience of young officers-in-training would already be likely to have some experience with, and who might also benefit from gaining further familiarity with as they played (Wintjes, "When a Spiel is Not a Game" 9).

For all its advantages, the reintroduction of the map brought with it a novel problem for Reisswitz to solve in order to maintain his game's fidelity to the realities of war. By using a scale map, retaining chess-like figurines of the sort employed by Hellwig was out of the question, and having already ruled against the imposition of a grid, Venturini's solution was also not under consideration. Thankfully, his father had already developed an innovation that could be carried over. In lieu of figurines or miniatures, the Reisswitz games employed colour-coded rectangular unit counters made to scale that represented the actual dimensions of the formations of the troops they stood in for (Peterson 228). When such a piece was placed on the board it would accurately occupy the amount of space its real-life counterpart would on the terrain of the battlefield. Furthermore, as such a unit of troops began fighting and saw their numbers in a given formation diminish their block piece could also be replaced with a smaller rectangle so as to reflect its newly reduced size. With this development, scale was made consistent across both terrain and units, rendering their movements realistic, while also carrying over the potential for even more sophisticated emulation of the effects of time as well as space than was possible in Venturini's game.

In perhaps his greatest innovation from the precedents handed down along the continuum of wargame design spanning Hellwig to Reiswitz Sr, the younger Reisswitz introduced the use of an umpire who would come up with an initial objective or victory condition for each player (or team), and from there manage the flow of the game. Where Hellwig's game was always decided when a player's home fortress was captured, games in the Reisswitz *Kriegsspiel* were played in response to particular predetermined scenarios, and so could unfold in a much less rigid fashion. As Reisswitz himself observed, "a retreat is not always the sign of faulty leadership or a lost game because it may be that one side has to hold their ground against superior numbers for a certain length of time to fulfill their objective" (qtd. in Peterson 229-230). There was now much greater possibility for emergent gameplay to occur, and in ways that did not necessarily have to involve symmetrical compositions of forces, or a neutral terrain or battlefield which conferred no advantage to one side or the other. Thanks to his combination of design innovation and synthesis, Reisswitz had created a game in which historical battles could now be reviewed and reenacted, and even had the potential to aid in the planning of future engagements that had yet to occur.

The actual gameplay of the 1824 Reisswitz game took place on three distinct maps, one for each player (or team of players), and one for the umpire. This enabled the implementation of a double-blind system, where the participants on each side would only see their own pieces, as well as those which they had discovered through reconnaissance, on their own board. At the outset of a game players would only have access to whatever information the umpire deemed they might reasonably have had access to at the beginning of the scenario, and so the likelihood is that neither player has much awareness of the respective positions or compositions of their rival's forces (Peterson 230). Only the umpire would have access to the full board state, enabling them to act as a go-between, with players transmitting their moves to the umpire, who would in turn inform them of the discovery of any opposing troops.

The presence of the umpire as a mediator between the players and their own units plays a crucial role in injecting uncertainty into the game, since it creates a situation where the participants do not have complete or direct control over what happens on the map. Rather, as players progressively plot the movement and positions of their own forces and those of the enemy as they are relayed by the umpire the potential for human error looms large. Only the umpire's board is regarded as an accurate representation of the "reality" of the game-state, while those of the players depicts only their relative impressions of it (see Figure 2). The consequences of this development could be clearly seen in a series of experimental games that Jorit Wintjes conducted at his institute, the Julius-Maximilians-Universität Würzburg, using an 1867 ruleset based heavily on Reisswitz Jr's 1824 original. As Wintjes' games progressed, it was found that "as a general rule the side with better overall awareness of the whereabouts of its own troops usually wins, and that gaining and maintaining this awareness is a difficult process, as both sides can grossly miscalculate not only the position of the enemy but also of their own forces" ("When a Spiel is Not a Game" 12). Where in chess (and its descendants), players are never in doubt as to the actual state of the board, in the Reisswitz *Kriegsspiel*, simply maintaining a relatively accurate picture of events as they progressively unfold is a major obstacle, and often a decisive one.[19]

---

[19] Clausewitz refers to this problem (albeit in the context of war) as the "difficulty of *accurate recognition*" and includes it as an important component in his understanding of the role of chance within the general theory of friction (Book 1, Chapter 6, 117).

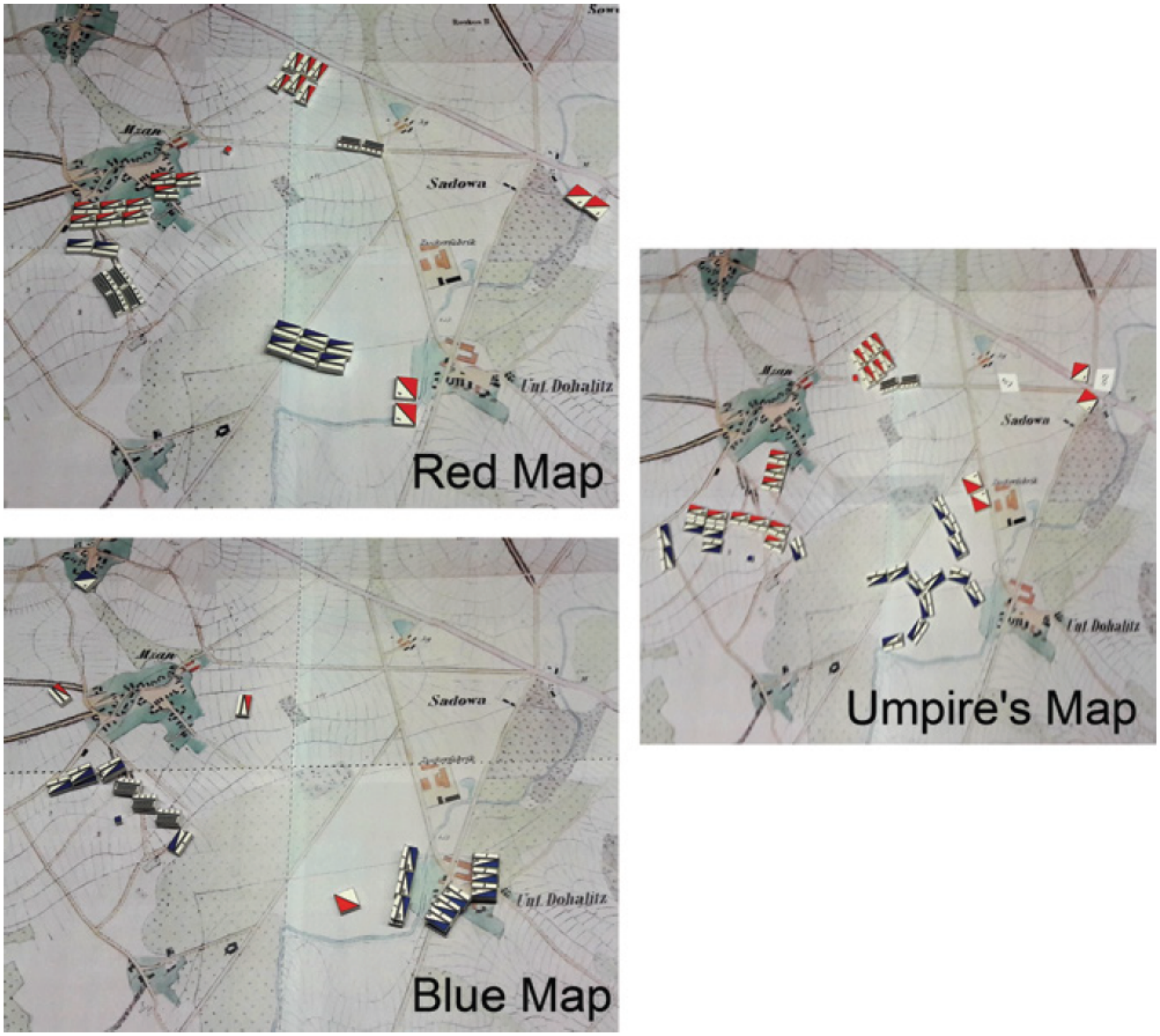

Figure 2: The FOW in a Reisswitz *Kriegsspiel*. Red, Blue, and Umpire's maps of the same turn. Reproduced from Wintjes, "When a Spiel is Not a Game."

Another major potential source of uncertainty that was novel to the Reisswitz game stemmed from the system for communication *between* players that it implemented. Generally, games would involve two teams, each with a commander, or General, whose role was to oversee and direct several additional officers, each of whom was placed in charge of a subset of the pieces on the map. The General would therefore not command any individual pieces, but rather would write orders on paper, to be passed on to their officers as notes of instruction that they could carry out using their own discretion. By adding multiple "links" in the chain of interaction (commander, officers, umpire) in this fashion, Reisswitz effectively introduced further opportunities for errors, miscommunications, and other forms of noise to disrupt the operation of the forces of each respective side in the game. Individual players needed to keep track of the positions of their own troops, but also the movements of those being overseen by other officers on their own side. They also had to interpret orders from their commander, and do all this under conditions of extreme uncertainty and ambiguity regarding the positions, movement, capabilities, and numbers of the enemy forces.

Finally, Reisswitz borrowed from Opiz, and reintroduced the use of dice to determine the odds of how damage would be dealt in combat. Moreover , the combat system he developed was far more sophisticated than that of Opiz's game, and for good reason. In his own words:

> Anyone who has observed the effect of fire power at the [artillery] ranges will know that the results achieved can differ considerably, even when the circumstances are the same. The difference in performance is likely to be even more pronounced in battle, when gunners may be affected by the excitement of the moment, and when errors may be made in estimating the range. If, therefore, we were to give fixed results for the fire effect we would arrive at a very

> unnatural situation. . . . Only when the player has the same sort of uncertainty over results he would have in the field can we be confident that the *kriegsspiel* will give a helpful insight into maneuvering on the field (qtd. in Peterson 230-231).

With this statement, Reisswitz decisively articulated why the incorporation of chance was a vital component of any attempt to simulate the dynamics of war. What makes it remarkable is the extent to which it broke with the prevailing scientific, mathematical, and philosophical wisdoms of his time. Although, as we have already seen, there was a burgeoning awareness of aleatory forms of probability by 1824, the prevalence of determinism was still widespread. For instance, Pierre-Simon Laplace's groundbreaking *Philosophical Essay on Probabilities*, which was first published in 1814, declared that man's reliance on probability to make sense of the world was strictly a function of our imperfect knowledge. Laplace attempted to demonstrate this by positing the presence of an omnipotent intellect (subsequently referred to as "Laplace's Demon") who could track every particle in the universe:

> We ought then to consider the present state of the universe as the effect of its previous state and as the cause of that which is to follow. An intelligence that, at a given instant, could comprehend all the forces by which nature is animated and the respective situation of the beings that make it up, if moreover it were vast enough to submit these data to analysis, would encompass in the same formula the movements of the greatest bodies of the universe and those of the lightest atoms. For such an intelligence nothing would be uncertain, and the future, like the past, would be open to its eyes (2).

For Laplace, such a being would be able to know all past states of the universe, and predict the future with absolute certainty and accuracy. Man's reliance on probability was therefore simply a consequence of imperfect knowledge, rather than a product of an irreducibly chancy physical universe. This view was shared by the French mathematician Abraham de Moivre (1667-1754), in his *The Doctrine of Chances* (1711)—perhaps the most well known probability textbook before Laplace—in which fundamental chances were understood as equipossible outcomes of any given physical set-up (Hacking, *The Taming of Chance* 12). As Hacking puts it, "everything that happened was itself determined by physical properties of the set-up, even if we did not know them. Any other idea of chance is wicked" (*The Taming of Chance* 12).

In the accounts of de Moivre and Laplace, the act of firing a cannon would produce the exact same outcomes if the setup was replicated perfectly. But Reisswitz does not appear to share this outlook, because for him "the results achieved can differ considerably, even when the circumstances are the same" (qtd. in Peterson 230). This uncertainty is only exacerbated further when the chaos and stresses of battle are introduced into the equation, and so we find that Reisswitz anticipates Clausewitz's insistence that chance "makes everything more uncertain and interferes with the whole course of events" (Book 1, Chapter 3 117). Also like Clausewitz, Reisswitz was not satisfied by an overdetermination of the effects of chance. The outcomes of actions in his *Kriegsspiel* are not entirely random, nor are they based on arbitrary figures or ratios. Instead, Reisswitz strove to ensure that the consequences of actions in *Kriegsspiel* reflected their real-world counterparts, and drew on the emerging discipline of statistics in order to ensure a continuity between the aleatory forms of probability in his game mechanics and those of the real world systems they were designed to emulate.

Thankfully for Reisswitz, an effort was already underway in his native Prussia to ascertain how certain aspects of warfare might be made empirically reducible to statistical measures. The primary driver behind the cultivation of this martial mathematics of probability was none other than the great reformer of the Prussian war machine, its Chief of Staff, Scharnhorst who, by 1813, had published an extensive manual, entitled *Über die Wirkung des Feuergewehrs* ("On the Effects of Firearms") quantifying in statistical terms the performance of the various armaments used by the Prussian army and its potential adversaries (Peterson 233). The data presented in this manual was derived from a series of experiments that Scharnhorst conducted to test firearms with different types of ammunition at different ranges, and in different terrains. This study enabled Scharnhorst to develop an empirical understanding of the operation and effectiveness of the weaponry of his time from which he could advise on matters such as "on how to adjust the elevation of cannons in the face of advancing troops, the ideal amount of gunpowder to be used in various circumstances and the relative quality of the rifles issued by the major European powers" (Peterson 234). Reisswitz cited this data extensively, using it as the basis for the underlying mechanics governing the operation of artillery fire and infantry fire in his *Kriegsspiel*.

In order to express this data mechanically his *Kriegsspiel* included a variety of custom built dice designed to be used in tandem with a complimentary set of statistical firing tables that were provided alongside the game's ruleset. With this combination, Reisswitz's *Kriegsspiel* had not only introduced chance into the chain of causality between action and outcome within the space of the wargame, but also decisively transformed his medium from an abstract representation of certain features of war to a seminal simulation of its actual conduct. When played, the "game" would reward players who were able to combine strategic nous with a good grasp of the actual operations of their weapon systems.

Laying an ambush and firing upon the unsuspecting rival unit from an advantageous position at high ground would generally yield a positive and plausible outcome. However, because the outcome of any act of combat is non-deterministic, and awareness of the boardstate is imperfect, the game encourages players to account for "worst-case" scenarios in their planning, and to balance the risks and rewards of their every decision.

3.5 The Ludic Fallacy

For all its innovations, the ability of Reisswitz's game to insert contingency was inherently limited by the bounded nature of its status as a game. In particular, it is subject to what Nassim Nicholas Taleb refers to as the "ludic fallacy," which explains that because predictive models taking place in games or simulations tend to be based on idealised forms predicated on mathematical purity they inevitably leave out significant variables that might otherwise affect an outcome, but were either unanticipated by the game's designers, or were beneath the threshold of detectability due to the inability of measurement devices to be perfectly precise (126-128). This fallacy is applicable to Reisswitz's *Kriegsspiel*, as any mistakes in the calculation of real world processes, such as the range and effectiveness of firearms, would be carried over into the game, and therefore compromise its capacity for verisimilitude. Though we have already seen how Reisswitz explicitly acknowledged the possibility of combat degrading the effectiveness of firearms as part of his justification for his game's usage of dice, indicating that he was at least somewhat aware of the modelling problem that he was faced with, the statistical tables that he incorporated from Scharnhorst's firing manuals were nonetheless based on controlled weapons tests directed towards stationary screens, and so were unlikely to account even for the effects of battle on the effectiveness of the firearms they were attempting to evaluate.

In his history of 19th century firearms, Hughes points out that attempts to study the effectiveness of rifles during this period tended to overlook the compromising effects of technical failures, such overheating, as well as the physical inefficiencies of their wielders. Hughes points out that when tests were being conducted on firearms in the 18th and 19th centuries the weapons tended to be operated by well trained marksmen who could be relied upon to hit their fixed targets with a high degree of accuracy, whereas in an actual battle the degree of training and proficiency of soldiers was likely to be far more variable (60). Further confounding for these early attempts at developing an empirical evaluation of firearms was the difficulty to account for the effects of the din, chaos, and stress of battle upon the aim of soldiers. To illustrate this point, Hughes relays an account from Lieutenant Godfrey Pearse, who was commanding an artillery unit during the siege of Multan in 1849, where he tasked his men to fire upon a Sikh unit that had sallied forth from the fort they had been bombarding to charge their position:

> Pearse gave the order to load with case shot, and as soon as the enemy was within range he ordered the battery to fire. There was a huge multiple flash and a vast cloud of white smoke—but when the smoke cleared, it was seen that only three men had been hit by the 916 bullets discharged. What had happened was that in the stress and nervous excitement of the moment the layers had been careless in the task of depressing their great pieces from the elevations at which they had been bombarding the fort and had not brought them down to the horizontal. Consequently, practically every bullet in their case shot had passed harmlessly above the heads of the enemy (60).

But what if these errors in measurement were relatively minute? Would they really have had a meaningful impact upon the dynamics of Reisswitz's game? Unfortunately, as Taleb points out, even very minor errors in a model can significantly warp the results when one attempts to progressively forecast events into the future, as the effects of the error compound the farther one moves from the initial conditions (176-177). Taleb explains this difficulty with reference to the work of the French mathematician Henri Poincaré (1854-1912), observing that

> [A]s you project into the future you may need an increasing amount of precision about the dynamics of the process that you are modelling, since your error rate grows very rapidly. The problem is that near precision is not possible since the degradation of your forecast compounds abruptly—you would eventually need to figure out the past with infinite precision (176-177).

In other words, the more protracted the simulation, the greater the chance that errors of measurement baked into the game mechanics can start to play a significant role in its outcomes.

Taking all this into account, it is almost certain that the Reisswitz *Kriegsspiel* overstated the effectiveness of the firearms of its time, and in a fashion that would likely have had consequences for the game's ability to provide a realistic portrayal of how events might unfold on the battlefield. But even more constraining than this is the game's reliance on the knowledge and biases of its human participants, and especially those of its chief mediator, the umpire. Where in war there are occurrences that might erupt in a fashion entirely unanticipated by its human participants, in the Reisswitz *Kriegsspiel* uncertainty will always stem from the same sources:

1. Limited awareness regarding the positions of pieces on the map as a result of the game's double-blind system.
2. Acts of miscommunication occurring between members of each team.
3. The chancy nature of dice rolling.
4. Contingencies (weather etc.) introduced by the umpire.
5. The limited cognitive faculties of the human players. For instance, their inability to make accurate combat calculations, the tendency to make mistakes are a result of stress or overwhelming decisional labour, and so on.

Ultimately, the dynamics of the model are always to some extent a reflection of the biases and blindspots of its designers, and so any factors they are not collectively able to account for, but that might in reality crop up and have a substantial effect upon the outcome will go unanticipated by them.

Taleb refers to such events as "Black Swans," and outlines their three distinguishing characteristics: "First, it is an *outlier*, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme impact. Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence *after* the fact, making it explainable and predictable" (xvii-xviii). For Taleb, Black Swan events have had an immense impact in shaping the course of history. He views them as the key engines or drivers of events across both global and local scales, and argues that as human societies have become more complex, networked, and globalised, their effects are also being increasingly intensified (xvii-xviii). But to what extent do Black Swan events determine the outcome of war? Surprisingly, Clausewitz was sceptical about the presence of unexpected variables playing a decisive part at least, in situations where a battle has been commenced:

> Even if the course of battle is not predetermined, it is in the nature of things that it consists in a slowly shifting balance, which starts early, but, as we have said, is not easily detectable. As time goes on, it gathers momentum and becomes more obvious. . . . Battles in which one unexpected factor has a major effect on the course of the whole usually exist only in the stories told by people who want to explain away their defeats (Book 4, Chapter 9, 295-296).

However, elsewhere in his work, Clausewitz makes clear that when a wider view is taken, war is still subject to disruption by unexpected events (Book 1, Chapter 3 103; Book 2, Chapter 2, 139). For him, even if the unexpected cannot be wholly anticipated, it can at least be negotiated by those with experience, fortitude, and a willingness to take risks when the circumstances demand. Though the Reisswitz *Kriegsspiel* could not subject its participants to all of war's existential risks, and though its capacity for accurate prediction and forecasting may have been limited, its synthesis of the advances in game design made by its predecessors had nonetheless put forward an unprecedented simulation of many of the features of the general theory of friction that Clausewitz would later elaborate. That this synthesis was achieved *before* the posthumous publication of Clausewitz's *On War*, and anticipated many of its insights, is worth stressing. And from Reisswitz's "Vorrede" we know that the lengths which the game went to incorporate war's uncertain nature into its mechanics was made as part of an explicit effort to maintain its fidelity to its real world counterpart. Indeed, so uncannily do the uncertainty mechanics of the Reisswitz *Kriegsspiel* mirror aspects of Clausewitz's own thought that it is worth asking whether these two harbingers of the FOW had any influence upon one another.

3.6 After Reisswitz

Clausewitz once claimed that "in the whole range of human activities, war most closely resembles a game of cards," because both enterprises involve "an interplay of possibilities, probabilities, good luck and bad" (Book 1 Chapter 1, 97). But on the topic of wargames there are some indications that he was less sanguine. In an earlier draft of *On War,* Paul Schuurman found Clausewitz to be highly critical of "late eighteenth-century wargames whose chess-like character constituted the very epitome of a mechanistic way of thinking about warfare" ("A Game of Contexts" 518). But what of the Reisswitz *Kriegsspiel,* which so decisively broke with the rigid determinism of chess? We cannot be certain, but some clues suggest that he had at least encountered it. Indeed, it is possible that he had already played the elder Reiswitz's game at the Prussian palace, as Clausewitz served as a tutor to the crown Prince and his younger brother from October 1810 until he left Berlin to fight for Russia against Napoleon on March 31, 1812 (Stoker 85, 99). Reiswitz presented his bespoke *Kriegsspiel* to the King at some point between January 1 and April 21, 1812, so there would have been a short window in which the Prussian princes—who by all accounts were utterly enamoured with Reiswitz's gift to their father, and played it regularly until at least 1817—may have introduced their tutor to the game (Peterson 237). However, the more likely scenario is that Clausewitz encountered Reisswitz the younger's game at the *Kriegsakademie* after its official release.

Upon completing his game in 1824, Reisswitz Jr was, like his father, given the opportunity to demonstrate Kriegsspiel at Berlin castle, this time at the behest of Prince Wilhelm, who was by this point in his mid twenties, and serving as a commander in the Prussian military. The Prince had fond memories of Reiswitz senior's game, and was so impressed by the refinements that had been made in this new addition that he recommended that Reisswitz have an opportunity to demonstrate its potential value as a pedagogical tool for the Prussian army to its Chief of Staff, Friedrich Karl Ferdinand von Müffling. This pairing proved to be fortuitous, for although Müffling was initially sceptical of Reisswitz's presentation, he soon became enthusiastic, exclaiming "This is no ordinary game, this is a school of war!" (qtd. in Wintjes, "A School of War" 65). Before long, the game was subject to mass production, and was widely disseminated throughout the Prussian military. By this point, Clausewitz had taken up a position as the director of Prussia's *Kriegsakademie* ("War College"), overseeing the curriculum and instruction of the very same young officers who were quickly taking up Reisswitz's game, so there is every chance that he came into contact with it in the years before his return to the army in 1830.

Even if *Kriegsspiel* did not have any meaningful impact upon Clausewitz's thought[20] its potential to at least partially simulate the FOW made it an invaluable training tool for the young officers, giving them a taste of the challenges of making decisions under pressure and under conditions of limited perception, but without having to risk their lives (Wintjes, "When a Spiel is Not a Game" 12). However, in order to retain its usefulness as a training aid, the game needed to maintain its fidelity to the military apparatus of its time. Wintjes notes that by 1828 a supplement to the existing rules of the game was published in order to reduce the effects of artillery fire, as the original ruleset was deemed to have overestimated its effectiveness ("When a Spiel is Not a Game" 13). From there, the game would be subject to at least 16 further revisions and republications between 1824 and 1888 so as to ensure

[20] Clausewitz had already begun developing the concept of friction as early as 1806 (Stoker 101).

that the ruleset could keep pace with the rapid developments in military technology which were occurring across Europe during that period (Wintjes, "Europe's Earliest Kriegsspiel" 18). These refinements are indicative of a continual feedback loop being established between the production of the game and the actual practice of war in 19th century Prussia and beyond. And this feedback loop moved in both directions. In addition to the game's continual revision, Wintjes argues that *Kriegsspiel* quickly became a regular feature of the mess life of regiments within the Prussian army, and may well have contributed to the strategic proficiency of its officers as well as their literacy with standard issue topographical maps ("Europe's Earliest Kriegsspiel" 17).

The success of the Prussian military following the conclusion of the Napoleonic wars did not go unnoticed around Europe. Victories over Austria (1866) and France (1871) in the second half of the 19th century came as something of a surprise to observers on the continent, who until that point may have viewed the Prussian state as an underperformer in martial affairs. *Kriegsspiel* was booming during this period, marking wargaming out as a conspicuous and distinctive element of the Prussian war machine. No other European state had incorporated wargaming into its internal operations the way that the Prussians had to that point, but following the conclusion of the Franco-Prussian war that began to change, with translations, adaptations, and imitations of the Reisswitz game popping up in Britain, France, Italy and Belgium by 1875, and the United States by 1880 (Peterson 244-248). By the First and Second World Wars, the planning of all major German campaigns made use of wargames (Young 23-91). As Clausewitz once observed, the only "lubricant" (Book 1, Chapter 8, 141) that might ease the effects of friction on an armed force was experience, and in wargaming the Prussians appeared to have hit upon a method for sharpening the judgement of their officers against the vicissitudes of contingency in advance of the actual joining of battle. Wargaming's Pandora's box had been opened, and by the 20th century it had become a ubiquitous practice in the armed forces of all the major powers.

1942: Western Approaches Tactical Unit

The safe transportation of supplies in large convoys across the Atlantic ocean from North America to the United Kingdom was a vital component of the Allied strategy during the Second World War. By the end of December 1939, German U-Boats had sunk 114 Allied ships, placing a strain on Britain's ongoing capability to hold out against Nazi Germany (Doherty 42). Over the next four years, an existential game of cat and mouse would unfold above and below the perilous waters of the Atlantic's epipelagic zone. It would be defined by an adversarial dynamic where the line between success and failure often hinged on the capacity of each side to gauge and then exploit the limits of the other's sensory capabilities. What follows is a brief account of this spiralling struggle through the Atlantic FOW, with particular attention given to the role played by a British wargame in securing what would ultimately prove to be a crucial advantage for the Allied anti-submarine efforts.

Coming into the war, the Royal Navy had placed their faith on ASDIC (Anti-Submarine Division, or perhaps Anti-Submarine Detection),[21] a shipboard transmitter (and predecessor of Sonar) that emitted a fan-shaped soundwave which could be used to sweep for submarines (Doherty 22-23). However, the ASDIC system—which the Royal Navy would equip on both conscripted civilian craft that were used as auxiliary anti-submarine patrol vessels, and on more specialised warships—could not detect surfaced submarines , and had a limited average range of up to around 1,300 yards (Doherty 22-23, 32-33). These limitations were already known to the German Naval command, and particularly

[21] In 1939 Oxford University Press asked the admiralty to explain the origin of this acronym, and were told that it stood for Anti Submarine Detection Investigation Committee. However, Doherty notes that it is unlikely that a committee existed under this title, so there remains some confusion about precisely what the acronym stood for.

Konteradmiral (Rear Admiral) Karl Dönitz, who oversaw the U-Boat fleet, as they had already been aware of ASDIC's rough specifications thanks to pre-war intelligence gathering, which was subsequently verified following the inspection of captured Allied ships equipped with ASDIC systems in July of 1940 (Doherty 49-50). Dönitz was therefore able to devise a tactic predicated around nighttime surface attacks on convoys, which largely negated the initial threat of detection posed by their ASDIC equipped anti-submarine escort vessels:

> Remaining at extreme range in daylight the boats closed on the convoys at dusk. With little more than conning towers showing, they were difficult to spot, especially as they stayed on the convoy's dark side; if spotted they could always dive. They usually shadowed an escort, to hide in the boat's wake, before firing at selected targets and turning to escape. If not counterattacked, a boat might reload its tubes and attack again before dawn (Doherty 50-52).

These nighttime attacks prompted significant concern in Britain's high command. The British situation continued to worsen throughout 1940, as Germany's occupation of Norway, in April, and then France, in June, provided them with access to a much greater number of air and naval bases from which they could launch operations to threaten Allied shipping in the Atlantic (Milner 29-30). Converting French naval bases in Lorient, Brest and La Rochelle into submarine ports proved to be particularly invaluable, as their greater proximity to the Atlantic in comparison to Germany's home bases in the Baltic enabled U-boats to lengthen their operations by up to ten extra days per ship, which in turn extended their range across the entire ocean, opening up the possibilities for attacks along the coastline of North America (Parkin 16). By this point, U-boat construction had been given absolute priority by Germany's naval command, with a target of twenty-five new submarines per month being set in the hopes of subduing Britain through the continued disruption of Atlantic shipping (Milner 26-27). The removal of the French navy from the war meant a reduction in the availability of potential convoy escorts, and the increased power projection thanks to Germany's newfound strength along the Channel meant that only Western ports, like Liverpool and the Clyde, could be relied upon as safe destinations for supply convoys (Milner 30-33).

By February 1941, Britain's Western Approaches Command, which was by then entirely responsible for overseeing the defence of the Atlantic shipping routes, was moved to Liverpool, and began to consolidate all aspects of anti-U-boat warfare under one central command structure (Milner 41-43). A key breakthrough soon followed in May, when the capture of U-110 and her Enigma encryption machine facilitated the deciphering of U-boat communications by the code-breakers (including Alan Turing) stationed at the British Government's Code and Cypher School in Bletchley Park (Milner 61-62). Once translated, Western Approaches could now monitor the wireless communications of the entire North Atlantic U-boat fleet. As a result, the efficacy of U-boat operations was severely affected for the remainder of 1941, with German submarines primarily forced to operate in the Mid-Atlantic Air Gap, where Allied convoys were out of range of anti-submarine aircraft, and focus their attention on stragglers rather than whole convoys. However, by early 1942 fortunes had begun to swing back towards Dönitz and his U-boat fleet, as the Japanese attack on Pearl Harbour on the 7th of December 1941 prompted the United States to transfer a substantial portion of its Atlantic escort presence towards the Pacific. By this point, Dönitz had become suspicious that an intelligence breach from within U-boat command was compromising the positions of his fleet. In an effort to improve operational security, on February 1 1942, Atlantic U-boats began employing an updated version of the Enigma cypher machine, that devastated the decryption efforts at Bletchley Park (M. Freedman 122). As a result, the *U-bootwaffe* was gifted an extended period of secure communications that lasted until the 13th of December 1942, when British codebreakers—aided by Royal Navy's capture of U-599 and its shipboard encryption documents and equipment—were finally able to make a breakthrough, and resume their decoding of German submarine transmissions (M. Freedman 131). In the meantime, the total size of the German U-boat fleet had doubled between April and December of 1941, prompting a dramatic increase in sinkings off the coast of North America, including those of several crucial oil tankers, whose supplies were an essential component of the U.S. and Canada's ongoing support of the British war effort (Milner 63-64, Strong 6). By this point in the war attacks were at times being carried out by the infamous "wolf-packs"—large attack groups consisting of up to forty submarines—that were often able to overwhelm the sparsely defended allied convoys and inflict heavy damage upon them.

In response, a new unit was established in January of 1942 at Western Approaches HQ, headed up by Captain Gilbert Roberts, with a briefing to devise new anti-U-boat tactics in which the commanders of escort ships could be trained so that they could better safeguard the Allied convoys as they ferried supplies across the Atlantic (M. Williams 85-86). Roberts' new school, entitled Western Approaches Tactical Unit (WATU)—which was predominantly staffed by officers and typists drawn from the Women's Royal Naval Service (the WRNS, who were commonly referred to as Wrens)—employed a two pronged approach to devising new tactics. First, Roberts began by interviewing the commanders of escort ships so as to ascertain how U-boat captains operated, and also whether any of the pre-existing protocols employed by the escorts had merit (Strong 5-6). Most of the escort captains interviewed by Roberts had little to offer as far as effective countermeasures against the

U-Boats, but they did at least help him realise that there had been little consideration on the part of the Allies regarding the point of view of the German submarine commanders themselves during an attack on the convoy (Strong 8). Having carried out his interviews, Roberts further determined that there was no systematic approach governing ASDIC search patterns, nor escort attack tactics. In order to address these oversights he would need to develop a clearer picture of how the U-boat commanders were operating. To do this, Roberts' second move as the head of WATU was to devise a novel wargame with which he could attempt to simulate the dynamics of an engagement between an Allied convoy and one or more attacking German U-boats:

> The WATU facility was primitive, with tactical tables, a tactical floor divided into squares, basic ship models, and a small lecture theatre, but Roberts quickly got to work. A basic set of wargame rules were developed, and a set of processes were designed to represent real-time decision cycles, tactical doctrine, and communications issues. Then the room was re-arranged so that players representing escort commanders could only see the gameplay through a restrictive canvas screen to represent the limited information that they would have in a real battle while the adjudication team moved the model ships according to the orders submitted by the players and their unseen adversaries. Orders were simplified to facilitate gameplay; each chit outlining the vessel's course, speed, radar track, ASDIC profile, and the commander's intent—each turn represented two minutes of time. The U-boat track was drawn on the tactical floor in brown chalk line, so it would be invisible to players looking through their assign [sic] canvas slit but allow the umpires and 'movers' to still follow its progress (Strong 7).

Thanks to Roberts ingenious wargame design which, like Reisswitz before him, implemented a FOW mechanic through the use of a canvas screen that denied vision to players who had assumed the role of escort commanders, the staff at WATU were able to reverse engineer some of Germany's most effective U-boat attack tactics. Their first major finding was the realisation that the optimal approach for a U-boat was not to attack a convoy from outside of its formation, but rather to run along the surface in order to evade ASDIC sweeps, close in on the convoy from astern, and infiltrate its lines (Doherty 91). Once it had insinuated its way into the convoy, it would then select a target, narrow the distance, and torpedo it from close range before diving. The U-boat would then perform a 180 degree turn beneath the waves, cut as much shipboard noise as possible (in order to avoid detection by ASDIC), and then wait for the convoy to pass overhead before surfacing behind, ready for a follow-up attack if chance and opportunity permitted (Doherty 92-93).

This discovery did not stem from a moment of unique genius or insight on the part of the WATU wargamers, but rather from the careful collation, presentation, and re-enactment of the available data from previous U-boat attacks on allied convoys. All of this data had previously been available to the Royal Navy and its escort commanders, but nobody had until that point thought to unify and evaluate it in a systematic fashion. Instead, the prevailing assumption was that U-boats made their attacks from beneath the surface, and from beyond the perimeter of the convoy's formations (Doherty 86-87).

As it happened, the reverse-engineered U-boat tactics which WATU hypothesised were perfectly in line with an approach to submarine warfare that had been pioneered by Otto Kretschmer, the commander of U-99, in a series of patrols he conducted throughout 1940 (Williamson 5-6). Kretschmer would go on to explicitly articulate his methods as part of a set of twelve standing orders that were initially intended as guidelines for his own crew, but were eventually passed on to Dönitz himself for wider implementation across Germany's submarine fleet:

> 6. In normal circumstances U-99 will use daylight hours for shadowing a convoy and working up to a favourable attacking position by nightfall. A favourable attacking position is on the dark side of a convoy when there is moonlight, so that the convoy will be silhouetted to us, while our small bows-on silhouette will be almost impossible to detect.
>
> [. . .]8. U-99 will abide by my principle that fans of torpedoes fired from long range are not guaranteed to succeed and must prove wasteful. It should not be necessary to fire in the first instance more than one torpedo for one ship.
>
> 9. The principle stated above makes it necessary that we should fire at close range, and this can be done only by penetrating the escort's anti-submarine screen and at times getting inside the convoy lanes. This should be the objective of all our attacks.
>
> 10. Once an attack has been opened under these conditions, at night, we must not under any but the most desperate of circumstances submerge. As a general rule I alone must decide when to dive. This instruction is based on my belief that a submarine on the surface can manoeuvre at high speed to avoid danger, and if necessary can fight back with her speed and fire-power in torpedoes. If we are being chased, it is a general principle that once a submarine submerges and loses the use of speed she is at the mercy of the hunter (Robertson 83-86).

With these principles, Kretschmer sought to exploit a number of atmospheric (the direction of the wind) and astronomical (the darkness of night, the position of the moon) conditions in order to obtain an advantage during U-99's approach to an Allied ship formation. Having closed the distance, he then leveraged what was an apparent strength of a convoy, the grouping of large numbers of ships together so that they could be protected more efficiently by their escorts, as an improvised form of cover behind which the low profile of U-99 was difficult to detect. In this way, his insistence upon remaining on the surface throughout the duration of the ensuing attack was a direct reaction to the inherent blindspots of the ASDIC system upon which the escorts were so reliant. By grasping or modelling the sensory web being cast by an Allied convoy and its escorts in this fashion, Kretschmer had found a way to operate within the threshold of uncertainty, and exploited it again and again to devastating effect until U-99 was finally sunk and its crew (including Kretschmer) taken prisoner on the 16th of March, 1941.

