Mathematics and War

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War Cannot Be Calculated

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"Cry Havoc! And let slip the dogs of war."
Shakespeare, *Julius Caesar* III.i.270

War is throughout influenced by policy, but who can predict political interventions? War is about breaking soldiers' will to fight, but who can predict when it happens? In war, for a number of reasons, small deviations and misunderstandings occur, and they start avalanches of misfortune which only the iron will of a commander can attenuate, but never stop completely. It is called friction. For all these reasons war cannot be calculated.

1 Introduction

1.1 Setting the stage

"When the dogs of war slip loose accurate prognosis is almost impossible; the surreal becomes the typical."[1] Shakespeare's havoc and the quoted surreal represent the semantics of most principal statements one can find in the so-called Western thinking on this particular phenomenon – war. The "fog of war" is another all embracing expression, which has been widely accepted as a dictum. To go to war means to enter a fog of uncertainty.

In order to cope with this, specified authority to react according to circumstances is delegated down the chain of command. The origin of this particular approach to warfare is found in the Prussian/German General Staff, which existed 1657–1945. So far, this system has proven itself effective.

It should be noted, however, that the Marxist-Leninist thinking on war was – and in some parts of the World still is – based on the appreciation that war can be waged in a scientific manner, i.e., within the framework of the dialectics of historical materialism. It meant that the armed forces had to fight in accordance with rigid rules.

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[1] Both quotations from *The Dogs of War.*

Especially during the Stalinist era, the Soviet Union had to pay dearly for this. In the winter war (1939) against Finland the Red Army initially suffered terrible losses to a seemingly very inferior, but determined Finnish army, which fought Western style.

Equally astonishing – on the East front, after having suffered terrible losses at Moscow (December 1941) and Stalingrad (December 1942), the German army succeeded in fighting a series of successful delaying battles against an – on paper – increasingly superior enemy. Against all odds, the German army succeeded in maintaining a cohesive defense until January 1945.

It should be noted, too, that in the so-called Eastern thinking on war, pragmatism always has been predominant:

> To the great Chinese military writer Sun Tzu, war was neither a duel nor a sport like contest. Rather, it represented one way, and a rather undesirable way, of settling disputes between social and political groups. For him it was a question, not of honorably meeting an opponent face to face, but of settling the dispute with the least possible disturbance of cosmic harmony, or dao. [...] In marked contrast to the West, the East has always considered the ambush not only perfectly respectable but much the most effective means of waging war. This leads to an emphasis on traps of all kinds, from the feigned retreat that was the specialty of the Mongols to the excreta-smeared bamboo stakes that so angered the Americans in Vietnam. When war involved a struggle between civilizations whose patterns of thought differed in this way, the results were often markedly savage. Unable to agree as to what constituted acceptable behavior and what did not, each side took the enemy‘s action as a pretext for reprisals.[2]

In brief, we see three archetypical approaches to what war is really about. There are, of course, other variations of organized violence: Symbolic tribal wars, for example, which involved very little bloodshed, have been used as an entry to manhood, and clan and family feuds have lasted for generations. But these activities can hardly be defined as wars in this connection.

Large scale terrorism is excluded as well as an act of war. The current so-called[3] humanitarian laws of war forbid it. These laws define – broadly speaking – that it is states only that can wage war, with one exception. Rebels, who are in control of a certain area and are able to live up to a number of requirements, are protected by the same laws.

Wars fought with an extensive and continuous use of weapons of mass destruction (nuclear warheads, biological or chemical agents) against large population centers have not been seen yet. However, there is no reason to believe that such wars would be less chaotic than so-called conventional war. This type of war will not be discussed in the paper, as we – fortunately – have no experiences to draw on.

[2] Creveld, *Technology and War*, p. 73.

[3] So-called, because it is a set of international conventions which are not fully accepted by all countries. Add to this that law enforcement seems to be the domain of the winners only.

Figure 1. Carl von Clausewitz at 50 years of age in a Prussian general's uniform. Lithography: Franz Michelis jr. after a painting by Wilhelm Wach. [Courtesy: Chris Bassford, National War College, Washington]

1.2 The main sources

In order to provide a common point of departure for a discussion of the topic in question I have chosen to use Karl A. Popper's harsh critique of what he calls "historicism" in his main work: *The Open Societies and its Enemies*. This is, of course, an *ideological choice*, and as such disputable.

My particular arguments concerning the unpredictability of war rest on the Prussian officer Carl von Clausewitz's book *On War*.[4] This choice is obvious, as Clausewitz's analysis of the relationship between politics and war, and of war itself, has had, and still has, a marked impact on the central European and American perception of war. Lenin studied On War as well, but failed to draw a lesson from it.

2 True Science?

Can the phenomenon "war" be approached in a truly scientific manner? It is obvious that the equipment of war (weapon systems, communications systems etc.) is to be regarded as a product of mathematics, natural sciences and technological development.

But how do we handle the imponderables of war? I return to this, but at first it is necessary to define what war is. It is obvious that war is evil, but war is also a

[4] Since this work is quoted copiously in the following it is referred to by the abbreviation OW, meaning the edition [Clausewitz 1982].

matter of fact. It is also a matter of fact that it is people who fight wars. The international society has in a number of conventions agreed on the legal definitions of which situations can be regarded as war and what is acceptable behavior in war.

Clausewitz invested much effort into uncovering how war can be defined as a phenomenon. Doing so, he realized that the relationship between policy and war is the key to uncovering the mysteries of war.

The following quotations from *On War* lead to a definition of war:

> War is the continuation of policy by other means. We see, therefore, that war is not merely a political act, but also a real political instrument, a continuation of *political intercourse*,[5] a carrying out of the same by other means.[6]

In a note from 1827 about plans for a revision, Clausewitz called attention to "...that *war is nothing but the continuation of state policy with other means*."[7] And he stressed that by keeping this in mind, the reading of *On War* would be easier.

Clausewitz's initial definition of war in *On War* was "*War therefore is an act of violence intended to compel our opponent to fulfill our will*."[8] (Clausewitz underlined this sentence.)

Elsewhere in *On War*, Clausewitz several times returned to the theme that war is an instrument for (foreign) policy, and he distinguished between the political purpose of war and the manifest goals "inside" the war.

In connection with a discussion over whether or not war is a science or an art, Clausewitz concluded:

> War is part of the intercourse of the human race. We say therefore war belongs not to the province of arts and sciences, but to the province of social life. It is a conflict of great interests which is settled by bloodshed, and only in that it is different from others. It would be better, instead of comparing it with any art, to liken it to business competition, which also is a conflict of human interests and activities; and it is still more like state policy, which again, on its part, may be looked upon as a kind of business competition on a great scale…"[9]

It is obvious that organized violence with a purpose has existed as far back in human existence as archaeology makes sense. We also find an abundant number of historical indicators pointing in the direction that war is a social phenomenon both within and among the warring parties. War *is* a conflict between people, and wars have always been decided upon and fought by people using whatever technol-

[5] In the source, the word (political) "commerce" is used. In another translation form 1976 by Michael Howard and Peter Paret, the word "activity" is used. I find a Danish translation "samkvem" (intercourse) more correct. (See list of sources)
OW, p. 119. (Bk. I, ch. 1: *War is a mere continuation of policy by other means*).

[6] ibid.

[7] My translation from the Danish text.

[8] OW, p. 101. (Bk I, ch. 1: *Definition*).

[9] ibid., p. 202. (Bk. II, ch. 3: *War is part of the intercourse of the human race*).

ogy is at hand. Wars have always been started because one or more parties at the moment of decision have found war either beneficial or unavoidable.

The ability to use organized violence (the military capabilities) can in itself be a motivating factor, if one of the parties finds itself militarily superior. But it does not exclude the fact that it is people who decide to go to war, plan and fight wars, campaigns and battles, and perform the combat, and it is people at all levels of war who make the final decision when enough is enough on their part.

I have chosen to consolidate the above observations in the following definition of war:

> War is the continuation of policy with other means, a political, social and human intercourse, which includes the use of organized violence for a political purpose.

It should be noted that this definition takes into consideration that diplomatic activities take place during war.

The decision makers at all levels of war have, since the beginning of the industrialization with an ever accelerating momentum, been supported by technology. Today this support ranges from off-the-shelf commercial communication and information systems to government controlled, secret complex simulations supported by extremely powerful computers.