However, this tactical approach could only remain effective so long as the initial assumptions upon which it was predicated continued to hold: that the Allied convoy escorts would continue to maintain and exhibit the same pattern of behaviour that Kretschmer's tactics had been specifically tailored in response to, and that their sensory capabilities were not subsequently enhanced in a fashion such that a U-boat operating along the surface could be detected while attempting to operate within a convoy's lines. But once Kretschmer's protocols had been reverse-engineered by Roberts and the Wrens at WATU the British were quickly able to devise novel tactics that would in turn exploit the pattern of behaviour that Kretschmer had established for the U-boats. The first of these tactics, codenamed 'Raspberry' (see Figure 3) by WRNS officer Jean Laidlaw, was to be enacted if a ship within a convoy spotted a U-boat operating within the formation, or was torpedoed (Doherty 92). Upon either eventuality, a command was to be issued to all escort ships, upon which all but those which were positioned ahead of the convoy would turn, and travel at maximum speed until they lined up approximately two miles *behind* the convoy (Doherty 92). From there, the escorts would again match speeds with the convoy, and begin an ASDIC sweep, trawling behind the convoy until the submarine was detected, upon which point it could be targeted with depth charges (Doherty 92).

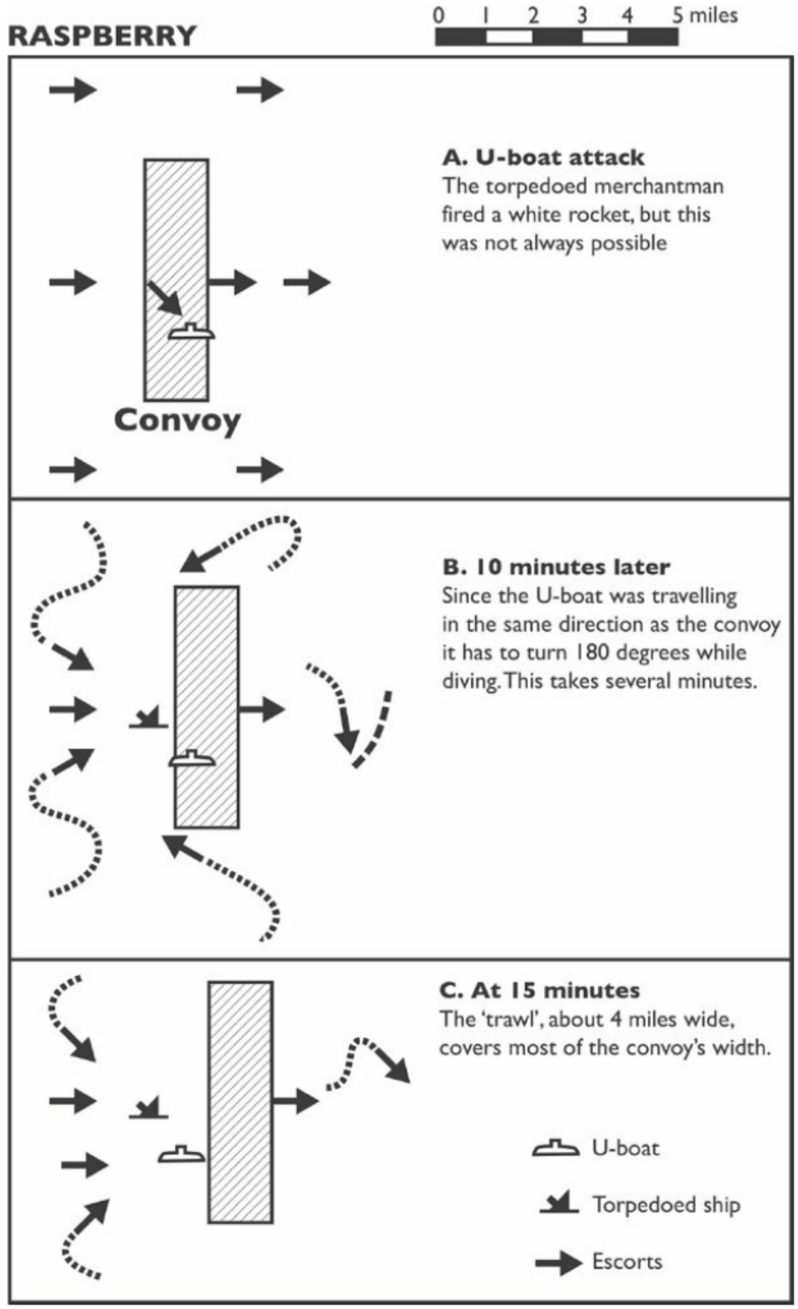

Figure 3: The "Raspberry" tactic developed during the WATU wargames. Reproduced from Doherty, *Churchill's Greatest Fear*.

This entire tactic was devised and tested by Roberts and the Wrens in the WATU wargames, and upon its demonstration to a number of high ranking Royal Navy staff, including Sir Percy Noble, the admiral in charge of Western Approaches HQ, was rapidly disseminated to all ships in the escort fleet (Doherty 92-93). Soon, reports began to come in that 'Raspberry' was leading to successful U-boat sinkings, but Roberts was well aware that it would only be a matter of time before Dönitz would figure out what was going on and make adjustments to his submariners' attack protocols that might invalidate 'Raspberry.' In order to head this off, Roberts sought to establish a vital feedback loop in his operations. He would continue to interview escort captains upon their return from patrol duty, and would also conduct weekly courses on anti-submarine tactics, which quickly became filled to capacity as escort commanders and other Royal Naval staff became regular attendees. These courses and interviews provided Roberts with a steady stream of data and observations courtesy of the escort commanders during the height of the battle of the Atlantic throughout 1942 and early 1943 regarding any shifts in U-boat attack patterns. The result of this effort was the design of a number of additional novel anti-submarine tactics to complement 'Raspberry.' These included 'Strawberry', 'Pineapple', and 'Gooseberry', as well as several specialised search patterns developed specifically for escort ships on the offensive against U-boats that had been sighted outside the perimeter of their convoys (M. Williams 103).

As the war drew on, the Allies gradually began to overcome the U-boat threat. By mid 1942 Dönitz was primarily relying upon large-scale, coordinated assaults by substantial "wolf-packs" operating in the Mid-Atlantic Air Gap, but the combination of effective anti-submarine tactics provided by WATU, together with gradual improvements in ASDIC systems, radar (invaluable for its ability to detect surfaced U-boats, even at night, especially when deployed on anti-submarine patrol aircraft), radio instrumentation, air-cover, escort numbers, and the development of airdropped depth charges, all helped to deprive Germany's submarine fleet of many of the advantages which it had held going into the war (Doherty 300-303). With each of these technical and tactical improvements, gaps in the Allied sensory web were progressively filled, narrowing the range of viable avenues which a U-boat might exploit for its attack on a convoy. This difficulty was compounded by the fact that the *U-bootwaffe's* own technical advances did not progress at the same rate. Though some improvements—such as better guidance systems for their torpedoes; radar warning systems to help with the detection of Allied aircraft; radio direction systems to help with detecting the transmissions from nearby convoy ships and their escorts; and a '*schnorchel*' ("snorkel") that could provide the requisite air to their diesel engines, enabling them to operate underwater for longer periods—were made as the war progressed, none were sufficient to overcome the Allies' respective gains in the Atlantic struggle over detection and counterdetection (Möller and Brack 158-171).

Between January 1942 and June 1943 over two hundred U-boats were sunk, leading to a gradual decline in Allied shipping losses (M. Williams 116). The Battle of the Atlantic was drawing to a close, and WATU's wargames had played a substantial role in turning the tide of fortune in the Allies' favour. Significantly, these wargames were not simply employed as training devices (though this was one of their advantages), nor did they function as a predictive act of modelling to be carried out in advance of a potential conflict. Rather, their virtue stemmed from their ability to provide a virtual testing ground that was fully integrated into the operational processes of an ongoing and unfolding conflict. Along the way, the WATU wargame's potential as a tool for the simulation of action and the conditions of uncertainty facilitated emergent acts of hypothesis formation and iterative testing via trial-and-error that enabled their adversary's tactics to be reverse-engineered on the fly. Paradoxically, in order to retain some fidelity to reality, and thereby provide an insight into how U-boat commanders were exploiting the structural uncertainties stemming from the distinctive dynamics of Allied convoy tactics, Roberts had to introduce built-in sources of uncertainty in the form of game mechanics that delimited perception.

In order to gain an advantage within the context of the game, players performing the roles of both U-boat commander and escort ship captain may well have been engaging in a subtle process of tactical mimicry that Amy Ireland terms "dark side empathy":

> If empathy is understood as a heightened capacity for modelling the desires and affects of another, then unchecked and alone, it can be taken for a weakness, but coupled with abstraction, it becomes a weapon. . . . Extract empathy from the usual connotative swamp of emotional or irrational affectivity that is all too often associated with women and weakness, exile it from the Western, folk-psychological notion that considers it simplistically as a mark of moral virtue, and its shadow side becomes subtly apparent (116).

For Ireland, the combination of empathy and abstraction enables affective modelling to be deployed in a tactical fashion, where a narcissistic image "of the same against itself" is generated through an act of simulation (Ireland 117). Ireland provides the example of the matriarchal Yukaghir culture of Eastern Siberia, within which specially trained clan members undergo a series of rituals so that they can take on the form of their most prized prey: the moose. In an act of mimesis, Yukaghir hunters rub themselves with birch leaves so as to obscure their human scent, before donning full-length moose-pelt coats and long-eared headgear so that they can avoid startling their prey when they encounter them in the frozen forest (Ireland 117). Though role-playing in a game does not necessarily entail as intensive a commitment to mimicry and empathy as is required of these cunning hunters, the act of situating a player under the set of formal constraints established by a competitive adversarial game complimented by the evocative world-building of a detailed scene or scenario may nonetheless lead to opportunities for tactical modelling along the lines that Ireland outlines. As Wolfendale and Franklin observe, "while the players' interests are important to the experience of role-playing, it's not because the players collectively plan their actions to ensure the game satisfies them, but because the more or less messy interaction of their goals helps *embed* the players in the game world" (221). Here, the act of embedding parallels the role of ritual in the Yukaghir hunting practice, facilitating the attainment of a sufficient level of mimesis within the game world to engage in the tactical form of dark-side empathy described by Ireland. Evidently, the Wrens, who would sometimes showcase novel tactics during Roberts' demonstrations by taking on the role of escort ship captains, quickly developed an affinity for anticipating and exploiting the behaviour of their adversaries, to the extent that they were often able to perplex and frustrate the British submarine officers who were sometimes tasked with role-playing the U-boat commanders in the WATU wargames:

> Max Horton was a famous submariner of the First World War and Roberts invited him to be the U-boat in the Beta Search tactic. Operating the escort against him was a very young Wren, Janet O'Kell. Sir Max had five attempts to get away from the escort, each time the young Wren caught him. . . . He was not so pleased that it was a young eighteen-year-old Wren who had tracked him down each time! (M. Williams 105).

One final advantage of the WATU wargames was that Robert's design methodology enabled them to avoid falling into Taleb's ludic fallacy. Crucially, they were not being used as part of an effort to make long term forecasts of future events. Rather, they provided a constrained and repeatable environment in which analysts could carefully lay out the data available to them regarding anti-submarine battles that *had already taken place* so that the lessons of a very near history could be properly gleaned. Adopting this approach enabled Roberts and the Wrens to separate signal from noise, creating a clearer picture of how the U-boats were carrying out their attacks than was available to the escort commanders embroiled in the actual engagements which the wargames were attempting to recreate. By virtue of their access to a somewhat abstracted yet still relational model of the events of these engagements WATU could then develop specially tailored tactical responses to patterns of behaviour which they were able to observe in the process. This approach did not require acts of long-term prediction whose reliability would have been compromised by the ludic fallacy. Rather, WATU analysts simply filled in the gaps in the picture they had begun to create regarding the decision making of the U-boat captains, and then tested their hypotheses in an iterative fashion, with the Wrens often taking on the role of the commanders of the escort ships, while Naval officers (including British submarine commanders) would often play the role of the U-boats (M. Williams 104-105). By having staff members attempt to situate themselves within the mind of their enemies through the "darkside empathy" of role-playing, WATU's wargames were able to emulate one of *mêtis* most devious capacities: the ability of the hunter to trap or ensnare their target by using their own tendencies against them.

4.0 Atmospheres of War

It's hard

from the world of all possible things

to choose the things that are actually happening.

—GREGORY KAN, *Under Glass*

Unreal City,

Under the brown fog of a winter dawn,

A crowd flowed over London Bridge, so many,

I had not thought death had undone so many.

—T. S. ELIOT, *The Waste Land*

In *The Eye of War* (2018), Antoine Bousquet traces the emergence and intensification of a "martial gaze" that threatens anything that falls under it with total destruction (2). As Martin Libicki once grimly observed, in war "visibility equals death" (*Information and Nuclear RMAs* 2). Emerging out of the concurrent rational organisation of vision and the mathematisation of space during the Renaissance, Bousquet's genealogy of the martial gaze traces the progressive solicitation, augmentation, and assimilation of the human eye "within an extensive array of sociotechnical assemblages" (*Eye of War* 41). Bousquet then takes Paul Virilio's "logistics of perception," which describes the increasing imperative to provision war machines with "images, with information, with visual intelligence"(Virilio *Live* 186) and situates it within a wider martial technoscientific regime that encompasses the acts of *sensing*, *imaging*, and *mapping* (Bousquet, *Eye of War* 18-19). Together, these constitute "the entire range of sensorial capabilities relevant to the conduct of war," which for Bousquet have progressively tended towards collapsing the distinction between the acts of looking and killing (*Eye of War* 11). With these developments, Marshall McLuhan's understanding of media as extensions of the human sensory apparatus takes on a much more sinister tone, one which is perhaps best expressed by Paul Virilio in *War and Cinema* (1989):

> There is no war, then, without representation, no sophisticated weaponry without psychological mystification. Weapons are tools not just of destruction but also of perception—that is to say, stimulants that make themselves felt through chemical, neurological processes in the sense organs and the central nervous system, affecting human reactions and even the perceptual identification and differentiation of objects (8).

As acts of perception and destruction become aligned, martial outcomes increasingly depend upon struggles over visibility, with "the nature of conventional warfare" shifting "from force-on-force to hide-and-go-seek" (Libicki, *Information and Nuclear RMAs* 2). For this reason, Kittler once argued that "searchlights . . . render light available for tactical purposes. . . . armed eyes emerge with searchlights that mobilize and mechanize vision itself" ("A Short History" 63). Or, as W. J. Perry, a former Under Secretary for State Defence, once quipped: "if I had to sum up my current thinking on precision missiles and saturation weaponry in a single sentence, I'd put it like this: once you can see the target, you can expect to destroy it" (qtd. in Chow 31). Once weapons systems had advanced to the level of pinpoint accuracy, and could combine extended range with a devastating kinetic yield, inaugurating what Rey Chow has called "the age of the world target," any form of defence predicated on armour or fortification is rendered obsolete (35). For Bousquet, the advent of this "global imperium of targeting" is indicative of a transformation in the scale and modalities of warfare (*Eye of War* 191). When the martial gaze has expanded and intensified to the point where a target can be located and destroyed anywhere on the globe, the notion of a discrete, geographically bounded battlefield becomes increasingly untenable (Bousquet, *Eye of War* 4). Instead, war machines find themselves confronted with an unbounded *battlespace*, "a domain increasingly coterminous with the globe," and seek to exert control over its topologies by extending their perceptual webs across its various constitutive strata (Bousquet, *Eye of War* 2).

In response, warfare takes on the dynamics of the hunt, becoming, in the words of Gregoire Chamayou, a *cynegetic* practice where the primary objective switches from immobilising the enemy "to identifying and locating it" (*A Theory of the Drone* 33-34). Within this pattern of interaction, the hunted is faced with a deadly choice: stand and fight, but risk destruction, or direct your energies towards evading the pursuer's gaze. Bousquet elaborates on such efforts in an account of the martial practice of *hiding,* which encompasses acts of concealment and dissimulation that form the martial gaze's "constitutive obverse by simultaneously counteracting its operation and providing a key impetus for its further elaboration" (*Eye of War* 154). Like Chamayou, Bousquet traces the origins of hiding and concealment back to the "primaeval activity of the hunt," but aside from its employment in order to ensure the success of scouting and reconnaissance operations, he suggests that acts of concealment and dissimulation have only played a sporadic role throughout much of war's history because large standing armies were simply too difficult to hide en masse (*Eye of War* 155). However,"the dramatic increase in the range and accuracy of gunnery and the advent of aerial photoreconnaissance" prompted a shift towards systemic practices of concealment that, from the First World War onwards, span the breadth of the military apparatus, and in doing so have rendered the practice of hiding a virtual necessity in modern warfare (Bousquet, *Eye of War* 154).

Though Chamayou was principally concerned with examining the operational practices of UAVs as part of the contemporary "War on Terror," his treatment of the dynamics of cynegetic war aptly describes the deadly epipelagic game of hide-and-go-seek that took place in the Atlantic between the Allies and the *U-boatwaffe* during the Second World War. Throughout these engagements, German U-boats took on the role of the hunter, with the Allied convoys as their prey. However, as Chamayou once observed: ". . . hunter and the hunted do not belong to different species. Since the distinction between the predator and his prey is not inscribed in nature, the hunting relationship is always susceptible to a reversal of positions. Prey sometimes band together to become hunters in their turn" (*Manhunts* 10).

Upon being spotted by an escort ship, a U-boat that is forced to dive, and can then be subject to ASDIC sweeps and targeting by depth charges, is incredibly vulnerable, as the shock wave from a nearby detonation can cause catastrophic damage to its hull. In order to evade detection, some of the more cunning German submariners developed a practice of "silent running," which entailed the shutting down of all nonessential systems, and instructing the submarine's crew to remain silent until sufficient time had passed for the hunting escort ships to have passed overhead (Williamson 45). With improvements in anti-submarine warfare, including the tactical innovations made during the WATU wargames, as well as increased aerial coverage and improvements to ASDIC and shipboard radar, the tables would gradually come to be turned on the U-boats until their numbers had dwindled to the point where they were no longer able to pose a serious threat to the Allied war effort.

The dynamics of this struggle were in many ways defined by the respective capabilities of each side's martial sensorium: the limitations of the human eye at night, the range of an ASDIC sweep, the reliability of German torpedo guidance systems, and the capacity of WATU to simulate all of these within their wargames. As well as illustrating the competition between the martial gaze and the practice of hiding from it, what is also on display in this case study is the wider atmosphere of uncertainty which stems from the very *limits* of these two countervailing tendencies, as well as from the efforts of each party to both interfere with and exploit the perceptual capabilities and hiding capacities of the other. What follows in this chapter is a further explication of the notion of Clausewitz's atmosphere of war, with particular attention to acts of uncertainty engineering where the object is to cut through the predator-prey dynamic by either destabilising an enemy's capacity to interface with its wider environment, or by targeting the environment itself in an attempt to subvert the gaze's deadly glass eye and thereby make it more conducive towards one's own operations. Here, particular attention is given to the emergence of a martial *meteorology* during the Second World War which promised to generate novel affordances for both negotiating and exploiting the uncertainties of the martial environment.

4.1 Atmoterror

Peter Sloterdijk's *Terror from the Air* (2002) opens with an account of a chlorine gas attack conducted by German forces against French-Canadian troops in Ypres, Belgium on April 22, 1915. During the attack 150 tons of chlorine were released into the air, forming an immense yellow poison cloud almost six kilometres wide that was blown towards the allied line by favourable winds (Sloterdijk, 10). This "killer fog of war," which caused severe damage to the lungs and respiratory tracts of any soldiers who inhaled it, prompted a rapid retreat from the Allied line, creating a sizable breach in their defensive position which the advancing German forces were able to exploit in the ensuing battle (Packer and Reeves, 74-75). For Sloterdijk, the Battle of Ypres constitutes a moment of rupture in the history of warfare, bringing about an age where the target of martial action was no longer the human body (or its technological extensions), but instead its surrounding *environment* (14): "In the evening hours of [April 22, 1915], a hand jumped on the clock of ages, marking the end of the vitalistic, late-Romantic modernist phase and the beginning of atmoterrorist objectivity. No caesura of equal profundity has occurred on this terrain since" (Sloterdijk 30). Sloterdijk refers to the "discovery of the environment" as a novel development in war, underscored by the importance and eventual mass production of gas masks as a vital last point of defence against the growing prevalence of gas attacks on the Western front of the First World War (Sloterdijk 30). Sloterdijk terms this approach to warfare "atmoterrorism," and argues that it entails an integration of "the most fundamental strata of the biological conditions for life into the attack: the breather, by continuing his elementary habitus, i.e. the necessity to breathe, becomes at once a victim and an unwilling accomplice in his own annihilation" (22-23). Where cynegetic warfare explicates the martial expansion of the predator-prey dynamic *within* the environment of the battlefield, under atmoterror the very air and atmosphere, the "primary media for life" become subject to a martial technicity capable of designing novel approaches for attaining advantages on the battlefields of the 20th century (Sloterdijk 25).

Though one might dispute Sloterdijk's contention that acts of war predicated upon altering the "enemy's acute environmental living conditions" had not been realised with the same degree of intensity until 1915,[22] what is distinctive about the concept of atmoterror is its attention to an

[22] See, for example, Emmanuel Kreike's history of environmental warfare, *Scorched Earth* (2021), which conceptualises total war as "the indiscriminate and simultaneous destruction of society *and* environment," and *concludes* its chronology with a

interplay between war's environment and the emergence of a martial technics that seeks to affect it. When engaging in atmoterror, one is not simply exploiting pre-existing features or dynamics of the environment of war to gain an advantage, but rather attempting to re-engineer or sabotage fundamental qualities of that environment towards fatal ends. Where Bousquet's concept of the martial gaze (along with its countervailing practice of hiding) primarily encompass acts that seek to enhance (or evade) perception *within* what Clausewitz once termed the "medium" of war (Book 1, Chapter 8 141), Sloterdijk's atmoterror invokes the spectre of a martial practice that goes one step further by seeking to target or reshape the very *conditions* of the medium itself. For Sloterdijk, this is framed in terms of acts of destruction that render the environment hostile or unlivable, but we can also find in war's history a related tendency that instead seeks to engineer uncertainty (whether by reducing or intensifying its effects) through acts of cunning design directed towards the transformation of environmental conditions in the pursuit of a strategic advantages.

This shift in conception has important implications for the FOW, for it draws attention to the history of attempts to fight "environmentally," and especially in ways that contribute to negotiating as well as exploiting asymmetries of uncertainty on the battlefield. As we have already seen in Chapter 1, there is a long tradition for engaging in acts of "uncertainty engineering" stretching back to the dawn of recorded history. With his concept of atmoterror, Sloterdijk provides a jumping off point from which to examine how these efforts are entangled within the wider process that Jairus Grove terms "the becoming atmospheric of contemporary warfare" (66).

---

discussion of the First World War because: "by 1914, total war had been central to the practice of war across the globe for four centuries" (1).

4.2 The Medium of War

In order to conceptualise the FOW as the *medium* of war this chapter repurposes an insight from the media theorist John Durham Peters, who stresses that just as media technologies function as environments within which communication can occur and cultures can form, "environments are also media" (3). As Peters argues, "our very existence depends on a vast array of techniques for managing nature and culture, most of them ignored by recent communication theory due to their supposedly poor qualities of meaning-making" (3). Put another way, where media studies is often preoccupied with media as sites for the production and transmission of meaning, Peters gestures towards the "layers of even more fundamental media that have meaning but do not speak" (3). With this move, Peters seeks to reconnect the concept of media to nature: "Medium has always meant an element, environment, or vehicle in the middle of things. One key ancient Greek source is Aristotle's concept of τὸ περιέχον (to periekhon)—more or less 'surrounding' or environment—which expressed 'sympathy and harmony between the universe and man'" (46).

This notion of media as environment is also related to Aristotle's theory of vision, which proposed a transparent "in-between"—τὸ μεταξύ (to metaxu)—through which human eyes could establish contact with the object of their gaze (Peters 46). To do this, Aristotle distinguished between perception by contact (as in the form of touch or taste) and perception by distance (as in the case of vision or sound) (Alloa 157). From there, he established that where perception by contact "corresponds to perception by itself" the act of perceiving by distance highlights the distinction between the object and organ of sensation (Alloa 157). Having established this schema, Aristotle then determines that any act of perception at a distance must necessarily imply the existence of a *space* that sits between the seen and the seer (Alloa 157). This space is not taken to be empty, but rather must contain a necessary amount of density or texture for, as Aristotle explains: "if there were nothing, so far from seeing with greater distinctness, we should see nothing at all" (qtd. in Alloa 158).

Following Aristotle, Peters is interested in the sense in which the medium-environment relation implies a certain interconnectivity between subject, object, and environment. This gesture is not intended to replace the idea of a medium as a channel for conveying information to the senses, nor the notion of medium as a language or semiotic structure, but rather to complement these commonplace understandings with a wider view of media as "ensembles of nature and culture, *physis* and *technē*" (Peters 48-49). Here, media are regarded as "conceptual and perceptual environments; nurturing or adverse systems that condition, but are also the basis for, the very process of what is understood as, say, art, expression, and reception" (Michelakis 5).

The FOW can be understood as a medium in this wider sense also, as war's space of "in-between," albeit one whose predominant effect is not simply to facilitate or enable acts of perception or communication or even conception, but rather functions as an encapsulating environment or milieu whose dynamics tend towards the *suppression* or *distortion* of the war machine's attempts to operate instrumentally. Clausewitz makes this very explicit when, in an attempt to convey the stultifying effects of friction in war, he makes recourse to the metaphor of a man attempting to wade across a body of water: "Action in war is like movement in a resistant element. Just as the simplest and most natural of movement, walking, cannot easily be performed in water, so in war it is difficult for normal efforts to achieve even moderate results" (Book 1, Chapter 7, 139). Even more strikingly, in the same passage, Clausewitz extends his aquatic metaphor into an ecological one:

> Moreover, every war is rich in unique episodes. Each is an uncharted sea, full of reefs. The commander may suspect the reefs' existence without ever having seen them; now he has to steer past them in the dark. If a contrary wind springs up, if some major mischance appears, he will need the greatest skill and personal exertion, and the utmost presence of mind, though from a distance everything may seem to be proceeding automatically (Book 1, Chapter 7, 139).

Here, Clausewitz presents the commander as *kybernḗtēs (*"steersman") operating under the shroud of night while attempting to navigate to safety in a hostile environment. Deprived of his senses, he can rely solely upon his skill, his experience, and his mental fortitude in order to prevail.

However, as the philosopher Reza Negarestani makes clear in one of his reflections on the FOW in his work of theory-fiction, *Cyclonopedia,* the 'texture' of the FOW as medium is not always already opaque, but rather becomes so through a continual process, where "as they kick up dust during their activities, war machines contribute to the Fog of War, and consequently to their own blindness" (103). For Negarestani, a war machine does not merely enter a sandstorm and become blind. Rather, the sandstorm is itself a byproduct of the war machine's passing as it interfaces with the encapsulating martial environment: "One should not miss the fact that the Fog of War is also agitated and contagiously spread by warmachines' frenzy, their dynamism and their tactical lines" (103). The U.S. Army's Atmospheric Sciences Laboratory reached similar conclusions in research it conducted during the late 1970s and early 1980s into deliberate acts of air pollution, a practice also known as smoke screening:

> The visual range in the atmosphere is directly affected by natural aerosol concentrations and particle size distributions occurring over any optical path. Visibility may be reduced by dry haze, wet or relative humidity haze, fog, or air pollution. Battlefield visibility can be compromised by the additive effects of the fog of war, i.e., pollution induced by deliberate smoke screening, dust thrown up by the mass movement of heavy vehicles and intense artillery barrages, or smokes from burning vehicles (Hansen et al. 167).

Army researchers observed that deliberate attempts to create smoke screens using chemical smokes, such as white phosphorus or hexachloroethane, needed to take into account "ambient atmospheric conditions, forecasts, and the aptly named 'fog of war' and its affects [sic] upon the optical characteristics of the atmosphere" (Hansen et al. 165). Their objective was to determine the "optimum smoke density" required to render the atmosphere entirely opaque, not only to a human viewer experiencing the world through the visible spectrum, but also to infrared and electromagnetic spectra as well (Hansen et al. 165). The product of this research, an algorithm called KWIK (Crosswind Integrated Concentration[23]), was ostensibly developed in order to help battlefield engineers to straightforwardly calculate the amount of munition expenditures required for their artillery to provide effective and reliable smoke screens in support of other friendly military units (Umstead et al. 2).

In one sense, this is hardly a novel development, as the practice of smoke screening has a long history, stretching back at least to the Mongol invasion of Europe in the 13th century. During these campaigns, Mongol engineers would use siege engines appropriated from the Chinese to fire containers

[23] The authors chose to replace the letter C with a K in the abbreviated "KWIK," presumably to make pronunciation more intuitive.

packed with burning tar towards the enemy lines (Chambers 63). Upon impact, these projectiles would create dense smoke screens intended to disrupt the vision of massed European armies and their archers, whose static positions could then be exploited by the more mobile Mongol horsemen (Chambers 64). What particularly distinguishes screening from other related practices of dissimulation, such as camouflaging, is that where the latter acts *upon* the entity, object, or figure attempting to hide, in the hopes of making them harder to perceive by the hunter, the screen works through an act of environmental saturation, throwing out dense particles that compromise the very conditions upon which the act of perception depends.

Thus, what makes the Army's research into what it termed the "art of smoke screening," significant was that it had, perhaps somewhat inadvertently, led to the formalisation of "seeability on the battlefield" (Hansen et al. 165, 177):

> A battlefield may be considered as being mesometeorological in scale, i.e., areas ranging from hundreds to thousands of square kilometres. If the density of meteorological observations is large and timely, the optics portion of KWIK may be used to calculate the attenuation of optical paths for each weather observational site. The attenuations may be plotted and analyzed much like synoptic data to prepare 'seeability' charts for a battlefield. Battle plans for future engagements with estimates of munition expenditures anticipated number of burning vehicles and vehicular dust conditions can be used to predict visibility conditions which may be used for attenuation forecasts. Seeability prognostications can be used for planning purposes, i.e., what weapons system will be effective on the next day's predicted dirty battlefield (Hansen et al. 177).

Here, KWIK's formal description of atmospheric conditions extends to encompass not only natural phenomena, but is tailored to describe the effects of air pollution that are specific to the anticipated martial environment (burning vehicles, vehicular dust, and so on). Furthermore, the ability to continuously measure, abstract, and model the battlefield's mesometeorological conditions, combined with the possibility of deliberate acts of air pollution in the form of smoke screens invokes the promise of a KWIK-smart military force that can not only anticipate the appropriate weapons for fighting through the FOW, but also play an active role in engineering war's atmosphere to its desired specifications.

Examined from this perspective, Clausewitz's observation that the general theory of friction coalesces to form the "atmosphere of war" can be considered in terms of how the war machine itself is at once constituted by and itself constitutes its surrounding environment. As Emmanuel Kreike puts it, "war affects environment and society simultaneously because humans are shaped by and in turn shape the environments they inhabit" (2). This environment encapsulates not only the mesometeorological conditions of the battlefield, but also, following Clausewitz—especially as reconstructed by Watts and Beyerchen—the constraints imposed by human physical and cognitive limits, the nonlinear dynamics of warfare, and and the informational uncertainties arising from the gap between reality and the martial epistemologies (including those of the martial gaze) that attempt to make sense of it. Here, the spectre of KWIK and its capacity to not only evaluate, but also generate the "dirty battlefield" loom large, for it threatens to obviate the martial gaze, not through acts of decoying or camouflage, but rather by subverting the entire perceptual field upon which it depends.

4.3 Environmental Warfare

But what does it mean to grasp war as an environmental or ecological phenomenon, as Clausewitz hints at with his image of the commander as a steersman navigating a hostile reef in the pitch black? As Grove observes, in its most common usage, ecology refers to the relationships between flora, fauna, and habitat (67-68). However, in the work of the anthropologist Gregory Bateson, ecology takes on an expanded meaning that incorporates Lamarckian notions of evolution: "it is a theory of evolution that is creative and participatory at multiple levels of complexity and organization—species, populations, individual organism, and assemblages of living and nonliving things" (Grove 68). Thus, for Grove, an ecological conception of war attempts to grasp the bundles of relations between all of the assemblages that participate in the war-system, with particular attention to war's status as a *generative* or *creative* phenomenon that exceeds its narrow function as an instrument of policy by other means (74). From this point of view, Grove views the advent of atmoterror, and with it Sloterdijk's conception of war upon an environment, as underpinned by a shift in the scale of war brought about by European colonial endeavours from the 13th century onwards. With the emergence of capitalism and the Westphalian nation state system, Grove argues that European war machines not only spread conflict across the face of the globe, but did so in a fashion that had profound environmental and geological effects:

> The machinic and amplifying relations between ever more portable forms of warfare, primitive accumulation, finance, credit to enable investments (before the return on those investments had created new capital), and the demand for security in newly formed settlements created

> *terraforms* and institutionalized a new kind of planet—that of the Eurocene (86; my emphasis).

With his coinage of "Eurocene," Grove attempts to explain *how* anthropocentric effects on the Earth's climate and geology are undergirded by European expansionist projects that were (and still are) global in their scale, and radically *terraformed* the environments they came into contact with, for instance through the introduction of European flora and fauna; by scorched earth tactics; or by the devastating impact of kinetic weaponry on the landscape.

Perhaps his most striking example of war becoming ecological is a discussion of Captain Bernardo de Vargas Machuca's 1610 counterinsurgency field manual, *The Indian Militia and Description of the Indies*. Grove notes that where most European military manuals until that point were predominantly focused upon enhancing one's own martial capacities, Vargas' text "is devoted to one specific target and its environment" (91). Rather than setting out to destroy or defeat his enemy, Vargas' goal is one of colonisation and subjugation. Consequently, the environment, and the indigenous people's knowledge of and familiarity with it poses a fundamental threat—he is especially concerned by the affinity he sees indiginous peoples as having with various natural poisons and toxins—for they have yet to be made amenable to the European way of life (Vargas 91). In order to 'domesticate' the Americas, Vargas describes a number of ecological approaches to warfighting. The opening of roads by march and machete is of particular importance to him, for the jungle is described as a dangerous and uncertain environment where the risk of encountering an ambush or a trap set by indigenous people who seek to resist the Spanish colonists is high:

> The need to open roads in order to continue will often present itself. And for this, if it is dense forest, the machete wielders will go ahead, opening the path, changing places often so that everyone works and does not receive so much damage to their hands, for they usually become blistered. And in order to safely open the path on a mountain or in dense forest, the camp will halt at a comfortable place, until a good stretch has been opened. Here they are safe from ambushes, for the Indian will not reach his objective in their direction. And if the Indian should come following the camp and they desire to lay an ambush on the road they are opening, he will fall into it without a doubt (Vargas 96).

By opening roads, Vargas hopes to establish networks between places of interest (mines, fortifications, settlements, ports etc.), but also to extend the perceptual apparatus of the coloniser into the jungle, creating clear and unobstructed lines of sight within which they can pass safely from place to place. Note that by carving open paths through a densely forested area the sensory apparatus of the martial gaze is not being extended directly. Rather, Vargas advocates for transformations at the level of the environment itself so that it is more amenable to the activities of the colonising forces. Nor is Vargas above exploiting distinctive environmental conditions when it suits him. For instance, in an extended discussion of the merits of night attacks on indigenous communities, Vargas proclaims that "the best night attack of all . . . is on a rainy and tempestuous night, for this provides two assurances: one is not being noticed, and the other is that the Indians are all gathered inside their huts or hovels" (112). In this respect, Vargas' manual can be situated within a long tradition of martial practitioners for whom understanding and exploiting the weather was a vital component of warmaking.

4.4 Towards a Martial Meteorology

A substantial component of war's ecology is shaped by meteorological processes. The Earth's weather is a profoundly complex entity, and its study contributed greatly to the wider human understanding of the operation of complex dynamical systems, with the pioneering work of meteorologists such as Vilhelm Bjerknes and Edward Lorenz being particularly notable in this regard. Though an association between the weather's complexity and its unpredictability was not well understood until Lorenz's discovery of deterministic chaos during a series of modelling experiments which he conducted during the 1960s, it is nonetheless striking that Clausewitz opted for meteorological metaphors as part of his attempts to convey the uncertain nature of war. As Packer and Reeves explain, Clausewitz's "choice of 'fogs' is relevant insofar as the optical requirements of war in Clausewitz's day were specific to the form of warfare dictated by the ballistic capabilities and tactical consequences of lining up armies and munitions across from each other's formation and then advancing on those positions" (67). As a result, Clausewitz was well aware of the specific role played by the weather itself in contributing to friction's "atmosphere of war," and made a number of explicit references to the adverse effects of meteorological phenomena on the conduct of martial operations in order to illustrate the point. For instance, Clausewitz writes that: "Fog can prevent the enemy from being seen in time, a gun from firing when it should, a report from reaching the commanding officer. Rain can prevent a battalion from arriving, make another late by keeping it not three but eight hours on the march, ruin a cavalry charge by bogging the horses down in mud, etc" (Book 1, Chapter 7 139).

Of course, Clausewitz was far from the first to observe the potential of the weather to hinder the conduct of war, let alone to have a profound effect on human societies more generally. Indeed, the practices of recording weather observations, and of attempting to divine the behaviour of the wind and rain, are ancient. Aristotle proposed a theoretical meteorology, which sought to replace the atomism of Democritus with a theory of the elements (fire, wind, water, earth). Though his understanding of many of the characteristics of the weather have since been found lacking by modern science, he nonetheless was able to describe the basic features of the hydrological cycle in his *Meteorologica* (ca. 340 BC). The Greeks also maintained records of wind direction from around the time of Meton (ca. 430 BC), and interpreted celestial and climatological signs as omens portending the divine will of the gods (Nebeker 1, Dillon 179).

In particular, thunder and lightning were closely associated with warfare. The sound of thunder coming from a general's right was deemed to be an auspicious sign from Zeus (Dillon 182), whereas the arrival of a thunderstorm might portend that he intended to destroy an army: "the Greeks knew thunder and lightning . . . as a jealously guarded sign of domination sent down by their highest god from the highest mountain" (Kittler, "Fragments of a History of Firearms" 69). A sodality between the capacity to control the environment through manipulating both the weather and the cosmos, and victory in war was also a persistent feature in the mythologies of the ancients. In Hesiod's *Theogony*, Zeus is able to deliver the Olympians from the tyranny of the Titans through his acquisition of the power to control and direct lightning, while the Indian *Mahabharata* contains a number of references to natural and astrological phenomena as portents of catastrophe:

> Strong winds are blowing fiercely and the dust ceaseth not. The Earth is frequently trembling and *Rahu* approacheth towards the sun. The white planet (*Ketu*) stayeth, having passed beyond the constellation *Chitra*. All this particularly bodeth the destruction of the Kurus. A

> fierce comet riseth, afflicting the constellation *Pusya*. This great planet will cause frightful mischief to both the armies (qtd. in Petriello 8-9).

Thanks to its destructive potential and unpredictable nature, the weather has long been a matter of grave concern for military commanders. Throughout history, the weather, astronomical phenomena, and other assorted natural disasters, have been both a blessing and a hindrance in various campaigns, battles, and sieges, to the extent that they may even have played a decisive role in determining the outcome in some cases. In *The Tide of War*, David Petriello compiles an extensive survey of some of the more historically significant of these moments:

> Halley's Comet helped to announce the fall of the Shang Dynasty in China, a solar eclipse frightened the Macedonian army enough at Pydna in 168 BC to ensure victory for the Romans, a massive rain storm turned the field of Agincourt to mud in 1415 and gave Henry V his legendary victory, fog secured the throne of England for Edward IV at Barnet in 1471, wind and disease conspired to wreck the Spanish Armada, snow served to prevent the American capture of Quebec in 1775 and confined the Revolution to the Thirteen Colonies, excessive heat gave rise to the legend of Saladin at the Horns of Hattin in 1187, freezing cold stopped Washington's crossing of the Delaware, and an earthquake helped to spark the Peloponnesian War (Petriello 7-8).

However, as with Vargas' preference for conducting night raids during a rainstorm, these examples mostly involve situations where a general or ruler exploited a prevailing weather phenomenon for a momentary and spontaneous benefit. A more pre-meditated practice for manipulating the environment for advantageous ends which has often been employed throughout history is the use of flooding as a means of slowing down an advancing army. For instance, Petriello details William of Orange's attempts to flood the countryside around Antwerp, Ghent, and Bruges during the Eighty Years' War (158). Unfortunately, because the flooding made use of seawater, these efforts also devastated the soil quality in the affected areas, with profoundly adverse consequences for farming that would affect the region for centuries (Petriello 158). But for the most part, the weather's complex and unpredictable nature, combined with the relatively limited ability on the part of war machines to interfere or direct it, meant that although it was often a subject of cautionary warnings in military manuals throughout antiquity and the Medieval period it remained difficult to wholly exploit outside of short-term acts opportunism of the kind described by Vargas until certain necessary advances in understanding its dynamics had taken place.

The first major tipping point in this direction occurred during the 17th century, with the invention of instruments such as the thermometer and barometer, which together permitted more accurate and detailed measurements of the elements of the weather, precipitating the emergence of quantitative forms of meteorological study and analysis (Nebeker 1). However, as Frederik Nebeker notes, during the 19th century a trifurcation occurred within the nascent discipline, encompassing:

1. The observer, who engages in the empirical activity of studying and recording the characteristics of weather phenomena. Known as "climatologists" these observers tended to employ statistics, and strove to produce a scientific account of the "average weather."

2. The natural philosopher, who attempts to explain the dynamics of atmospheric behaviour in a theoretical fashion on the basis of general principles which were derived from the laws of physics.
3. The forecaster, who carries out the practical activity of predicting the weather . These were typically professional figures who made short-term predictions based on limited, local data, and were often regarded by empiricists and theoreticians as unscientific (Nebeker 1).

These traditions remained separated until the novel demands of modern warfighting across the principle domains of land, sea, and air, during the World Wars of the 20th century brought about a renewed interest in the study of the weather which, once catalysed by the development of electronic computers in the 1950s, eventually led to their unification in the form of the modern science of meteorology (Nebeker 1-2). However, at the outset of World War I, and in the face of advice from its scientific community, the British armed forces did not at first see much value in meteorology: "the attitude of the general staff to a deputation of representatives of science urging its importance was briefly that 'the British Army fights its battles with guns and bayonets and not with meteorology. Mud, gas and aviation rapidly effected a change'" (Gold 220). But as their mechanised forms of transportation and combat gradually became bogged down in the muddy terrain of the Western Front; as inclement weather severely affected the flight capabilities of their earliest military aircraft; and as the dispersion of poison gas which they first encountered during the Battle of Ypres was subject to immense variability depending on the direction and strength of the winds; the importance of meteorological information could no longer be ignored (Nebeker 83-84). Another decisive factor was the growing realisation of the impact that climatic conditions had on the effectiveness of artillery in the field:

> When it is remembered that the biggest element in the effectiveness of a modern army is its artillery and that the effectiveness of the artillery is dependent entirely upon these wind corrections it will be seen how incalculably valuable the work of the trained physicists and mathematicians [working for the British Meteorological and Aerological Service of Signal Corps] proved to be to the practical problems of the great war" (Millikan, "Contributions of Physical Science (312).

With the advent of martial meteorology, the causes of the great variability in the performance of artillery that prompted Reisswitz to incorporate elements of chance into his *Kriegsspiel* was beginning to be better understood. In addition to wind, variables such as temperature and humidity also had to be taken into account, and with the assistance of meteorologists the ballistic tables being developed by the British during the First World War constituted a dramatic improvement over those of the previous century (Nebeker 84).

At the outset of World War I, the state of meteorological research in the United States was lagging behind its European counterparts, as it had predominantly fallen under the purview of the Weather Bureau, which was itself overseen by the Department of Agriculture. Its remit, which focused primarily on producing immediate, practical results, for the benefit of American citizens (and especially farmers), was sufficiently narrow that there was little effort to combine the three main strands of observation, theory, and forecasting described by Nebeker (Harper 12). However, two smaller weather services were gradually being formed in the War and Navy departments with the objective of producing specialised forecasts for their respective native domains. Eventually, a special appropriation of $100,000 was provided to establish a number of aerological weather stations, as well as to fund a variety of meteorological services which would be directed towards both the War and Navy departments (Harper 12). This funding had a substantial impact, and by the war's end the American armed forces were being provided with measurements of temperature, density, and wind speed from surface level, as well as at a cross-section of altitudes up to 5000m every two hours (Millikan, "Meteorological Work" 210). This data was primarily gathered from theodolite observations made by weather balloons which were in a continual state of operation across 37 newly completed meteorological stations in the United States, and a further 20 that had been established overseas (Millikan, "Meteorological Work" 210).

4.5 The Weather War

By the Second World War, meteorology had gone from being a relatively narrow and predominantly academic discipline to a full-fledged profession that was undergirded by significant institutional support both within and beyond the armed forces of all the major powers (Nebeker 84). The armed forces had also fully come to terms with the weather's significance, and this appreciation would only continue to expand as its effects continued to play a part in the outcomes of a number of major events throughout the war:

> Major German offences were slowed dramatically by the early Russian winter of 1941/1942, the most severe on record, and by the sudden spring thaw in the Caucasus in March 1943. The

> Allies suffered from the fog and dense cloud of the Battle of the Bulge and from typhoons that struck a fleet off the Philippines in December 1944 and a fleet off Okinawa in June 1945 (Nebeker 113).

Meanwhile, public weather forecasts were managed carefully in Britain, with all references to particularly inclement forms of weather which might hamper aviation, such as gales, snow, fog, and severe frost, being excluded entirely (Nebeker 114). Similarly, the United States forbade the publication of weather maps until the data was at least a week old, and also engaged in the careful controlling of broadcast forms of meteorology (Nebeker 114). Meteorological data was now a military secret of the utmost importance, prompting both sides to deploy weather reconnaissance aircraft and weather ships as mobile measurement platforms in an effort to maintain an informational edge for their operations in both the Atlantic and on land in continental Europe. By the end of the war, six whole squadrons of RAF (Royal Air Force) planes were making twice-daily flights up to a distance of 700 miles to the south, southwest, and northwest of the British Isles in order to gather meteorological data and gauge weather patterns (Nebeker 114).

Because weather systems affecting Central Europe typically move from West to East, being cut off from weather information from the northern Atlantic and Britain deprived the Germans of many of the weather forecasting capabilities they had attained during the interwar period (Kuettner 5). Before 1939, the majority of Atlantic meteorological readings were provided by weather stations being operated by Denmark in Greenland, and by Norway on the island of Jan Mayen and the archipelago of Svalbard. Initially, these stations continued to provide data to both sides as normal, with the Svalbard Treaty of 9 February 1920, prohibiting military activity on the archipelago (Barr IX). However, by

1940, British High Command determined that the reports from the various stations encircling the arctic were in all likelihood providing greater benefit for the German war effort than their own, and so actions were taken to deny their adversary access to this information (Barr IX). In response, Germany conducted its own aerial and naval meteorological operations until 1945, and supplemented them by deploying several manned and unmanned weather stations in a series of clandestine missions carried out across the Atlantic. These missions were extremely risky, requiring German forces to access, and in some cases occupy, remote and harsh locations in the Arctic circle, while simultaneously avoiding detection by Allied forces operating in the region.

In one such operation, carried out in October of 1943, U-537 sailed all the way to Martin Bay, located at the northernmost tip of the Hutton Peninsula in Canada's remote province of Labrador. It was a risky journey. The ship lost its anti-aircraft guns during a heavy storm near Greenland, and had to navigate a largely uncharted coastal region before landing and dispatching a ground team to deploy its precious cargo and establish the automatic "Weather Station Kurt" in what would prove to be the only land operation conducted by Germany in North America during the Second World War (Douglas 44). The U-boat would be incredibly vulnerable during this process, as Alec Douglas' transcription of the ship's log indicates:

> [U-537's Captain] had to open up all the hatches to unload the equipment, place it in rubber dinghies and land it on the beach. He could neither submerge, run for it, nor defend himself if attacked. Working through the night, the crew man-handled 10 heavy canisters containing nickel-cadmium and dry-cell batteries, transmitter and weather measuring devices, as well as the tripod and mast, over the beach, and 170 ft. up a hill about a quarter-of-a-mile inland. The

U-boat stayed long enough to verify that the station was functioning properly on its frequency of 3940 kilo-hertz and then slipped out to sea. The operation had taken 28 hours (44).

Eventually, the station was rediscovered in 1981 after a retired Austrian engineer, Franz Selinger, came across the submarine's log and notified the Canadian authorities of his findings. They in turn dispatched a team of six investigators to examine the site. To their surprise, they found that the metal canisters intended to protect the station's automatic measuring equipment had already been opened. Their contents had been strewn across the ground, and their cables had been systematically cut in an act of sabotage. Though the investigators were initially baffled by this discovery, they eventually hypothesised that Canadian or American forces may have conducted a counter-operation to locate and destroy the station based on intelligence gathered from intercepted U-boat transmissions (Douglas 45-46).

Several other Nazi weather stations, including a number located in Northeast Greeland, became the targets of similar skirmishes and airstrikes carried out by the Allies, while others were recalled after the Germans learned that their discovery was immanent (Barr X-XIX). Though the Germans had at times been able to maintain a steady flow of meteorological data from their Atlantic and Arctic stations, their efforts were gradually being hampered by British and American actions. By June 1944, Allied forces had seized or destroyed German weather stations operating in Iceland, Greenland, Spitsbergen, and Jan Mayen, decisively crippling their capacity for forecasting, and effectively rendering them blind to meteorological conditions (Hastings, *Overlord* 66-67).

Historians refer to the struggles to obtain meteorological information in the Arctic and Atlantic regions between 1939 and 1945 as the "Weather Wars" (Barr IX). What is particularly striking about these operations is the nature of their objectives. In each case, they involved attempts to either enhance one side's capability to conduct meteorological observations—and thereby be able to at least anticipate imminent weather conditions which would otherwise be a highly uncertain variable within the war ecology or system—or to inhibit the capacity of its adversary to do the same. Where in the past the objective of a martial confrontation might be to secure a territory, or to defeat the army of a rival, or even to assume the role of predator in the cynegetic dynamic (as in the Battle of the Atlantic), the Weather Wars emphasised the grave importance that timely knowledge regarding the particulars of meteorological conditions had achieved as a precondition for the effective operation of war machines during the first half of the 20th century.

The arms race to reduce meteorological uncertainty during the Second World War came to a decisive head in Operation Overlord, the Allies' planned invasion of Normandy in June of 1944. On May 29th, General Dwight D. Eisenhower, the commander of the Allied forces, had given the order for the immense invasion force—whose numbers included more than 5,000 ships and landing craft, 11,000 aircraft, and over two million military personnel—to prepare for an attack on the morning of June 5th (Nebeker 111). This date had been chosen after a series of extended deliberations between Eisenhower and Dr. James Stagg, a Scottish meteorologist who oversaw the meteorological team attached to SHAEF (Supreme Headquarters Allied Expeditionary Force).

Stagg's forecasts indicated that tides would be low, which would make it easier to evade underwater obstacles which the Germans had positioned along the French coastline in order to deter beach landings, and that there would be sufficient moonlight to make night-time parachute and glider landings viable (Nebeker 111). However, a forecast made on June 1st, the day before battleships were due to depart from their moorings at Scapa Flow, suggested that inclement weather was inbound from

West of the British Isles, with a complex system of low-pressure a bringing with it the potential for rough seas in the English Channel, and low cloud which might shroud the German coastal batteries which Allied aircraft would be required to knock out in support of the amphibious beach landings (Beevor 1-2, Nebeeker 111). Such an eventuality would have spelled disaster for the invasion, as:

> [C]ommanders of the airborne units had stipulated that there be no fog or low clouds, no more than 60% cloud cover, and winds below 20 mph. . . . The naval bombardment could hardly proceed in high seas or if visibility was less than 3 miles. And, most importantly, for the amphibious landings there could be no fog and on-shore winds could not exceed 12 mph (Nebeker 111).

Though some ships had already departed, at 4:30am on June 4th, Stagg advised Eisenhower that conditions were continuing to worsen, prompting the General to call for a 24-hour postponement of the invasion (Beevor 10-11). This delay caused great alarm among the armed forces, for it had been determined that if the window of June 5-7 was missed, the entire invasion would have to be postponed for at least another fortnight, for the tides would not be sufficiently low to make a safe landing otherwise (Petterssen 214) The meteorologists continued to monitor the data from their weather stations throughout the day of June 4th, and were able to establish that although the approaching low front had concentrated, it was also slowing down. Stagg was confident that a small but sufficient window of opportunity would present itself on June 6th before conditions would worsen again on the 7th (Beevor 19).

By June 5th, the storm had hit Britain and its waters as predicted, but Stagg's assessment that conditions on June 6th, though far from ideal, might still be acceptable, was enough to encourage Eisenhower to give the order to proceed with the invasion (Nebeker 112). As it turned out, Stagg's predictions were not only correct, but the arrival of the storm on June 5th had blocked German reconnaissance efforts, preventing their provision of an early warning of the approaching invasion fleet. The destruction of German meteorological stations across the Arctic and North Atlantic during the Weather Wars had also played a role. Without advanced warning of the status of the low pressure system, German meteorologists were not able to anticipate the brief interval of acceptable weather on the 6th of June, and so their reports indicated that an invasion was unlikely. As a result, German units in northern France were not on high alert, with many of their commanders, including Rommel himself, using the opportunity provided by the inclement weather conditions to attend to other matters that took them away from their usual posts (Nebeker 112).

The ensuing invasion caught the German forces off guard, and upon its success, demonstrated the importance of being able to anticipate, even if only by a small amount, the shifting conditions of the martial environment. A landmark in military planning, Operation Overlord seemed to be proof that the Aristotelian approach could be insulated against contingency thanks to the newfound ability to model environmental sources of friction which might otherwise have compromised the proceedings. In this sense, the advent of martial meteorology can be viewed as a precursor to the progressive expansion of the scope of the Western military apparatus from beyond the discrete confines of the arena of the battlefield in its pursuit of what the U.S. armed forces today refer to as "full spectrum dominance" across the operational domains of land, air, sea, but also the electromagnetic spectrum and towards "information warfare" (Shalikashvili 2). For Bousquet, as targeting becomes simultaneously more global in scope and more precise in effect, "the notion of distinct temporal and spatial bounds for the exercise of armed force becomes ever more untenable" (Eye of War 4). Indeed, as Mégret observes:

> The nineteenth century probably witnessed the last true battles. The First World War (WWI) retained unity of space but trench warfare prolonged combat in a zone far beyond what would normally have been considered a battlefield. Effectively, battlefield and theater of war merged so that, for example, although World War I remains famous for particular battles—the Somme, Ypres or Verdun—these battles really combined seamlessly over a front that extended over hundreds of miles (142).

But where Bousquet and Mégret are particularly attentive to the role played by the pervasive martial gaze and its coupling with increasingly long ranged kinetic weapons in inaugurating the transition from a local battlefield to a global battlespace,[24] the ecological and meteorological treatments of the "atmosphere of war" outlined in this chapter emphasise the adversarial struggles over the capacity to assess, negotiate, and exploit the very conditions of uncertainty within the martial environment as another driver of this transformation.

[24] See also Bousquet, "The Battlefield is Dead" (2017).

1943: Fog Investigation and Dispersal Operation

During the early years of the Second World War, Britain's attempts to pursue a bombing offensive against German targets was severely hampered by the frequency of aircraft crashes as a result of poor visibility caused by the prevalence of fog. In September and October of 1940 alone, fifty five RAF aircraft crashed while attempting to land on their home runways. The night of the 16th of October was particularly disastrous. Seventy three British bombers conducted air raids on German targets, sustaining three losses during the operation. However, ten Hampdens and four Wellingtons crashed in England when attempting to land on runways that had been shrouded in a dense fog (G. Williams 2). News of this event was brought to the attention of Churchill, who promptly submitted a memo to his chief of air staff, Sir Charles Portal, prompting him to take action on the matter: "What arrangements have we got for blind landings for aircraft? How many aircraft are so fitted? It ought to be possible to guide them down quite safely as commercial craft were before the war in spite of fog. Let me have full particulars. The accidents last night are very serious" (qtd. in G. Williams 2).

In the meantime, Churchill's chief scientific adviser, Lord Cherwell, began his own enquiries into the matter, and found that while there had been some pre-war experiments in clearing airfields of fog these had been discontinued as a result of their high costs. These experiments had determined that a combination of two fundamental factors tended to influence the process of fog formation: "These are the concentration and type of nuclei and the concentration and temperature of the water" (Colbeck 367). Any effective fog dispersal system would need to effect changes upon one or the other of these parameters. In the pre-war experiments, the two main methods had been proposed for this, one chemical, and one thermal. "The first aimed to remove part of the water vapor from the air, with consequent evaporation of the water drops" (Colbeck 367). This would be achieved by spraying a saturated solution of calcium chloride into the air. However, this would entail the construction of pipes which could distribute the chemical spray from the level of the top of the fog, a system which proved to be far too impractical to install above an airfield (Colbeck 367). The thermal approach would be predicated upon an extensive system of heating: "if initially the temperature within the fog increases by 5°C from the ground to 110 yards, it would be necessary to heat the air sufficiently to convert the variation of temperature with height to the adiabatic rate to cause the fog to dissipate" (Colbeck 368). This was obtainable, but would require the burning of 7,500 cubic feet of domestic gas, or approximately 20 gallons of paraffin per minute (Colbeck 368). Trials of this method carried out between 1936 and 1939 did not generate sufficient heat to fully dissipate fog, but did at least demonstrate that better results were achievable with further refinements, albeit at the cost of extremely high fuel consumption (Colbeck 368).

Cherwell received Churchill's blessing to resume fog dispersal tests in earnest, but before he could present the prime minister with an update on their progress another large bombing raid had suffered extensive losses due to bad weather conditions (G. Williams 4, Hastings, *Bomber Command* 126). Churchill's response was unequivocal: "I have several times in Cabinet deprecated forcing the night bombing of Germany without due regard to weather conditions. There is no need to fight the enemy and the weather at the same time!" (qtd. in G. Williams, 4). Unfortunately, Portal's requests for a resumption of fog dispersal experiments at the behest of Lord Cherwell met a significant amount of resistance, delaying them until rising RAF losses finally prompted the Committee for the Co-ordination of the Bomber Offensive to take action. And so, on the 2nd of September, Britain's

Petroleum Warfare Department (PWD) was ordered to undertake "full scale trials in fog dispersal" as soon as they were able (G. Williams 5).

The problem the PWD faced was substantial. The south of Britain, where many RAF airfields were located, was a particularly favourable region for the accumulation of fog, as the incoming air would be cooled as it crossed the nearby sea surface before making its way over the southern cliffs onto land. Furthermore, wartime Britain suffered from pervasive air pollution generated by the great prevalence of coal-fired factory and domestic chimneys dotting its urban landscapes: "Emissions from chimneys consisted of millions of minute particles of soot which provided nuclei for condensation drops to form as they gradually drifted out to country areas where radiation fogs were forming and where airfields were situated. Oil-fired installations and waste fumes from chemical and metallurgical plant [sic] also contributed to the murk" (G. Williams 7). Under the codename FIDO (Fog Investigation and Dispersal Operation), a number of different potential solutions to dispersing the British fog were trialled, including flame-throwers mounted on Bren–gun carriers, coke-filled braziers, and lines of Four-Oaks petrol burners (G. Williams 13-14). The basic principle underpinning all of these devices was that by heating the air, the relative humidity of the atmosphere above a foggy runway would be lowered, which in turn allowed the water droplets constituting the fog to evaporate (Kunkel 118). Though these initial experiments were largely unsuccessful, a prototype known as the Haigas system, consisting of long lines of petrol burners intended to be placed along either side of a runway, was deemed to have promise.

By April of 1943, photographs of a successful fog clearance using a FIDO system installed at an RAF base in Graveley were shown to Churchill, who immediately insisted that the scheme be expanded (G. Williams 20-21). During this trial, the pilot reported that the excess heat from the burners had not produced much turbulence, and that conditions were comparable to daylight (Colbeck 370). Further trials, conducted on July 16-17, found that the FIDO system had raised the fog visibility in the atmosphere above the runway from 100-200m to 1300m (Kunkel 118). Though the large amounts of petrol required to fuel a FIDO system made it expensive to operate, by the end of 1943 the British were able to secure a relatively safe supply from North America thanks to their successes against the *U-bootwaffe* in the battle of the Atlantic. As a result, by November of 1943 FIDO systems were being installed across Britain, and by the spring of 1944 eight operational airfields had been equipped with petrol burners, and a further seven were under construction (G. Williams 39).

The actual effectiveness of FIDO is difficult to determine. British Bomber Command recorded a testimonial for FIDO expressing an appreciation for its effectiveness during operations which took place during December in 1944: "Over a thousand aircraft landed with the aid of FIDO. . . . Despite the fog the crews were able to do their job thoroughly, knowing that when they returned the weather would not stop the landing" (qtd. in G. Williams 40). Though some statistics detailing FIDO's effectiveness did survive the war, they are largely incomplete, making it hard to provide a meaningful analysis of the system's success rate. Geoffrey Williams notes that from November 1943 when the system was installed until the end of the Second World War an estimated 2,700 Allied aircraft took off or landed with its aid. Of these, approximately 700 landings were carried out with FIDO under conditions of fog (41). Williams estimates that somewhere in excess of 3,500 aircrew survived landings in which they might otherwise have faced injury or death thanks to the system (41).

Regardless of the extent of its efficacy, FIDO's development is notable because it marks the beginnings of significant shift in the capability of the war machine to not only anticipate, measure, or predict a source of uncertainty as complex as the weather, but also to be able to meaningfully alter its effects, albeit in a limited fashion. Rather than attempting to enhance the perceptual capabilities of aircraft,[25] the act of heating air in order to evaporate vapour particles that together form fogs constitutes a modification of the medium of the atmosphere at a local scale. Where the proponents of geometric warfare during the 18th and 19th century could only eliminate the presence of irregularities from their *models* of war, FIDO's promise to disperse an otherwise opaque FOW is indicative of a growing awareness on the part of Western war machines that it might be possible to mitigate friction and uncertainty by simply eliminating it from the environment altogether.

[25] FIDO would be phased out of operation in Britain by 1949, as improvements in radar rendered it obsolete (Colbeck 374).

1961: Operation Ranch Hand

The British FIDO system had highlighted the possibility that adverse environmental conditions,which had hitherto provided an intractable source of friction for martial operations, might be mitigated through the application of technical solutions that sought to directly influence meteorological phenomena. As the 20th century progressed, martial experimentation in this area would only intensify, especially in the hands of the United States, who emerged from the ruins of World War II in an ascendant position as a major superpower, and whose approach to martial uncertainty shall be the central focus for the remainder of this thesis. Certainly, by the Vietnam War, the U.S. military was exhibiting a willingness to engage in forms of environmental modification whose object not only entailed the alleviation of friction for their own operations, but also its intensification for their adversaries.

During the most well known of these programs, codenamed Operation Ranch Hand, the U.S. military sprayed a 50:50 mixture of the synthetic chemical compounds 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid), known as Agent Orange, across approximately five million acres of forests in South Vietnam over the course of the war (Zierler 1-2). The most frequently stated objective of Ranch Hand was to deprive the National Liberation Front of South Vietnam's (NLF) armed forces of vital jungle cover, and in doing so make the conditions more suitable for American tactics and weaponry. For instance, in 1963, one military official advocated that:

> The best way for the U.S. to achieve its military aims in Southeast Asia would be to rely on chemical warfare. The United State will never have enough counterinsurgency troops to comb every rice paddy in the battle zones of South Vietnam. We cannot send armored personnel carriers down every irrigation canal. Not enough helicopters can be produced and manned to track down every band of guerillas hiding in wooded areas. But it *is* possible to "sanitize" an area with chemical weapons, with gases and sprays, that destroy animal life and crops. We can create a no-man's land across which the guerillas cannot move. We can clean up an area so that the enemy won't dare attempt to operate in it (qtd. in Zierler 68).

Ranch Hand was not the first time a military application of herbicides had been considered. British forces had previously used chemical herbicides during the 1950s as part of a counterinsurgency in Malaysia (Wilcox 14, Zierler 63). However, Ranch Hand's origins can be traced back even further back, to research conducted by Ezra Kraus, who was the chair of the University of Chicago's Department of Botany during World War II (Zierler 38). Originally, herbicides were conceived for the purpose of killing weeds that hampered agricultural production. Having overseen a number of collaborative research efforts on the manipulation of plant growth, including by the application of weed-killing herbicides, the Japanese attack on Pearl Harbour prompted Kraus to offer his services to the U.S. Government (Zierler 39). In a secret meeting of the Biological and Chemical Weapons Committee of the War Bureau of Consultants (WBC) held on February 17, 1942, Kraus presented a paper titled 'Plant Growth Regulators: Possible Uses,' which outlined his theory for the strategic application of herbicides (Zierler 39-40).

The crux of Kraus' proposal was the spraying of chemical defoliants over Japanese occupied islands in the Pacific in order to both destroy rice fields, and therefore destabilise Japanese agriculture, but also to reveal concealed military depots or forces in heavily forested areas (Zierler 40). In addition to Kraus' paper, a further twelve presentations were heard by the WBC concerning various methods for the chemical destruction of cropland and forests, including one proposing the deployment of potato blight microbes against Germany's primary agricultural stable (Zierler 41). However, despite a great deal of subsequent research into plant growth manipulation following Kraus' initial presentation to the WBC, for which a substantial amount of funding was granted by the U.S. Army, and a consensus among both civilian scientists and U.S. military officials that a herbicidal program of operations in the Pacific theatre would be effective, the Japanese surrender following the atomic bombing of Hiroshima and Nagasaki ended the war before herbicide operations being tested by the Biological Warfare Center, based at Camp Detrick in Maryland, were deemed battle ready (Zierler 42).

Further research into herbicidal warfare was largely shelved in the years immediately following the end of WW2, with scientists at Fort Detrick focusing on the development of insecticides rather than herbicides during the late 1940s and early 1950s. It would not remain dormant for long however, as the advent of a concerted effort to diversify Cold War strategy under the leadership of Maxwell D. Taylor, the Chief of Staff of the U.S. Army between 1955 and 1959, would soon bring it back into vogue (Buckingham 6, Zierler 42). Taylor's concern that too much faith was being placed in the principle of deterrence eventually prompted John F. Kennedy to announce, in May 1961, an umbrella strategy known as "Flexible Response," which called for a massive expansion and diversification of the U.S. military's offensive capabilities in order to combat what it perceived as the growing influence of communism across the globe:

> I am directing the Secretary of Defense to undertake a reorganization and modernization of the Army's divisional structure, to increase its non-nuclear firepower, *to improve its tactical mobility in any environment*, to insure its flexibility to meet any direct or indirect threat, to facilitate its coordination with our major allies, and to provide more modern mechanized divisions in Europe and bring their equipment up to date, and [to provide] new airborne brigades in both the Pacific and Europe (qtd. in Zierler 49; my emphasis).

A driving force behind Flexible Response's concept were the new counterinsurgency studies being developed in reaction to the extant literature on insurgent and guerilla warfare written by revolutionaries such as Ernest "Che" Guevara and Mao Zedong (L. Freedman, *Kennedy's Wars* 288, Zierler 53). The rapidly deteriorating situation in South Vietnam would prove to be the first test of both this counterinsurgency literature, and the Flexible Response policy more generally.

Upon his inauguration as President, Kennedy was immediately confronted with reports that the NLF insurgency was posing a significant threat to President Ngo Dinh Diem's government in the South. Preferring to avoid the deployment of a large-scale ground troop detachment, Kennedy instead chose to place his faith in the promise "nation-building" invoked by the literature of counterinsurgency which had already begun to capture the imagination of the White House. On April 12, 1961, Walt Rostow, Kennedy's Deputy National Security Advisor, handed the President a memo detailing nine courses of action that the U.S. should pursue to repel the impending communist revolution in South Vietnam (Zierler 58-59). The fifth recommendation called for a military research team to be sent to

Vietnam in order to explore the development of various "techniques and gadgets" which might be used to gain an advantage against the NLF (Zierler 59).

Upon its approval, the Pentagon's Advanced Research Projects Agency (ARPA) established the United States/Government of South Vietnam Combat and Development Test Center (CDTC) under the command of Lt. Gen. McGarr. One of the CDTC's first tasks was to revive the WW2 research into herbicidal warfare with a particular focus on developing chemical compounds suited to the destruction of forest cover and crops being used by NLF guerilla forces (Zierler 59). The testing phase, codenamed Project Agile, took place at Camp Detrick. Its director, James W. Brown experimented extensively with Dinoxol, a herbicide compound containing 2,4-D and 2,4,5-T, (the chemicals which would later make up Agent Orange). Pleased with the early results, he reported that the herbicides could play a prominent role in the strategy to defeat the NLF, noting that: "No one appreciates food or visibility . . . more than those deprived of it" (qtd. in Zierler 59).

Once these tests were completed, the first active defoliant operations commenced under the auspices of an advisory project, where U.S. experts provided training and equipment for South Vietnamese Air Force (VNAF) personnel in herbicidal warfare. And so, by August 10, 1961, the VNAF conducted its first aerial defoliant missions targeting roadside foliage using U.S.-issued H-34 helicopters (Zierler 59). Later that month, further operations were conducted using fixed-wing C-47 planes provided by the U.S., and directed towards forest targets that had been selected personally by President Diem, who was a supporter of the program from its inception (Buckingham 11-12).

However, by September of 1961 NLF forces were continuing to gain ground in South Vietnam, with Kennedy receiving reports that Diem's government would collapse without further U.S. intervention. Undeterred, Kennedy resisted appeals calling for a large-scale ground deployment, and instead continued to place his face in an expansion of counterinsurgency operations. As part of this response, he authorised U.S. forces to take an active role in herbicide operations in a memorandum signed on November 30 (Zierler 65). The objectives for this programme were detailed in a CTDC memo issued on September 23 as part of a wider series of emergency counterinsurgency measures designed to support the Diem government:

> Stripping the Cambodian-Laotian-North Vietnam border of foliage to remove the protective cover from Viet Cong reinforcements. Defoliating a portion of the Mekong Delta area known as 'Zone D' in which the Viet Cong have numerous bases. Destroying numerous abandoned manioc groves which the Viet Cong use as food sources. Destroying mangrove swamps within which the Viet Cong take refuge (qtd. in Zieler 61).

The CDTC first codenamed the program Operation Farm Gate, but this would be revised to Operation Ranch Hand by the time the first herbicidal spraying missions were being conducted in January of 1962 by a group of U.S. Air Force (USAF) C-123s spray aircraft under the designation "Special Aerial Spray Flight" (SASF) (Zieler 72). Following the plan outlined in its September memo, herbicidal targets would encompass the destruction of cropland, the defoliation of forests along supply lines and suspected ambush paths, as well as roadside defoliation along routes intended to be frequented by U.S. and South Vietnamese personnel in order to improve visibility (Zieler 71). Early reports evaluating the first January herbicidal missions flown by the SASF deemed them to be successful, with Brown observing that "the chemicals used are sufficiently active to kill a majority of species in Vietnam if: (1) they are applied properly to the vegetation (2) they are applied during a period of active growth. . . . With respect to timing of application, the chemicals are plant growth regulators and can only attack plants effectively during active phases of the growth cycle" (qtd. in Zierler 74).

However, these herbicides was also found to produce an unforeseen side-effect following their application to the canopy of the Vietnamese jungles: "defoliation permitted sunlight to reach the forest floor, where it triggered dense vegetative growth at ground level, particularly bamboos and *imperata* (buffalo) grasses" (Brown qtd. in Zierler 74). From the perspective of aerial reconnaissance, they would not pose any problems, as soldiers moving in among bamboo or tall grass were still much easier to spot than in the jungle, however lateral visibility from roadsides or military bases would be heavily compromised (Zierler 74). Nonetheless, Brown was confident that the application of Agent Orange would be effective in both the process of defoliation, and also in inhibiting subsequent forest growth. And so, having garnered Brown's approval, it would not be long before Secretary of Defence McNamara would encourage President Kennedy to expand the operation so that its efficacy could be tested against a wider variety of Vietnamese vegetation.

Following Kennedy's authorisation, another wave of herbicidal spraying operations, beginning on February 8, was conducted against a wider variety of targets, including the defoliation of several air bases and ammunition depots (Zieler 75). Once these operations were completed, it was decided that spraying would be halted for five months so that the overseers of Operation Ranch Hand could evaluate their effects and determine whether the project would have merit as part of the wider counterinsurgency effort against the NLF guerillas. The evaluation process, led by representatives from the U.S. Army Chemical Corps and scientists from the Department of Agriculture, would begin in

April 1962. The ensuing report suggested that the different varieties of vegetation which comprised the Vietnamese jungles would react to the same chemicals in different ways. In particular, the mangrove forests along the southern coast and Mekong Delta, and the evergreen tropical forests which could be found spanning the country's central highlands responded each had to be accounted for. The report stressed that if Ranch Hand was to be expanded further, it needed to take advantage of the rainy season (May-October) when plant and tree growth was at its most active (and therefore would be most susceptible to chemical intervention), and that greater care would need to be taken to account for the effects of meteorological conditions (Zieler 76). However, it did confirm that aerial visibility had indeed increased in many of the areas sprayed during the missions, with upwards of 85 percent defoliation taking place in mangrove forests in particular (Zieler 76).

Brig. Gen. Fred J. Delmore, who oversaw the evaluation team, indicated that another year of widespread spraying would be required to judge the overall effectiveness of large-scale herbicidal warfare, and also that there was no way to anticipate how the NLF would respond to the changes in the martial environment (Zieler 76). Finally, he concluded that if the operation was to have a discernible effect on the NLF's ability to operate in the mangrove and evergreen tropical forest biomes the U.S. would need to undertake a sustained, large-scale effort to defoliate a vast swath of South Vietnam (Zieler 76-77). In effect, only two possible paths could be taken, either the program would be closed down, or operations would have to be expanded substantially.