But we have to bear in mind that war is a "dialectic clash", where the decision makers on both sides and at all levels try to establish a number of suitable options, estimating or calculating ends and means, causes and effects. But would it be chimerical to expect any estimate or calculation to provide a lasting solution? The answer to that question is what this paper is all about.

In view of the chosen definition of war, it seems to be an obvious choice to turn to social science in order to find a way to provide a deeper insight into the dynamics of war.

3 Popper

Popper's views on the social sciences are found in the following quotations:

> The future depends on ourselves, and we do not depend on any historical necessity. There are, however, influential social philosophies which hold the opposite view. They claim that everybody tries to use his brain to predict impending events; that it is certainly legitimate for a strategist to try to foresee the outcome of a battle; and that the boundaries between such a prediction and more sweeping historical prophecies are fluid. [...] They also believe that they have discovered laws of history which enable them to prophecy the course of historical events.[10]

[10] *The Open Society and its Enemies (OSE)*, volume I, p. 3.

> [...] in spite of their plausibility they are based on a gross misunderstanding of the method of science, and especially they neglect the distinction between scientific prediction and historical prophecy.[11]
>
> [...] in science, we never have sufficient reason for the belief that we have attained the truth. What we usually call "scientific knowledge" is, as a rule, not knowledge in this sense, but rather information regarding the various competing hypotheses and the way in which they have stood up to various tests [...] This view means, furthermore, that we have no proofs in science (excepting, of course pure mathematics and logic). In the empirical sciences, which alone can furnish us with information about the world we live in, proofs do not occur, if we mean by "proof" an argument which establishes once and forever the truth of a theory. (What may occur, however, are refutations of scientific theories). On the other hand, pure mathematics and logic, which permit of proofs, give us no information about the world, but only develop the means of describing it. Thus we could say: "In so far as scientific statements refer to the world of experience, they must be refutable; and, in so far as they are irrefutable, they do not refer to the world of experience." But although proof does not play any part in the empirical sciences, arguments still does; indeed, its part is at least as important as that played by observation and experiment.[12]

But Popper's cure for historicism is at hand:

> The only course open to the social sciences is to forget the verbal fireworks and to tackle the practical problem of our time with the help of the theoretical methods which are fundamentally the same in all sciences. I mean the methods of trial and error, of inventing hypotheses which can be practically tested, and of submitting them to practical tests. *A social technology is needed whose results can be tested by piecemeal social engineering.*[13]

What did Popper mean by "social technology"? I consulted a comprehensive dictionary[14] and found that the adjective "social" has a number of applications, ranging from
– "of or pertaining to society or its organization" to
– "grouping compactly".

Concerning the noun "technology", I found it can be defined as
– "theoretical knowledge of industry and the industrial arts" and as
– "the application of science to the arts" and as
– "that branch of ethnology which treats the development of the arts".

Concerning the noun "arts", I found it can be defined as
– "the skilful, systematic arrangement or adaptation of means for the attainment of some end, especially by human endeavor as opposed to natural forces" and as

[11] ibid.

[12] OSE, volume II, p. 13.

[13] ibid., p. 222.

[14] Webster's comprehensive Dictionary of the English Language, encyclopedic edition.

– "the practical application of knowledge or natural ability; skilled workmanship; mastery; dexterity" and as
– "a set of system or rules, principles etc., devised for procuring some scientific, esthetic, or practical result, as by exercise; a branch of learning to be studied in order to be applied."

The following example illustrates my interpretation of Popper's requirement for a scientific approach, based on the above specifications.

Within this particular field of social and human intercourse,[15] war, Popper's cure for historicism has been used for as far back in history as we have credible historical facts at hand. Take the ancient Greek phalanx, the very structure of the city state army. In a psychological perspective it can be regarded as a product of social technology, the purpose of which was to maintain social coherence[16] during battle. The main components of this particular social technology were the following:
– Knowledge of, and conviction in, the value of ones own rights and duties as a free citizen.
– Knowledge of, and conviction in, the necessity of discipline (in the sense of voluntary obedience).
– Knowledge of, an ability to handle, and possession of up to date weapons and armor.
– Knowledge of, and an ability to execute proven effective tactics.
– Conviction in the proven leadership qualities of commanding officers.
– A deliberately amplified, culturally induced sense of honor and dishonor.

The need for this social technology was extreme. It was a matter of life or death to maintain social coherence within the phalanx during battle. If the coherence broke, the phalanx would decompose and the individual foot soldier, the hoplite, would be an easy prey for the pursuing enemy cavalry.

The result of the social technology, the coherence, was tested by piecemeal social engineering, for example adjustments in tactics and change of leader, in order to improve the coherence in the next battle.

This process still goes on. We may use expressions as "team building" or "indoctrination" to classify the process, but social coherence is still extremely necessary within political crisis management groups, military staffs, military formations, tanks, aircraft, submarines etc. – not to forget infantry squads.

But how do we – in the mathematical context we deal with here – quantify the components in this particular social technology and measure the effects of any social engineering? Add to this that it is only to a minor degree that we can test the result, the coherence, through questionnaires, simulations, and peacetime

[15] One can speculate if there is a distinction at all between social and human intercourse?

[16] I use the word "coherence" in order to indicate the product of a logical proces. "Cohesion" is used as a more "loose" concept.

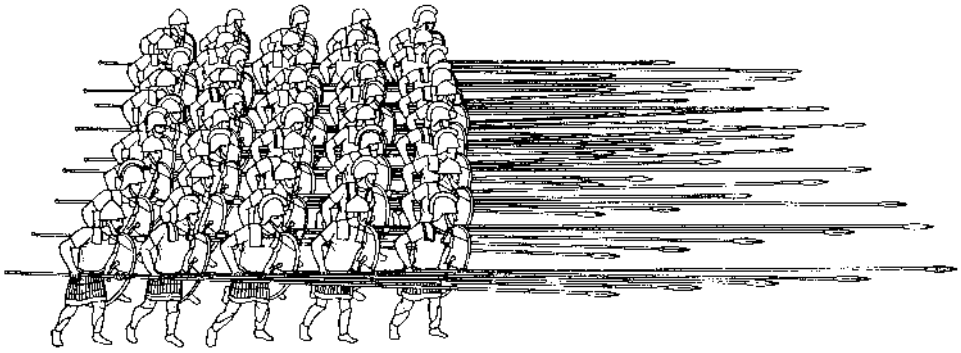


Figure 2. The first archeological proofs of disciplined attacks with massed infantry formations using pointed weapons are dated to app. 650 B.C. and are accredited to the Greek hoplite phalanx. Some of the last attempts to carry massed charges home with the bayonet as a primary weapon were done 1914–1915. The picture shows a fraction of a Macedonian phalanx as it was used by the emperor Alexander the Great (356–323 B.C.). [Illustration from *The World Atlas of Warfare*, Mitchell Beazley Publishers 1988]

exercises. The final test is combat, and only then we will know for sure. Here we find the first major source of uncertainty:

1) ***The social coherence of military units cannot be tested precisely during peacetime.***

Social sciences may provide deeper insight in the dynamics of war and warfare. But we have not solved the crucial problem: It is possible to predict the outcome of war and battles.

Could mathematics provide the answer? Let us turn to Clausewitz for a more particular analysis of *war as a phenomenon* and *warfare as an activity.*

4 Clausewitz

4.1 How do we read Clausewitz?

Clausewitz was a child of the period of enlightenment in the last half of the 18th century, where philosophy and sciences flourished in Central Europe. His war experiences were the Napoleonic wars. He tried to establish an all-embracing theory on war as a phenomenon.

He died before he could finish his work. In a note on revision, probably from 1830, he stated that only the first chapter of the first book was fully finished. In this chapter he answers the question: What is war? He regarded the rest of *On War* as a collection of materials, where only the main lines can be used to recognize what war and warfare are all about.

When reading Clausewitz we have to keep a few preconditions in mind:

– We must try to understand the mindset of a well educated and intellectual officer who lived 1780–1831 in Central Europe.

– We also have not just to translate his contemporary German into modern German but we also, if desired, have to translate the modern German into any other modern language we master. These are no easy tasks at all. Important nuances may disappear and concepts be twisted.
– And most important – we have to be very careful not to accept concepts, information and conclusions which simply are outdated. Clausewitz's introduction to *On War* offers a clue where to be cautious.

> We propose to consider first the single elements of our subject, then each branch or part, and, last of all, the whole, in all its relations – therefore to advance from the simple to the complex. But it is necessary for us to commence with a glance at the nature of the whole, because it is particularly necessary that in the consideration of any of the parts their relation to the whole should be kept constantly in view.[17]

In the introduction to an unpublished manuscript on the theory of war, written between 1816 and 1818, he wrote:

> Thinking and observation, philosophy and experience must never despise or exclude each other – they mutually stand surety for each other.[18]

Obviously Clausewitz's ambition was to develop an all-embracing coherent theory from a conceptual structure – and to test it against reality. Though it is not mentioned in the introduction to chapter 1, in *On War* he tried to test both the conceptual framework and his theory against the reality he had at hand from historical sources and own experiences.

But we have to consider, if some – or even many – of the single elements or branches or parts in his conceptual structure may be irrelevant or plain obsolete.

Some guidance can be found in the following discourse:

> The description of phenomena and the communication of experiences are two principal and interdependent functions of language. The unambiguous description of a particular phenomenon excludes from consideration all other similar phenomena, but if the experience of the particular phenomenon is to be communicated to another person who has not observed the phenomenon, the description must in some way transcend the particular case. Otherwise, of course, communication is not possible. *Thus the interaction between particularity and generality must be fundamental in linguistic communication*. As an example one may take any noun from ordinary language. A noun has a dual function: first, it denotes a particular phenomenon or experience; second, it is a concept, that is, it also denotes a particular class of phenomena or experiences. The context in which the noun occurs may focus the attention on the particular significance, but the conceptual significance is the knowledge by means of which the particular case is understood.[19]

[17] OW, p. 101. (Bk. I, ch. 1: "*Introduktion*").

[18] My translation from a Danish translation of *On War.*

[19] T. Bergstein, *Quantum Physics and Ordinary Language*, p. 1.

A few remarks on the levels of war are needed, too. In brief, Clausewitz's perception of war and warfare were the following:

1. The political level generates the purpose of war.
2. The strategic level is responsible for the deployment of the armies for the battle.
3. The tactical level is responsible for the maneuvers, which bring the army units in contact with the enemy.
4. The combat level is where the actual use of violence takes place.

However, Clausewitz indicated that the above stratification was insufficient as far as both strategy[20] and tactics[21] are concerned. Later the German general staff introduced an operational level, the purpose of which was to establish a domain of their own, where the realities of warfare could be handled by professionals.

This construction was much disputed in the rest of Europe, because the German General Staff, besides its legal activities, also sought to influence policy making and committed war crimes during both world wars. But the construction proved itself effective, and today the following stratification is generally accepted:

1. The political level generates the purpose of war.
2. The strategic level is responsible for providing the overall idea of how to fight the war (the strategic concept).
3. The operational level is responsible for the deployment of the armies, navies, and air forces for the war.
4. The tactical level is responsible for the maneuvers, which bring the military units in contact with the enemy.
5. The combat level is where the actual use of violence takes place.

These levels of command are, of course, not sharply separated, but represent a continuum. Statesmen at Clausewitz's time often were mostly occupied with preparing for or fighting wars and thus were supposed to have insight in military matters. Napoleon was the last head of state who was able to manage war between states down to and including the tactical level. Stalin and Hitler tried too, but failed. Stalin realized his failure, when the German army threatened Moscow. Hitler continued to the very end.

Clausewitz had a somewhat dubious attitude to the concept "the art of war". In book II, "On the Theory of War" he initially used it to define all activities in war,[22] including the formation of units, logistics etc. Later in book II he used a whole chapter[23] to discuss "Art or Science of War", where he concluded: "We say therefore war belongs not to the province of art and science, but to the province of social life." (As I have quoted earlier.)

[20] OW, p. 243. (Bk. III, ch. 1, section beginning with: *But let us admit: there is no question here* […] (ending with) […], *the moral quantities are already reduced to a very small number.*)

[21] OW, p. 173. (Bk. II, ch. 1, section beginning with: *That doubtful cases may occur,* […] (ending with) […] *for the passage of a river at several points, etc.*)

[22] OW, p. 172. (Bk. II, ch. 1, section beginning with: *The Art of War is therefore* […] (ending with) […], *belong to the Art of War.*)

[23] OW, pp. 201-203. (Bk. II, ch. 3).

Today we use two expressions, more or less at random; "art of war" or "operational art". Both are really the same concept, and refer to the operational level, where the strategic intentions (the strategic concept) are transformed into operational plans; i.e., orders specifying, which units are going where, doing what, and when.

Let us turn to one question which is rather important in this connection: What did Clausewitz mean by "laws of probability" and "calculation of probability" – concepts he refers to in *On War*?

4.2 Probability

It is basic knowledge that all probability calculation in the end must rest on empirical data. And it should be noted that when attempting to predict the *outcome* of a war and the *overall progress* of the warfare "within" it, probability calculation must *begin* with gathering empirical data in order to be able to calculate the end state.

Now – land warfare in the Napoleonic era was a rather cumbersome affair measured with nowadays' standards. All armies moved by foot or horse, and alone the problem with providing fodder for the horses caused predictable stops in movements. All armies were much alike, too. There were three main branches, infantry, artillery, and cavalry. Weapons were by and large the same: Muzzle loaded guns and cannons, bayonets, sabers and lances.

Thus – if a commanding general of an army had reliable intelligence concerning the quantity, composition and whereabouts of an enemy army and equally reliable information concerning the terrain (including the possibility of providing fodder and food), it could not have been too difficult to estimate or calculate for example the probability of the position of that particular army at a particular time if it marched along a particular route. The following quotation supports this interpretation:

> But the slower the action proceeds in War, the more frequent and longer the periods of inaction, so much more easy can an error be repaired; therefore so much bolder a General will be in his calculations, so much more readily will he keep them below the line of the absolute, and build everything upon probabilities and conjecture. Thus, according as the course of the War is more or less slow, more or less time will be allowed for that *which the nature of a concrete case particularly requires, calculation of probability based on given circumstances.*[24]

In other words – Clausewitz pointed out that the premises must be specific. But the problem with providing reliable in-time intelligence was significant:

> Great part of the information (i.e. intelligence reports, my comment) obtained in War is contradictory, a still greater part is false, and by far the greatest part is of a doubtful character. What is required of an officer is a cer-

[24] OW, p. 116. (Bk. I, ch. 3: "*Frequent periods of interaction in war…*")

> tain power of discrimination, which only knowledge of men and things and good judgment can give. The law of probability must be his guide. This is not a trifling difficulty even in respect of the first plans, which can be formed in the chamber outside the real sphere of War, but it is enormously increased when in the thick of War itself one report follows hard upon the heels of another; *it is then fortunate if these reports in contradicting each other show a certain balance of probability, and thus themselves call forth a scrutiny.*[25]

Clausewitz most likely meant that beside the information overload (a stress factor in itself) reliable but contradicting intelligence reports for example could indicate a diversionary attack, the purpose of which was to lure the defender to concentrate forces in the wrong direction.

After having reflected on danger, courage, and the relationship between courage and prudent calculation Clausewitz concluded

> And we see therefore, how, from the commencement, the absolute, the mathematical as it is called, nowhere finds any sure basis in the calculations in the Art of War; *and that from the outset there is a play of possibilities, probabilities, good and bad luck, which spreads about with all the coarse and fine threads of its web, and make War of all branches of human activity the most like a gambling game.*[26]

Had Clausewitz conceptual problems here? He integrated the concepts of possibility, probability and luck in one sentence. He seemingly had troubles in constructing a conceptual structure. On the other hand – he did not state that war is a gambling game.

Having only sporadic knowledge of mathematics myself – not to mention a complete ignorance of its state at the beginning of the 19th century – I had the above quotations and arguments reviewed by a mathematician, who suggested inserting the following:

> It is worthwhile to observe, that the mathematical probability concept as well as the elementary rules of probability calculation were founded through the study of games as a means to calculate the likelihood of winnings and losses during a game (Fermat, Pascal, Huygens). The exact rules defining a game make the calculated probabilities indisputable. More advanced applications of mathematical probability theory also rest on a number of exactly defined assumptions, which make the calculated probabilities indisputable within the conceptual framework in question. In the case of warfare Clausewitz points out that probability calculations always rest on an insufficient number of real world information, which are, furthermore, often highly uncertain. If Clausewitz is right, any calculated probability of the outcome of a warfare operation must therefore be highly disputable.[27]

[25] ibid., p. 162. (Bk. I, ch. 6, second section).