In August 1962, Kennedy would in effect authorise the commencement of the latter approach, with the approval of a large-scale herbicidal operation to defoliate the Ca Mau peninsula's mangrove forests, which had been heavily infiltrated by NLF forces over the previous few months (Zieler 77). Spraying in this region was conducted between September and October, saturating nine thousand acres of mangroves with Agent Purple (a "Rainbow Herbicide" similar to its more well known cousin, Agent Orange) (Zieler 77). In October, another major spraying operation was conducted along the Laotian border, in an area that would later come to be known as the Ho Chi Minh Trail, which contained a maze of interconnected routes which constituted a major supply network through which NLF forces received supplies from the north (Zieler 77). These two operations would be followed by another wave of evaluations. This time, the reports were more effusive, detailing that horizontal and vertical visibility was increased by 60-95 percent after one or more sprayings (Zieler 78). However, what the evaluations did not establish was any meaningful correlation between the clearing of foliage and a decrease in the incidence of NLF ambushes in those areas (Zieler 78). Nonetheless, Kennedy was encouraged by the reports, particularly as they provided him with an avenue to resist committing to a large-scale U.S. troop deployment in Vietnam. Zierler argues that the U.S. approach to counterinsurgency, into which Kennedy had by this point invested significant political capital, was predicated on the belief that denying NLF guerilla forces the tactical advantage of forest cover was of the foremost importance (Zieler 78, 82). This strategy was entirely predicated upon "the substitution of high-technology solutions for ground troops," and Ranch Hand's apparent successes to that point meant that it was increasingly presenting itself as an exemplar for the wisdom of this approach. As a result, SASF defoliation spraying operations were expanded throughout 1963, with the administrative process for requesting approval for future operations being decentralised and expedited in order to shorten the time between field requests for tactical defoliation and the execution of spraying missions (Buckingham 89).

By 1971, the U.S. Air Force had conducted 19,905 spray missions, at an average of thirty-four per day. The effects of this operation were devastating:

> In some regions, defoliation changes the amount of rainfall, heat and wind on the forest floor. Grasses, shrubs, and bamboo spread over the defoliated forests. Bamboo grows in high thickets, preventing hardwood forests from regrowing. Attempts to defoliate, burn, and cut bamboo do little to keep it in check. Vietnamese report that chemicals entering the Mekong River upstream are killing biological life in the estuary. Herbicides are destroying the food wild animals depend on for their survival. . . . The destruction of Vietnam's environment is so great that even before the war ends, some scientists are calling it "ecocide" (Wilcox 12-13).

In 1970, *Science* published the findings of an extensive study conducted by the American Association for the Advancement of Science (AAAS), which determined that one fifth to one-half of South Vietnam's mangrove forests had been completely destroyed; that half the trees in the hardwood forests north and west of Saigon were dead; and that the U.S. Army's crop destruction failure had been a total failure, because "nearly all the food destroyed would actually have been consumed by civilian populations" (qtd. in Zierler 132). The human costs were equally stark, as the 2,4,5-T in Agent Orange was contaminated with TCDD-dioxin, "a carcinogenic, fetus-deforming, and quite possibly mutagenic chemical" (Wilcox 7). Vietnamese scientists have since determined that "dioxin hotspots are responsible for thousands of congenital malformations (birth defects) among Vietnamese," while American veterans have also accused the U.S. armed forces of exposing them to harmful chemical compounds (Zierler 7-8).

By this point, scientists and journalists in the United States had expressed criticisms of the program, and multiple attempts had been made by members of congress to cut off funding for herbicidal warfare in Vietnam, though these failed in each instance by substantial margins (Wilcox 16). By the late 1960s, the U.S. was also beginning to face international pressure through the United Nations to put an end to its use of chemical weapons in Vietnam. The U.S. government maintained that herbicidal weapons fell outside the remit of the Geneva Protocol 1925 which outlawed the use of antipersonnel chemical weapons (Zierler 101). Though the U.S. was not a party to this protocol, President Nixon was by this point developing plans to become a signatory, and in order to do so while also maintaining that the U.S. had at no point contravened it since its inception it was deemed imperative to argue that the military application of herbicides did not constitute a breach of its core principles and prohibitions.

However, by April 1970, after mounting pressure both domestically and internationally, the federal government moved to limit future operations which might expose humans to 2,4,5-T, both in the United States and in South Vietnam (Zierler 125). The Department of Defence (DOD) initially attempted to maintain that Ranch Hand operations had never sprayed Agent Orange in populated areas so as to maintain that the project had at no point employed *antipersonnel* chemical weapons. But following further pressure from U.S. scientists, who had by that point determined that pure 2,4,5-T was causing deformities in lab mice subjected to repeated doses of the substance, the DOD would eventually relent and change its policy, leading to a subsequent April announcement by Deputy Secretary of Defence David Packard that there would be a total suspension of Agent Orange spraying missions "pending a more thorough evaluation of the situation" (qtd. in Zierler 125).

A few crop destruction sorties using herbicides that did not contain 2,4,5-T were conducted by SASF units during the remainder for 1970, but Agent Orange and other 2,4,5-T based herbicides would not be used as part of Ranch Hand in South Vietnam again (Buckingham 175). After further internal deliberations, a series of official statements by the White House and the DOD announced that future uses of herbicides in South Vietnam would conform to the same policies restricting their use in the United States, meaning that they would only be employed in to clear foliage in the immediate vicinity of U.S. bases. Ranch Hand operations were progressively phased out from this point, with even crop destruction operations being terminated by January 16, 1971 (Buckingham 175).

With Operation Ranch Hand, the U.S. military had sought to re-shape the battlefields of Vietnam from the teeming jungle environment; where visibility was at a minimum, and the local knowledge of Vietnamese guerillas provided the revolutionary forces with a persistent tactical advantage; to a flattened wasteland which it presumed would create scant opportunities for insurgents to hide from the overwhelming firepower of its artillery, helicopters, and aircraft. In his history of the conflict, James Gibson characterised the U.S. approach in Vietnam as one of "technowar," which conceived of war "as a production system that can be rationally managed and warfare as a kind of activity that can be scientifically determined by constructing computer models" (156). Under such an approach, which strives to elevate the Aristotelian theory-practice model to frictionless apotheosis, the outcome of war would be determined by one prevailing logic: "Machine-system meets machine-system and the largest, fastest, most technologically advanced system will win. Any other outcome becomes *unthinkable"* (Gibson 23).

So pervasively had the U.S. become wedded to this approach during the conflict that it was extended not just to scientific systems for quantifying the dynamics of the war as it unfolded; or to the production of ever more sophisticated ways of extending the martial gaze, and therefore the destructive capabilities of U.S. weapons systems; but also to the strategic outlook for evaluating the environment in which the Vietnam War was to be fought. Where historically a commander confronted by hostile terrain deemed to be favourable to the adversary might have withdrawn and sought confrontation elsewhere, under the rubric of technowar the U.S. war machine instead simply opted to direct its efforts towards transforming that environment so as to make it more conducive to its preferred method of warfighting. Having determined that it had the means to defoliate Vietnam on a massive scale it proceeded to do so, largely ignoring what few data points it did gradually accrue which suggested that the practice of deforestation might not be yielding the desired tactical advantages in as decisive a fashion as it had initially assumed.

Viewed in this light, Operation Ranch hand begins to resemble an attempt to carry out an inversion of the logics presented in the treatments of the "vanishing battlefield" by the likes of Bousquet and Mégret. In their accounts, the crisis of the battlefield is described as stemming from "the appearance of more accurate and far-ranging weaponry in the second half of the 19th century," which would in turn force would-be belligerents who wished to challenge the conventional armed forces of the world's major powers to conduct their operations in environments less amenable to their war machines, such as jungles or urban environments, where the relative security conferred by a FOW might still be counted upon as a shield against the martial gaze (Bousquet "The Battlefield is Dead"). In response, Operation Ranch Hand appears as indicative of a desire on the part of the U.S. war machine during the mid 20th century to engineer a *return* of the battlefield through the chemically assisted obliteration of the jungle, that last redoubt of the guerilla fighter.

5.0 Negentropy and the Fantasy of Omniscience

Light in the absence of eyes illuminates nothing.

Visible forms are not inherent in the world, but are granted by the act of seeing.

—TREVOR GOODCHILD

If the doors of perception were cleansed, everything would appear to man as it is, infinite.

For man has closed himself up till he sees all things thro' narrow chinks of his cavern.

—WILLIAM BLAKE, *The Marriage of Heaven and Hell*

In mathematics you had peer review, definite proofs and answers,

but war was nothing but uncertainty multiplied by uncertainty.

—YOON HA LEE, *Ninefox Gambit*

Alongside the application of technical solutions designed to render the martial environment more amenable to the American way of war, another distinctive feature of the U.S. military's operational approach during the middle of the 20th century was the emergence of a new approach to command, predicated upon a quest for *control* over the battlespace. In a further elaboration of Gibson's notion of "technowar," Bousquet suggests that this shift, from traditional conceptions of command towards those of "command and control," was itself a consequence of a wider series of transformations towards a distinctive technoscientific regime of *cybernetic warfare* that took place during the Cold War (*Scientific Way* 123). The emergence of this way of warfare was fueled not only by the development of computers during the Second World War, but also the proliferation of a variety of a "conceptual and methodological apparatus which emphasises the controllable and predictable nature of war" (Bousquet, *Scientific Way* 123). The prospect that the next major geopolitical conflict, the Cold War, could turn "hot" at any moment loomed large, as it demanded that military institutions be able to "spring into action within the shortest of delays," an imperative which in turn led to the adoption of "new conceptual frameworks, techniques, and organisational dispositions that promised to restore control and predictability" (Bousquet, *Scientific Way* 123). In a harbinger of the contemporary U.S. military's pursuit of full-spectrum dominance, its Cold War counterpart's quest for control was often expressed in the form of a *fantasy of omniscience*, predicated upon the possibility of a frictionless, risk-free form of war that might dispel the FOW altogether. However, as we shall see, the reality of the application of the increasingly sophisticated assemblage of computational and communicative technologies, simulations, and statistical analyses that was central to U.S. technowar was often to produce an excess of information and abstraction often predicated as much on assumption and speculation as meaningful empirical data. In this way, the prevailing drive towards the quantification of all aspects of war tended to generate its own FOW, exacerbating the very problems it intended to solve (Bousquet 156).

What follows is an elaboration of the first inklings of the logics of control in the cyberneticist Norbert Wiener's early 1940s wartime research into the automation of anti-aircraft weapons systems. During this time, Wiener developed a model for control predicated upon establishing informational feedback loops between the target (aircraft plus pilot) and targeting system (anti-aircraft gun and operator) which he would eventually extrapolate outwards into the science of cybernetics. With reference to the work of Peter Galison and Théo Lepage-Richer, the chapter outlines the distinctive logics of an a*dversarial epistemology* underpinning Wiener's cybernetic theory which sought to distinguish between nature's blind, "Augustinian" tendency towards disorder and entropy, and the cunning, deceitful behaviour of an intelligent "Manichaean" opponent (Wiener, *Human Use* 11). From there, we shall examine how, under the unique pressures posed by the threat of nuclear warfare, cybernetics coalesced with the systems focused outlook of Operations Research, and the game theory of John von Neumann into what Paul Edwards refers to as a "Closed-World" discourse that produced "a radically bounded scene of conflict, an inescapably self-referential space where every thought, word and action is ultimately directed towards a central struggle" (12).

Emerging in response to U.S. concerns over the increasing influence of international communist movements, we shall see how this discourse found in the computer a privileged tool and metaphor for command and control that, in combination with the increasing range of air-power and the destructive potential of nuclear weapons, it was hoped would safeguard the U.S. national interest during the Cold War. Though originally intended to provide a bulwark against the cunning Manichaean intellect of its adversaries, the chapter concludes by affirming Bousquet's argument that the U.S. military's cultivation of cybernetic practices during the Vietnam war tended to treat its antagonists as idealised projections of own their own worldview (*Scientific Way* 158). Instead of being attentive to the multi-layered nuances of the grand strategy being employed by the North Vietnamese which, in the words of two of their foremost generals "combined military struggle with political struggle and at certain stages of the revolution also with diplomatic struggle" (qtd. in Giáp and Dũng 24), the cyberised American war machine's overreliance on statistical models and game theoretic axioms could only make sense of their adversary's plans and behaviours in terms of their own limited conception of "rational" decision making (Bousquet, *Scientific Way* 158).

5.1 The Predictor

In *The Closed World*, Paul Edwards locates the genesis of cybernetics in the Allies' struggle to develop reliable ground-based anti-aircraft weapons during World War II (*Closed World* 45). Aircraft technology had advanced considerably since World War I, with aeroplanes becoming substantially faster and more manoeuvrable in the process. In order to protect Britain from the threat of German bombing raids, and eventually from unmanned V-1 flying bombs, ground-based antiaircraft guns provided a critical line of defense, but their human operators were struggling to keep up with the agility of their targets. The key difficulty here was that antiaircraft weapons needed to anticipate the future trajectory of their targets in order to score a hit (Edwards, *Closed World* 45). As Wiener himself would later explain in *Cybernetics*:

> [U]nlike all previously encountered targets, an airplane has a velocity which is a very appreciable part of the velocity of the missile used to bring it down. Accordingly, it is exceedingly important to shoot the missile, not at the target, but in such a way that the missile and target may come together in space at some time in the future. We must hence find some method of predicting the future position of the plane (9).

In an attempt to address this problem, Wiener conducted research into the possibility of developing an analogue calculating device called "the antiaircraft (AA) predictor," capable of characterising "an enemy pilot's zigzagging flight, anticipate his future position, and launch an antiaircraft shell to down his plane" (Galison, "Ontology of the Enemy" 229). However, in order to develop a mechanism that could do this Wiener would need realistic data from which to model of the movement of an evading aircraft:

> We realised that the 'randomness' of irregularity of an airplane's path is introduced by the pilot; that in attempting to force his dynamic craft to execute a useful manoeuver, such as straight-line flight or 180 degree turn, the pilot *behaves like a servo-mechanism*, attempting to overcome the intrinsic lag due to the dynamics of his plane as a physical system, in response to a stimulus which increases in intensity with the degree to which he has failed to accomplish his task (qtd. in Galison, "Ontology of the Enemy" 236).

The task of modelling this behaviour was challenging to say the least. In the end, Wiener, working in collaboration with Paul Mooney and Julian Bigelow, developed a rudimentary mechanical device designed to simulate the basic features of the dynamic of a gunner taking aim at an evading aircraft: "On a laboratory wall, a light-spot projector shot an intense white spot that followed a smooth but irregular back-and-forth motion, careening its way from wall to wall every fifteen seconds" (Galison, "Ontology of the Enemy" 236). An operator, wielding an analog control stick that was designed to be deliberately sluggish, would then attempt to guide the movement of a second colored light spot, with the objective of targeting the white light. The position of the operator's light signal would be recorded on magnetic tape, whose data, upon review, would highlight "the fluctuating difference between the 'intended' position and the actual position of the operator's light dot" in a fashion that the researchers hoped would mirror the properties of irregular motion exhibited by an aircraft in flight (Galison, "Ontology of the Enemy" 236).

The data from these experiments produced two significant findings. First, that there was little correlation across the recorded fluctuations of different operators. Second, that there was a high degree of autocorrelation between the same operator's earlier and subsequent movements. Reflecting on these two patterns, Wiener and his colleagues determined that while prediction would be unreliable if the data from one operator was used to project the trajectory of another, the data of any given operator could be relied upon to be quite self-consistent (Galison, "Ontology of the Enemy" 238). This "suggested that a more refined AA predictor would use a pilot's own characteristic flight patterns to calculate his particular future moves and to kill him" (Galison, "Ontology of the Enemy" 238). Because the AA predictor's algorithm was based on statistical input derived from the pilot/aircraft's past performance, the mechanism functioned as a kind of iterative learning machine. But what was of even greater significance, from Wiener's point of view, was that in order to combat a fast moving aircraft his AA predictor effectively necessitated the reconceptualisation of the pilot/aircraft, and gunner/AA predictor "as servomechanisms within a single system" who, from the perspective of the overall pattern of behaviour established by the movement and exchange of information through the process of feedback, were irreducible from each other (Galison, "Ontology of the Enemy" 240).

In a nod to the *kybernḗtēs*—the ancient Greek word for steersman—Wiener would coin the term "cybernetics" in 1947 in order to inaugurate what he saw as a novel science of command and control that emerged out of his wartime research into servomechanisms. Wiener chose this reference because he saw a parallel between the steersman holding a rudder and the model of an anti-aircraft unit, as both function as self-steering systems whose direction is governed by an information feedback loop. Unfortunately, Wiener's attempts to develop an AA predictor that could anticipate the future behaviour of the pilot/aircraft did not prove fruitful, as a pair of geometrical prediction machines developed by Hendrik Bode were able to outperform his more sophisticated prototype (Galison, "Ontology of the Enemy" 244). Though Wiener's system showed promise, the computing power simply didn't exist in 1940s America to produce a sufficiently large statistical base upon which to base the algorithm for his predictor. In his initial evaluation of the project's failure, Wiener speculated:

> To what extent the negative result of this investigation is due to bad tracking, . . . and to what extent to the fact that the enemy plane has a very considerable chance to change its flight pattern, whether voluntary or involuntary, in the twenty seconds of projectile flight, is not yet fully clear. I intend to study these matters with somewhat greater thoroughness, although I am convinced that the last named effect is preponderant (*Statistical Method of Prediction* 7).

Though more work would be required to provide a proof, Wiener was certain that it was the ability of the pilot to conduct unpredictable manoeuvres in the brief window after the projectile was fired that had scuppered his efforts to develop an effective predictor. Wiener's pursuit of a solution would lead him to a behaviourist conception of the function of both living organisms and inanimate machines. In this schema, the straightforward chain of causality, where A might be viewed as the cause of effect B that was typical of Newtonian mechanics was replaced with a circular account, where a feedback loop can create a dynamic in which A is the cause of effect B which is itself the cause of A (Bousquet, *Scientific Way* 104). As a result, reductionist scientific frameworks that sought to study physical mechanics by evaluating the operation of parts within a whole were replaced by "systemic holistic understandings of any object of study" (Bousquet, *Scientific Way* 104).

5.2 Information, Entropy, Adversariality

By 1950, Wiener had fully globalised his views, leading him to posit that, from the perspective of scientific enquiry, there was no meaningful difference between human intentionality and the self-regulation of machines:

> In the air-ground battle, it was a short step for Wiener and Bigelow to take the pilot-as-servomechanism directly over into the AA gunner-as-servomechanism and thence to the operation of the heart and proprioceptive senses. From the body, it was us more generally-we humans-whose intentions could be seen as none other than self-correcting black-boxed entities and finally nature itself that came to be seen as a correlated and characteristic set of input and output signals (*Ontology of the Enemy* 264).

However, Wiener had not forgotten the aircraft pilot whose cunning manoeuvres had so cruelly stymied his plans to construct a working AA predictor. In order to account for the possibility of the intervention of intelligence within a self-regulating system, Wiener's research into cybernetics would eventually provide him with a framework through which he could reconceptualise science in general (and cybernetics in particular) as a decidedly *adversarial epistemology* levelled against both the limits of knowledge and the chaos of disorganisation: "The scientist is always working to discover the order and organization of the universe, and is thus playing a game against the arch enemy, disorganization" (*Human Use* 34). Here, in order to produce knowledge, and in doing so maintain order, the scientist engages with knowledge's limits by treating them as an adversary to be overcome (Lepage-Richer 205).

Underpinning Wiener's view that cybernetics was embroiled in an adversarial struggle against the limits of knowledge was a very particular understanding of the concept of information that was both informed by, but also departed in a very significant way, from the work of the American mathematician and electrical engineer, Claude Shannon.

Prior to World War II, information was typically understood as the communication of human knowledge (Bousquet, *Scientific Way* 102). However, Shannon's research into fire-control systems and cryptography at AT&T Bell Labs in the late 1940s would provide a novel conception that would sever the link between the *meaning* of information from the *process* by which it was transmitted. In his 1948 paper, "A Mathematical Theory of Communication" Shannon frames the problem of communication as being one of reproducing at one point a message being sent from another point (3). Although Shannon acknowledged that messages have meaning, he observes that their semantic content is irrelevant to the engineering problem of reliably transmitting the message. Instead, "the significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design" (Shannon 3).

As Katherine Hayles observes, this definition treats information as "a probability function with no dimensions, no materiality, and no necessary connection with meaning" (18). In order for a message to be sent, Shannon determines that a communication system is needed in order to encode it into a signal and then decode it at the other end. Therefore, he suggests that any such communication system will contain five essential parts:

1. An *information source* that produces a message to be communicated.

2. A *transmitter* converts the message into a transmissible signal.

3. A *channel*, or medium for transmitting the signal.

4. A *receiver* that can reconstruct the message from the signal.

5. A *destination,* which is the person (or thing) for whom the message is intended (7).

In addition, Shannon theorised the inevitable presence of a *noise source* that hampers the straightforward transmission of the signal by introducing stochastic interference within the channel or medium (Bousquet, *Scientific Way* 104). In order to resist the corruption of the signal by noise, Shannon stresses the need for some amount of redundancy, which would in effect preserve the order of the original message in the face of the chaos of the noise source (13). From here, Shannon's next step would be to quantify the amount of information being conveyed in a signal through a basic unit of measurement, which, on the suggestion of his colleague, the statistician J. W. Tukey, he named the binary digit, or *bit* (32). One bit would represent the choice between two mutually exclusive choices, creating a binary logic of true or false, or zero and one. Thus, if information is to be transmitted, it will "therefore be broken down into a sequence of optimal (i.e. more or less equally probable) binary choices that would identify the correct message from the range of possible messages" (Bousquet, *Scientific Way* 105).

In this way, Shannon's "The Mathematical Theory of Communication" (1948) establishes a certain correspondence between the amount of *uncertainty* concerning the number of possible alternative states (or symbols) contained within any given information source, which he refers to as its *information entropy* (14). The larger number of possible alternative states a message can have, the higher its informational entropy. For example, the English Alphabet has 26 letters, or possible states, so any one letter has a higher information entropy than a number in binary code, which has only two possible states. Here, the quantity of information in any given message is never a measure of the content, but rather describes a function of the relation between this message and all possible other messages which might have been assembled under the equivalent constraints (Malaspina 40). Similarly, the more *improbable* a message is, the more information it will contain when compared with a highly probable one. As Shannon's colleague, Warren Weaver put it: "[I]n this new theory the word information relates not so much to what you *do* say, as to what you *could* say. That is, information is a measure of your freedom of choice when you select a message. . . . The concept of information applies not to the individual messages, as the concept of meaning would, but rather to the situation as a whole." In other words, the more predictable or redundant a message is, the less *new* information it provides.

However, when Wiener incorporated Shannon's work into his own modelling of communication in command and control systems he emerged with an inverted account of the concept of information. Instead of aligning information with uncertainty, Wiener defined it as the *negation* of entropy, or *negative* entropy—a term which would eventually settle, following its coinage by the physicist Leon Brillouin, into the neologism *negentropy* (Malaspina 17). As Wiener himself put it: "The notion of the amount of information attaches itself very naturally to a classical notion in statistical mechanics: that of *entropy*. Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other" (*Cybernetics* 17). Since the 1930s, scientists had used the term *homeostasis* to refer to the process through which living organisms self-regulate in order to maintain a stable state in the face of change (Bousquet 110). Wiener adopted this term, and applied it to all systems, both animate and inanimate, which exhibit behaviour that relies on negentropic processes to maintain internal order and stability in the face of entropy and an ever changing surrounding environment. Thus, where Shannon's entropy functions as a measure of information, in Wiener's usage it describes the amount of disorder or noise in a system. Information, on the other hand, switches from being a measure of the degrees of freedom or possibility within a message in the hands of Shannon, to "a measure of increased constraint, associated with ideas of organization and order, bound to decrease entropy" (Malaspina 17).

Though these two polarised accounts of information and uncertainty were for the most part describing the same phenomena albeit with an inverted terminology, the discursive implications of their respective framings would nonetheless have a significant impact on subsequent developments in the study of many different kinds of systems, as well as in both the concept and conduct of war throughout the 20th and 21st centuries. Despite the fact that Shannon in particular was quite judicious in how he applied information theory, repeatedly stressing that it described a very specific context encompassing the efficient transmission of a message through a communication channel, as Hayles notes, "others were quick to impute larger linguistic and social implications to the theory" (54). Wiener was among those who could not resist engaging in wider extrapolations based on the breakthroughs in information theory. For him, the key implication of his inversion of Shannon's concept of information was the view that nature provides a "passive" source of resistance against attempts to capture it as an object of knowledge (*Human Use* 36). This outlook would lead him to framing the task of a self-regulating system in terms of a struggle against the inexorable force of entropy: "It is my thesis that the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback" (*Human Use* 26).

From here, Wiener would then proceed to characterise the two principal shortcomings of science, but also of the cybernetic task of communication and control, by what he called the two "evils" or "demons" of knowledge: the Augustinian evil of contingency, chaos, and entropy, which he associated with nature; and the Manichaean evil of deception and trickery, which he associated with the presence of an oppositional intelligence of precisely the sort one would associate with the qualities of *mêtis* (Lepage-Richer 200):

> The scientist is always working to discover the order and organization of the universe, and is thus playing a game against the arch enemy, disorganization. Is this devil Manichaean or Augustinian? . . . The Manichaean devil is an opponent . . . who is determined on victory and will use any trick of craftiness or dissimulation to obtain this victory. In particular, he will keep his policy of confusion secret, and if we show any signs of beginning to discover his policy, he will change it in order to keep us in the dark. On the other hand, the Augustinian devil, which is not a power in itself, but the measure of our own weakness, may require our full resources to uncover, but when we have uncovered it, we have in a certain sense exorcised it, and it will not alter its policy on a matter already decided with the mere intention of confounding us further (Wiener, *Human Use* 34-35).

Crucial to this distinction is the idea that where the rules of nature are unchanging, an oppositional intelligence, such as the pilot of an evading aircraft, is not bound by any particular set of rules, and may actively and wilfully attempt to sow confusion by changing their patterns of behaviour in a fashion analogous to a poker player employing the art of the bluff against their opponent. For this reason, though one can regard the straightforward application of the scientific method as a reliable approach for the study of natural laws, it "tends to make [the scientist] the dupe of unprincipled people in war and politics" (*Human Use* 36). Viewed from this perspective, Wiener affirms that the Aristotelian scientific method of induction-deduction, which makes observations, creates models, and then tests those models against reality in a continual cycle can ultimately attain purchase on the Augustinian forces of nature. The sticking point is the Manichean demon, who "is playing a game of poker against us and will resort readily to bluffing; which, . . . is intended not merely to win on a bluff, but to prevent the other side from winning on the basis of a certainty that we will not bluff" (Wiener, *Human Use* 35). In this way, an opposition possessed of Manichean *mêtis* becomes an "active source of resistance," and thereby represents the ultimate foil for the pursuit of order, certainty, whereas nature's resistance is "passive," and the scientist "need not fear that [she] will in time discover his tricks and method and change her policy" (*Human Use* 36).

Wiener also acknowledges that although the scientist's struggle against entropy may seem hopeless because the second law of thermodynamics insists that systems will tend towards disorder, this trend can only be valid for an entire closed system (or indeed, at a maximal scale, the universe itself), but that it does not necessarily apply to a non-isolated section of it, where one can produce "local and temporary islands of decreasing entropy" (*Human Use* 36). Thus, it is the task of the scientist, or better yet, the cyberneticist, to engage in a continual warding off of the precipitous slide into entropy caused by both the Augustinian and Manichaean demons.

Where Wiener was happy to unambiguously point the finger towards the Manichaean demon when assigning the blame for introducing disorder into a social system, his account of the source of disorder in Augustinianism was more complicated. Wiener was well aware of the breakthroughs in statistical physics made by the likes of James Clerk Maxwell, Ludwig Boltzmann, and Josiah Willard Gibbs, who had each demonstrated in different ways how the seemingly ordered universe described by Newtonian physics could only be accounted for through a recourse to statistical measures. The key problem that classical mechanics was attempting to deal with concerned the question of how to account for the thermal behaviour of macroscopic bodies when applying a classical mechanical model to their microscopic components (Uffink 923). In principle, by comparing the state of a system at any moment in time with a measure or equation of motion which can project the state forwards in time the state of the system can be calculable at any point in the past or present. However, in practice, when carrying out a process at the macroscopic scale it is impossible to precisely measure the exact positions and velocities of all the particles at the microscale. As David Lindley explains: "atoms have definite properties at all times and behave, in theory, with absolute predictability. But the physicist cannot hope to know precisely what every atom is doing, so is forced to resort to a statistical description" (161). Statistical mechanics was developed in order to bridge this gap via what Gibbs termed the "statistical ensemble," which refers to a large (or potentially even infinite) number of virtual idealizations of the system at any given moment that can collectively account for all of the possible states that the referent system might be in (Uffink 995-997).

For Wiener, the necessity of employing statistical measures, such as Gibbs' ensembles, in order to understand natural processes destabilised the certainties science strives to acquire, and thus "function as manifestations of nature's resistance to revealing itself" (Lepage-Richer 206). However, Wiener did not accept that nature was ineffable, nor that its resistance to science was absolute: "the Augustinian devil is stupid. He plays a difficult game, but he may be defeated by our intelligence as thoroughly as by a sprinkle of holy water" (*Human Use* 35). For Lepage-Richer, Wiener's Augustinian Devil can therefore be regarded primarily as a description of the limits of science's own "tools and knowledge," rather than as an attempt to regard nature as being inherently inaccessible to a scientific approach (206-207) . Of course, Wiener remained an adherent to the second law of thermodynamics, while nonetheless arguing it might at least be negotiated through the "production of a local zone of organization" in the face of the general tendency towards entropic disorder (34). As Lepage-Richer puts it, "knowledge, in the context of Wiener's Augustinian framework, was thus reformulated into the production of a localized, cybernetically enforced order against chaos and disorganization" (208).

As Wiener worked to generalise and abstract the principles of cybernetics from its humble origins as the study of "control and communications in the animal and the machine" throughout the late 1940s and early 1950s the size and scope of its study and application expanded dramatically (qtd. in Heims, *von Neumann and Wiener* 184). At the first of what would become a series of Macy conferences on cybernetics, held between 1946 and 1953, Wiener proposed that the fields of statistical mechanics, communication engineering, biology, psychology, and social science could all be brought together via their overlapping concern with the role of communication (Bousquet, *Scientific Way* 116):

> The neuromuscular mechanism of an animal or of man is certainly a communication instrument, as are the sense organs which receive external impulses. Fundamentally the social sciences are the study of the means of communication between man and man, or, more generally, in a community of any sort of being. The unifying idea of these disciplines is the

> MESSAGE, and not any special apparatus acting on messages (qtd. in Heims *The Cybernetics Group* 22).

In the wake of the first Macy conference a number of social scientists would adopt the principles of cybernetics and translate them into their own fields of inquiry. For example, by 1956, the anthropologist Gregory Bateson was overseeing a collaborative research project that sought apply a communicational approach "to the study of a wide range of human (and some animal) behaviour" with a particular focus on schizophrenia, while also encompassed family dynamics, psychoanalysis, evolutionary processes and more (Bateson et. al 154-156). Others, such as the political scientists Karl Deutsch, and David Easton, were incorporating notions of informational feedback in their examinations of governance and political systems (Bousquet, *Scientific Way* 117). As Bousquet observes, "the scope and ambition of cybernetics entailed the development of a new language that would be common to all the scientists and social scientists studying systems of control and communications across all disciplines" (*Scientific Way* 118). But while the field of cybernetics was expanding, Wiener himself was becoming increasingly wary of the dehumanising potential of applying cybernetic outlooks to human social systems. In particular, the devastating effects of the atomic bombing of Hiroshima and Nagasaki prompted him to reflect on the growing role being played by science in intensifying the horrors of war:

> Ever since the atomic bomb fell I have been recovering from an acute attack of conscience as one of the scientists who has been doing war work and who has seen his war work a[s] part of a larger body which is being used in a way of which I do not approve and over which I have

> absolutely no control. I think the omens for a third world war are black and I have no intention of letting my services be used in such a conflict (qtd. in Galison, "Ontology of the Enemy" 253).

Despite Wiener's unease, Pandora's Box had already been opened, and the rapidly growing "cybernetic conceptual apparatus" of control and communication to which he had contributed so much would soon play a substantial role in transforming the hierarchical command structures of the U.S. armed forces throughout the 1950s and 1960s (Bousquet, *Scientific Way* 118).

5.3 The Closed World

As the new geopolitical balance of power that would define the Cold War throughout the middle period of the 20th century began to take shape, the U.S. military increasingly turned towards the dual promises of cyberisation and computerisation as a bulwark against the manifest uncertainties of a potential future nuclear conflict. During this time, the backdrop established by the threat of a nuclear war between the West and the Soviet Union quickly became the pervasive and exclusive geopolitical framework through which all other martial policies, discourses, and rhetoric were both interpreted and formulated (Bousquet, *Scientific Way* 123). In its search for an appropriate response that would safeguard its national security, the U.S. military adopted what Edwards refers to as a "Closed-World" discourse that carried over the adversarial relationship that Wiener had cultivated towards entropy and disorder into the martial sphere. Because the threat of nuclear devastation was so immense, a conception of war predicated on chance, chaos, and uncertainty was not particularly savoury in the atmosphere of paranoia created by the Cold War. In its attempt to assuage political and civilian concerns about how to safely manage the existential risk of a potential nuclear exchange, the conceptual framework of the Closed-World viewed war's many contingencies as the products of "information deficiencies" which it was hoped could be "overcome by the appropriate deployment of negentropic information technologies and computerised simulations of conflict" (Bousquet, *Scientific Way* 124).

For Edwards, a discourse consists of a distinctive language; a set of common values, practices and technologies; and an overarching worldview informing attendant political and institutional structures ("Systems Discourse" 247, *Closed World* xiii). In this sense, Edwards' usage of discourse shares some commonalities with Kittler's notion of the "discourse network," which encompasses a "network of technologies and institutions that allow a given culture to select, store and process relevant data" (*Discourse Networks* 368). In the case of the Closed-World discourse, Edwards describes the Truman Doctrine, which sought to "contain" the spread of communism, as the cornerstone of U.S. foreign policy throughout the Cold War period. This outlook had a profound effect on establishing the U.S. worldview from the 1950s on in a fashion that would gradually lead to a wide-ranging restructuring of American civil society, as well as a particular focus "on the development of technological means to project military force across the globe" (Edwards, *Closed World* 8). In order to achieve this ubiquitous military presence, the U.S. military placed its faith in computers, which were viewed as technological "force multipliers" that could help to reduce the numbers of necessary combat personnel, and thereby enable U.S. forces to be spread more widely as needed (Edwards, "Systems Discourse" 246). Furthermore, computers promised to restrict the chances for human error (for example, during acts of mathematical calculation), provide more sophisticated possibilities for modelling and processing data garnered from military intelligence operations, automate a variety of difficult tasks, and generally increase the coordination and speed of fighting forces (Edwards, "Systems Discourse" 246).

As computers became increasingly integrated into the U.S. military's command apparatus, a language of "systems, gaming, communication, and information [was] erected, privileging abstract formalisms over 'experiential and situated knowledge' (Bousquet, *Scientific Way* 124). As a result, forms of martial uncertainty towards which there had been a burgeoning awareness thanks to the contributions of Clausewitz, Berenhorst, Hale, and others during the 19th and early 20th centuries were now, thanks in part to a growing familiarity with cybernetics and information theory, coming to be conceptualised as forms of entropy, information uncertainty, and disorder. However, where Clausewitz had stressed the importance of combat experience, a familiarity with military history, and the incisiveness of the commander-as-genius as the key tools for mitigating the effects of friction, the Closed-World discourse sought to overcome what it viewed as the sources of martial disorder through the appropriate application of negentropic information technologies, carefully-designed command and control structures, wargames, and various other forms of conflict simulation. For Edwards, computers played a pivotal role in this process for two main reasons: "First, they allowed the practical construction of central real-time military control systems on a gigantic scale. Second, they facilitated the metaphorical understanding of world politics as a sort of system subject to technological management" (*Closed World* 15).

Underpinning the impetus to transition the U.S. military towards computerised cybernetic warfare was the unprecedented strategic problem posed by the threat of nuclear conflict. Of all the technological advances that had occurred during the two World Wars, no other development had a remotely comparable effect upon the field of martial thought than did the atomic bomb. For Bernard

Brodie, a member of Yale University's political science faculty who would go on to lay down many of the principles of nuclear deterrence, news of the atom bomb's destruction of Hiroshima on August 7, 1945 prompted an emphatic declaration: "Everything that I have writen is obsolete" (qtd. in Kaplan 9). As Fred Kaplan observes in his brilliant history of American nuclear policy, *The Wizards of Armageddon*, "the whole conception of modern warfare, the nature of international relations, the question of world order, the function of weaponry, had to be thought through again" (9). Though his initial focus had been on naval strategy, by 1950, Brodie had decidedly changed course. Recognising that "historically, navies have had value primarily in long wars, and the atom-bomb war would not last very long," he opted to join the Air Staff of the U.S. Air Force, who were at that time the ascendant force within the main branches of the American military thanks to their de-facto status as the delivery service for the atomic bomb (Kaplan 25).