[26] OW, p. 117. (Bk. I, ch. 1: *War is a game both objectively and subjectively*).

[27] T. Bergstein, author of *Quantum Physics and Ordinary Language.*

I find it reasonable to claim that Clausewitz's use of the words "calculation" and "probability" is not to be understood in a strictly mathematical sense. They are "loose" ordinary language concepts. His reflections over the concept "friction" [28] support this interpretation.

But we have to remember, too, that military forces of today are both very different from and extremely agile and maneuverable compared to Clausewitz's armies. A clarification of the current conditions, under which armies, navies, and air forces operate during war may be useful.

4.3 Current conditions for operations

Assuming that we in war are not able to gain exact knowledge of the enemy's intentions, but only of his whereabouts and force compositions, we can sketch the conditions as follows:

Ground operations
Though the dividing line between air and land operations is rather fluid (armies do transport troops with helicopters, and use helicopters as weapon systems), the overarching problem in land operations is the terrain. The decisive components of an army, the tanks and other combat vehicles, the artillery (be it rockets or cannons) and not least the immense amounts of supplies needed, can in reality not be transported with sufficient speed by air in an operations area. The number of transport aircraft needed would be enormous.

Therefore the terrain dominates army operations. Especially the so-called passability factor is important. Mountains and swamps are insurmountable obstacles for heavy army units, and other terrain types, rivers, lakes, urbanized areas etc. can hamper movements considerably. Thus it is possible to deduce the routes heavy units are able to use. This is a decisive factor in planning an army operation.

But though we may have solid intelligence on the enemy's force composition, position and previous behavior, we should only estimate his *possible* intentions by analyzing the overall situation, where the available routes of approach are a dominating factor. When doing so, in a defensive operation we will be able to identify a number of our own *possible* options. The next step in the process is to identify the option, which is best suitable to counter all of the enemy's possible intentions. (In an offensive operation, the process is reversed.)

It would be plain stupid to select the enemy's most probable intention and plan on that alone, as the enemy will do his very best to deceive us with false information. If we did so, we would run a risk to find ourselves trapped, as swift movements can only be done with airborne light forces.

[28] Discussed later under the headline **Friction**

Naval operations
In confined waters (archipelagos, river deltas etc.) we may be able to identify possible routes of approach. But the *major* naval battles are fought in open waters over long distances using aircraft from carriers and long range missiles from surface ships or submarines, including torpedoes. The primary mission will be to gain control over the sea lines of communications, in order to insure that military transports and commerce can continue even during periods of war. Other missions, such as support of land or air operations, are likely, but as a principle, they must not hamper the primary mission.

Looking at the overall strategic and operational situation, we may be able to guess the enemy's most likely intentions (there are no mountains or swamps at sea). But good intelligence on the range and effectiveness of the enemy's weapon systems, and effective real time surveillance technologies (satellites, submarines, reconnaissance aircraft and drones) are the decisive factors.

But the surveillance technologies will be targeted by the enemy's counter-technologies be it in the form of so-called hard kills by interceptors or so-called soft kills using the electromagnetic spectrum to disturb transmissions. Counter-counter technologies and tactics are developed to cope with this problem, but we will never know for certain who has the upper hand here, until the systems are used during war, or are compromised one way or another.

Thus modern open water naval warfare will have the character of probing for possibilities, that is trying to get close enough to be in-range of the enemy with one's own weapon systems without exposing one's own forces. This probing for possibilities can be done for a considerable time (if the mission allows for it) because of the endurance of the naval vessels.

Air operations
The primary mission in air warfare is to gain air superiority. That is denying the enemy the use of the airspace. As a principle this is done primarily by targeting the enemy's ground facilities, air-stations and support facilities in order to reduce the enemy's capacity to launch aircraft or air defense missiles. A part of one's own air assets have to be kept in reserve to counter enemy attacks. In reality this principle is often turned upside down, because the weaker part is forced into the defensive.

Though the technology factor is very important in air warfare, there is no probing for possibilities to be done due to the relatively short endurance of aircraft compared to ships. The situation in air combat changes rapidly due to the speed of the aircraft, and the ability to maintain so-called situational awareness is of crucial importance in order to survive. In modern aircraft, the crew‘s efforts to maintain situational awareness is supported with computerized warning devices, which can literally speak to and warn the crew and recommend evasive maneuvers and other survival measures.

Especially when it comes to attacks on enemy installations on ground by several aircraft, there is not much room for improvisations. Detailed planning is mandatory in order to ensure timing and coordination, which are vital in order to hit the target with maximum concentration and minimum exposure to the defenses

on ground. If attacked en route to the target, the timing and coordination can be completely spoiled and cause serious losses to enemy defenses in the actual attack phase.

On top of this, the technological counter-counter problematic also dominates in air warfare.

Having come so far in my explanations, I will specify my hypothesis.

5 The Hypothesis

The outcome of a war and the overall progress of the activities in it, the warfare, cannot be calculated with mathematics.

It should be noted that the adjective "overall" has been used for the following reason:

At the lowest level of warfare, where for instance a single air defense missile system engages an enemy aircraft, it is of course possible to describe an idealized situation, make a proper mathematical model and feed it with empirical data. The stochastic output of such a simulation can be used to develop a *procedure*. A procedure which states how many missiles the defenders have to launch against an approaching aircraft in order to ensure a sufficiently high probability of destruction. But when we approach the higher levels of warfare, we very rapidly realize that procedures become meaningless.

In the following I have used quotations from *On War* in order to identify additional major sources of uncertainty which can support the hypothesis.

6 On War

6.1 The quotations

I did my best to keep all of the previous observations in mind when I selected the quotations from *On War*. Doing so, I especially hope that I have been able to avoid the parts of *On War* that are too particular for Clausewitz's timeframe to be valid today.

The purpose of the quotations is to support my hypothesis. This means that I have been very selective in my choice of quotations. This was no easy task, of course, not least because *On War* is an unfinished work. Chapter 1, book I, is consistent, and is the only chapter Clausewitz himself found finished. The rest of *On War* is somewhat erratic.

Book I, "On the Nature of War", is so general in arguments and conclusion, that it by and large can be regarded as "durable". To a certain extent this can be said

as well about book II, "On the Theory of War". Book III–VII are in general too specific for Clausewitz's timeframe to be of use in this context. Book VIII, "Plan of War", is partly "durable". (It is also difficult, but recommendable reading everybody who occupies themselves with arguing for the use of military forces).

For each quotation arguments will be provided concerning why this specific quotation points out a major source of uncertainty, which has to be observed during any attempt to establish a scientific prediction of war and warfare.

Let us begin with war as a phenomenon and continue with the praxis of warfare.

7 War

7.1 War as a phenomenon

After a lengthy analysis of what war is all about, Clausewitz came to the following conceptual conclusion on war as a phenomenon (I have made a minor editing of the text):

> War is therefore, not only chameleon-like in character, because it changes its color in some degree in each particular case, but it is also, as a whole, in relation to the predominant tendencies which are in it, a remarkable[29] trinity, composed
> - of the original violence of its elements, hatred and animosity, which may be looked upon as blind instinct;
> - of the play of probabilities and chance, which make it a free activity of the soul; and
> - of the subordinate nature of a political instrument, by which it belongs purely to the reason.
>
> The first of these three phases concerns more the people; the second, more the General and his army; the third, more the Government. The passions which break forth in War must already have latent existence in the peoples. The range which the display of courage and talents shall get in the realm of probabilities and of chance depends on the *particular characteristics* of the General and his Army, but the political objects belong to the government alone [...] The problem is, therefore, that theory shall keep itself poised in a manner between these three tendencies, as between three points of attraction.[30]

[29] It is disputed, whether "strange" would be a more correct translation.

[30] OW, pp. 121–122. (Bk. I, ch. 1: "*Result for theory*").

Arguments
That war is "chameleon-like" and "changes its color in some degree in each particular case" is obvious: History shows that even wars which were fought repeatedly over the same stretch of land progressed differently. This was not necessarily only because of a factor of unpredictability, but could as well be caused by for example changed strategy or tactics. After a war we would know the end state and might be able to reproduce the courses of events from war diaries etc. and establish a model of what happened.