By 1950, Brodie was firmly ensconced within the USAF's atomic intelligentsia thanks to the positive reception of a series of publications on the potential dynamics of nuclear strategy and its implications for the future of war. In these texts, Brodie argued that there would be no winner in an atomic exchange between two superpowers, and from there began laying down the basic principles of nuclear deterrence (Hables Gray 150). His newfound status as a doyen of nuclear strategy helped him land a leading role at the recently founded RAND (an abbreviation of "Research and Development") Corporation, a nonprofit research institute based in Santa Monica, California, that was contracted to work on a number of classified projects for the USAF. RAND's staff was made up of civilians, including many scientists who had carried out military research during the Second World War. Many had a background in Operations Research (OR)—or its civilian analogue, Systems Analysis (SA)—a field which sought to apply quantitative reasoning and mathematical models to the study of logistics, weapons, tactics, and strategy. OR emerged in response to the many new technological inventions which were being employed during the World Wars, such as radar, long-ranged bomber aircraft, torpedoes, depth charges, sonar and so on. As Kaplan observes, "thinking about new problems was not an integral feature of the military profession. Someone had to devise new techniques for these new weapons, new methods of assessing their effectiveness and the most efficient way to use them" (52).

This task invariably fell upon the shoulders of scientists working on both sides of the Atlantic, including both Wiener and Shannon. Instead of concentrating on specific problems, the object of OR is to yield an improvement in the efficacy of operations by studying the dynamics of an entire system in order to identify significant patterns of behaviour. As Gene Rochlin explains: "the new agenda differed from the old in a major expansion of the scope of analysis; instead of treating the [system] as a series of isolated, interacting operations to be integrated from the top, it was now visualised as a single, complex, interrelated pattern of activities, to be analysed, coordinated, and optimised as a whole" (59).

During World War II, applying a systems focused analytical approach to technical problems in relatively constrained tactical environments yielded a number of promising results. For example, The British scientist Evan Williams was able to dramatically increase the efficacy of depth charges dropped from RAF anti-submarine aircraft after his modelling determined that the existing system was calibrated to detonate at too high an altitude (Wilson 55). Though this would in principle work well in situations where a U-boat captain had seen the incoming aircraft and responded by giving orders to dive so as to escape the impending depth charge, Williams' research determined that such situations were unlikely to yield a successful hit on the submarine regardless of when the depth charge was detonated. Instead, Williams demonstrated that better results would stem from optimising depth charges to detonate at low-altitudes in order to exploit the less frequent, but more advantageous situation where a U-boat does not realise it has been spotted, and can be still targeted on the surface (Kaplan 53). Once the RAF's Coastal Command had acted upon his recommendations "the results were so spectacular that U-boat crews thought the British were using a new and more powerful explosive" (Wilson 55).

By the end of World War II every unit in the USAF had its own operational analysis division. OR work extended from research facilities in the U.S. to fieldwork conducted on the frontlines in Europe and the Pacific, where military scientists could both gather data and provide guidance concerning the use of new weapons systems (Kaplan 54). This intermingling of civilian scientists and military personnel continued after the war, to the effect that scientists were not simply asked for advice, but were increasingly becoming involved at an earlier stage in war planning. Indeed, so pivotal to the war effort had America's scientists been that a concerted effort was made on the part of high ranking members within the USAF to ensure that their services would not be lost to more lucrative jobs in universities and private industries during the impending post-war demobilisation (Kaplan 55-56). In December of 1945 a lengthy report entitled *Toward New Horizons*, authored by Theodore von Kármán, the USAF's chief scientific advisor, was circulated among high ranking military officials in the Air Staff, informing them of the imperative that they "be advised continuously on the progress of scientific research and development in view of the potentialities of new discoveries and improvements in aerial warfare" (Kármán ix) through the creation of "a nucleus for scientific groups such as those which successfully assisted in the command and staff work in the field during the war. In these studies experts in statistical, technical, economic and political science must cooperate" (Kármán 103).

The formation of the RAND Corporation was a direct product of this initiative. Initially, it began as an Air Force Project established under a contract with the Donald Aircraft Company in 1945, before becoming an independent entity in 1947. RAND swiftly became the home of OR and SA, as well as the hub of an attempt to produce a form of rational analysis that was capable of "thinking about the unthinkable,"[26] i.e. the strategy of nuclear war. As Edwards observes, its "most important contribution was not any specific policy or idea but a whole way of thinking: a systems philosophy of military strategy" (*Closed World* 116). Planning for how to manage the use of nuclear weapons in the event that the Cold War with the Soviet Union turned hot was the central concern of the think-tank from its earliest days.

Because such a conflict was entirely unprecedented, and with only the U.S. military's own unchallenged deployment of nuclear weapons in Japan as a case study, RAND's analysts turned to wargames and simulations in order to model the dynamics of a potential future nuclear exchange. These models were breathtakingly complex, as analysts sought to account for all of the possible variables and contingencies in their efforts to generate a scientific understanding of how this new form of war might unfold (Bousquet, *Scientific Way* 143). Consider, for instance, this account of an attempt by RAND's Ed Paxson to create a plan for a potential World War III:

> His dream was to quantify every single factor of a strategic bombing campaign—the cost, weight, and payload of each bomber, its distance from the target, how it should fly in formation with other bombers and their fighting escorts, their exact routing patterns, the refueling procedures, the rate of attrition, the probability that something might go wrong in each step along the way, the weight and inaccuracy of the bomb, the vulnerability of the target,

[26] "Thinking about the Unthinkable" was the title of a 1962 book on the subject of nuclear strategy by the RAND systems theorist Herman Kahn.

the bomb's 'kill probability,' the routing of the planes back to their bases, the fuel consumed, and all the extraneous phenomena such as the weather—and put them all into a single mathematical equation (Kaplan 87).

However, there were a number of fundamental differences between the OR modelling that took place during World War II, and the new work on nuclear strategy being conducted at RAND in the 1950s. In the case of the former, OR analysts were frequently working with empirical combat data, often derived from a combination of fieldwork, weapons tests, and interviews with military personnel, whereas RAND's scientists could only produce their data regarding a hypothetical nuclear exchange from "speculation, theories, derivations of weapons tests [sic] results, sometimes from thin air" (Kaplan 87). Furthermore, the scope of the models being developed at RAND had expanded enormously compared to those of their counterparts in World War II. Where many of the situations in which OR had been applied up until 1945 described a relatively constrained tactical scenario, such as the targeting of a U-boat with a depth charge, or an aircraft with a ground-based gunnery system, in the words of RAND analyst Norman Dalkey, "[our] simulations range all the way from a very detailed representation of a full-scale global aerospace war down to, e.g., a computation of the damage inflicted on a static battalion of troops by a group of tactical aircraft dropping conventional high-explosive bombs" (*Simulation of Military Conflict* 2).

In the same report, Dalkey observes that the only possible way to calculate and optimise the increasingly complex, multivariable mathematical models being developed at RAND was to rely on the use of computers (*Simulation of Military Conflict* 2-3). However, this meant that models could only be constructed from data that could straightforwardly be translated into computer code, "that is into a program that can convert quantifiable inputs into quantifiable outputs" (Bousquet, *Scientific Way* 139). Or, as system analysts James Martin and Adrian Norman put it, "a model without numbers cannot be manipulated so measurement and quantification is a fundamental part of the description resulting from analysis, and the basis of the evaluation of systems design" (569). The problem here was that any phenomenon or dynamic that could not be quantified numerically or expressed in terms of a logical relationship was inevitably excluded from the model. The historian David Hackett Fischer refers to this as the "quantitative fallacy," which "consists in the idea that the facts which count best count most" (90). Hackett regards this as a fallacy because it presumes that the significance of a phenomenon is proportional to its susceptibility to quantification, and will tend to overlook "many ideational and emotional problems [which], cannot be understood in quantitative terms" (90). Similarly, Bousquet argues that within the Closed World discourse, any non-quantifiable aspects of warfare, such as "intuition, courage and willpower, those attributes which had been considered central to war for centuries, were thereby devalued" (*Scientific Way* 151).

Despite being heavily predicated upon empiricism, statistical modelling, and scientific rigour, the application of OR and SA at RAND was nonetheless inevitably compelled to rely upon a not insignificant amount of speculative estimation, especially regarding factors for which there was a dearth of information available. For the political scientist Klaus Knorr, SA tended to struggle under conditions of imperfect information, particularly in its efforts to account for less straightforwardly quantifiable variables, such as those stemming from the interactive nature of war:

> Costs may be uncertain, technology may be uncertain, the properties of military conflict situations may be uncertain, and the reactions and capabilities of the potential enemy nations

> are apt to be uncertain. The last uncertainty is of particular import; it is imperative that military choices be examined within a framework of interaction. An opponent's responses to our choices may, after all, curtail or altogether nullify the advantage we seek (qtd. in Wilson 133).

Compounding this issue, the existential stakes of nuclear war, which brooked no possibility of risk-taking, combined with a desire for predictability, lead analysts to "[constrain] uncertainty by either setting the possible variations of factors within clearly delineated numerical ranges and probability sets or by simply discounting all those elements that could not be treated in this bounded way" (Bousquet, *Scientific Way* 152). Where Wiener's cybernetics at least sought to negotiate uncertainty by temporarily establishing local islands of order through negentropic feedback processes, the prevailing approach in RAND's conflict simulations was, like the geometricist warriors of the 17th century before them, to simply ignore or heavily minimise its presence.

5.4 Game Theory

In addition to modelling the technical aspects of a nuclear exchange, RAND scientists also became increasingly preoccupied with the psychology and strategy of nuclear war. Where for the most part the martial science of World War II was preoccupied with Augustinian problems concerning the technical performance of kinetic weapons systems, or the sensory capabilities of systems such as RADAR and ASDIC which, though complicated, were nonetheless explainable through the application of the principles of well-established scientific fields such as physics and chemistry, the modelling of the actions of a Manicheam adversarial intelligence within the dynamic of a nuclear exchange required an altogether different approach. In order to deal with this problem, RAND turned to the strategic paradigm of game theory, developed by John von Neumann in a 1928 paper entitled "On the Theory of Games of Strategy," before subsequently being generalised for a much wider range of social and economic applications in a 1944 book written in collaboration with the Princeton economist Oskar Morgenstern. Employing a similar logical approach to the one employed in Pascal's Wager, game theory outlines a mathematics for the "rigorous analysis of situations of strategic interdependence" under conditions of uncertainty (M. A. Dimand and R. W. Dimand 2). Indeed, for von Neumann, the term "game theory" was something of a misnomer, as this anecdote recounted by the British Operations Research Jacob Bronowski illustrates:

> I [said] to him, since I am an enthusiastic chess player, "You mean, the theory of games like chess." "No, no," he said. "Chess is not a game. Chess is a well-defined form of computation. You may not be able to work out the answers, but in theory there must be a solution, a right procedure in any position. Now real games," he said, "are not like that at all. Real life is not like that. Real life consists of bluffing, of little tactics of deception, of asking yourself what is the other man going to think I mean to do. And that is what games are about in my theory" (qtd. in Poundstone 6).

In von Neumann's initial formulation, the term "game" refers to an adversarial situation where players make choices while also attempting to anticipate the decisions being made by their opponents. In order to make effective decisions under these conditions each player has to produce a calculus that accounts for the potential actions of their opponent, which in turn generates what the French

Mathematician Émile Borel called "psychological uncertainty" where "a stochastic element is introduced not by some truly random process, but by player A's lack of knowledge about the play of other agents" (M. A. Dimand and R. W. Dimand 2). More precisely, the object of game theory was to explain how rational players should make optimal strategic decisions in scenarios that can be described as "zero-sum" games, where the result is always an advantage for one side and an equivalent loss for the other, as is the case in poker. In order to do this, von Neumann demonstrated how, under these conditions, players can devise a strategy tailored towards maximising their potential gains and minimising their potential losses through a mathematical analysis of all possible combinations of moves. He named the proof which described this process the "minimax theorem" (Poundstone 7), and posited that a two-person, zero-sum game requires that both participants "act on the premise that the opponent has examined the potential payoffs in each case and acts in his or her self-interest" (Heims, *von Neumann and Wiener* 87).

By 1948, von Neumann was working as a RAND contractor, and by 1950 the institute was applying game theoretic analyses in their attempts to model a wide range of scenarios:

> [In the study of] systems for strategic bombardment, air defense, air supply, or psychological warfare, pertinent information developed or adapted through survey, study, or research by Rand [in its mathematics division] is integrated into models. . . . In this general area of research . . . the guiding philosophy is supplied by the von Neumann-Morgenstern mathematical theory of games (RAND's *Fourth Annual Report*, March 1950, qtd. in Edwards, *Closed World* 117).

Nonetheless, the problem that game theory proved to be particularly valuable for addressing, and for which it would ultimately become infamous, was that of nuclear strategy. As Edwards notes, "since no past experience applied, and since the threat of nuclear attack outstripped all others, predicating the actions and reactions of a nuclear-armed opponent carried a special urgency" (*Closed World* 118). Indeed, the RAND economist Alan Einthoven made the U.S. defence establishment's lack of prior experience with nuclear war pointedly clear during an argument with a USAF general when he remarked: "General, I have fought just as many nuclear wars as you have" (qtd. in Kaplan 254). The fact that a nuclear standoff between the United States and the Soviet Union seemed, to the RAND analysts, to closely mirror the dynamics of von Neumann's two-player, zero-sum games only helped to further ensconce game theory as the go-to methodology for modelling a nuclear crisis.

Perhaps the paradigmatic case of game theory, and especially of the efforts to encapsulate the principles of nuclear strategy, was the Prisoners' Dilemma,[27] which was first framed by the RAND mathematicians Merrill Flood and Melvin Dresher in 1950. It proposed a hypothetical scenario where two prisoners are accused of committing a crime together and placed in isolated prison cells. Unable to confer with each other, the prisoners may either choose to *cooperate* with each other and claim innocence, or *defect* by testifying against their accomplice. However, they are each offered a Faustian bargain: if only one prisoner betrays the other, then they are exonerated and can go free, while the betrayed is given a three year sentence; if both prisoners defect, then they each receive a two year sentence; finally, if both cooperate, then they both receive only a one year sentence.

[27] Though it is most commonly referred to as the "Prisoner's Dilemma," I follow Ian Hacking in preferring the terminology of "Prisoners' Dilemma" because, as he astutely observes, "the two prisoners are in it together" ("Winner Takes Less").

While the global payoff of the final choice has the highest combined value—a combined two years in prison, compared to one prisoner serving three years if one defects and one cooperates, and a combined four years if both defect—because neither prisoner has any way of knowing whether they will be betrayed by their accomplice there is nonetheless an apparently "rational" incentive for each to defect, using the following reasoning: "If my partner does not betray me, then I walk out free, while if [they do] betray me, then at least I can avoid the stiffer sentence" (DeLanda 85). In other words, the adversarial rationality that arises in game theory revolves around playing the best possible move for oneself that also accounts for the best move of one's opponent. Although this approach will likely not lead to a maximum gain that is optimised for *all* players, it will nonetheless assure that you as an individual agent can avoid a catastrophic maximum loss (Kaplan 65).

The reason the Prisoners' Dilemma became so well known was that it seemed to perfectly describe the dynamics of a nuclear standoff. Replace the two prisoners with a pair of atomic superpowers locked in a nuclear arms race with each other. Although the optimal global payoff is to disarm, if there is distrust and a lack of communication between the two superpowers then the prevailing logic is likely to go like this: "*if you can't maximize your gains by disarming, then minimize your losses with a nuclear buildup*" (DeLanda 97). However, as the Prisoners' Dilemma grew in popularity at RAND the mathematicians and scientists who made up the bulk of its staff soon ran into one of its major limitations: in order to be a reliable modelling tool, the analyst needed to be able to accurately calculate the precise expected values for each scenario under consideration. This was especially difficult in situations where the games involved more than two players, and more than two possible decisions for each player. Indeed, some situations would likely involve games where "players would have to play according to a mixture of random selection and laws of probability, just as a good poker player bluffs systematically but randomly, so that his strategy is not discovered" (Kaplan 67). Further complicating matters, in order to make optimal decisions in a zero-sum game, a player needs to establish not only the value of his own prospective decisions, but also those of his opponent so that they can be weighed against each other within a payoff matrix. If different players value the same conditions in different ways, then the minimax calculus shifts as well, potentially leading to a very different optimal strategy than the one outlined in the Prisoners' Dilemma as it is most commonly presented.

The difficulty of reliably quantifying the values of the adversary were further compounded by a problem of verification. As Duncan Luce and Howard Raiffa put it in their 1947 work on game theory:

> [We should like] to see if under any conditions, however limited, the postulates of the model can be confirmed, and if not, to see how they may be modified to accord better at least with those cases. It will be an act of faith to postulate the general existence of these new constructs, but somehow one feels less cavalier if he knows that there are two or three cases where the postulates have actually been verified (37).

Here, Luce and Raiffa observe that unless there is an independent way to verify the findings from any given game or simulation one is in effect submitting to an act of faith. Similarly, for the economist Thomas Schelling, who was at that time working as a researcher at RAND, attempts to simulate nuclear war could not be viewed as reliable, but were nonetheless necessary simply because there were no superior alternatives available: "We are poor in alternative ways of studying the phenomena empirically. . . . The knowledge we can get from experimenting with a game may not be comprehensive or terribly reliable, but, compared with what we have or can get in any other way, it looks good (qtd. in Ghamari-Tabrizi 179). But perhaps the greatest oversight being made during the early years of RAND's excursions in game theory was a lack of consideration to what happens when you substitute real human players for von Neumann's hypothetical minimax optimisers and observe what they actually do when placed in scenarios such as the one described by the Prisoners' Dilemma. The results, as Ian Hacking explains, tend to look rather different:

> In a one-shot game many people cooperate at once. There are, in most experiments, at least as many initial cooperators as initial exploiters. . . . People do not enter a game with a total strategy any more than chess players have a total strategy. We might ask: could there be a best simple-minded strategy for use in any circumstance? No, for just as in chess, it depends who you are playing. If your opponent is a villain who has decided always to defect, you would do best if you, like him, never cooperate. If your opponent is a Kantian who cooperates so long as you cooperate, then you should cooperate too ("Winner Takes Less").

The crucial insight here is that if you do not have some prior indication of how the other 'players' are going to behave, then you are entering the game blind, and will in all likelihood play suboptimally. Put another way, presuming that the enemy will always defect simply because that is the optimal behaviour to maximise your own gains in a finite zero-sum two player prisoner's dilemma does not guarantee that your opponent will reach the same conclusions and conform to your expectations. In fact, in order to play optimally against an array of possible strategies in an iterative prisoner's dilemma, where the ‘game’ is played many times, rather than just once, so that players can study and adapt to each other’s behaviours, the preferred strategy is to engage in what the mathematician Anatol Rapoport describes as “tit-for-tat,” where one cooperates on the first game, and from there simply copies your adversary’s last used strategy and repeats it back to them: “When he plays a villain who always defects, he defects after the first game. When Rapoport plays a fellow tit-for-tatter, they both cooperate forever” (Hacking “Winner Takes Less”). Rapoport’s strategy does not beat an individual defector, but in a mixed field of defectors and cooperators, which more closely mirrors how actual humans handle prisoner’s dilemmas, the defectors will sabotage each other’s gains, and the tit-for-tatter will emerge with a higher profit against the field on the whole (Hacking “Winner Takes Less”). However, because this discovery would not be made until Rapoport employed it while competing in a computer tournament held by Robert Axelrod in 1979, RAND were working with a flawed, pro-conflict model that was poorly equipped to deal with the actually existing tendencies exhibited by real humans (DeLanda 86).

Nonetheless, by 1965, awareness of the dangers of game theory’s widespread application was growing. Concerns were clearly on display in an internal report published by Norman Dalkey, which highlighted what its author viewed as a fundamental flaw in RAND’s game theory informed conflict simulations up to that point:

> Military events are determined by a large number of parameters most of which are stochastic; that is they consist of probabilities. In addition, for a large number of these, and in particular for those which refer to the future, their values are uncertain. The traditional notion of the *fog of war* should be supplemented by the notion of *the fog of the analysis of war*. The outcome of a conflict is determined as much by the forces and the strategies of the enemy as they are by the

> forces and strategies of the friendly side. Unless the analyst can take into account the wide range of options open to the enemy, the analysis is likely to furnish a completely inadequate picture of the worth of new weapons or their employment (*Models of War* 1-2; my emphasis).

Here, Dalkey extends the concept of the fog of war—which, like many military thinkers who have invoked it before and since, he neglects to define—to encompass the *analysis* of war, particularly as it pertains to the plans, values, and intentions of the Manichaean intelligence of the adversary. Though he was seemingly unaware of the pro-conflict bias that limited the efficacy of game theory's application to modelling real-world human dynamics, Dalkey's "fog of the analysis of war" nonetheless seems to describe its effect, in that it highlights the limits or biases of analysis as another potential source of uncertainty that can risk expanding, rather than mitigating, the FOW. Mirroring Wiener's account of Augustinianism, Dalkey implies that known stochastic values, such as those which might govern the effectiveness of weapons systems, or environmental conditions such as the weather, are at least somewhat discernable, and instead expresses a particular concern regarding the uncertainty stemming from a (Manichean) adversarial intelligence whose intentions and strategic disposition is opaque.

For Dalkey, this issue could be ameliorated by incorporating yet another technical solution, which entailed the application of a set or family of models rather than a single one. Though this move had some merit, for it promised to streamline the process of simulation and make it easier to make granular adjustments and correct for errors, it was also emblematic of a general tendency that was leading RAND's analysts towards an increasing degree of abstraction away from the situated experience of actual combat. As Sharon Ghamari-Tabrizi observes, this preference for simulation over experience was symptomatic of a growing belief within the atomic intelligentsia that "in order to approach nuclear war properly, one had to become a perfect amnesiac, stripped of the intuitions, judgements, and habits cultivated over a lifetime of active duty" (48). Nor was this outlook limited to the doors of RAND's offices in Santa Monica, as the appointment of Robert McNamara, a Harvard Business graduate with a background in systems analysis, to the position of Secretary of Defence in 1961 prompted a the rapid uptake of the tools and methods that had become commonplace at RAND across the U.S. military.

5.5 Command and Control

The first true test of a computerised U.S. military was the Vietnam war. The OR and SA approaches were applied throughout the conflict, as both of the two primary American overseers, the aforementioned McNamara, and General William Westmoreland, who commanded the U.S. forces in Vietnam between 1964 and 1968, "appear to have loved statistics for their own sake and surrounded themselves with men whose predilections were similar" (van Creveld, *Command in War* 252). For the first time, the U.S. had at its disposal an extensive cybernetic system of computers with which to gather and process real-time data concerning the progress of the war, while U.S. air-superiority seemed to promise that a clear and continuous picture of the circumstances on the ground could be maintained. Though there were few signs that the North Vietnamese would be defeated, by 1969 the U.S. war machine was nonetheless, in the view of Westmoreland at least, already on the brink of achieving omniscience over an entirely frictionless battlefield:

> On the battlefield of the future, enemy forces will be located, tracked, and targeted almost instantaneously through the use of data links, computer assisted intelligence evaluation, and

> automated fire control. With first round kill probabilities approaching certainty, and with surveillance devices that can continually track the enemy, the need for large forces to fix the opponent becomes less important. I see battlefields that are under 24-hour real or near-real time surveillance of all types. I see battlefields on which we can destroy anything we can locate through instant communications and almost instantaneous application of highly lethal firepower. . . . In summary, I see an Army built into and around an integrated area control system that exploits the advanced technology of communications, sensors, fire direction, and the required automatic data processing. . . . With cooperative effort, no more than 10 years should separate us from the automated battlefield (qtd. in Bousquet, *Scientific Way* 126).

For Westmoreland, the prospect of attaining battlefield omnipotence on this scale was no mere fantasy, but rather a logical extrapolation based on the technologies of command and control which were already being implemented by the U.S. military in Vietnam. In the period since 1945 the U.S. military had undergone an unprecedented expansion, complexification, and centralization of its armed forces and their command systems. The number of radio sets rose from one for 38.6 men in 1943, to one for every 4.5 men in 1971, while the invention of transistors—which replaced the vacuum tubes that had been commonplace in much electronic equipment before the 1960s—"greatly improved reliability and portability," and an "Integrated Wide Band Communications System (IWBCS) constructed in Vietnam between 1966 and 1968 at a cost of $500 million employed the new technique of topographic scatter to do away with the old cable network in providing voice, teleprinter, and data relay services from one end of the country to the other" (van Creveld, *Command in War* 238-239). Meanwhile, an extensive communications network was assembled bridging U.S. bases and command centres in

Vietnam, Guam, the Philippines, Honolulu, San Francisco, and Washington that combined underwater cables and the first satellite relay systems (van Creveld, *Command in War* 239).

The cumulative effect of implementing this vast communicative architecture was the production of an unprecedented and overwhelming amount of data, which, thanks in part to the heavily centralised command structure being employed within the U.S. military under McNamara's oversight, lead to informational oversaturation and bottlenecking (Bousquet, *Scientific Way* 156). The number of different technical systems which the U.S. military employed in Vietnam is simply to vast to enumerate in full here,[28] but if there is one example which best captures the spirit of its commitment to an all-encompassing cybernetic system of command and control it is most likely the covert electronic warfare operation codenamed Igloo White, which was conducted between 1967 and 1973, and cost almost $1 billion a year (Edwards, *Closed World* 3). The plan was ambitious, to say the least. It called for the establishment of an electronic barrier comprised of a vast array of camouflaged sensors to be deployed along a 100km strip of the Ho Chi Minh Trail—the labyrinthine network of roads, trails and jungle paths that together formed a vital supply route between Laos and North Vietnam (Jacob 12). "The sensors—shaped like twigs, jungle plants, and animal droppings—were designed to detect all kinds of human activity, such as the noises of truck engines, body head, motion, even the scent of human urine" (Edwards, *Closed World* 3). Once these sensors picked up a signal, it was transmitted to a terminal at the Infiltration Surveillance Center (ISC), housed inside the largest building in Southeast Asia, in Nakhom Phanom, Thailand. ISC staff would then use their computers to calculate the direction and rate of motion of the contact. This data, together with the sensor's coordinates would

[28] General Westmoreland seemed to be especially fond of pursuing advantage through the application of experimental, and often unconventional, technological "solutions." His autobiography, *A Soldier Reports*, recounts many of them.

then be radioed to Phantom F-4 jets on patrol above the Trail, whose navigational systems "automatically guided them to the 'box' or map grid square, to be attacked" (Edwards, *Closed World* 3).

Initial reports evaluating the effectiveness of the Igloo White operation were effusive, detailing the destruction of over 35,000 North Vietnamese and Pathet Lao trucks—at an approximate cost to U.S. forces, as Edwards wryly observes, of $100,000 per truck (*Closed World* 3)—a number which, if accurate, would have exceeded the total number of trucks in existence in all of North Vietnam (Bousquet, *Scientific Way* 157). In reality, Air Force reconnaissance flights were rarely able to locate the destroyed vehicles, and thereby verify the data being produced by the sensors. Instead of being destroyed at an alarming rate, North Vietnamese guerrillas were simply becoming adept at detecting, evading, or confusing the American sensors with their own technological responses, such as tape-recorded truck noises, bags or urine, and other decoys (Edwards, *Closed World* 4). For Edwards, the disparity between the ISC's reported successes and the reality of its profound limitations in the face of ingenuity on the part of the North Vietnamese forces was a microcosm of the entire U.S. approach to fighting the Vietnam War (Edwards, *Closed World* 4-5). Similarly, Bousquet argues that "by applying bargaining models based on game theory which assumed a common utility-maximising rationality and cost-benefit framework of analysis on all sides, American strategists erected an understanding of the enemy that was a mere reflection of the their [sic] own worldview and was presumed to obey the same strategic rationales" (*Scientific Way* 158).

Evidently, the U.S. forces' attempts at applying a cybernetic approach to war was, at best, barely capable of accounting for the Augustinian demons inherent to the martial environment of Vietnam, and at worst exacerbating them through the creation of internal sources of entropy and friction in the form of informational bottlenecks and overloads. Indeed, the situation parallels and anticipates the fundamental paradox of our contemporary moment of "infoglut" described by Marc Andrejevic, where "at the very moment when we have the technology available to inform ourselves as never before, we are simultaneously and compellingly confronted with the impossibility of ever being *fully* informed" (12-13). Though the U.S. military establishment had within it a great many prominent thinkers, such as Bernard Brodie and Andy Kaufman, who considered themselves Clausewitzians, their views were not able to sufficiently permeate its apparatus, and as a consequence the heavily centralised cybernetic command and control apparatus, dominated by OR, SA, and game theory, ended up exhibiting a narrow view of uncertainty as a lack of information that could be alleviated through a straightforward expansion of information gathering and communications technologies. As a result:

> [a]n entire regular command structure designed for conventional warfare was transplanted into a guerrilla environment for which it was not suitable. Extreme specialisation of personnel and of units, coupled with adherence to the traditional triangular chain of command, meant that headquarters was piled upon headquarters and that coordination between them could only be achieved, if at all, by means of inordinate information flows. . . . Though the signals network that the U.S. Army established in South Vietnam was the most extensive, expensive, and sophisticated in history, it proved in the end incapable of dealing with this 'bottomless pit'" (van Creveld, *Command in War* 258).

But perhaps even more damning than the Americans' implementation of a command structure that more often than not exacerbated sources of friction, and extended rather than mitigated the FOW, was its absolute failure to conceive of the revolutionary North Vietnamese forces as anything but a limited and mechanical projection of its own rational calculus:

> Since military effectiveness could only be measured by the yardstick of 'technological-production systems,' the North Vietnamese were necessarily inferior and victory was the only conceivable outcome for the American war machine. The closed-self-referentiality of cybernetic warfare effectively blinded its practitioners to the effectiveness of the asymmetric strategy deployed by their adversaries (Bousquet, *Scientific Way* 159).

In sharp contrast, the North Vietnamese were intimately familiar with the U.S. war machine, and therefore were able to benefit not only from their local knowledge regarding the environmental conditions and geography within which they were fighting, but were also able to maintain a much more effective model of their adversary's values, dispositions, and predilections.

This familiarity extended back to the Second World War, as throughout 1945 Hồ Chí Minh, Võ Nguyên Giáp and a number of other men who would go on to become key figures in the Việt Minh leadership received military training in both conventional and guerilla warfighting in order to assist their struggle against the Japanese occupation of Vietnam from a group of American special forces, codenamed Deer Team, led by Major Archimedes Patti (Currey, 88-92). Deer Team, who had been sent to liaise with Việt Minh guerillas by the Office of Strategic Services (OSS),[29] provided the Vietnamese

[29] The OSS, which was in effect the predecessor of the CIA, served as the principal U.S. intelligence agency during World War II.

with equipment, supplies, and training, and accompanied them during several of their first combat operations against the Japanese throughout August of 1945.

Though this brief initial encounter with Americans could scarcely prepare Giáp for the significantly transformed war machine that the U.S. would deploy in Vietnam throughout the 1960s, he was an astute and experienced commander, was mindful of the lessons of history—he had carefully studied Mao's lessons on guerilla warfare—, and had been fighting almost continuously since 1945, so it is perhaps unsurprising that he would go on to provide the following characterisation of his eventual adversary: "The United States has a strategy based on arithmetic. They question the computers, add and subtract, extract square roots, and then go into action. But arithmetical strategy doesn't work here. If it did, they would have already exterminated us with their airplanes" (qtd. in Hables Gray 160). Here, Giáp's account presents the U.S. as an inflexible and predictable opponent, whose strategy can, and was, anticipated and exploited by an adversary who simply refused to fight on its terms. It suggests that for all the effort RAND had put into demystifying the behaviour of the Manichean demon via the application of the techniques of OR, SA, and game theory, the end result was a state of affairs where the American war machine, caught up in a fantasy of omniscient and frictionless war, in actuality resembled a faulty servomotor stuck in a circular loop, its overwhelmed sensors clogged by an excess of unreliable data, ignorant to the actual strategies being realised by a more cunning and determined opponent.

2008: Body of Lies

In the vast desert expanse that opens out from the outskirts of the city of Dar'a, Syria, a lone van hurtles along an unpaved gravel road, its trajectory clearly visible thanks to the long line of dust it leaves in its wake. Eventually, having left the city limits far behind, the van comes to a halt. Its driver steps out to open the rear door, and releases his prisoner, a bearded American, who is instructed to "stay here." The American replies, "for how long?" The driver replies, "I don't know." The driver re-enters his van, and drives away, leaving the American standing alone in the sweltering heat of the desert. The American glances skywards, as if looking for something, but is forced to avert his gaze on account of the sun's harsh glare. Nonetheless, his intuition is correct, as an MQ-1 Predator, a remotely piloted aircraft (RPA), circles the scene at a sufficiently high altitude to evade detection by the naked eye.

The American is Roger Ferris, an agent for the U.S. Central Intelligence Agency (CIA), and his handlers, safely stationed at the CIA's headquarters in Langley, Virginia, watch him remotely through the MQ-1's nose camera as the scene unfolds from below. As Ferris wipes the sweat from his brow his commanding officer (CO), Ed Hoffman, calls for the camera's magnification to be increased so that he can confirm the identity of his agent. As the RPA's operators carry out their CO's instructions, Ferris' attention is drawn to a convoy of four large sports utility vehicles (SUVs) that have suddenly appeared on the horizon. They close the distance quickly, but do not stop. Instead, all four vehicles drive in circles around the isolated man, kicking up a dense cloud of dust and sand that completely shrouds the scene from its remote onlookers. Amid the commotion, Ferris is bundled into one of the SUVs by a group of heavily armed men, and before the dust can settle all four vehicles have exited the cloud, each one headed in a different direction. Back in Langley, the RPA's operators ask the CO which SUV he wishes to have followed so that he can continue to monitor the whereabouts of his kidnapped agent, but he is no gambler, and simply exclaims "sorry buddy."

This scene, which is over in a matter of minutes, occurs during the denouement of Ridley Scott's hackneyed orientalist[30] 2008 spy thriller, *Body of Lies*. In many ways, it represents a re-telling of many of the circumstances described in the previous chapter. It depicts a world where the technologically advanced American armed forces have further intensified their quest for battlespace omniscience and frictionless war, with the networked drone replacing the computer as the pre-eminent symbol of this endeavour. In contrast, a resourceful adversary—in this case an unnamed Islamist terrorist organisation obviously modelled upon Al-Qaeda—exploits the strategic and sensory limits of the U.S. war machine through an environmental tactic, using their SUVs to manufacture their own FOW out of dust and sand in order to stage an artfully choreographed escape from the Predator circling overhead.[31] This act embodies many of the qualities of *mêtis.* Contained within it is an implicit familiarity with the environment, with the vehicle, and of course with the behaviours and capabilities of their adversary, all of which are exploited in a moment of spontaneous creativity.

As a result, there is a suggestion in this moment that Hoffman's obstinate desire to maintain a continual state of overwatch has become somewhat predictable. During the film's opening set piece, Ferris observes a Predator overhead just before he is about to conduct an information exchange with a potential defector, and hastily calls Hoffman in order to implore him to reposition the drone, since its

[30] For an insightful treatment of Edward Said's orientalism as a failure of panoptic model of surveillance elaborated by Michel Foucault in the context of the U.S. state's global "war on terror" see Josef Teboho Ansorge's "Orientalism in the Machine."

[31] In reality, this particular scenario would likely have played out rather differently, as the operators of the Predator could have simply switched to an infrared sensor with which they could have attempted to track Ferris' movement through the dust cloud, and thereby determine which of the SUVs he was being transported in.

presence is making him appear conspicuous. Though Hoffman grants his request, and orders the Predator to turn away, leaving the skies momentarily clear, much of the rest of the film is experienced through the seemingly omniscient view of established by the RPV's cameras, implying that wherever Ferris is present, his handlers' remote eye is not far behind. In doing so, an obvious pattern of behaviour is established, which, by the time of Ferris' kidnapping, has clearly been noted by the terrorist cell, enabling them to devise the perfect stratagem to negate the Predator's gaze.In this sense, Hoffman's efforts to reduce uncertainty by maintaining a continual pattern of surveillance ends up creating the very conditions of possibility for the Manichean intelligence of the terrorist-cell to exploit through an act of uncertainty engineering. Here, a connection can be made to Jean Maria Arrigo's account of the epistemology of adversarial dynamics, which in many ways reads like a response to or development of Wiener's account of the ways in which a Manichean intelligence can disrupt scientific inquiry.

In her work, Arrigo sets out to provide an account of the "methodology of Intelligence" in the form of an *adversarial epistemology* by outlining a distinctive theory of knowledge that is applicable under the specific conditions of an adversarial dynamic (5). Though Arrigo's use of "Intelligence" here refers specifically to "the ideology, methodology, lore, and practices of inquiry for the national security goals in the United States" she is nonetheless careful to stress that the principles being outlined "should enable outsiders to reason from the perspective of Intelligence without mastery of political and military history and the arcane lore of Intelligence" (5). In contrast to what she views as the "cooperative epistemology" of science , adversarial epistemology is applicable to any situation in which two (or more) [Manichean] intelligences are engaged in an adversarial struggle for or competition over knowledge, which in turn might be part of a wider effort to attain a military, strategic, or political advantage (5-6).

In a scientific inquiry, the value of knowledge is determined by how truthfully it conforms to reality. However, in an adversarial dynamic, the value of knowledge primarily stems from its *utility* (6). In this sense, "adversarial epistemology aims for a temporary, not permanent, stock of knowledge of particulars" (6). Advantage determines the value of knowledge in an adversarial setting, so Arrigo stresses that this introduces "a gap between the validity of knowledge and the value of knowledge" because "on occasion, ignorance, error, or deliberate omission may serve advantage better, as when knowledge might evoke fears or sympathies or moral obligations that would compel us to act contrary to our advantage" (6). In other words, for reasons of strategic advantage there will often be situations where the truth is of little use, and instead it is preferable to dissimulate, to obfuscate, to exaggerate, to feign ignorance, or to induce doubt.

Within an adversarial dynamic, the firmest criterion for knowledge of any given phenomenon does not simply account for one's own knowledge, but also accounts for "all parties powerful enough to affect the phenomenon or our observations or interpretations of it" (6). In this respect, there can be different levels of enquiry into a given phenomenon. For instance, Arrigo characterises that the atomic bomb programs of both the U.S. and Germany constituted a first level form of inquiry, while also seeking to gauge the progress of the other, constituting a second level of enquiry (6). Following the conclusion of World War II, British armed forces captured ten German atomic scientists, and interviewed them regarding their assessments of the U.S. nuclear program—a third level of enquiry (7).

Because an adversary is dangerous, Arrigo asserts that a trade-off exists between the speed at which knowledge is obtained and the relative accuracy of that knowledge. An imprecise, but minimally sufficient form of knowledge that permits a decision to be made and action to be taken, even if it is predicated upon belief, may be preferable to more reliable, but less timely knowledge (7). However, the crucial feature which distinguishes adversarial epistemology from science is the possibility of deliberate deception on the part of the adversary. This deception can cut across all the aforementioned levels of enquiry, as the adversary may "deceive us about the nature of the phenomenon itself, about his knowledge of it, about his knowledge of our knowledge of it, and so on" (8). Where in science, a sustained, systematic approach to observation is often privileged, this approach can create a site of critical vulnerability within an adversarial dynamic since, as we see in *Body of Lies*, it can make the observer's behaviour quite predictable, and therefore easy to exploit. Instead, Arrigo suggests that it is preferable to employ techniques which limit the predictability of the knowledge gathering process, for example through the generation of superfluous data (Arrigo 9). Similarly, the best strategy to employ in order to detect deception is to search for *inconsistencies* and anomalies, rather than the regularities which science strives for, since a savvy adversary will know not to present a predictable pattern of behaviour.

In this way, Arrigo highlights a key vulnerability in the straightforward application of the Aristotelian method of enquiry to the adversarial environment of war. Instead, one must approach the gathering and processing of information through a Manichean lens, with care given to ensure that on the one hand the methods of gathering information do not present a predictable and exploitable pattern of behaviour; and on the other that a healthy scepticism is maintained during the *interpretation* of all knowledge developed under adversarial conditions, because it is possible that any observed phenomena may itself be the product of a "conceptual deception" (Arrigo 9). Put another way, where a naive Aristotelian approach may be enamoured with the expansion of a sensory net in order to reduce situational uncertainty, and thereby enhance the apparent fidelity of its models to reality (as in the Weather Wars of WWII, to give but one example), from the point of view of *mêtis*, a network of sensors is simply another opportunity for cunning acts of subterfuge and deception.

6.0 Entropy as Opportunity

Come, every frustum longs to be a cone, And every vector dreams of matrices.

Hark to the gentle gradient of the breeze: It whispers of a more ergodic zone.

—STANISLAW LEM, *The Cyberiad*

Fate lies within the light cone.

—LIU CIXIN, *The Dark Forest*

Despite the failure of the American war machine to achieve its objectives during the Vietnam war, Westmoreland's fantasies of omniscience would linger in the imaginary of the U.S. defence establishment for the remainder of the 20th century. As Bousquet points out, the main lesson that seemed to have been learned in the immediate aftermath of Vietnam was to avoid getting drawn into a similar asymmetrical conflict against a counterinsurgency, and so the opportunity for a sober assessment of the actual methods employed by the U.S. throughout the conflict was largely missed (*Scientific Way* 215-216). Instead of attempting to systematically address the limits of the cybernetic approach, the U.S. defence establishment instead returned to its main preoccupation: preparing for the possibility of a 'near-peer' confrontation with the Soviet Union. Many of the principles of cybernetic warfare persisted as a consequence, thanks in large part to the widely discussed prospect of an impending Revolution in Military Affairs, or RMA. This idea had its origins in the 1980s, but really came into its own during the 1990s, where a number of prominent figures within the U.S. military establishment became vocal advocates for the uptake of new technologies so as to ensure that America's armed forces would maintain their edge heading into the 21st century.

As the Cold War drew to a close, American defence intellectuals saw an opportunity to secure the United States' status as a global hegemon, but also had to confront the realities of substantial reductions in military spending as the absence of a major near-peer competitor following the collapse of the U.S.S.R. made maintaining bloated defence budgets seem less worthwhile to American politicians seeking reelection. The solution, for Andrew Marshall, who held the position of Director of the DOD's Office of Net Assessment between 1973 and 2015, was to cultivate what he referred to in an internal memorandum advocating for the RMA as "information superiority" over its opponents (3). Though Marshall viewed the development and uptake of new technologies as important, he also affirmed the need to instigate attendant changes in the organisational and operational domains of the American armed forces: "technology makes possible the revolution, but the revolution itself takes place only when new concepts of operation develop and, in many cases, new military organizations are created" (1). In this way, the hope was that more could be done with less, provided that the U.S. was able to seize the potential advantages inherent in being the *first* nation to carry out a transformational RMA (Marshall 3).

By 2000, there was sufficient optimism stemming from the recent American experiences in the Gulf war that Admiral William Owens outlined what was in effect an updated vision of Westmoreland's "battlefield of the future" as part of his advocacy for the RMA in his book, *Lifting the Fog of War*. In this work, written in collaboration with Ed Offley, Owens castigates the "hoary dictums about the fog and friction of war, and all the tactics, operational concepts, and doctrine pertaining to them" (15). Much like Westmoreland, Owens viewed the source of martial advantage through a relatively narrow, technologically deterministic lens, and as a result felt that the U.S. military was on the brink of a transformative shift:

> Never in history . . . has a military commander been granted an omniscient view of the battlefield in real time, by day and night, and in all weather conditions. . . . Today's technology promises to make that possible. . . . That technology can give us the ability to see a 'battlefield' as large as Iraq or Korea—an area 200 miles on a side—with unprecedented fidelity, comprehension, and timeliness; by night or by day, in any kind of weather, all the time. In a future conflict, that means an Army corps commander in his field headquarters will have instant access to a live, three-dimensional image of the entire battlefield displayed on a computer screen, an image generated by a network of sensors including satellites, unmanned aerial vehicles, reconnaissance aircraft, and special operations soldiers on the ground. The commander will know the precise location and activity of enemy units—even those attempting to cloak their movements by operating at night or in poor weather, or by hiding behind mountains or under trees. He will also have instant access to information about the U.S. military force and its movements, enabling him to direct nearly instantaneously air strikes, artillery fire, and infantry assaults, thwarting any attempt by the enemy to launch his own attack" (14-15).

For Owens, the RMA is underpinned by three core concepts: First, *battlespace awareness*, generated by advanced sensors for intelligence gathering, reconnaissance, weather monitoring, geolocation and the like. Second, *command, control, communications, computers, and intelligence,* which Owens refers to collectively by the acronym *C^4I*. Here, a network of computers and software is used to gather and process the data generated by the sensors devoted to establishing battlespace awareness. Third, *precision force use*, established through developments in precision and laser guided munitions, as well as cruise missiles directed by navigational satellites, but also extending to the deployment of computer viruses for targeting the information network of an adversary (15-16).

Despite its incorporation of some new technologies, Owens' account of the RMA and its implications hews remarkably closely to Westmoreland's vision. It maintains a heavily centralised command structure, envisioning a general or admiral giving orders and directing action from the security of a remote command facility. In this sense, in the words of RMA evangelist Norman Davies, there is an assumption that "what was referred to as the 'fog of war' is in reality disorder—the inability to maintain unity of action due to the shortcomings in the C3I systems" (86). For Bousquet, relatively simplistic accounts of the RMA such as these appear as "mere extensions of the ideals of cybernetic warfare and allied with a scientific worldview that has not taken on board the most significant developments in the field" (*Scientific Way* 218).

In the meantime, the computerisation of the U.S. military had been greatly intensified following the invention of the principles and protocols that would eventually culminate in the formation of the Internet at the DOD's Advanced Research Projects Agency (ARPA) during the 1960s and 1970s (Bousquet, *Scientific Way* 204). Just as the network steadily emerged as the pre-eminent form of social organisation by the 1990s, and the Internet the "central piece of an emerging network culture," a form of "network-centric" warfare (NCW) that was attentive to both the significance of network logics and also to developments in the non-linear sciences of chaos and complexity theory began to emerge during the same period (Bousquet, *Scientific Way* 185-186).

Although NCW was not always able to wholly disentangle itself from the problems of the cybernetic approach that were prevalent in the literature of its close cousin, the RMA, and could at times slip back into propagating Westmoreland's fantasy of omniscience, there were nonetheless explicit efforts within this new school of thought to break with the command and control model by appealing to notions of emergence and self-organisation in complex systems theory, through which order and novelty can emerge out of the chaos of disorder.

What follows is a brief overview of the history and precepts of NCW, beginning with the influential work of John Boyd, who developed his own idiosyncratic account of the fundamental principles of war, strategy, and organisation filtered through the lenses of a variety of scientific and mathematical developments, such as Heisenberg's uncertainty principle, Godel's incompleteness theorem, and an understanding of entropy that was heavily informed by the second law of thermodynamics. We shall then examine how Boyd's ideas, along with a burgeoning familiarity with the non-linear sciences, percolated throughout the U.S. armed forces, informing the first major wave of NCW literature during the late 1990s and early 2000s. Where the cybernetic way of warfare maintained the Aristotelian party line towards uncertainty by either dismissing it from its models entirely, or else by conceptualising it as a disruptive form of entropy that needed to be eliminated through the application of the appropriate negentropic command and control processes, it is argued that in its maximalist Boydian conception, NCW regards uncertainty as being at once an ineffable feature of complex systems, while also providing the basis for new forms of martial efficacy. The chapter then proceeds to trace the fate of NCW during the Iraq war, and its eventual demise in the face of its failure to curb the ensuing insurgency. The chapter concludes with an examination of a new wave of doctrinal approaches which have emerged to fill the vacuum left behind, but which nonetheless conform to many of its fundamental principles and assumptions.

6.1 Destruction and Creation

John Boyd (1927-1997) had a winding, yet influential career that touched many different aspects of the U.S. defence establishment. As a fighter pilot, Boyd served a short and relatively uneventful tour of duty in 1953 during the Korean war, but would later gain notoriety for his skill at aerial manoeuvring during his post-war career as an instructor at the USAF's Fighter Weapons School, where he acquired the nickname "Forty-Second-Boyd" in honour of a running bet of $40 he maintained that he could best any other pilot in a one-on-one dogfight within forty seconds (Osinga 22). By 1960, Boyd had developed a sophisticated account of air combat tactics, which he committed to paper in a 150 page manual entitled *Aerial Attack Study*. This text detailed so comprehensive a compendium of aerial manoeuvres and heuristics that it has been the go-to instructional guide for air-to-air combat in the USAF to this day (Osinga 22).

Following the successful reception of the *Aerial Attack Study*, and a period of time spent studying industrial engineering at Georgia Tech in the early 1960s, Boyd began a collaboration with the mathematician Thomas Christie. Together, they developed the energy-manoeuvrability theory, or EM theory, of aerial combat, which drew on the principles of thermodynamics in order to model the various stages of a dogfight in terms of energy relationships "in which altitude is potential energy to be traded for speed—kinetic energy—and vice versa. Turns became energy-consuming manoeuvres, with the rate of consumption depending on the number of g-forces of the turn, and engine power an energy provider for gaining altitude, gaining speed, or sustaining a turn, or a combination of these" (Osinga

23). EM theory provided a framework that generated substantial insights into how the USAF should design its jet fighters, but also became the source of some anxiety when Boyd conducted a comparative analysis demonstrating that the latest generation of Soviet fighters possessed superior energy-manoeuvrability characteristics than their U.S. counterparts (Osinga 23).

By 1966 Boyd was hired by Pentagon, where he was assigned to work on the design of the next-generation air superiority fighter for the USAF in a project codenamed FX, which would eventually produce the F-15. Boyd disagreed with the direction of the project, advocating for a slower, but lighter design optimised for fast, transient manoeuvres. Though Boyd's proposal was initially rejected, the USAF had sufficient interest in his ideas that his designs would eventually be realised—albeit in a somewhat watered down fashion that was not consistent with Boyd's original vision—in the form of the F-16 (Osinga 25). Boyd retired from active duty in 1975, but his final project, which had necessitated extensive research into the dynamics of air-to-ground combat as part of the design process for the USAF's A-10 "Warthog" attack aircraft, introduced him to the study of military history. Captivated, Boyd would spend the next two decades engaged in a flurry of research that yielded a peculiar body of work that addressed the foundations of strategy and operational art, albeit through an idiosyncratic philosophical lens that was as much preoccupied with the processes of learning and inquiry as it was with distilling the principles of manoeuvre. Nevertheless, his reflections on manoeuvre warfare made during this period were well received, especially within the Marine Corps, whose doctrinal documents would eventually be so profoundly impacted by Boyd's ideas that they would bestow upon him the title of "honorable Marine" (Osinga 47).

Boyd never published a book during his lifetime. Nevertheless, the bulk of his post-retirement writings were compiled into a collection of notes for a monumental 327 slide briefing entitled *A*

Discourse on Winning and Losing,[32] which Boyd would present to both military and civilian audiences throughout the 1980s and early 1990s. By 1987, the *Discourse* contained seven sections, of which by far the most substantial was a 193 slide presentation entitled "Patterns of Conflict," which distilled the various insights Boyd had gleaned from his extensive studies into military history. Throughout the remainder of the volume Boyd's approach shifts from the analysis of concrete and empirical examples derived from military history towards increasingly abstract general concepts. Though ostensibly concerned with the pursuit of martial efficacy, Boyd immediately makes it clear in the opening statement of the *Discourse* that the true scope of his project has grander concerns in mind: "to flourish and grow in a many-sided uncertain and ever-changing world that surrounds us, suggests that we have to make intuitive within ourselves those many practices we need to meet the exigencies of that world" (15).

As his biographer, Frans Osinga observes, for Boyd uncertainty "is the pervasive element of human endeavour, indeed, it is the prime characteristic of life" (234). A persistent theme in the *Discourse* is that one of the key lessons from 19th and 20th century breakthroughs in fields such as quantum mechanics, thermodynamics, and the nonlinear sciences has been to underscore the immense difficulties of obtaining and maintaining a clear, stable, and coherent picture of our reality. Compounding this problem, Boyd suggests that the very "theories, systems, and processes" which we employ in our pursuit of knowledge about the world "contain features that generate mismatches that, in turn, keep such a world uncertain, everchanging, and unpredictable" (357).

[32] Boyd's *Discourse* would eventually be published as a book by the Air University Press in 2018, which is why I choose to refer to it in italics. I use quotation marks when referring to the individual presentations and essays contained within it.

Boyd elaborates upon this point during the essay “Destruction and Creation,” which appears towards the end of the *Discourse*. In this text, Boyd outlines a minimal treatment of strategy—which he defines as “a mental tapestry of changing intentions for harmonizing and focusing our efforts as a basis for realizing some aim or purpose in an unfolding and often unforeseen world of many bewildering events and many contending interests”—as a form of adaptive learning (313). It is concerned with how humans develop concepts and mental patterns, which we then seek to apply to the world around us. However, Boyd points out that we run into a significant problem if the methodology we adopt for this process is inward looking, and primarily predicated upon continually improving “the match-up of concept with observed reality” (322). In order to explain why this is, Boyd refers to three important scientific and mathematical discoveries: Kurt Gödel’s incompleteness theorem, Werner Heisenberg’s indeterminacy principle, and the concept of entropy as described by the Second Law of Thermodynamics.

Gödel’s incompleteness theorem, developed in 1931, consists of two fundamental claims. The first states that no *consistent* system—i.e. a system that does not contain any logical contradictions—can be said to be *complete*. For a system to be complete, any given statement made using the axioms of that system must be provable (or can be negated) through the application of its own axioms. For example, if the system of natural numbers which forms the basis of mathematics is to be regarded as complete then its axioms must “contain enough information to enable the truth-value of any basic arithmetical proposition to be deductively extracted by deploying familiar step-by-step logical rules of inference” (Smith 2). Or to put it another way, within any given system, there will be statements that are true, but which nonetheless cannot be provable solely through recourse to the axioms of that system. Similarly, the second axiom of Gödel’s incompleteness theorem states that “even though such a system [may be] consistent, its consistency cannot be demonstrated within the system" (Boyd 320). In other words, there is no way to demonstrate that a system contains no logical contradictions using only the axioms of that system. Note that Gödel's two statements do not preclude the possibility of demonstrating the consistency of a system. Rather, they demonstrate that in order to prove that any given system is consistent one must necessarily appeal to systems that lie outside of it.

The import of this discovery is not lost on Boyd, who uses it to argue that "in order to determine the consistency of any new system we must construct or uncover another system beyond it. Over and over this cycle must be repeated to determine the consistency of more and more elaborate systems." In particular, Boyd is concerned with two kinds of consistencies: first, the consistency of a concept, and secondly, the consistency of the "*match-up* between observed reality and concept description of reality" (320; my emphasis). In both cases, Boyd argues that Gödel's incompleteness theorem will hold:

> [A] concept must be incomplete since we depend upon an ever-changing array of observations to shape or formulate it. Likewise, our observations of reality must be incomplete since we depend upon a changing concept to shape or formulate the nature of new inquiries and observations. Therefore, when we probe back and forth with more precision and subtlety, we must admit that we can have differences between observation and concept description; hence, we cannot determine the consistency of the system—in terms of its concept, and match-up with observed reality—within itself (320).

Nor, for Boyd, is this the end of the problem, as the difficulty of maintaining a correspondence between a model and the world is exacerbated further by Heisenbergian indeterminacy. Developed in 1927, the indeterminacy principle describes a situation in quantum mechanics where one attempts to measure the erratic movements of a subatomic particle by gauging its speed and position. It states that you can measure the speed of the particle, but as your precision increases, you become increasingly less able to measure the particle's position, and vice versa (Lindley 4). Heisenberg explained this by suggesting that the act of measurement changes the particle's momentum:

> At the instant of time when the position is determined, that is, at the instant when the photon is scattered by the electron, the electron undergoes a discontinuous change in momentum. This change is the greater the smaller the wavelength of the light employed, i.e., the more exact the determination of the position (62).

Boyd points out that in Heisenberg's exposition of indeterminacy as the distinction between observer and observed narrows the observer will perceive more uncertain or erratic behaviour in the observed (321). He argues that "under these circumstances, the uncertainty values represent the inability to determine the character or nature (consistency) of a system within itself" (321).[33] Thus, Boyd suggests

[33] Boyd's reading of Heisenberg doesn't quite capture the whole situation. Early quantum mechanics does indeed highlight the impossibility of "separating in the phenomena that which belongs to the object and that which belongs to the measuring agent" (Bitbol 3). However, Heisenberg's 1927 paper also suggests that perturbations in the position of quantum particles were not, in fact, solely a product of disturbance induced by an act of measurement, but also stem from "the *intrinsic* uncertainty any quantum state must possess" (Rozema et al. 100404-1). As a result of this discovery, the probabilistic status of quantum mechanics is generally regarded as being ontological (a feature of quantum states) rather than epistemological (a feature of our inability to measure what is happening within a quantum state).

that once the observer is firmly entangled within the system they are in effect now a part of it, and can no longer conduct a precise measurement of that system.

Having worked through Gödelian incompleteness and Heisenbergian indeterminacy, Boyd applies the Second Law of Thermodynamics to the problem of verification. He observes that because all natural processes generate entropy, one will expect there to be an entropy increase in any "closed system—or, for that matter, in any system that cannot communicate in an ordered fashion with other systems or environments external to itself" (322). Just as a room in a house will tend to become increasingly cluttered over time unless concerted action is taken to clean it, a thermodynamic system inevitably and inexorably slides towards a more entropic state unless some mechanism exists to transport the excess heat elsewhere. Since any given system is therefore moving irreversibly towards a more disorderly state Boyd points out that this tendency will have a detrimental effect on attempts to observe the system from within itself.

Taken together, the lessons of Gödel, Heisenberg, and the Second Law suggest to Boyd that any sustained inward-oriented attempt to maintain the match-up of concept and observed reality will inevitably experience increasing degrees of mismatch, and be further compromised by the presence of entropy and the unreliability of measurement (322). Though it is framed in entirely abstract terms, "Destruction and Creation" reads like a direct critique of the Closed-World discourse that was so prevalent in the U.S. defence establishment during the Vietnam war, and which Boyd would undoubtedly have had a great deal of first hand experience with. As Bousquet explains:

> Cybernetic warfare conceptualised as a negative feedback system necessitates a complete modelling of war in which all factors and parameters have to be accounted for. Indeed for a

negative feedback system to adjust to changes in the environment, it must be designed so that all eventualities have been foreseen . . . otherwise, it will be enable [sic] to initiate the required self-correcting behaviour. This fuels attempts to effect a systemic closure of our understanding of the phenomenon of war that characterise the drive of operations research and systems analysis to model and simulate war" (*Scientific Way* 189).

As if in response, Boyd highlights the inherent danger of maintaining a closed, self-referential system, and of attempting to verify that system without recourse to the construction of other systems outside of itself. The difficulty of resolving such a pervasive account of the problematic of uncertainty might have been dispiriting for Boyd. Indeed, elsewhere in his *Discourse*, he produces an expanded list enumerating several more features which "generate mismatches that, in turn, keep [the outside] world uncertain, everchanging, and unpredictable" (357):

- <u>Uncertainty</u> associated with the confinement, undecidability, and incompleteness theorems of mathematics and logic.
- <u>Numerical imprecision</u> associated with using the rational and irrational numbers in the calculation and measurement process.
- <u>Quantum uncertainty</u> associated with Planck's Constant and Heisenberg's Uncertainty Principle.
- <u>Entropy increase</u> associated with the Second Law of Thermodynamics.
- <u>Irregular or erratic behavio</u>r associated with far-from-equilibrium, open, nonlinear processes or systems with feedback.

- Incomprehensibility associated with the inability to completely screen, filter, or otherwise consider spaghetti-like influences from a plethora of ever changing, erratic, or unknown outside events.
- Mutations associated with environmental pressure, replication errors, or unknown influences in molecular and evolutionary biology.
- Ambiguity associated with natural languages as they are used and interact with one another.
- Novelty generated by the thinking and actions of unique individuals and their many-sided interactions with each other (357).[34]

Though he does not classify them specifically as military problems per se, this list is nonetheless perhaps the most comprehensive attempt on the part of any martial thinker to describe all of the many sources of uncertainty which, in various direct and indirect ways, make it difficult to render the battlespace fully comprehensible. Along the way, it addresses a variety of stochastic processes and epistemic issues, while still accounting for what Boyd refers to as the "novelty" introduced by the presence of active Manichean intelligences.

Where many of his predecessors were either ignorant of these processes, or presumed that they could be sufficiently alleviated through the application of some combination of technical or social solutions, Boyd took a rather different approach. He began by accepting the inevitable presence of some amount of uncertainty—"there is no way out," as he puts it—while also searching for ways to achieve timely moments of alignment between between concepts and reality as part of a continual

[34] This list is quoted verbatim from Boyd's *Discourse*, and preserves his decision to underline each major source of uncertainty.

process whereby concepts are iteratively created, applied to reality, and then destroyed: "we must continue the whirl of reorientation, mismatches, analyses/synthesis over and over again ad infinitum as a basis to comprehend, shape, and adapt to an unfolding, evolving reality that remains uncertain, ever changing, unpredictable" (Boyd 359). The key to this process is a concept that Boyd terms "creative or constructive induction," where "we [proceed] from unstructured bits and pieces to a new general pattern or concept" (Boyd 318). Though he lacks the terminology, Boyd appears to be describing what Charles Sanders Peirce refers to as abduction: "the process of forming explanatory hypotheses. It is the only logical operation which introduces any new idea" (5, 172). Peirce proposed that abduction was a kind of inferential reasoning that was nonetheless distinct from deduction and induction. Where the former establishes a conclusion that *must* be true based on a stated set of premises (assuming those premises are themselves correct), and the latter takes the form of a generalisation based on a specific set of observations in order to produce a conclusion that is *probable*, abduction consists of a *possible* conclusion, expressed in the form of a hypothesis that proposes to explain a set of facts. Abduction is subject to greater fallibility, since there can be many possible explanations for any given set of facts, but where deduction and induction cannot introduce novelty, the speculative hypothesis can, as Boyd himself explains:

> As the unstructuring or, as we call it, the destructive deduction unfolds it shifts toward *a creative induction* to stop the trend toward disorder and chaos to satisfy a goal-oriented need for increased order. Paradoxically, then, an entropy increase permits both the destruction or

unstructuring of a closed system and the creation of a new system to nullify the march toward randomness and death (Boyd 323).

Where Wiener was content to navigate towards "local islands" of order amidst the sea of entropy, here we find Boyd coming to the realisation that entropy itself might be the basis for the creation of novel solutions to employ in the face of a Manichean adversary. We also find in Boyd's schema of destruction and (abductive) creation a certain resonance with our earlier accounts of both the cunning intelligence of *mêtis* and the *coup d'oeil* of Clausewitz's genius. As Forsythe explains, "abduction, *the logic of discovery*, can be seen as the pragmatic process involved in the skillful creation or identification of opportunities within contingent environments, both an inscrutable element of scientific practice, and a form of seemingly extra-scientific cognition, an inexact but practically efficacious knowledge" (29).

As well as having some consonance with Peirce's abduction and Odysseus' *mêtis,* Boyd's account of the emergence of novelty out of disorder also echoes many of the core ideas of complexity theory. For Osinga, this was no mere coincidence, as he points out that after retiring from active duty, Boyd studied a number of scientific and philosophical works by the likes of Popper, Polanyi, Kuhn and Piaget which explored in various ways the "pervasive presence of uncertainty . . . [and] the need to embrace it and turn the capacity to their advantage by introducing uncertainty and novelty into the environment themselves" (103). Boyd was also familiar with the early writings on non-linear dynamics, and referred to the importance of accounting for the "erratic behaviour associated with far-from-equilibrium, open, nonlinear processes or systems with feedback" during his overview of key sources of uncertainty in the *Discourse* (358).

The study of complex systems emerged out of cybernetics, as well as the study of dynamical systems in the 1970s, and the study of cellular automata, which has a history dating back to the late 1940s (Ladyman and Wiesner 12). It is a relatively new discipline, and so there is no consensus among its practitioners regarding precisely what complexity is, the extent to which it is measurable, or whether complex systems all have some minimally sufficient set of common properties (Ladyman and Wiesner 2). Nonetheless, for our purposes, we shall defer to the work of Ladyman and Wiesner, whose exhaustive comparative study, *What is a Complex System?* (2020), presents a credible argument that most systems which scientists think of as being complex tend to involve some combination of the following four features:

1) Numerosity: complex systems involve many interactions among their components.
2) Disorder and Diversity: the interactions in a complex system are not coordinated or controlled centrally, and the components may differ.
3) Feedback: the interactions in complex systems are iterated so that there is feedback from previous interactions on a time scale relevant to the system's emergent dynamics.
4) Non-equilibrium: complex systems are out of thermodynamic equilibrium with the environment and are often driven by something external (65).

In addition, Ladyman and Wiesner suggest that these four conditions can give rise to some combination of the following products: *spontaneous order* and *self-organisation*, *nonlinearity*, *robustness* (ie. that the structure and function of the system is stable under relevant perturbations), *nested structure* and *modularity*, *history* and *memory* (ie. that they have some capability to store information), and *adaptive behaviour* (66). Wiesner and Ladyman's crucial contribution is to stress that these various products are not essential *features* of complex systems themselves, but rather are the collective result of the aforementioned conditions of *numerosity, disorder and diversity, feedback,* and *non-equilibrium* (66).

Where early cybernetic accounts focused primarily on systems that relied upon negative (negentropic) feedback in order to maintain homeostasis and stave off entropy, complex systems do not maintain thermodynamic equilibrium with their environment, and tend to be characterised by positive forms of feedback. For this reason, the early cyberneticists abjured positive feedback, and sought to eliminate its presence whenever they were engaged in designing self-regulating systems. But by the 1970s there was increasing scientific attention being given to the study of non-linear systems in which a disproportional relationship between outputs and inputs could generate exponential shifts or changes: "while negative feedback is the essential condition for stability, positive feedbacks are responsible for growth, self-organisation, and the amplification of weak signals" (Helighen and Joslyn, qtd. in Bousquet, *Scientific Way* 167). Having already determined that maintaining a closed, "steady-state" was tantamount to signing your own death-warrant under the conditions of existential adversity that are characteristic of war, Boyd was quite happy to hitch his conceptual wagon to the intensifying spiral of positive feedback instead. Indeed, this would be the basis of his model of efficacy, which he predicated upon the capacity to "produce change via novelty" (346).

6.2 The OODA Loop

The culmination of Boyd's thought in this direction was the elaboration of what he termed the OODA (Observe-Orient-Decide-Act) loop,[35] which was a composite model encompassing the processes of thinking, learning, and acting (see Figure 4). During the *observation* phase, the actor/system assesses its environment, as well as its relation to that environment. It can also encompass scanning for the adversary, and more generally for threats and opportunities. The *orientation* phase is where the actor/system interprets or processes this information through extant frames of analysis in order to create knowledge, and from there develop a range of possible responses. These possible responses are then sorted through and evaluated via a "many sided implicit cross referencing process of projection, empathy, correlation, and selection" in order to *decide* upon a preferred course of *action* (Boyd 385). For Boyd, the decision to act is not final, but rather functions as a kind of hypothesis test which will in all likelihood require future revision and iteration.

[35] Boyd initially used "sensing" instead of "observation" but decided that "SODA loop" didn't sound quite right.

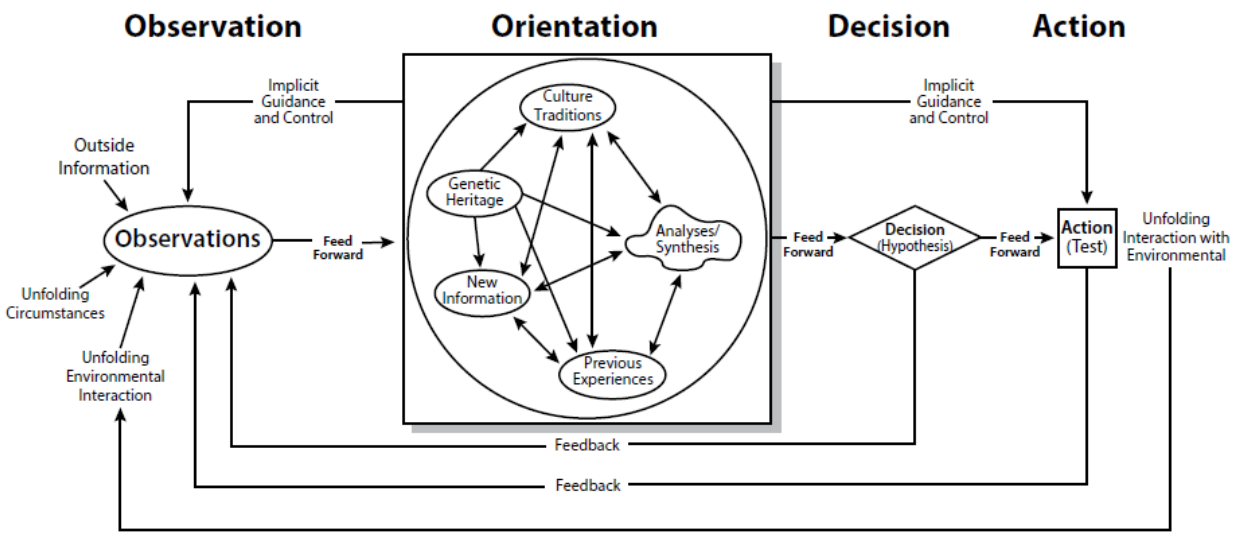

Figure 4: The OODA Loop, reproduced from Boyd, *A Discourse on Winning and Losing*.

Indeed, though it may resemble a "typical cybernetic loop whereby a system adjusts its behaviour to incoming information from its interaction with the environment in order to meet a desired objective" the way Boyd treats the orientation stage complicates such a straightforward interpretation of its application (Bousquet, *Scientific Way* 188). As Bousquet notes, "a closer look at the diagram of the OODA 'loop' reveals that orientation actually exerts 'implicit guidance and control' over the observation and action phases as well as shaping the decision phase" (*Scientific Way* 188). One does not simply cycle through the OODA loop in a linear fashion, but instead

engages in a "many-sided implicit cross referencing process of projection, empathy, correlation, and rejection" which can lead to winding and circuitous non-linear paths through its four phases (Boyd 232). For example, one might conduct a series of observations, evaluate them, and then recognise that one needs to carry out further observations before a decision can be made. For this reason, Bousquet points out that the "OODA 'loop' is not truly a cycle [at all] and is presented sequentially only for convenience of exposition" (*Scientific Way* 189).

Similarly, Venkatesh Rao argues that the OODA loop should not be interpreted or enacted solely in the manner implied by the prescriptive diagram provided by Boyd, but rather as "a *class* of description diagrams that can capture the state of a decision-making system/mind of a decision maker, using a visual alphabet of four primitive elements (observe, orient, decide, act). In other words, it is not so much a diagram as a diagramming *language.*" Rao goes on to detail several examples of common system/agent conditions that the OODA language can portray, including: the "simulation," where one unplugs action, and instead engages in a process of speculation about the possible outcomes of a decision; the "tuned open loop," where observe and orient are offline, and a "feedforward" circuit is being enacted, as in the case of a washing machine; or a situation of "analysis paralysis," where one becomes so preoccupied with the observation and orientation phases that no meaningful decisions or actions are being taken (see Figure 5) (Rao).

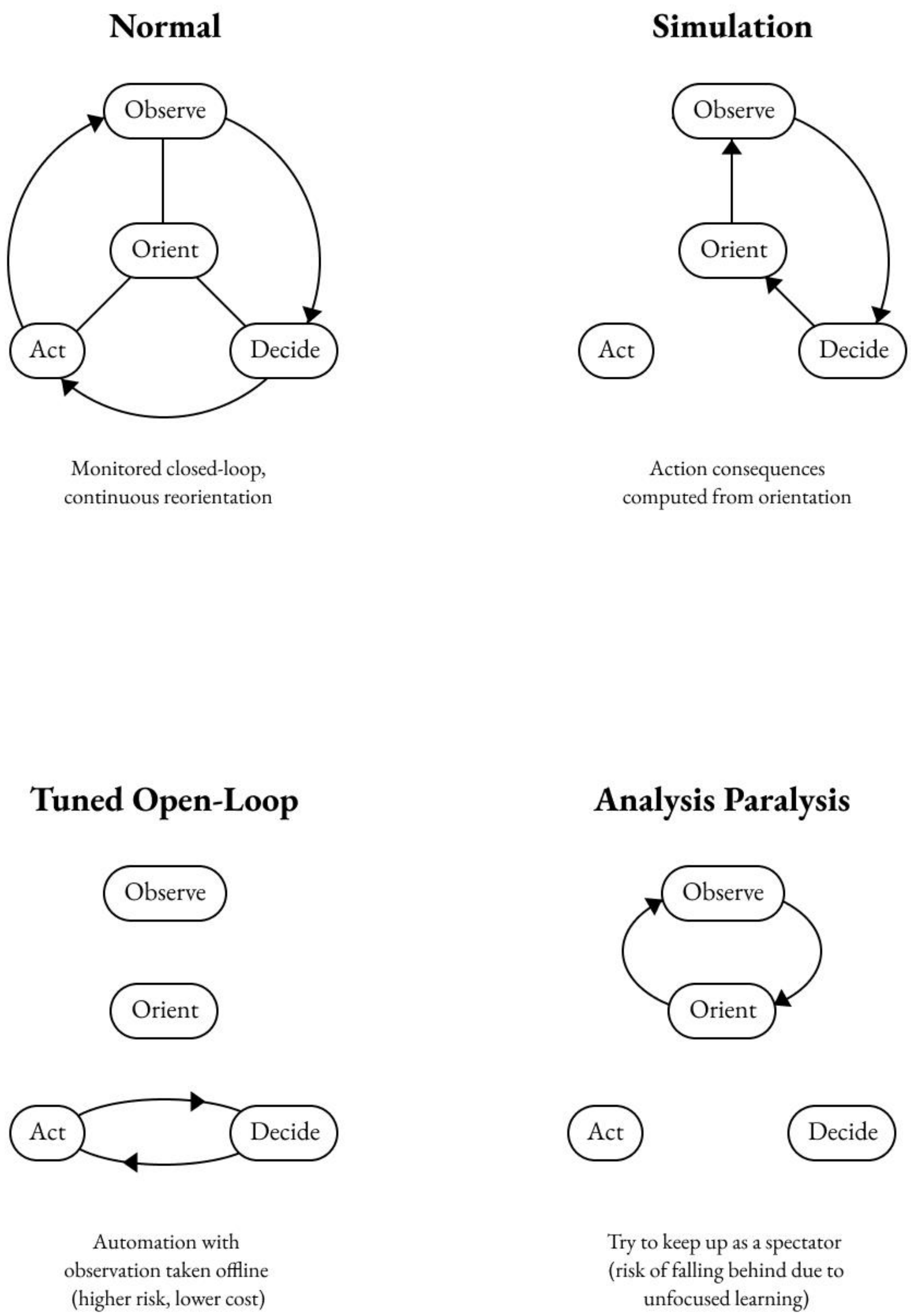

Figure 5: Various OODA Loops, reproduced from Rao, "The Use and Misuse of the OODA Loop."