Especially the possibility of acquiring knowledge of the probability of effectiveness of individual weapon systems dueling with other individual weapon systems could provide valuable empirical data to use in probability calculations of battles. The problem is that the validity of these data would quickly erode as major weapon systems (tanks, aircraft, naval vessels etc) are continuously modified in order to improve their effectiveness and survivability.

Summing up
2) The validity of empirical data gathered in war quickly erodes.

Let us look more closely on t*he passions, the particular characteristics*, and the *political objects* as they are described in the above quotation.

7.2 Passions

> The passions which break forth in War must already have latent existence in the peoples.

Arguments
Passions are without doubts important for the will to fight and the social cohesion of the people in general, including the armed forces. But how can we measure the degree of hatred and animosity, which break forth in war, with sufficient precision to be of value in a probability calculation? Opinion polls could be an option, but could we really rely on answers given in a much-stressed situation? Would it be possible at all for practical reasons? Would the polling itself push passions? And is the government interested in "honest" opinion polls at all? The results could be devastating for the policy.

Another matter is that opinion polls could disclose the latent passions in the people before war was even threatening. This could be useful for a government which for one reason or another wanted to go to war. But this would only be one of many deciding factors in the decision making process, whether or not to go to war.

But experience shows that passions can change rapidly in an information open society. The Vietnam War is a gloomy example. At the beginning of the war, the American people in general had a neutral or positive attitude towards the war. The positive attitude was only steeled when the American casualties began to show. But as the casualties increased, a breaking point was reached and the general

attitude became more and more negative. An amplifying factor was the TV-transmissions of filmed and rather horrible events in the war. In the end it was public reaction which made the war policy impossible.

Summing up:
3) We cannot predict the impact of passions on the war effort.

7.3 Particular characteristics

> The range which the display of courage and talents shall get in the realm of probabilities and of chance depends on the particular characteristics of the General and his Army [...].

Arguments
This is without doubt true, but how should we be able to measure the courage and talents of the Commanding Officers in the chains of command in the armed forces? And if it was possible – how could we provide exact quantification for the whole of the armed forces? Especially when we take into consideration the metaphor that "a chain is not stronger than its weakest link."

Thus:
4) We cannot quantify the courage and talent of the armed forces as a whole.

7.4 Political objects

War is "[...] *of the subordinate nature of a political instrument, by which it belongs purely to the reason.*"[31] and "[...] *but the political objects belong to the government alone.*"

Arguments
This raises the question, whether politics during war is reasonable. Apart from the fact that governments in democracies do exercise political control of the war efforts within the limitations of a political system of checks and balances, the leaders of states at war are under heavy psychological pressures – in brief, stress.

A long period of continuous excessive stress can do strange things to some people. The cognition processes can be disturbed to such a degree that the person in question is seriously hampered in his efforts to perceive, understand, and learn from events or experiences.

[31] OW, p. 121. (Bk. I, ch. 1: "*Result for theory*").

On top of this, there is a significant risk that the political and military top leaders simply do not understand the messages sent to them by their enemy counterpart, be it by diplomacy or via television, because the cultural gap is too wide.

Some of us may remember how Saddam Hussein on television asked a hostage, a little boy, whether he had had cornflakes and milk for breakfast. By doing so, he sent a message to the majority of Arab people in the Middle East, that the hostages were not hostages at all, but guests, as it is an Arab tradition, that when you have served a stranger bread and milk, he is accepted as a guest and thus protected by the host. To most of the world the remark seemed so absurd that it raised questions on the man's sanity.

The combined effects of stress and misperception do not promote reason. And there is a considerable risk of a reciprocal escalation of misperceptions. Therefore we cannot rely on a reasonable (in the sense "objective") political decision making process during war.

The following quotations from *On War* paint an even more complex picture of the influence of policy making on war and warfare:

> Policy, therefore, is interwoven with the whole action of War, and must exercise a continuous influence upon it, as far as the nature of the forces liberated by it will permit.[32]
>
> If the aim of the military action is an equivalent for the political object; that action will in general diminish as the political object diminishes, and in a greater degree the more the political object dominates. Thus it is the explanation how, without any contradiction in itself, there may be Wars of all degrees of importance and energy, from a War of extermination down to the mere use of an army of observation.[33]

(More) arguments

The continuous political influence upon warfare ("the whole action of War") can have both positive and negative effects:

During the Cuban Missile Crisis in 1962, President J. F. Kennedy prevented that the cold war (a war of mutual military observation) exploded into a war of extermination. Among other measures taken, he did that by direct control of the individual U.S. warships which confronted the Soviet warships in the waters off Cuba.

During the Second World War, on the East Front, NAZI Germany fought a war of extermination. Before the German onslaught, Stalin for his part was unable to perceive what was coming (he may have suffered from cognition disturbances). He forbid his generals to make preparations, and his political commissars through a terror regime made sure that his orders were followed.

The history of war is filled with evidence of both successes and disasters caused by political influence upon warfare, down to minute details.

Summing up

5) The effects of political influence upon warfare are unpredictable.

[32] ibid., p. 119. (Bk. I, ch. 1: "*War is always a serious means for a serious object*").

[33] ibid., p. 110. (Bk. I, ch. 1: "*The political object now reappears*").

7.5 Context for a theory

Clausewitz also found he here had established the context for a theory of war:

> These three tendencies, [the remarkable trinity of war, Bergstein] which appear like so many different law-givers, are deeply rooted in the nature of the subject, and at the same time variable in degree. A theory which would leave any of them out of account, or set up any arbitrary relation between them, would immediately become involved in such a contradiction with reality, that it might be regarded as destroyed at once by that alone. The problem is, therefore, that theory shall keep itself poised in a manner between these three tendencies, as between three points of attraction.[34]

That the three tendencies are variable in degree, I have just pointed to. But what Clausewitz meant with "poised between points of attraction" is a little mysterious.

But in Book II,[35] chapter 2, he after a lengthy argumentation identified the premise for a theory for the conduct of war (i.e., warfare); a headline stating that:

> Theory must be of the nature of observation, not of doctrine.[36]

Under this headline he analyzed the premise and came to a conclusion written in a rather florid language:

> If maxims and rules result themselves from the considerations which theory institutes, if the truth accretes itself into that form of crystal, then theory will not oppose this natural law of the mind; it will rather, if the arch ends in such a keystone, bring it prominently out; but so does this, only in order to satisfy the philosophical law of reason, in order to show distinctly to the point to which the lines all converge, not in order to form out in an algebraical formula *for use upon the battlefield*; for even these maxims and rules serve more to determine in the reflecting mind the leading outline of its habitual movements than as landmarks indicating to it the way in the act of execution.[37]

With the reference to the battlefield we now leave the concept of war as a phenomenon and enter the concept of warfare.

[34] OW, p. 122. (Bk. I, ch. 1: "*Result for a theory*")

[35] ibid., pp. 180–190

[36] ibid., p. 190.

[37] OW, pp. 191–192. (Bk II, ch. 2: "*Theory must be of the nature of observation, not of doctrine*").

8 Warfare

8.1 Doctrines

Before we go further, a few comments on the word “doctrine” are needed. I find that the word “learning” would have been a better translation of the original text, as it indicates that the aim of theory-making cannot be a textbook in itself, but rather reflections over reality. In “Western” military language of today the concept “doctrine” means “broad guidelines for waging war” at all levels of warfare, i.e., the operational, and tactical.

Arguments
What Clausewitz wrote in the last three lines in the last quotation is a definition of military doctrines, as they have existed for at least a hundred years under names as “Field Manual” or “Field Regulation” or “Air force Doctrine” etc. Doctrines of today are continuously reviewed by study groups, in order to keep them up to date with the latest developments within threats, technology, organization etc. These reviews can be supported by operations analysis, for example in order to study the probable effects of new weapon systems in a number of scenarios.

As said, doctrines are found at the operational and tactical levels in the armed forces. The army, the air force, and the navy, each branch and each type of military units have their own doctrines. There is an obvious need for that, as the guidelines for operational art and tactics must be different for tank units and infantry, aircraft carriers and submarines, bombers and fighter planes and so on. But cruel experiences in warfare show that even the most well thought out doctrines can fail, if for example ones own tanks or tank crews show themselves inferior to the enemy’s for one reason or another.