Having outlined the basic principles of the OODA loop, let us now consider how Boyd seeks to apply it. First, let us recall that Boyd is adamant that the possibility of attaining and maintaining a complete mental model of any given war is impossible due to the problems of incompleteness, inconsistency, and entropy that will inevitably compromise the modelling process. As a result, the process of continuously building up and tearing down models through acts of "destruction and creation" (Boyd 316) during the orientation phase is the only possible way to keep up with the vicissitudes of reality:

> People using theories or systems evolved from a variety of information will find it increasingly difficult and ultimately impossible to interact with and comprehend phenomena or systems that move increasingly beyond and away from that variety—that is, they will become more and more isolated from that which they are trying to observe or deal with, unless they exploit the new variety to modify their theories/systems or create new theories/systems (Boyd 340).

In this description of the cycle of destruction and creation Boyd introduces another of his major themes: the dynamics of isolation and interaction. Because Boyd views systems which are isolated/closed/self-referential as tending towards sclerosis and disintegration, there is on the flipside a great advantage to be found in pursuing and developing *open* systems capable of engaging in a wide-range of dynamic interactions with both their internal and external environments, as these practices promote "vitality and growth" (284). Indeed, this insight forms the basis of one of Boyd's guiding strategic principles, which he calls "The Strategic Game" whereby in order to obtain an advantage "we must be able to diminish [our] adversary's ability to communicate or interact with his environment while sustaining or improving ours" (286). Similarly, in "Patterns of Conflict" he advises that one should strive to: "subvert, disorient, disrupt, overload, or seize [your] adversary's vulnerable, yet critical, connections, centers, and activities that provide cohesion and permit coherent observation–orientation–decision–action in order to dismember organism and isolate remnants for absorption or mop-up" (148).

In an inversion of Wiener's negentropic schemata, Boyd points towards entropy as providing the basis or condition through which acts of creation and novelty can emerge that transform a decaying closed system into something more dynamic (Bousquet 190): "an entropy increase permits both the destruction or restructuring of a closed system and the creation of a new system to nullify the march toward randomness and death" (Boyd 323). Thus, as Bousquet argues, "Boyd moves from the dominant view of uncertainty as a threat that must be overcome to one in which it is an irreducible characteristic of being and nothing less than the very condition of possibility of change and creativity" (*Scientific Way* 193). We can clearly see this valorisation of uncertainty when Boyd outlines what he sees as being a basic strategic principle for attaining advantage in adversarial situations. Here, Boyd observes that orderly and predictable patterns of military behaviour are susceptible to being easily read by an aware opponent, who can then make what will in all likelihood be reliable predictions in order to exploit you. Instead, it is better to act in a fashion that is unpredictable and, to some extent, disorderly, as this will make it difficult for one's opponent to reliably model your behaviour and distinguish a pattern from the "noise" created by your random actions (Bousquet, *Scientific Way* 194): "Employ a variety of measures that interweave menace–uncertainty–mistrust with tangles of ambiguity–deception–novelty as basis to sever adversary's moral ties and disorient or twist his ental images, hence mask–distort–magnify our presence and activities" (Boyd 148). Boyd underscores this point throughout "Patterns of Conflict," including in one notable instance where he chastises

Clausewitz for failing to consider the possibility of magnifying the adversary's exposure to friction and uncertainty (58). In this respect, Boyd views the FOW not just as a mere inevitability, but rather as a space of *possibility* within which you can ensnare your adversary.

Another key source of advantage predicated on the exploitation of uncertainty can stem from modulations in the *tempo* of observations. A common misreading of Boyd often proclaims that he is an unambiguous advocate for operating at a rapid speed or pace, both operationally, but also in terms of the OODA loop. At times, Boyd refers to "getting inside" an opponent's OODA cycle, by which he means that the opponent is reacting to what they perceive as your existing pattern of behaviour, but at a moment where you have already introduced novelty, and are able to exploit their anticipated response because you are in effect "ahead" in the respective attempts to match reality with conceptual models of it. However, one need not necessarily achieve this through taking faster actions (indeed, skipping over the Orientation phase in particular could prove fatal). Instead, in a passage where Boyd references the influence of Sun Tzu's deceptive approach to war, he advises that one can achieve such an advantage by introducing variations in the tempo or rhythm of your operations such that you can condition your adversary to expect events to unfold in accordance with one rhythm, and then bewilder them by introducing another: "Pull adversary apart and bring about his collapse by causing him to generate or project mental images that agree neither with the faster tempo/rhythm nor with the hidden form of transient maneuver patterns to must [sic] compete against" (Boyd 177).

Ultimately, Boyd's work constitutes a substantial shift in the conception of the role of uncertainty in martial affairs. In some respects, his thinking is a callback to the cunning stratagems of the Byzantines, but perhaps even more so to the *mêtis* of Odysseus and the amorphous manipulation of propensity advocated by Sun Tzu. Like Clausewitz before him, he was also mindful of the scientific and mathematical advances of his age, and drew from them in order to construct an account that placed uncertainty at the very heart of his concept of strategy. Also like Clausewitz, he had his fair share of imitators. Indeed, it would not be long before an approach which bore many similarities to Boyd's and which, like his, was similarly invested in valorising the condition of uncertainty, would begin to dramatically reshape the U.S. armed forces.

6.3 Network-Centric Warfare

Where the first major wave of RMA literature was overly invested in remixing the cybernetic visions of Westmoreland, a second, more Boydian strand began to take hold in the mid 1990s that would eventually attain the status of official U.S. military doctrine during Donald Rumsfeld's tenure as the Secretary of Defence following his establishment of the Office of Force Transformation in 2001. According to its director, and foremost evangelist, Vice Admiral Arthur Cebrowski, this "network-centric warfare looks at war as a complex, adaptive system where non-linear variables continuously interact" (qtd. in Bousquet, *Scientific Way* 218). In a 1998 report detailing NCW's "Origin and Future" Cebrowski, together with systems engineer John J. Garstka set out to differentiate NCW from earlier, "platform-centric" forms by creating a novel "operational architecture" that combines "sensor grids and transaction (or engagement) grids hosted by a high-quality information backplane. They are supported by value-adding command-and-control processes, many of which must be automated to get required speed" (Cebrowski and Garstka).

Where Owens and Westmoreland emphasised a heavily centralised command and control structure, NCW is instead predicated upon a network of "linkages and interactions among units and the operating environment" which will enable "forces to organize from the *bottom up*—or to self-synchronize—to meet the commander's intent" (Cebrowski and Garstka). Cebrowski and Garstka also explicitly acknowledge the influences of both complexity theory, from whom they borrow the concepts of self-organisation predicated on a decentralised network and forms of interactivity between its constituents, and Boyd's OODA loop: "In contrast [to top-down command], bottom-up organization yields self-synchronization, where the step function becomes a smooth curve, and combat moves to a high-speed continuum. The 'Observe-Orient-Decide-Act (OODA) Loop' appears to disappear, and the enemy is denied the operational pause."

As was the case with the first wave of RMA literature, to which NCW nonetheless owed a substantial debt, Cebrowski, Garstka, and their acolytes shared Marshall's belief that information superiority would pave the road to victory. The way they articulated this, though superficially similar to Boyd, suggests that some of his other lessons had not been so successfully imparted: "We define NCW as an information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization" (Alberts et al., *Network Centric Warfare* 2). Similarly, for Donald Rumsfeld: "we must achieve: fundamentally joint, network-centric, distributed forces capable of rapid decision superiority and massed effects across the battlespace" (qtd. in *The Implementation of Network-Centric Warfare* 2).

Though the rhetoric of a "higher tempo of operations" and "rapid decision superiority" seems to chime with Boyd's insistence on pursuing advantages through exploiting mismatches in the adversary's model of the environment, it frames this solely in terms of speed, and misses the importance of transient movement which Boyd clearly carried over from his old dogfighter days.

Furthermore, where Boyd is more interested in exploiting informational mismatches and asymmetries, and emphasises the importance of enhancing one's own capacity for interaction on the one hand, while isolating the adversary from their environment on the other, NCW's proponents "all share a common understanding of uncertainty as generated by a lack of information" and as a consequence "the response is consistently the same: deploy technology to acquire, process and distribute more information and ensure certain victory through information superiority" (Bousquet, *Scientific* 220).

Though the Office of Force Transformation's thinkers are less sanguine than Owens regarding the possibility of completely dispelling the FOW, they nonetheless aver that its effects can be substantially diminished: "the Information Age will not only have a dramatic effect on reducing the fog and friction of war, but will also permit us to consider and employ force with greater precision and granularity" (Alberts et al., *Network Centric Warfare* 80). Elsewhere, they clarify that while the problem of Manichean intelligence remains a sticking point, NCW promises to heavily alleviate the influence of Wiener's Augustinian demon over the battlespace:

> "The fact that warfare will always be characterized by fog, friction, complexity, and irrationality circumscribes but does not negate the benefits that network-centric operations can provide to the forces in terms of improved battlespace awareness and access to distributed assets. While predicting human and organizational behavior will remain well beyond the state of the art, having a better near real-time picture of what is happening (in situations where this is possible from observing things that move, emit, etc.) certainly reduces uncertainty in a meaningful way" (Alberts et al., *Network Centric Warfare* 11)

Going a step further, Martin Libicki proposes that the abstract logical conclusion of NCW is an all-encompassing net of sensors that absolutely exploit the possibilities proffered by the medium of the battlespace, and from which any chance of hiding or escape is entirely foreclosed:

> Even with stealth, everything ultimately can be found. All objects have mass and thus gravity. Every object moving in a medium creates vortices and must expend energy to do so. If nothing else, objects of a certain size have to occupy some space for some time. A set of sensors placed sufficiently close together can, in theory, eventually trap everything by getting close enough. A line of sensitive receivers placed close together will find its line-of-sight to a beaming object cut if a bomber—not matter how stealthy—rolls past . . . sensors of certain minimum discrimination placed close enough together can, at some epsilon, catch anything (*The Mesh and the Net* 23).

For Bousquet, treatments such as these fundamentally misunderstand some of the basic precepts of complexity theory and nonlinearity that they claim to emulate. He points out that because non-linear systems (including war) exhibit sensitivity to perturbations in their initial conditions the long term predictability of information about their operation and state is severely hampered, if not entirely impossible (*Scientific Way*, 220). Instead, the best one can hope for is a situation where, assuming one's sensory net is reliable and widespread, one strives for short term predictability, coupled with an approximation of long-term predictability provided the system's patterns of behaviour can be discerned (*Scientific Way* 221). However, the assumption that one's sensors will be entirely reliable and that one's computer systems can consistently and coherently synthesise the incoming data to sort signal from noise is asking a great deal: "Such a view rests on several crucial assumptions such as the infallibility of sensors and computer systems, discounting the ability of adversaries to fool sensors and create a misleading picture, and presuming that common data will necessarily be interpreted in the same manner by all units" (*Scientific Way* 221). Other potential issues include, but certainly are not limited to: the problems of infoglut, entropy, ambiguities in human natural languages, which may cause problems in internal communications, and the difficulty of accounting for Black Swan events.

If there is one aspect of NCW warfare which does meaningfully depart from the cybernetic paradigm it is its privileging of *self-organisation* or self-synchronisation. The key influence here stems from complex systems theory's notion of *emergence.* For Ladyman and Wiesner, though there is no conception of complexity or complex systems without emergence, it is nonetheless a difficult term to define "over and above the minimal idea of novelty in the sense of the whole behaving in ways that the parts in isolation do not" (73-74). Human cognition, the meta-organism-like self-organising behaviour of beehives and ant colonies, and the coding for proteins in DNA are all examples of spontaneous forms of emergent behaviour (Ladyman and Wiesner 3-4). Crucially, emergence enables creative and coordinated forms of behaviour to arise without requiring a controller to direct the action. As Capra explains: "self-organisation is the spontaneous emergence of new structures and new forms of behaviour in open systems far from equilibrium, characterised by internal feedback loops and described mathematically by non-linear equations" (85).

For the proponents of NCW, the allure of self-synchronisation was that it would enable tactical units to operate nearly entirely autonomously. Thanks to satellite based GPS systems, friendly units have mutual access to each other's positions, and as a result can, in theory, coordinate more smoothly with each other without needing to continually relay their respective movements. Though it is not articulated with the same level of detail and care as given by Boyd, NCW is similarly invested in the pursuit of emergent forms of novelty and creativity which it is hoped will confer a distinctive edge throughout the battlespace. In this respect at least, NCW valorises uncertainty, and in doing so manages to distinguish itself from the cybernetic paradigm in the way that the early advocates of the RMA could not.

Perhaps the most influential eulogy of this sort was David S. Alberts and Richard E. Hayes' *Power to the Edge* (2003), which presents itself as a NCW informed response to the new security environment shaped by the events of September 11, 2001, and the Bush administration's subsequent declaration of a Global War on Terror. In this text, the authors declare that the existing command and control model and systems are not up to the task in a time when "the complexity of operations is increasing as strategic, operational, and tactical levels merge, as operations serve a mixture of military and civil objects, and as operations are carried out by coalitions of the willing" (Alberts and Hayes 1).

Instead, what is needed is a movement of "power to the edge," which entails "the empowerment of individuals at the edge of an organization (where the organization interacts with its operating environment to have an impact or effect on that environment) or, in the case of systems, edge devices. Empowerment involves expanding access to information and the elimination of unnecessary constraints" (Alberts and Hayes 5). Self-synchronisation, which Alberts and Hayes wish to achieve by enhancing shared situation awareness, adopting less constrictive rules of engagement, "authoritative resource allocation" and "congruent command intent" (27). In this way, units at the "edge," can become less reliant upon hierarchical command, thereby establishing a condition of possibility in which troops can coordinate autonomously and be able to take initiative, seize affordances, and adapt to the changing environment as they see fit. This recognition leads Alberts and Hayes to make some fairly grandiose claims regarding what is possible and novel in NCW: "the magic of NCW, the leap from shared awareness to self-synchronization, is a form of emergent behavior. NCW works because it has identified, in general terms, the initial conditions that need to exist in order to achieve effective self-synchronization" (208-209).

Alberts and Hayes present self-synchronisation as a form of emergent behaviour predicated upon novel forms of coordination and a superior situational awareness achieved through the networking of units and weapons platforms (Bousquet, *Scientific Way* 224). Though this approach in theory resolves many of the problems of communication specific to the platform-centric approach, it does not, in Bousquet's view, "automatically mean greater autonomy and initiative for subordinate units," and in fact may just as well create opportunities for micromanagement from the top (*Scientific Way* 224). Indeed, one possibility is that NCW will create a situation where only command is granted the widest possible picture of the battlespace, and from there can carefully sculpt or curate portions of it for dissemination as they please across the lower levels (*Scientific Way* 225). Indeed, the Office of Force Transformation staff concede that the reality of NCW may be more about cutting out the "middleman" and instead giving greater powers to the top of the chain: "Current discussion of the need for new command and control approaches in an era of Information Age Warfare explicitly considers situations where the best (most current, accurate, and complete) information may no longer be located at the subordinate command engaged in the field, but rather may be located at senior headquarters" (Alberts et al., *Understanding Information Age Warfare* 178).

6.4 Shock and Awe

On the battlefield, NCW's prospects initially looked promising. Its first major test came in 2003, when the U.S. and its "coalition of the willing," conducted a swift operation, codenamed "Iraqi Freedom," to invade Iraq and overthrow Saddam Hussein's government. During this initial phase of the war, a small but technologically sophisticated Western army confronted "an Iraqi army degraded and enervated by its earlier defeat [in 1991] and by twelve years of isolation from its foreign sources of supply and, during three weeks of high-speed advance over long distances, brought about not merely its disintegration but its apparent evaporation from the field of battle" (Keegan 117). Where the Gulf War of 1991 was largely determined by a prolongued six-week bombing campaign of blanket bombardment, of which "only ten per cent of the munitions delivered by air, whether air-dropped bombs, air-launched missiles or sea- or land-launched cruise missiles, had been 'smart,'" the invasion in 2003 was instead characterised by a brief, but much more carefully targetted—seventy percent of munitions used during the Operation Iraqi Freedom contained guidance systems—series of airstrikes directed "almost exclusively at military targets" (Keegan 130).

Almost simultaneously, on the 20th of March, coalition ground forces conducted a surprise advance, catching off-guard many Iraqi divisions who had been anticipating a prolonged airstrike prior to the commencement of battle on the ground. Covering the 500 kilometres between their staging grounds in Kuwait and the Iraqi capital of Baghdad in just over two weeks, the U.S. armed forces were able to either rapidly destroy or bypass a substantial portion of the Iraqi military along the way in an overwhelming exhibition of force and manoeuvre that some U.S. army officials referred to as "shock and awe" (Keegan 130). Meanwhile, special forces troops working in collaboration with Kurdish *peshmera* units and the 173rd Airborne division pinned down Iraqi forces in the north of the country, preventing them from being able to retreat and reinforce the capital (Keegan 147).

By the 9th of April fighting had ceased in the capital, and the war appeared to be drawing swiftly to a close. In the immediate aftermath of the fall of Baghdad, General Tommy Franks, the commander-in-chief of the coalition forces declared "I've died and gone to heaven and seen the first bit of net-centric warfare at work" (qtd. in "Implementation of Network-Centric Warfare 18). Franks attributed much of the success of Operation Iraqi Freedom to the application of NCW principles, and framed the American strategic approach to the conflict in overtly Boydian terms:

> We had, by way of intelligence, a pretty good sense of where all the enemy's formations are. . . . So if you have a sense of where that is, and where the enemy happens to be sitting . . . then you simply plan to aggregate smaller, friendly forces at specific points against the enemy. . . . And that is the business of decision cycles, or inside the decision loop, as people say. If you figure out that an enemy has a certain number of trucks with which he can move his heavy equipment a certain number of miles at a certain rate, and you figure out that you can get inside his ability to react, and if, in fact, you can deceive him with respect to what you are going to do, to cause him further confusion and make him keep his force in place one day too long, then in fact, you find yourself all the way to Baghdad (qtd. in Boyer 70).

However, even in the immediate aftermath of the conflict, some critics within the U.S. defence intelligentsia were more hesitant to herald the dawn of a new age of NCW. In his 2003 analysis of Operation Iraqi Freedom, the paleoconservative William S. Lind pointed out that although the rapid push towards Baghdad "may indeed have followed maneuver warfare concepts, echeloning its forces, using mission-type orders, bypassing enemy strong points to keep up the speed of attack" the U.S. war machine was was not forced to "move quickly in response to unexpected threats and opportunities." Subsequent events would bear this out, as the profound inability of U.S. forces to prevent or subsequently defeat insurgencies in both Iraq and Afghanistan suggests that although it was well capable of overwhelming a weakened Iraqi military that still sought to engage it in relatively conventional terms, dealing with forces that were themselves heavily dispersed, irregular, decentralised, and autonomous remained—as it had been in Vietnam—a challenge of an entirely different magnitude.

6.5 The New Wave

The retirement of Donald Rumsfeld in 2006, shortly followed by the closure of the Office of Force Transformation, led to an institutional abandonment of NCW as a cornerstone doctrine of the U.S. armed forces. In its stead, the doctrine of Counterinsurgency (COIN), championed by figures such as General David Patreus, and Lt. Col David Kilcullen, gradually rose to prominence in the hopes that something might be salvaged from the protracted insurgencies in Iraq and Afghanistan. By 2007, Patreus had been installed as the commanding U.S. general in Iraq, instigating a new strategy that replaced the "enemy-centric" approach focused upon hunting and killing insurgents with a "population-centric" approach centred upon, in the words of David Kilcullen: "protecting local people and gaining their support" while simultaneously marginalising insurgent forces (129-130). This necessitated a substantial increase in troop numbers, as it demanded an ability to "flood" areas with troops so as to preemptively deter insurgent interference with the local population (Kilcullen 130).

Indeed, "this was less like conventional warfare and more like police work: cops patrolling a beat to prevent violent crime" (Kilcullen 130). This basic principle, predicated upon the prolonged occupation of a fixed territory with a large number of relatively homogenous ground forces, could not have been more removed from NCW's preference for a small, networked force conducting high-impact precision strikes and rapid, disorienting manoeuvres.

That said, COIN does bear some theoretical similarities to NCW. It conceptualises insurgencies as radically decentralised and autonomous networks, and as a result, seeks to adopt some of the same principles in order to succeed against them. This passage from the 2006 edition of the U.S. Army's *Counterinsurgency Field Manual*, which Kilcullen had a major role in shaping, is a typical example:

> Effective COIN operations are decentralized, and higher commanders owe it to their subordinates to push as many capabilities as possible down to their level. Mission command encourages the initiative of subordinates and facilitates the learning that must occur at every level. It is a major characteristic of a COIN force that can adapt and react as quickly as the insurgents (1-22).

Though NCW has officially been out of vogue since at least 2007, the example of COIN suggests that the influence of complexity theory, Boydianism, and network thinking upon the U.S. military establishment is still significant, even if it is not always explicit. Indeed, "US military gluttony for ever more information has continued unabated" (Bousquet, *Scientific Way* 232), even as the willingness to deploy boots on the ground falls, a trend underscored by the beleaguered withdrawal of U.S. troops from Afghanistan on the 30th of August in 2021. From a geopolitical perspective, there are clear parallels here to the withdrawal from Vietnam in 1973, with the U.S. war machine once again appearing exhausted by and disinterested in the prospect of fighting counterinsurgencies. Instead, its attention is once again being directed towards the spectre of "near-peer" conflict, a shift in focus that can surely only be exacerbated following Russia's decision to conduct a "special operation" in Ukraine at the time of writing. With COIN also being in something of a state of crisis since the failure to replicate Petraeus' "surge" strategy in Afghanistan in 2009, Bousquet suggests that the ensuing doctrinal void is increasingly being filled by new set of pronouncements that in many ways resemble a return to the original themes of the NCW paradigm (*Ghost in the War Machine*). However, where NCW was predicated on a conceptual armature lifted from the dominant 1990s technological forms of the network and the Internet, a new set of metaphors borrowed from the latest developments in information technologies is emerging to give the new doctrines a fresh gloss (Bousquet, *Ghost in the War Machine*).

One of the most prominent of these is known as the "Combat Cloud," a concept developed by General David A. Deptula, which borrows from the civilian concept of cloud computing, whereby data storage and computational processes no longer occur locally, but are instead conducted through a network of remotely located servers (Manovich 25). For Deptula, the need for a Combat Cloud is prompted by what he sees as a heightened "velocity of information" in the battlespace, and the need to shorten the targeting cycle in order to keep up:

> Consider just one example from Operation Iraqi Freedom. A Predator piloted from Nevada by the Air Force successfully spotted and identified a sniper who had pinned down a Marine

> ground force. The remotely piloted aircraft delivered video of the sniper's location directly to an on-site Marine controller who used it to direct a Navy F/A-18 into the vicinity. The Predator laser-designated the target for the Navy jet's bombs, eliminating the sniper. The entire engagement took less than two minutes. This is the synergy of precision and information we must achieve routinely ("A New Era" 8-9).

In order to compress the targeting cycle to this degree, Deptula's Combat Cloud entails combining the functionality of "sensor" and "shooter" and communication relay in all platforms so that "every object and person in this future force is a component, a router, and a node in a real-time IP based constellation with low enough latency to enable accurate effects against priority targets" ("Evolving Technologies" 5). The result is an "omnipresent defense complex that is self-forming and, if attacked, self-healing" ("A New Era" 10).

The atmospheric metaphor of the cloud explicitly foregrounds the expanded conception of the battlespace discussed in Chapter 4.0, and highlights the increasing pressure felt by the U.S. defence establishment to ensure that all components within its armed forces are capable of extending into the information domain. Other members of the defence intelligentsia have produced similar accounts to Deptula's stressing the need for the U.S. armed forces to adopt pervasive computing via the formation of an "Internet of Military Things" (IOMT) that promises to "revolutionize modern warfare [by] leveraging data and automation to deliver greater lethality and survivability to the warfighter while reducing cost and increasing efficiency (Zheng and Carter 25).

For Packer and Reeves, there is an implicit difficulty underpinning accounts such as these which Western militaries are struggling to reconcile in our contemporary moment. This difficulty revolves around the precise role to be played by the human, and the inherent uncertainties which this figure introduces, both as a dangerous Manichean intelligence to overcome on the one hand, but also as an irrational, unpredictable, and ultimately unreliable "weak-link" within what is becoming an increasingly accelerated and intensified tempo of combat operations on the other. Viewed in this light, Packer and Reeves propose that our fate is likely to be determined by one of two paths: one of which entails "a revolutionary ontological transformation" while the other leads takes the form of a grim "methodological physical extermination" (26):

> The first possibility would see the human following the course of Foucault's classic metaphor of a face drawn in the sand at the edge of the beach: as the face of humanity confronts the slaughtering waters of technology, it becomes so intermingled with the sand, the ocean, and the cyclical decay and rebirth of surrounding life that it is no longer perceptible as human. The second possibility would fulfil the haunting promise [of a] crescendoing will of artificially intelligent machines [that] would resolve to delete the human virus delaying the perpetual, peaceful reign of perfect codes, perfect commands, and perfect performance" (26).

In the former vision, which Paul Scharre has elsewhere described as "centaur warfighting," humans and machines are viewed as being able to attain higher levels of performance when operating in concert than either can when left to their own devices. For Scharre, the exemplary case study here is the performance of "advanced" or "centaur" chess players, composed of a human partnered with a variety of Artificial Intelligence (AI) chess engines (153). The AI can analyse possible moves and search for opportunities, while also eliminating the possibility of harmful blunders by pruning moves which lead to losing positions. Meanwhile, "the human player can manage strategy, prune AI searches to focus on the most promising areas, and manage differences between multiple AI" (153). Such collaborations have performed impressively, and typically can be relied upon to defeat single human or single AI opponents.

The main barrier to realising this collaborative vision rests upon the inherent costs of keeping humans in the loop, as well as upon the ability of human cognition and reactions to keep up with the heightened velocity of combat. For example, Packer and Reeves highlight how the transmission latency between UAVs and their remotely located USAF pilots induces an exploitable opportunity that is increasingly being capitalised upon by their would-be targets (131). Furthermore, they point out that "the human is no longer seen as an ideal instrument of control over robotic beasts of burden but instead becomes seen as a vulnerable, an unreliable cog in an otherwise flawless complex of machinery" (131-132).

During World War II, the cunning Manichean intelligence of the human pilot was the x-factor, the confounding quality that continually vexed Wiener's attempts to design a reliable AA predictor. But for the U.S. military of today, "humans—with their pathetic data processing speeds, their legal regulations, and their accountability procedures—are terribly slow" (Packer and Reeves 132). Perhaps even worse, they are also fallible, forgetful, brittle, irrational, emotional, and can easily succumb to the psychological stresses of battle. As Gordon Johnson of the US Joint Forces Command puts it, "[AI weapons systems] don't get hungry. They're Not afraid. They don't forget their orders. They don't care if the guy next to them has just been shot. Will they do a better job than humans? Yes" (qtd. in Packer and Reeves 16). Though contemporary militaries are still a long way away from creating, let alone deploying, a fully automated, AI operated Skynet, the status of the human within the war machine has never been as fragile. Viewed in light of these developments, the uncomfortable struggle between war's Aristotelian and *mêtic* traditions might appear to be on the cusp of a decisive turn, with the latter's "unsound methods," to quote Marlon Brando's Kurtz in *Apocalypse Now*, being regarded as an unreliable and outmoded human indulgence in a high velocity battlespace where every nanosecond counts.

Nonetheless, the martial tapestry of sensory nets, machine learning algorithms, interlinked weapons platforms, and wireless communication systems will continue to engender entropy and be subject to noise, while also providing opportunities for exploitation that a *mêtic* operator, whether human or otherwise, can still attempt to seize. Clausewitz was correct in identifying the play of chance and uncertainty as war's most distinctive facet. Though one might be able to envision scenarios where war can persist without the guiding hand of politics, the possibility of fighting a war under conditions of perfect omniscience will always run aground in the face of fundamental onto-epistemic limits (entropy, computational costs, noise, limitations in the precision of sensors and so on) that introduce uncertainty somewhere along the line. To be clear, while no one form of uncertainty or chance is wholly ineffable or intractable, the lesson of Boyd is that there is always a cost or tradeoff to be made somewhere along the chain, such that maintaining a simultaneous, perfect image of the battlespace in war is simply impossible, regardless of the level of technical sophistication involved, and this is before one even accounts for the inevitable presence of the Manichean adversary who can and will interfere in the process. Instead, the best one can hope for is to discern fleeting, transient advantages in timing, circumstance, and awareness amid the background murk and noise of the FOW.

2017: ZeroS

Peter Watts' near future science fiction short story "ZeroS" (2017) opens with the apparent death of its protagonist, Asante, a molecular marine ecologist turned protein farmer, at the hands of a group of armed raiders. To his horror, Asante wakes to find himself immobile, his body a corpse. A pair of soldiers, who arrived just in time to kill his killers, but not to prevent his death, inform him that he is now in a contract negotiation: either the galvanic stimulus that has temporarily reactivated his brain can be switched off, leaving him really dead, or he can agree to a five year tour of duty as a part of their unit, the ZeroS ("Zero Sum"), or "Zombie Corps" (319-320).

Asante agrees, and has a "retrospinal bypass" applied to his neocortex, a procedure that functionally decouples his mind and self, along with a raft of other neurological tweaks that enable control over his body to be toggled between his conscious mind and an autonomous "zombie" soldier reflex (321). Once engaged, this "ZMODE" confers the body with enhanced strength, and heightened reflexes—for these are the benefits acquired once the constant cognitive load required to maintain the link between sentient experience, embodiment and control is jettisoned—in order to aide its navigation of the battlespace. Left to its own devices, it turns out that the subconscious mind is perfectly able to run the show. It is not only capable, say Asante's handlers, of reflexive action, but of strategic thought as well. It can react, think, analyse, and make decisions, and—thanks to being unburdened by the lag time induced by subjective reflexivity—do all this at rates far faster than the conscious mind is typically capable. It retains its Manichean cunning, but trades consciousness for an overclock. The result is that a squad of troops in ZMODE can carry out sophisticated forms of coordination and teamwork, as each individual can anticipate the actions of its squadmates and incorporate them into its decision-making on the fly. Indeed, during a review of one of their early missions, the ZeroS commander observes of the zombies that "each one knew what it had to do to achieve an optimal outcome assuming all the others did likewise, and the group strategy just kind of—emerged" (332) .

When Asante's brain switches over into this subconscious autopilot soldier mode, his vision is largely obscured. Operating normally, the human eye jiggles endlessly in a continuous movement known as a saccade. The conscious mind does not register these constant motions, and instead edits together vision into a seamless "illusion of continuity" (320). However, when Asante hands over control to the full-body alien hand syndrome that he refers to as his "Evil Twin" (ET), his saccade rate is increased, providing the autonomous zombie with a heightened flow of images, but leaving him to experience the world as a continuous yet indistinct blur of light, colour, and motion that he cannot adequately parse. During training, Asante learns that he will spend the entirety of mission time in this peculiar state, relegated to being "a passenger in [his] own body" (319).

There is one exception. Whenever ET's eyes stop to focus on a target, whenever they lock on, Asante is able to look out clearly for the scant milliseconds that the act of taking aim requires, before being submerged back into the "sea of fog" (322) that constitutes unmediated human vision. Watts' terminology is telling in this respect. The bioware of the human body actually experiences the world around it as an indistinct blur that the wetware of the human mind has conveniently evolved to obscure from ourselves, presenting the world to us as an orderly, cinematic, curated experience. Here, the FOW is not a metaphor for uncertainty, but a fundamental description of how mind, body, and world are and are not experienced subjectively. As Steven Shaviro has noted in his discussion of *Blindsight*, another Watts story that explores similar conceits, "our ordinary mental states are every bit as mediated and constructed as these extreme conditions are. In ordinary life, as much as in pathological situations, we are blinkered by what [Thomas] Metzinger calls 'the illusion of naive realism: the inability to recognise a self-generated representation as a representation'" (72). In passenger mode, Asante gets to experience, for himself, how eyes really see when the peer out upon the world without the aid of the subconscious performing its default function as continuity editor.

The ability to toggle between Asante and ET comes at a cost however. The procedures to install their bypasses were not perfect: "Nerves nicked during surgery, a stray milliamp leaking into the fusiform gyrus, everyone's got at least one" (Watts, "ZeroS" 338). And so, once control has been re-established by their subjective minds, Asante and the other recruits experience a variety of physical symptoms, including muscle twitches and spasms, visual flickering, headaches, speech aphasia, and even debilitating seizures. However, these glitches are of little concern to their handlers, because they do not manifest during zombie mode. That is, until Asante is shot in the head mid-mission. His armour prevents the bullet from penetrating his skin, but the physical impact prompts "ZMODE" (341) to deboot, thrusting him back into control, and fully restoring his vision. The situation he finds himself in does not conform to the mission briefing. Instead of fighting the expected Shining Path forces, Asante looks around at the piled and charred bodies of refugees, children and adults alike. Before regaining control, Asante had seen ET take aim at three children. During a subsequent debrief, Asante learns that these child casualties were not innocents, or collateral, but a nascent bioweapon: a hive-mind comprised of a number of children linked together by a quantum-entangled 'bioradio" (358), giving them computational power far in advance of baseline humans, and even ones running in ZMODE. A subsequent encounter demonstrates their lethality, with most of Asante's squad getting butchered by a more mature subset of the hive-mind. Despite being unarmed, the quantum children wipe out the Zombie Corps after ambushing them with makeshift broken glass weapons, seizing their guns, and turning them against the zombie soldiers.

Asante barely escapes alive. In his final debrief, he is told that he has seen too much. As one of his handlers puts it:

> We do what we've always done. Feed you stories so you won't be compromised, so you won't compromise us when someone catches you and starts poking your amygdala. But the switch was for your protection. We don't know who we're up against.... All we know is that a handful of unarmed children can slaughter our most elite forces at will, and we are so very unready for the world to know that (359).

Aside from increased operational performance, one of the appeals of "ZMODE" to those in positions of command is the way it inherently extends a politically expedient FOW that occludes the particularities of each operation from the minds of the soldiers riding shotgun in their zombie controlled host bodies as it unfolds. Here, Watts captures two distinct facets of the FOW. On the one hand, "ZeroS" describes not just 'external' problems of inadequate intelligence about the battlefield or incomplete knowledge concerning operational matters, but the very limits of any form of looking or sensing, and as a consequence the attendant limits of knowledge generated on that basis. It stresses that any act of generating knowledge necessarily comes with a built-in tradeoff, a sacrifice made to the characteristics of the bioware (or hardware) that does the sensing, and which structures experience in any given way.

On the other hand, the FOW can also function as a preferable state of affairs, a shroud imposed across the operational environment that different lower and mid-level branches of the military institution interface with. This is not the FOW that John Boyd seeks to extend and exploit in order to confuse the enemy. Rather, it provides yet another means of maintaining compliance and control within the war machine's own forces, an affirmation that, as another member of the Zombie Corps remarks to Asante, the "Big Picture's way above our pay grade" (350). Where Clausewitz described spiralling frictions as hampering the smooth and orderly flow of information within the chain of command, Watts posits the blanket *withholding* of information from soldiers at lower levels as a fundamental *feature* of its operation. Indeed, this withholding of information can also be back-projected further in order to maintain civil and political compliance and consent via the careful control of media access to the frontlines, creating what former U.S. intelligence analyst Chelsea Manning referred to as a "Fog Machine of War":

> Among the many daily reports I received via email while working in Iraq in 2009 and 2010 was an internal public affairs briefing that listed recently published news articles about the American mission in Iraq. One of my regular tasks was to provide, for the public affairs summary read by the command in eastern Baghdad, a single-sentence description of each issue covered, complementing our analysis with local intelligence. The more I made these daily comparisons between the news back in the States and the military and diplomatic reports available to me as an analyst, the more aware I became of the disparity. In contrast to the solid, nuanced briefings we created on the ground, the news available to the public was flooded with foggy speculation and simplifications.

This is FOW as what Peter Galison terms "antiepistemology," a carefully curated *absence* of knowledge that productively maintains plausible deniability. As Galison puts it: "Epistemology asks how knowledge can be uncovered and secured. Antiepistemology asks how knowledge can be covered and obscured" ("Removing Knowledge" 237). In this context, the FOW's relation to martial media is not merely one of *representation*, or *simulation*, but also entails acts of *depresentation*, of suppressing meaning and knowledge as well as producing, inflecting, and refracting it. The only difference is that in "ZeroS," states of ignorance are not simply established via discursive or rhetorical interventions (or non-interventions), through the careful control of access to flows of information within the war machine, or by media management, but rather through the active rewiring of the human mind in a manner that reduces the soldier's conscious experience of the chaos of battle to a few brief glimpses through the fog. Here, only the act of locking on, that awful moment in which looking and killing converge, can still be disclosed.

Conclusion: War’s Unknown Unknown

As we know, there are known knowns; there are things we know we know.

We also know there are known unknowns; that is to say we know there are some things we do not know.

But there are also unknown unknowns—the ones we don't know we don't know.