Summing up
6) Even broad guidelines for waging war can fail.

A natural question to ask here is: Are we able to measure or estimate – by and large – the relative strength of the opposing military forces?

8.2 Relative strength, the problem

In case one part is overwhelmingly strong, is it then the sure winner? In order to answer this question, we have to make a detour into reality. Thereafter the question will be answered under the heading: Relative Strength, the Answer.

Our detour into reality begins with two questions:
1. What does it mean to “win” a battle?
2. What is military power really?

Let us turn to *On War* for an answer:

> The military power must be destroyed, that is, reduced to such a state as not to be able to prosecute the war. This is the sense in which we wish to be understood hereafter, whenever we use the expression "destruction of the enemy's military power".[38]

"Military power" is in itself as general a concept as it can be. The military power is the armed forces of a country, which are composed of army, air and naval forces, which again are divided in a number of branches, each with a number of military units (which often have different characteristics) and their logistical back up.

But what does it mean to "[…] reduce to such a state as not to be able to prosecute the war"? Does it mean that it is necessary to annihilate the enemy formation in order to win a battle?

8.3 To win a battle

In *On War* Clausewitz often pointed to the fact that it is the decisions in the individual engagements (combats) which add up to the overall decision in war.

Now we have three concepts in warfare to consider: *Destruction*, *decision* and *win* (or lose, for that matter).

The *destruction* can take place in a number of different ways: In air and sea warfare the word "destruction" is more often than not to be taken literally. When aircraft, ships and submarines are hit by modern weapons, the damage is often fatal. The vessels themselves are destroyed and their crews suffer heavy casualties. But they can also be "destroyed" in a more indirect way by denying them access to their bases or by destroying the bases. A remarkable thing is that the crews very seldom break down psychologically or rebel. Social coherence is normally very strong within these units. Another factor could be that they engage their enemies at long distances – the horrors are not right in their faces. A third factor could be an irrational sense of safety, as they fight their battles from cockpits, operation centers and other enclosures. The same irrational sense of safety that many car drivers have, when they (we) race the highways without realizing that they (we) sit in a tin can.

Much land warfare is fought from enclosures, too, i.e., tanks, armored personnel carriers, etc. But the horrors are right in the face of tank and carrier crews, when they see their own and the enemy's tanks and carriers blow up. Even when not in direct combat there are threats. Minefields, commando raids, artillery fire, air raids etc. And the urge to run away is always present, simply because there is a possibility to run, which does not exist in the air or at sea.

What makes soldiers run and what makes them fight on? It is a very difficult question, to which there are no straightforward answers. Here we will look at two examples only, and leave it with that.

[38] OW, p. 123. (Bk. I, ch. 2).

At the battle of Waterloo, June 18th, 1815, *the decisive moment* occurred when the best of the French infantry twice, *in column*, marched into the British *line* of infantry, which the French believed to be seriously shaken by artillery fire. This was proven tactics, and the idea was that the mere weight of the column should split the infantry line whereafter the French cavalry could chase the broken British infantry.

What happened was that the British infantry, rather unusually for the period, had been ordered to lay down in protection behind a low slope. When the front of the French column was within musket range, the British infantry rose, and began to fire salvo after salvo into the foremost part of the column. Something odd then happened inside the French columns:

> But the deliverance from seemingly certain death of so many Frenchmen at the head of the column also draws attention to another and more significant phenomenon. Although it was they who had suffered most from the British fire, it was also they who did what little was done in order to counter or return it effectively. The men at the rear did nothing, or did nothing useful. Indeed, it seems safe to go further. It was at the back of the columns, not at the front, that the collapse began, and the men in the rear who ran before those in the front.[39]

Immediately before the cease-fire in the Finnish-Soviet winter war (1939–40), a Finnish Army unit at a location named Kollaa fought a defensive battle, which is almost incomprehensible:

> Now as the Russian regiments advanced towards Tsumeikka and Kontro to attack the rear of the Kollaa defenders, other Russian tank divisions were pressuring the Finns at the Ulismainen swamps, trying to slash the road between Saarijärvi and Uomaa. The threat of being surrounded increased by the minute. Kollaa was weakening. [...] Even when the situation had seemed hopeless so many times in the past, the Finns had somehow managed to get some sort of help, so by that evening the lines were still intact. But by now the men were few; reinforcements were older troops who were unable to hold out the way experienced defenders had. And under the murderous artillery fire from the Reds, these older men were swallowed up almost daily, sometimes even before they reached the line. [...] But when the Ulismainen battles were over, there were only a few men left in the company and these remnants joined the small forces who still believed in the miracle at Kollaa. [...] Suddenly rumors of a cease-fire came from the front lines; now for the first time, the Kollaa defenders realized that foreign help was not coming after all. But whatever happened to the big Allied army? The world wants us to fight alone, they decided, and there would be now applause for the brave Finns.
>
> For the first time the Finnish counterassault did not succeed. The infantry was finished. The few men that were left never made it to the proper distance

[39] J. Keegan, *The Face of Battle*, p. 171.

> for throwing their hand grenades. They died of exhaustion and by Russian fire. The nerves of those who survived were gone.[40]

What is it that makes soldiers run? Week social coherence combined with a clear and present danger and a possibility to escape could be an answer.

What is it that makes soldiers counterattack against all odds? Strong social coherence combined with a belief in the cause could be an answer.

The classic example of a surprising outcome of air warfare is the Battle of Britain (1940, August 8 – October 30): The numerously very inferior Royal Air Force, thanks to the social coherence within the ranks and files and shrewd use of a new technology, radar, managed to stall the onslaught from the Luftwaffe. "Overall losses were 1.733 German planes shot down, to 915 British."[41]

Another example of the inferior beating the superior is the naval battle off Midway Island in the Pacific (1942, June 4–6). Three American aircraft carriers fought and won a strategically decisive battle against overwhelmingly strong Japanese naval forces.

> Two factors lead to the result: first and foremost, American knowledge of the Japanese secret codes, which presented Nimitz (the U.S. Admiral in command) with an accurate picture of the Japanese intentions and dispositions; second Yamamoto's (the Japanese Admiral in command) original dispersion of his tremendous armada to fit his own estimate of probable American intentions and reactions.[42]

In brief – superior intelligence on the American side combined with an ability to exploit it carried the day for the Americans. The Japanese fleet never recovered from the losses: four major aircraft carriers against one American. "Japan had lost her entire carrier force in being; the U.S. still had two in commission."[43]

So far we can sum up:

- If you destroy an enemy unit in combat, it means that this particular unit cannot fight for the rest of the war. This is certainly a win-situation, which often occurs in *air and sea combat*, where destruction often is to be taken literally. But sometimes a unit may slip away, unable to complete its mission for one reason or another.
- In *ground combat* we find a somewhat different situation. If you want to make sure, that the unit is destroyed, you will have to kill, seriously invalidate or capture the bulk of its soldiers. Otherwise they will withdraw and come back to fight another day.

[40] E. Engle and L. Paananen, *The Winter War*, pp. 137–138.
[41] *The Encyclopedia of Military History* (EMH), p. 1066.
[42] EMH, p. 1148.
[43] ibid., p. 1148.

But what does it really mean to win? It means to force through a *decision* to one's own advantage.

Now – both parties in a battle, be it big or small, have a mission to complete. At Waterloo the French columns' mission was to break through. The British infantry's mission was to hold the line. The British infantry won, as they completed their mission and the French pulled back. This was the *decisive moment* of the battle at Waterloo. The French Army began to loose its coherence and disintegrated, chased by the cavalry of the allied.

In the Battle of Britain, the mission of the Royal Air Force was to maintain air superiority[44] over the British Isles during daylight. The *decisive moment* occurred during the 15th of September 1940. "On that day Luftwaffe sent more than 1,000 bombers and app. 700 fighters against London. By nightfall, 56 assaulting planes had been downed at the expense of 26 British. The tide had turned and at the end of September Luftwaffe had to stop daylight operations".[45]

The Royal Air Force had won. *But they could not know on the 15th of September, that the decisive moment had occurred*. This is an important point to remember.

In the battle of the Midway Island both parties tried to gain control over the sea lines of communication in the central Pacific. The Japanese mission was to establish a naval base on the island in order to be able to maintain continuous naval presence. The American mission was to prevent it for the very same reason.