—DONALD RUMSFELD

Though the problematic of uncertainty implied by the metaphor “fog of war” has vexed war’s thinkers and practitioners since time immemorial, their approaches to it have varied immensely. In his tales of Odysseus, Homer described the exploits of a man who was willing to seek out its affordances through the application of a polyvalent, cunning intelligence: *mêtis*. But for the philosophers this simply would not do, and so Aristotle circumscribed uncertainty through the creation of ideal models, and in doing so established the ends/means tradition which continues to underpin Western conceptions of efficacy to this day. However, to paraphrase van Moltke the Elder, no plan survives first contact with the enemy, and so FOWs have continued to perplex Western military thinkers whose predominant preoccupation has, as a consequence, generally been the pursuit of ways to alleviate or mitigate its effects. Still, many early practitioners were able to find success, in many cases by seeking to exploit, or even engineer uncertainty through various cunning ruses and stratagems.

As the Medieval ages came and went, the notion of embracing, or even wielding FOWs faded. Instead, the pursuit of mechanistic order increasingly became viewed as the way forward. This tendency reached its apex during the Enlightenment period, as the advent of a martial geometry promised a formalisation of war so absolute that one could, in the words of Puységur, master the art "without war, without troops, without an army, without having to leave one's home, simply by means of study, with a little geometry and geography" (qtd. in Engberg-Pedersen 40). However, a burgeoning awareness of the mathematics of probability, together with the harsh empirical lessons provided by Napoleon tilted the pendulum, birthing *l'empire du hazard.* But reason would not be deterred, as both Clausewitz and Reisswitz, approaching their object from different directions, provided in their own ways unprecedented and novel conceptions of war that introduced for the first time a properly aleatory understanding of the operation of chance.

For Reisswitz, the key realisation was that for a game of war to bear any verisimilitude to its referent the incorporation of chance was imperative. In doing so, he created a template that many war planners have sought to emulate ever since. Similarly, for Clausewitz, friction is the crucial element which prevents Real War from ever ascending towards the extremes of absolute violence implied by its abstract, Absolute form. Thus, Clausewitz placed uncertainty and the haze of fog at the heart of his model of war, while also coming to an uncomfortable accommodation with the figure of the genius, upon whom he bestowed sufficient *mêtic* capabilities so as to be capable of exploiting the exigencies of the moment. Though Jullien argues that Clausewitz tilts towards the Aristotelian tradition, the great achievement of *On War* was nonetheless a critique of its applicability due to war's indeterminate and unpredictable nature, with the active resistance of an adversary squarely identified as a significant source of difficulty.

Where martial thinkers before the 17th century were shackled by a wholly epistemic conception of probability, the 19th and early 20th centuries were characterised by a veritable explosion of mathematical and scientific treatments that increasingly present us with a picture of what Hacking calls the "*universe of chance*" (*Taming of Chance* 200; my emphasis). And just as the ontological basis of indeterminism, and the attendant "hypostatisation of chance" (Wilkins 9) implied by some of these discoveries continue to be debated by philosophers, so to have the events of the past century birthed a range of perspectives on the extent to which martial uncertainties and FOWs can be mitigated, alleviated, exploited, or even engineered.

Meanwhile, the U.S. military has become increasingly preoccupied with controlling all aspects of the battlespace in its pursuit of full-spectrum dominance. Between WWII and Vietnam it went from fighting for control over the capacity to monitor meteorological conditions to actively working to re-engineer the martial environment so as to make it more conducive to its preferred way of war, albeit to little success and at much human and non-human cost. The same period also witnessed the progressive computerisation and cyberisation of the American war machine, culminating in the failed attempt to persecute a technowar in Vietnam. Though intended to help mitigate both the Augustinian and Manichean sources of uncertainty described by Wiener, the application of OR, SA, and game theory produced a distorted and confused picture of the conflict that only added to the FOW.

These lessons do not seem to have been learned, and, if anything, the contemporary U.S. military—having pinpointed the human factor as weak link in the chain—is pursuing the fantasy of omniscience more ardently than ever, albeit with a few caveats about the intractable nature of the FOW sprinkled in so as to assuage the concerns of any Clausewitzians who might be paying attention. Though members of the U.S. Defence intelligentsia have tried to caution of the dangers of a "fog of systems" hampering the interoperability of attempts to create complex battleswarms comprised of cheap, networked UAVs (Perrow 111), the overall trajectory being pursued in order to ensure that the war machine can project some semblance of reliability is clear.

Having acknowledged the conflicting approaches to, and uncertain origins of the FOW it becomes possible to speculate about what the implications of its conceptual indeterminacy might be for the project of martial thought. Where writers operating from within its ambit tend to see the FOW as providing a necessary and instructive account of the uncertain nature of warfare, one might instead posit that the FOW, when treated as a "foggy," indistinct, and potentially unresolvable problematic—an unknown unknown, if you will— can be harnessed in the service of a critique of the wider project of military theoretical and doctrinal production. The initial impetus for this closing observation is derived from the work of Reza Negarestani, who outlines a brief definition of the FOW that breaks radically from conventional martial wisdom in the glossary of his landmark work of theory fiction, *Cyclonopedia* (2008):

> ...the Fog of War shuts down all modes of cognition, it provides warmachines with an illusory but concrete vision based upon which the interactions between warmachines are divided into three planes: the planes of (a) command (b) logistics and (c) tactics. These tactical planes lead warmachines to the conclusion that war is the consequence of their interactions *and not the other way around*. The subterfuge of the Fog of War lies in dissimulating or distorting the radical obscurity of war. The strategy of Fog of War is to blind warmachines in regard to the quiddity of War itself. The Fog of War conceals the immanence of war, stirring up warmachines with the illusion that they are independent entities (240; my emphasis).

In this passage, Negarestani suggests that the FOW primarily serves to create a highly paradoxical illusion of instrumentality that is asserted most famously by Clausewitz's maxim that "war is merely the continuation of policy by other means" (Book 1, Chapter 1 99). As Negarestani argues, implicit in this statement is the logic that "war is something institutionalised as a social, political and economic object within the anthropocentric judicial system" (240) rather than an immanent phenomena that is unbounded by the nomos of the state. Or, to put it another way:

> What if, in its most extravagant, uninhibited and originary sense, war does not serve the State? In other words, what if war 'is not an instrument of any kind, least of all a political one?' Further, what if war is absolutely immanent, that is to say, what if war is not only immanent to particular circumscriptions—the state, the political, the human, etc.—but, more importantly, it is immanent *in* itself? (Guha 2).

Of course, the theorists of military theory and strategy rarely, if ever, consider or address the possibility of war as being immanent in itself precisely because they are, for the most part, themselves bound up within, and subservient to, the politics, discourses, and objectives of state aligned military institutions and their attendant industrial, scientific, and theoretical complexes. Indeed, the central justification for the existence of the military institution is the possibility that, on some level, war can (and must) be instrumentalized, even if in an imperfect, messy fashion.

Viewed in this light, the FOW functions as a kind of necessary problematic that sustains the ongoing theoretical production of military institutions and their attendant war machines. Though it may gesture to the actual state of things—ie. the presence of war's atmosphere of uncertainty—its existence, or at least, the existence of the various conditions that are ascribed to it in the spaces of military theory and doctrine, ie. complexity, disorder, uncertainty, contingency and so on, provide a substantial barrier or limit to martial efforts whose existence justifies and indeed necessitates (from the perspective of the state captured warmachine) the continued instrumentalisation of the act (and thought) of warmaking. Even approaches such as Boyd's, which meaningfully acknowledge the nuances of both the Augustinian and Manichean forms of uncertainty, and pursues a strategy predicated upon exploiting their affordances, can never produced an unalloyed guarantee of their own reliability because there is always the prospect of a more cunning adversary who has come to the same, or perhaps even superior, realisations. The military-theoretical-complex is therefore imprisoned in a Sisyphean task of continually producing novel treatments of martial uncertainty which distract it from meaningfully interrogating war's quiddity, from recognising its own status as an unknown unknown.

Works Cited

ADP: Land Operations. British Army, 2017.

Alberts, David S., John J. Garstka, and Frederick P. Stein. *Network Centric Warfare: Developing and Leveraging Information Superiority.* CCRP, 2000.

Alberts, David S., John J. Garstka, Richard E. Hayes, et al. *Understanding Information Age Warfare*. CCRP, 2001.

Alberts, David S., and Richard E. Hayes. *Power to the Edge: Command... Control... in the Information Age*. CCRP, 2003.

Allen, James. "Aristotle on Chance as an Accidental Cause." *Aristotle's Physics: A Critical Guide*, edited by Mariska Leunissen, Cambridge University Press, 2015, pp. 66–87.

Alloa, Emmanuel. "Metaxy: Aristotle on Mediacy." *Classics and Media Theory*, edited by Pantelis Michelakis, translated by Hayley Wood, Oxford University Press, 2020.

Ansorge, Josef Teboho. "Orientalism in the Machine." *Orientalism and War*, edited by Tarak Barkawi and Ketih Stanski, Oxford University Press, 2013, pp. 1–29.

Aristotle. *Meteorologica*. Translated by H. D. P. Lee, Harvard University Press, 1951.

---. *Nicomachean Ethics*. Translated by Robert C. Bartlett and Susan D. Collins, The University of Chicago Press, 2011.

---. *Physics: Books I and II*. Translated by William Charlton, Oxford University Press, 1992.

---. *The Eudemian Ethics*. Translated by Anthony Kenny, Oxford University Press, 2011.

Arrigo, Jean Maria. "The Ethics of Weapons Research: A Framework for Moral Discourse Between Insiders and Outsiders." *Journal of Power and Ethics*, vol. 1, no. 4, 2000, pp. 302–27.

Atteridge, A. Hilliard. *Famous Modern Battles*. Small, Maynard and Company, 1913.

Barr, William. "Introduction to the English Edition." *War North of 80: The Last German Arctic Weather Station of World War II*, by Wilhelm Dege, translated by William Barr, University of Calgary Press, 2004.

Bateson, Gregory, et al. "A Note on the Double Bind—1962." *Family Process*, vol. 2, no. 1, 1963, pp. 154–61.

Baudrillard, Jean. *Simulacra and Simulation*. Translated by Sheila Faria Glaser, The University of Michigan Press, 1994.

Beaumont, Roger. *War, Chaos, and History*. Praeger, 1994.

Beevor, Antony. *D-Day: The Battle for Normandy*. Viking, 2009.

Bernstein, Peter L. *Against the Gods: The Remarkable Story of Risk*. Wiley, 1998.

Beyerchen, Alan. "Clausewitz, Nonlinearity, and the Unpredictability of War." *International Security*, vol. 17, no. 3, 1992, p. 59.

Bitbol, Michel. "Quantum Mechanics as Generalised Theory of Probabilities." *Collapse*, vol. 8, 2014, pp. 87–121.

Borges, Jorge Luis. "On the Exactitude of Science." *On the Exactitude of Science. Collected Fictions*, translated by Andrew Hurley, Penguin, 1998.

Bousquet, Antoine. "A Short History of Wargames." *Simulation, Exercise, Operations*, edited by Robin Mackay, Urbanomic, 2015.

---. *Ghost in the War Machine: Martial Life in the Informational Episteme*. Session 8, The New Centre for Research and Practice.

---. "The Battlefield Is Dead." *Aeon*, 9 Oct. 2017, https://aeon.co/essays/how-the-bloody-field-of-battle-made-way-for-precision-drones.

---. *The Eye of War: Military Perception from the Telescope to the Drone*. University of Minnesota Press, 2018.

---. *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity*. Hurst, 2009.

Boyd, John R. *A Discourse on Winning and Losing*. Edited by Grant T. Hammond, Air University Press, 2018.

Boyer, Peter J. "The New War Machine: How General Tommy Franks Joined Donald Rumsfeld in the Fight to Transform the Military." *The New Yorker*, no. June 30, 2003, pp. 55–71.

Brooks, Victor. *The Boston Campaign: April 1775 - March 1776*. Combined Publishing, 1999.

Buckingham, William A. *Operation Ranch Hand: The Air Force and Herbicides in Southeast Asia, 1961-1971*. Office of Air Force History, United States Air Force, 1982.

Bülow, Dietrich Heinrich von. *The Spirit of The Modern System of Warfare*. Translated by C. Malorti de Martemont, Cambridge University Press, 1806.

Caffrey, Matthew B. *On Wargaming: How Wargames Have Shaped History and How They May Shape the Future*. Naval War College Press, 2019.

Capra, Fritjof. *The Web of Life: A New Synthesis of Mind and Matter*. Anchor Books, 1996.

CCRU. *Writings 1997–2003*. Time Spiral Press, 2015.

Cebrowski, Arthur K., and John J. Garstka. *Network-Centric Warfare: Its Origin and Future*. Proceedings, US Naval Institute, Jan. 1998.

Chamayou, Gregoire. *A Theory of the Drone*. Translated by Janet Lloyd, The New Press, 2015.

---. *Manhunts: A Philosophical History*. Translated by Rendall Steven, Princeton University Press, 2012.

Chambers, James. *The Devil's Horsemen: The Mongol Invasion of Europe*. Book Club Associates, 1979.

Chia, Robert C. H., and Robin Holt. *Strategy Without Design: The Silent Efficacy of Indirect Action*. Cambridge University Press, 2009.

Chow, Rey. *The Age of the World Target: Self-Referentiality in War, Theory, and Comparative Work*. Duke University Press, 2006.

Cimbala, Stephen J. *Clausewitz and Chaos: Friction in War and Military Policy*. Praeger, 2000.

Clarke, M'Donald. "Battle of Bunker Hill." *Poems of M'Donald Clarke*, J. W. Bell, 1836.

Clausewitz, Carl von. *On War*. Edited & translated by Michael Howard and Peter Paret, Everyman's Library, 1993.

Cockburn, Andrew. *Kill Chain: Drones and the Rise of High-Tech Assassins*. Verso, 2016.

Colbeck, Ian. "The Development of FIDO (Fog Intensive Dispersal Operation)." *Aerosol Science and Technology: History and Reviews*, edited by David S. Ensor, RTI Press, 2011, pp. 367–76.

Counterinsurgency Army Field Manual 3-24. University of Chicago Press/Department of the Army, 2006.

Creveld, Martin van. *A History of Strategy: From Sun Tzu to William S. Lind*. Castalia House, 2000.

---. *Command in War*. Harvard University Press, 1985.

---. *Wargames: From Gladiators to Gigabytes*. Cambridge University Press, 2013.

Currey, Cecil B. *Victory At Any Cost: The Genius of Viet Nam's Gen. Vo Nguyen Giap*. Brassey's, 1997.

Dalkey, Norman C. *Families of Models*. RAND Corporation, 1965, pp. 1–31.

---. *Simulation of Military Conflict*. RAND Corporation, 1967, pp. 1–20.

De Certeau, Michel. *The Practice of Everyday Life*. University of California Press, 1984.

DeLanda, Manuel. *War in the Age of Intelligent Machines*. ZONE Books, 1991.

Deleuze, Gilles, and Felix Guattari. *A Thousand Plateaus: Capitalism and Schizophrenia*. Translated by Brian Massumi, University of Minnesota Press, 1988.

Deptula, David A. "A New Era for Command and Control of Aerospace Operations." *Air & Space Power Journal*, no. July-August, 2014, pp. 5–16.

---. "Evolving Technologies and Warfare in the 21st Century: Introducing the "Combat Cloud"." *Mitchell Institute Policy Papers*, vol. 4, no. September, 2016, pp. 1–10.

Der Derian, James. *Virtuous War: Mapping the Military-Industrial Media-Entertainment Network*. Second Edition, Routledge, 2009.

Detienne, Marcel, and Jules-Pierre Vernant. *Cunning Intelligence in Greek Culture and Society*. Translated by Janet Lloyd, The University of Chicago Press, 1991.

Dillon, Matthew. *Omens and Oracles: Divination in Ancient Greece*. Routledge, 2017.

Dimand, Mary-Ann, and Robert W. Dimand. *The History of Game Theory, Volume 1: From the Beginnings to 1945*. Routledge, 1996.

Doherty, Richard. *Churchill's Greatest Fear: The Battle of the Atlantic 3 September 1939 to 7 May 1945*. Pen & Sword, 2015.

Douglas, Alec. "The Nazi Weather Station in Labrador." *Canadian Geographic*, vol. 101, no. 6, 1982, pp. 42–47.

Edwards, Paul N. *The Closed World: Computers and the Politics of Discourse in Cold War America*. MIT Press, 1996.

---. "The Closed World: Systems Discourse, Military Strategy and Post WWII American Historical Consciousness." *AI & Society*, vol. 2, no. 3, 1988, pp. 245–55.

Engberg-Pedersen, Anders. *Empire of Chance: The Napoleonic Wars and the Disorder of Things*. Harvard University Press, 2015.

Forsythe, Samuel. *The Concept of Stratagem in War and Politics*. King's College, 2018.

Freedman, Lawrence. *Kennedy's Wars: Berlin, Cuba, Laos, and Vietnam*. Oxford University Press, 2000.

---. *Strategy: A History*. Oxford University Press, 2013.

Freedman, Maurice. *Unravelling Enigma: Winning the Code War at Station X*. Leo Cooper, 2000.

Frontinus. *The Stratagems and The Aqueducts of Rome*. Edited by Mary B. McElwain, Translated by Charles E. Bennett, William Heinemann, 1925.

Gagarin, Michael. *Antiphon the Athenian: Oratory, Law, and Justice in the Age of the Sophists*. University of Texas Press, 2002.

Galison, Peter. "Removing Knowledge." *Critical Inquiry*, vol. 31, no. 1, Sept. 2004, pp. 229–43.

---. "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision." *Critical Inquiry*, vol. 21, no. 1, 1994, pp. 228–66.

Gat, Azar. *A History of Military Thought: From the Enlightenment to the Cold War*. Oxford University Press, 2001.

Gell, Alfred. *Art and Agency: An Anthropological Theory*. Clarendon Press, 1998.

Ghamari-Tabrizi, Sharon. *The Worlds of Herman Kahn: The Intuitive Science of Thermonuclear War*. Harvard University Press, 2005.

Gibson, James William. *The Perfect War: The War We Couldn't Lose and How We Did*. Vintage Books, 1986.

Godfrey-Smith, Peter. "The Strategy of Model-Based Science." *Biology and Philosophy*, vol. 21, 2006, pp. 725–40.

Gold, Earnest. "William Napier Shaw, 1854-1945." *Obituary Notices of Fellows of the Royal Society*, vol. 5, no. 14, Nov. 1945, pp. 203–30.

Goodman, Steve. *Sonic Warfare: Sound, Affect, and the Ecology of Fear*. MIT Press, 2012.

Gregory, Derek. "The Everywhere War." *The Geographical Journal*, vol. 177, no. 3, 2011, pp. 238–50.

Grove, Jairus Victor. *Savage Ecology: War and Geopolitics at the End of the World*. Duke University Press, 2019.

Guerlac, Henry. "Vauban: The Impact of Science on War." *Makers of Modern Strategy: From Machiavelli to the Nuclear Age*, edited by Peter Paret, Princeton University Press, 1986.

Guha, Manabrata. *Reimagining War in the 21st Century: From Clausewitz to Network-Centric Warfare*. Routledge, 2011.

Hables Grey, Chris. *Postmodern War: The New Politics of Conflict*. Guilford, 1997.

Hacking, Ian. *The Emergence of Probability: A Philosophical Study of Early Ideas About Probability Induction and Statistical Inference*. Second Edition, Cambridge University Press, 2006.

---. *The Taming of Chance*. Cambridge University Press, 1990.

---. "Winner Takes Less." *The New York Review*, 28 June 1984, https://www.nybooks.com/articles/1984/06/28/winner-take-less/.

Hale, Lonsdale. "The Fog of War." *Journal of the Military Service Institution of the United States*, vol. 19, 1896, pp. 522–37.

Handel, Michael I. "Clausewitz in the Age of Technology." *Clausewitz and Modern Strategy*, Frank Cass, 1986, pp. 51–94.

Hansen, Frank V., et al. "Deliberate Air Pollution: The Art of Smoke Screening." *Army Science Conference Proceedings*, vol. 2, Department of Defense, 1980, pp. 165–79.

Harper, Kristine C. *Weather by the Numbers: The Genesis of Modern Meteorology*. MIT Press, 2008.

Hart, B. H. Liddell. *Through the Fog of War*. Random House, 1938.

Hartley, A. C. "Fog Dispersal." *Journal of the Royal Society of Arts*, vol. 95, no. 4732, 1946, pp. 22–44.

Hastings, Max. *Bomber Command*. Michael Joseph, 1979.

---. *Overlord: D-Day and the Battle for Normandy 1944*. Pan Macmillan, 1999.

Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. The University of Chicago Press, 1999.

Hediger, Ryan, editor. *Animals and War: Studies of Europe and North America*. Brill, 2013.

Heims, Steve Joshua. *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death*. MIT Press, 1980.

---. *The Cybernetics Group*. MIT Press, 1991.

Heinl, Robert Debs. *The Dictionary of Military and Naval Quotations*. Naval Institute Press, 2014.

Heisenberg, Werner. "The Physical Content of Quantum Kinematics and Mechanics." *Quantum Theory and Measurement*, edited & translated by John Archibald Wheeler and Wojciech Hubert Zurek, Princeton University Press, 1983, pp. 62–86.

Heuser, Beatrice. *The Evolution of Strategy: Thinking War from Antiquity to the Present*. Cambridge University Press, 2010.

---. "Theory and Practice, Art and Science in Warfare: An Etymological Note." *War, Strategy and History: Essays in Honour of Professor Robert O'Neill*, ANU Press, 2016, pp. 179–96.

Hilgers, Philipp von. *War Games: A History of War on Paper*. Translated by Ross Benjamin, MIT Press, 2012.

Howard, Michael. *Clausewitz: A Very Short Introduction*. Oxford University Press, 2002.

Hughes, B. P. *Firepower: Weapon Effectiveness on the Battlefield, 1630-1850*. Sarpedon, 1974.

Hussain, Nasser. "The Sound of Terror: Phenomenology of a Drone Strike." *Boston Review*, 2013, https://bostonreview.net/articles/hussain-drone-phenomenology/.

Jacob, Arun. "Follow The Ho Chi Minh Trail: Analyzing the Media History of the Electronic Battlefield." *IDEAH*, vol. 2, no. 1, July 2021.

Jullien, François. *A Treatise on Efficacy: Between Western and Chinese Thinking*. Translated by Janet Lloyd, University of Hawai'i Press, 2004.

---. *The Propensity of Things: Toward a History of Efficacy in China*. Translated by Janet Lloyd, Zone Books, 1995.

Kahn, Herman. *Thinking About the Unthinkable*. Horizon, 1962.

Kaplan, Fred. *The Wizards of Armageddon*. Stanford University Press, 1983.

Kármán, Theodore von. *Toward New Horizons. Volume 1: Science, the Key to Air Supremacy*. U.S. Air Force, 1945, pp. 1–109.

Keegan, John. *The Iraq War*. Knopf, 2004.

Kiesling, Eugenia C. "On War Without the Fog." *Military Review*, vol. 81, no. 5, 2001, pp. 85–87.

Kilcullen, David. *The Accidental Guerrilla: Fighting Small Wars in the Midst of a Big One*. Oxford University Press, 2011.

Kington, John A., and Franz Selinger. *Wekusta: Luftwaffe Meteorological Reconnaissance Units & Operations 1938-1945*. Flight Recorder Publications, 2006.

Kittler, Friedrich. "A Short History of the Searchlight." *Operation Valhalla: Writings on War, Weapons, and Media*, translated by Ilinca Iurascu et al., Duke University Press, 2021, pp. 62–68.

---. "Animals of War: A Historical Bestiary." *Operation Valhalla: Writings on War, Weapons, and Media*, translated by Ilinca Iurascu et al., Duke University Press, 2021, pp. 123–26.

---. *Discourse Networks 1800/1900*. Translated by Michael Metteer and Chris Cullens, Stanford University Press, 1990.

---. "Fragments of a History of Firearms." *Operation Valhalla: Writings on War, Weapons, and Media*, translated by Ilinca Iurascu et al., Duke University Press, 2021, pp. 69–72.

---. *Optical Media: Berlin Lectures 1999*. Translated by Anthony Enns, Polity, 2010.

Kreike, Emmanuel. *Scorched Earth: Environmental Warfare as a Crime against Humanity and Nature*. Princeton University Press, 2021.

Kunkel, Bruce A. "Controlling Fog." *Weatherwise*, vol. 33, no. 3, 1980, pp. 117–23.

Ladyman, James, and Karoline Wiesner. *What Is a Complex System?* Yale University Press, 2020.

Land, Nick. *Hyperstition: An Introduction*. Interview by Delphi Carstens, Merliquify, 2009, http://merliquify.com/blog/articles/hyperstition-an-introduction.

Laplace, Pierre-Simon. *Philosophical Essay on Probabilities*. Translated by Andrew I. Dale, Springer, 1995.

Lepage-Richer, Théo. "Adversariality in Machine Learning Systems: On Neural Networks and the Limits of Knowledge." *The Cultural Life of Machine Learning: An Incursion into Critical AI Studies*, edited by Jonathan Roberge and Michael Castelle, Palgrave Macmillan, 2021, pp. 197–225.

Libicki, Martin C. *Information & Nuclear RMA's Compared*. Institute for National Strategic Studies, National Defense University, 1996.

---. *The Mesh and the Net. Speculations on Armed Conflict in a Time of Free Silicon*. McNair Paper 28, Institute for National Strategic Studies, National Defense University, 1994, pp. 1–127.

Lind, William S. "Don't Take John Boyd's Name in Vain." *CounterPunch.Org*, 1 May 2003, https://www.counterpunch.org/2003/05/01/don-t-take-john-boyd-s-name-in-vain/.

Lindley, David. *Uncertainty: Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science*. Anchor Books, 2008.

Luce, R. Duncan, and Howard Raiffa. *Games and Decisions: Introduction and Critical Survey*. Wiley, 1957.

Ludlum, David M. *The Weather Factor*. American Meteorological Society, 1989.

Lynn, John A. *Battle: A History of Combat and Culture From Ancient Greece to Modern America*. Basic Books, 2008.

Malaspina, Cecile. *An Epistemology of Noise*. Bloomsbury, 2018.

Manning, Chelsea. "The Fog Machine of War." *The Real News Network*, 16 June 2014, http://therealnews.com/the-fog-machine-of-war.

Manovich, Lev. *Software Takes Command*. Bloomsbury, 2013.

Marshall, Andrew W. *Some Thoughts on Military Revolutions - Second Version*. Office of Net Assessment Memorandum, Department of Defense, 1993, pp. 1–8.

Martin, James, and Adrian R. D. Norman. *The Computerised Society*. Penguin Books, 1973.

MCDP-1: Warfighting. U.S. Marine Corps, 1997.

Mégret, Frédéric. "War and the Vanishing Battlefield." *Loy. U. Chi. Int'l L. Rev.*, vol. 9, no. 1, 2011, p. 131.

Michelakis, Pantelis. "Introduction: Classical Antiquity, Media Histories, Media Theories." *Classics and Media Theory*, edited by Pantelis Michelakis, Oxford University Press, 2020.

Millikan, Robert A. "Contributions of Physical Science." *The New World of Science: Its Development During the War*, edited by R. M. Yorkes, The Century Company, 1920, pp. 33–48.

---. "Some Scientific Aspects of the Meteorological Work of the United States Army." *Monthly Weather Review*, vol. 47, no. 4, Apr. 1919, pp. 210–15.

Milner, Marc. *Battle of the Atlantic*. 2nd ed., The History Press, 2011.

Möller, Eberhard, and Werner Brack. *The Encyclopedia of U-Boats from 1904 to the Present*. Translated by Andrea Battson and Roger Chesneau, Greenhill Books, 2004.

Murray, Stewart Lygon. *The Reality of War: A Companion to Clausewitz*. Edited by A. Hilliard Atteridge, Hodder and Stoughton, 1909.

Nebeker, Frederik. *Calculating the Weather: Meteorology in the 20th Century*. Academic Press, 1995.

Negarestani, Reza. *Cyclonopedia: Complicity with Anonymous Materials*. re.press, 2008.

New Zealand Defence Doctrine NZDDP-D. Fourth Edition, New Zealand Defence Force, 2017.

Osinga, Frans P. B. *Science, Strategy and War: The Strategic Theory of John Boyd*. Routledge, 2007.

Owens, Bill, and Ed Offley. *Lifting the Fog of War*. John Hopkins University Press, 2000.

Packer, Jeremy, and Joshua Reeves. *Killer Apps:War, Media, Machine*. Duke University Press, 2020.

Parkin, Simon. *A Game of Birds and Wolves: The Ingenious Young Women Whose Secret Board Game Helped Win World War II*. Little, Brown and Company, 2020.

Pascal, Blaise. *Pensées and Other Writings*. Edited by Anthony Levi, Translated by Honor Levi, Oxford University Press.

Peirce, Charles Sanders. *Collected Papers of Charles Sanders Peirce*. Edited by C. Hartshorne et al., Harvard University Press, 1931.

Perrow, Chris. "Difficulties with Network Centric Warfare." *Information Assurance: Trends in Vulnerabilities, Threats, and Technologies*, edited by Jacques S. Gansler and Hans Binnendijk, National Defense University, 2004.

Peters, John Durham. *The Marvelous Clouds: Towards a Philosophy of Elemental Media*. University of Chicago Press, 2015.

Peterson, Jon. *Playing at the World: A History of Simulating Wars, People and Fantastic Adventures, from Chess to Role-Playing Games*. Unreason Press, 2012.

Petriello, David R. *Tide of War: The Impact of Weather on Warfare*. Skyhorse, 2018.

Petterssen, Sverre. *Weathering the Storm: Sverre Petterssen, the D-Day Forecast, and the Rise of Modern Meteorology*. Edited by James Roger Fleming, American Meteorological Society, 2001.

Plato. *The Laws*. Translated by Thomas L. Pangle, The University of Chicago Press, 1980.

Poundstone, William. *Prisoner's Dilemma: John von Neumann, Game Theory, and the Puzzle of the Bomb*. Anchor Books, 1992.

Rao, Venkatesh. "The Use and Misuse of the OODA Loop." *Ribbonfarm*, 13 Apr. 2018, https://studio.ribbonfarm.com/p/the-use-and-misuse-of-the-ooda-loop.

Robertson, Terence. *The Golden Horseshoe: The Wartime Career of Otto Kretschmer, U-Boat Ace*. Naval Institute Press, 2011.

Rochlin, Gene I. *Trapped in the Net: The Unanticipated Consequences of Computerization*. Princeton University Press, 1997.

Rozema, Lee A., et al. "Violation of Heisenberg's Measurement-Disturbance Relationship by Weak Measurements." *Physical Review Letters*, vol. 109, no. 10, 2012, p. 100404.

Sambursky, Samuel. "On the Possible and the Probable in Ancient Greece." *Osiris*, vol. 12, 1956, pp. 35–48.

Scharre, Paul. "Centaur Warfighting: The False Choice of Humans vs. Automation." *Temp. Int'l & Comp. LJ*, vol. 30, no. Spring, 2016, p. 151.

Schuurman, Paul. "A Game of Contexts: Prussian-German Professional Wargames and the Leadership Concept of Mission Tactics 1870-1880." *War in History*, vol. 28, no. 3, 2019, pp. 504–24.

---. "Models of War 1770-1830: The Birth of Wargames and the Trade-Off Between Realism and Simplicity." *History of European Ideas*, vol. 43, no. 5, 2017, pp. 442–55.

Scott, Ridley. *Body of Lies*. Warner Brothers, 2008.

Shalikashvili, John M. *Joint Vision 2010*. Joint Staff: Pentagon, 1996, pp. 1–35.

Shannon, Claude E. "A Mathematical Theory of Communication." *The Bell System Technical Journal*, vol. 27, no. 3, 1948, pp. 379–423.

Shaviro, Steven. *Discognition*. Repeater, 2016.

Singleton, Benedict. *On Craft and Being Crafty: Human Behaviour as the Object of Design*. University of Northumbria, 2014.

---. "Subtle Empires: On Craft and Being Crafty." *Design Ecologies*, vol. 1, no. 2, 2011, pp. 249–64.

Sloterdijk, Peter. *Terror from the Air*. Translated by Amy Patton and Steve Corcoran, Semiotext(e), 2009.

Smith, Peter. *An Introduction to Gödel's Theorems*. Second Edition, Cambridge University Press, 2013.

Stoker, Donald. *Clausewitz: His Life and Work*. Oxford University Press, 2014.

Strong, Paul Edward. “Wargaming the Atlantic War: Captain Gilbert Roberts and the Wrens of the Western Approaches Tactical Unit.” *PAXsims*, 2017.

Sun-Tzu. “The Art of Warfare.” *The Book of War: Sun-Tzu The Art of Warfare & Karl von Clausewitz On War*, translated by Roger T. Ames, The Modern Library, 2000, pp. 71–255.

Taleb, Nassim Nicholas. *The Black Swan: The Impact of the Highly IMprobable*. Random House, 2007.

The Implementation of Network-Centric Warfare. Force Transformation, Office of the Secretary of Defense, 2005.

Uffink, Jos. “Compendium of the Foundations of Classical Statistical Physics.” *Philosophy of Physics*, edited by Jeremy Butterfield and John Earman, North Holland, 2007, pp. 923–1047.

Umstead, Robert K., et al. *KWIK: An Algorithm for Calculating Munition Expenditures for Smoke Screening/Obscuration in Tactical Situations.* US Army Electronics Research and Development Command, 1979, pp. 1–79.

Väliaho, Pasi. “The Light of God: Notes on the Visual Economy of Drones.” *NECSUS. European Journal of Media Studies*, vol. 3, no. 2, 2014, pp. 99–111.

Vargas Machuca, Captain Bernardo de Vargas. *The Indian Militia and Description of the Indies*. Edited by Kris Lane, Translated by Timothy F. Johnson, Duke University Press, 2008.

Vegetius. *Epitome of Military Science*. Translated by N. P. Milner, Second Edition, Liverpool University Press, 1996.

Virilio, Paul. *Paul Virilio Live*. Edited by John Armitage, Sage Publications, 2001.

---. *War and Cinema: The Logistics of Perception*. Translated by Patrick Camiller, Verso, 1989.

Võ, Nguyên Giáp, and Tiến Dũng Văn. *How We Won the War*. Recon, 1976.

Watts, Barry D. *Clausewitzian Friction and Future War, Revised Edition*. McNair Paper 68, Institute for National Strategic Studies, National Defense University, 2004, pp. 1–123.

Watts, Peter. "ZeroS." *Infinity Wars*, edited by Jonathan Strahan, Solaris, 2017, pp. 315–64.

Weaver, Warren. "The Mathematics of Communication." *Scientific American*, vol. 181, no. 1, 1949, pp. 11–15.

Westmoreland, William C. *A Soldier Reports*. Doubleday, 1976.

Whaley, Barton. *Stratagem: Deception and Surprise in War*. 2007 Reprint, Artech House, 2007.

Wheeler, Everett L. *Stratagem and the Vocabulary of Military Trickery*. E.J. Brill, 1988.

Wiener, Norbert. *Cybernetics or Control and Communication in the Animal and the Machine*. Second Edition, MIT Press, 2019.

---. *Statistical Method of Prediction in Fire Control*. Office of Scientific Research and Development, 1942, p. 22.

---. *The Human Use of Human Beings: Cybernetics and Society*. Second Edition, Doubleday, 1954.

Wilcox, Fred A. *Scorched Earth: Legacies of Chemical Warfare in Vietnam*. Seven Stories Press, 2011.

Wilkins, Inigo. *Irreversible Noise: The Rationalisation of Randomness and the Fetishisation of Indeterminacy*. Goldsmiths, University of London, 2015.

Williams, Geoffrey. *Flying Through Fire: FIDO - The Fogbuster of World War Two*. Grange Books, 1996.

Williams, Mark. *Captain Gilbert Roberts R.N. and the Anti-U-Boat School*. Cassell, 1979.

Williamson, Gordon. *U-Boat Tactics in World War II*. Osprey Publishing, 2010.

Wilson, Andrew. *The Bomb and the Computer: The History of Professional Wargaming 1780 - 1968*. Edited by John Curry, History of Wargaming Project, 2014.

Wintjes, Jorit. "Europe's Earliest Kriegsspiel? Book Seven of Reinhard Graf Zu Solms' Kriegsregierung and the 'Prehistory' of Professional War Gaming." *British Journal for Military History*, vol. 2, no. 1, 2015, pp. 15–33.

---. "Not an Ordinary Game, But A School of War: Notes on the Early History of the Prusso-German Kriegsspiel." *Vulcan*, vol. 4, 2016, pp. 52–75.

---. "When a Spiel Is Not a Game." *Vulcan*, vol. 5, 2017, pp. 5–28.

Wolfendale, Pete, and Tim Franklin. "Why Dungeons and Dragons Is Art." *Dungeons & Dragons and Philosophy: Raiding the Temple of Wisdom*, edited by G. A. Reisch, Carus Publishing Company, 2012, pp. 207–24.

Young, John P. *A Survey of Historical Developments in War Games*. John Hopkins University, Operations Research Office, 1959, p. 116.

Zheng, Denise E., and William A. Carter. *Leveraging the Internet of Things for a More Efficient and Effective Military*. Rowman & Littlefield, 2015.

Zierler, David. *The Invention of Ecocide: Agent Orange, Vietnam, and the Scientists Who Changed the Way We Think About the Environment*. University of Georgia Press, 2011.