The so-called "center of gravity" (a metaphor for a vital force concentration) for the U.S. Navy was the Japanese carrier force. It had to be destroyed. This done, the Japanese ordinary battleships would be very vulnerable due to the lack of air cover. The Japanese thought the center of gravity was the land based air forces on the island. They were not aware of the presence of the U.S. carriers. The *decisive moment* of the battle occurred when the U.S. carrier aircraft caught the Japanese carriers with their flight decks crowded with aircraft in the process of being rearmed for another attack on the island. The Americans won.

But history tells us that sometimes a probable winner – be it in the air, at sea, or on the ground – does not appreciate that the decisive moment has come, and the chance of winning slips away. It is called an indecisive battle.

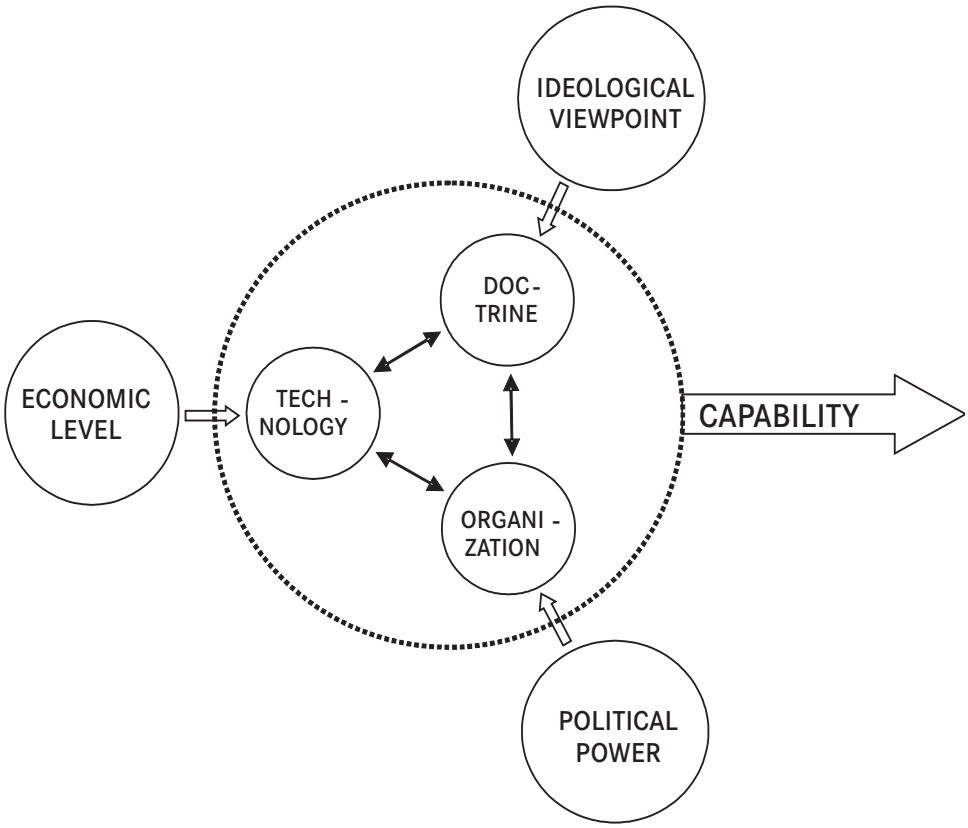
Lesson learned is the following:
7) Sometimes we cannot know for sure, whether we have won or lost.

8.4 Military power

What is military power? A more precise concept is "military capability". The following model – which like all models covers only parts of reality – provides a conceptual answer.

[44] In brief – Air Superiority means that you are able to press the enemy away from a certain airspace. Air Supremacy means that the enemy air forces are destroyed (in the Clausewitzian sense).

[45] EMH, p. 1065.



I have discussed the concept "doctrine" earlier. But who or what is it that in the end determines what a state finds to be acceptable guidelines for waging war. The mutual violence in warfare clearly has a tendency to escalate, so most civilized states today adhere to the international law of war, the set of conventions which restrains warfare: Excessive use of violence is forbidden, cultural heritage must not be damaged or used as cover, international red cross or crescent must not be used to deceive the enemy, prisoners must not be tortured or killed etc.

In essence doctrines are restricted by the ideological viewpoint on war by the state concerned. This ideological viewpoint has its roots in history and culture.

The concept "technology" refers to all the equipment of war, including the knowledge of how to handle and maintain it. The more advanced the economy of the state is, the more advanced equipment it can produce or acquire, handle and maintain.

Finally, the concept "organization" in this connection refers to the fact that military units are people equipped with, and organized in relation to, weapon systems, communication systems etc. Military organizations cost money, much money, and the funding must be provided through a political process, be it democratic or not.

The model can be used as well for a general description of a state's armed forces as for a detailed description of a specific unit.

Now – technology, doctrine and organization have to be balanced against each other in order to maximize the capability. (It is of little use to have a doctrine for fighting in swamps, if the unit in question is equipped with heavy tanks).

A well trained, properly balanced unit, supported by effective logistics *should* have maximum capability, i.e., be the stronger part if it confronted a less balanced unit. But it is not that simple. Let us turn to *On War*:

> But action in War is divided into two forms, attack and defense, which, as we shall hereafter explain more particularly, are very different and of unequal strength. Polarity therefore lies in that to which both bear a relation, in the decision, but not in the attack or defense itself.[46]

Read isolated from the context, the quotation makes little sense. It deals with phenomena at a conceptual level. What it means is the following:

- Attack is the weaker form, but it brings the decision.
- Defense is the stronger form, but it brings no decision.
- We cannot compare attack and defense directly, but only in relation to the decision.

Let us assume that we have two identical army units, A and B. A has dug in on the top of a slope in order to defend the position. B will attack in order to take the position. Both units want to complete their missions. All other parameters equal – on paper the two units have equal strengths. But B is doomed to lose, because the decisive moment will occur when B, on its way uphill, is shot to pieces by the protected and prepared defenders.

What Clausewitz wrote about attack and defense seems to be correct. B, for obvious reasons, was the weaker, but it tried to force through a decision. A, for the same reasons, was the stronger, but if B had not attacked, any discussion about a decision would have been irrelevant.

Let us assume that the officer who tasked unit B to attack, had read Clausewitz. He would then have started his planning process by looking at the desired decision, the conquest of the top of the slope. This would have led to reflections over which kind of unit was needed to traverse the open slope uphill, where the unit would be sure to take intensive fire from the defenders. A tank unit with support from artillery would be the ideal choice. At last he would investigate the size and composition of the defending force in order to estimate the optimal size of the tank unit and the amount of artillery fire needed. Thereafter orders would be issued and the attack would be carried through.

Or would it? Assume the defenders were of the same breed as the Finnish defenders at Kollaa or as the aircrews of the Royal Air Force. The attack could then have failed.

[46] OW, p. 113. (Bk. I, ch. 1: *"Attack and defence are things differing in kind and of unequal force. Polarity is, therefore, not applicable to them"*).

What if the British infantry at Waterloo had not been ordered to take shelter during the artillery bombardment? What if the Japanese had forced the U.S. secret codes and not vice versa?

There is a lesson to be learned from all this:
7) Relative strength can only be estimated, not calculated.

8.5 Relative strength, the answer

We can, of course, imagine situations where the capability of the attackers (or the defenders) obviously is overwhelmingly superior. Why then bother to calculate? And still, the calculation would have to take into consideration all the sources of uncertainty.

It gets worse.

8.6 Friction

> As long as we have no personal knowledge of war, we cannot conceive where the difficulties lie of which so much is said, and what the genius and those extraordinary mental powers required in a general have really to do. All appears so simple, all the requisite branches of knowledge appear so plain, all the combinations so unimportant, that in comparison with them the easiest problem in higher mathematics impresses us with a certain scientific dignity. But if we have seen war, all becomes intelligible; and still, after all, it is extremely difficult to describe what it is which brings about this change, to specify this invisible and completely efficient factor.
>
> Everything is very simple in war, but the simplest thing is difficult. These difficulties accumulate and produce a friction which no man can imagine exactly who has not seen war [and] in war, through the influence of an infinity of petty circumstances, which cannot properly be described on paper, things disappoint us, and we fall short of the mark. A powerful iron will overcome this friction; it crushes the obstacles, but certainly the machine along with them. We shall often meet with this result. Like an obelisk towards which the principal streets of a town converge, the strong will of a proud spirit stands prominent and commanding in the middle of the art of war.[47]

Clausewitz's friction and the cure for it, the iron will of a commander, is the underlying foundation of all basic training of cadets in military academies. People who want to command soldiers in war must be prepared to force their will through under the worst of conditions, as well as they have to prepare for the unexpected, no matter how minute their task may be.

[47] OW, p. 164. (Bk. I, ch. 7).

We have a proverb in Denmark which explains why: *"Little mound can overturn big load"*.

A mathematician would probably turn to chaos theory in order to explain the phenomenon. But this interesting theory carries a sinister message, too, if I have understood it right: The butterfly that flutters in Hong Kong could cause a number of disasters in the rest of the world.

Lets us look at a current example[48] of friction: On March 4, 2002, everything went wrong when a team of U.S. Navy Seals, esteemed commandos, were ambushed on the ridge of Mount Takur Ghar in Afghanistan. Seven soldiers died in a rescue effort that revealed both *mistakes* and *determination*. Let us have a look at the mistakes first.

The initial plan was to helicopter lift a U.S. Navy Seal team, well trained commandoes, to a safe landing zone at a distance from the top of the mountain. From there they, under cover of darkness, cautiously should deploy to the top of the ridge in order to establish a much needed observation post. But a number of "simple things" delayed the helicopter lift so much that is was decided to drop the team directly on the ridge top in order to be there before daylight.

But other "simple things" caused that the U.S. intelligence sources failed to detect enemy fighters on the ridge.

The helicopter approached the landing zone and lowered its ramp. The Navy Seal team was lined up to leave in a hurry. A few feet over the ground the helicopter suddenly took enemy fire and was seriously damaged. When it turned violently to get away, one from the team slid over the ramp. Social coherence made one of the helicopter crew members try to grasp him, but he, too, slid over the ramp and was only saved by his safety line which left him dangling under the helicopter. He was eventually hauled back as the helicopter flew away and eventually was forced to make an emergency landing four miles from the ridge top.

One team member was left on the ridge top. But well trained commandos have a very developed sense of honor. It is a dictum that they never leave a buddy behind.

Therefore another helicopter with a Navy Seal team later arrived on the scene. Because of communications failures, "simple things" you may call them, the helicopter crew knew nothing about the conditions on the ridge top, and when they arrived, they took heavy fire and crash-landed. The Navy Seal team and the crew got out and a fire fight erupted. Two of them were wounded. They withdrew to another position down the mountain.

Due to other communications malfunctions, the next two rescue helicopters with a rescue team of 20 Rangers (well trained troopers, too, and specialized in rescue operations) believed they had to land on the top of the ridge to extract the first team. When they arrived, the first of the helicopters took heavy fire, had casualties and crash-landed. The other helicopter escaped and landed at a considerable distance from the first.

Let us interrupt the tale here.

[48] "Bravery and Breakdowns in a Ridgetop Battle – A Wintry Ordeal at 10,000 Feet" by Bradley Graham, Washington Post Staff Writer, May 24/25, 2002.

What happened was "friction" in the most high tech force in the world. The "simple things" caused seven deaths and a number of wounded.

But on the ridge top, something remarkable happened, too: Our particular variant of Popperian social technology[49] seemed to work within both the helicopter crews, the Navy Seal teams, and the Ranger team, and the Clausewitzian iron will of leaders was demonstrated as well. Factors which were decisive, too, when the ancient Greek phalanx clashed with the enemy.

On the ridge top the ultimate disaster was averted by a devoted and professional force of U.S. Navy Seals and Rangers.

Were there anybody to blame for serious neglects? Probably not. "Little things" happened here and there, and they were most likely corrected as fast as possible – if they were observed at all.

But let us close this piece of current military history by telling that infrared films taken from an observation drone proved that the unfortunate Navy Seal, who slipped over the ramp in the first place, afterwards moved around on the ridge top and fought his enemies to the bitter end. I believe he had no doubts that his buddies were coming back to get him out.

The history of war is filled with examples of friction. Friction is to be regarded as a permanent condition in war, as Clausewitz stated.

Clausewitz's language was filled with metaphors. Why he used the word "friction" we cannot know. But the following quotation offers a hint what friction is all about:

> Perhaps Clausewitz's mention of friction and its effects on warfare operations has some resemblance with the increase of entropy (disorder) in many thermodynamic systems as well as with the concomitant decrease of informational content in such systems.[50]

The conclusion must be the following:

9) Even a small number of unavoidable minor deviations or accidents can cause disastrous effects.

9 Closing Remarks

I have identified a number of major sources of uncertainty in war and warfare. There are more to be found, for example the constantly diminishing so-called teeth-to-tail ratio: The number of fighting soldiers of all kinds is constantly dwindling in relation to the rest; administrators, logisticians, people manning the vast network of all kinds of communications means, intelligence personnel, specialists

[49] The components of this "military" social technology have of course been modified since the days of the Greek phalanx. A major new component is the dramatically improved probability to survive wounds as the military medical services have become more and more effective. See *The Face of Battle*, pp.269–279 for a more profound analysis of the will to combat.

[50] T. Bergstein, author of *Quantum Physics and Ordinary Language.*

in international law of war, welfare personnel etc. All of them are necessary for the high tech military machine to work.

But there are still low tech military forces around the world with very high teeth-to-tail ratios. In the future these forces most likely will try to fight a war on their own terms, not ours; i.e., what we today call asymmetric wars, for example in the enormous slum areas of mega cities with say 75 million or more inhabitants.

How would the Western democratic liberal states cope with a situation where the future al Quaeda fighters sought shelter, not in a rather desolated Afghanistan, but in the mega slum? Vast numbers of infantry soldiers would be needed (read extensive conscription). Could the Western democratic liberal states fight "Vietnam wars" in the "jungles" of the mega cities against people who would have nothing to lose but their lives?

There are other future horror scenarios to consider, but none of these appear to be more calculable than wars of today.

Anyway – for now we have the following nine major sources of uncertainty to consider:

1. The social coherence of military units cannot be tested sufficiently during peacetime.
2. The validity of empirical data gathered in war quickly erodes.
3. We cannot predict the impact of the peoples' passions on the war effort.
4. We cannot quantify the courage and talent of the armed forces as a whole.
5. The effects of political influence upon warfare are unpredictable.
6. Even broad guidelines for waging war can fail.
7. Relative strength can only be estimated, not calculated.
8. Sometimes we cannot know for sure, whether we have won or lost.
9. Even a small number of unavoidable minor deviations or accidents can cause disastrous effects.

Do these nine major sources of uncertainty support the hypothesis? The hypothesis is:

The outcome of a war and the overall progress of the activities in it, the warfare, cannot be calculated with mathematics.

Is it possible to construct a mathematical model which both takes into consideration the individual effects of the sources of uncertainty and the way those effects interact? I cannot provide an answer, as I myself have only limited knowledge of mathematics.

But I find the above nine sources of uncertainty to be strong indicators pointing in the direction that my hypothesis is valid.

If you do not agree – then allow me an unfair remark as a last resort:

How comes, that nobody so far has been able to develop a "durable" mathematical model for stock trading which could make the inventor rich in a hurry?

This should be an easy task compared to the problems we face in war. Not least, because stock brokers normally do not try to kill each other.

Figure 3. Problems worthy of attack prove their worth by hitting back [from: *Grooks* by Piet Hein]. But who or what is the problem?

References

Bergstein, T.: *Quantum Physics and Ordinary Language.* The Macmillan Press 1972.

Clausewitz, Carl von: *On War.* Penguin Books, London 1982. (OW)

–, *Om Krig.* Danish translation of *On War,* Rhodos, Copenhagen 1986.

Creveld, Martin van: *Technology and War.* Macmillan, New York 1986.

Dupuy, R. E. and Dupuy, T. N.: *The Encyclopedia of Military History.* 2nd. rev. ed. Harper & Row, Publishers: New York 1986. (EMH)

Engle, Eloise and Paananen, Lauri: *The Winter War.* Stackpole Books, Harrisburg, USA 1973.

Graham, Bradley: "Bravery and Breakdown in a Ridgetop Battle"; *Washington Post,* May 24, 2002.

–, "A Wintry Ordeal at 10,000 Feet"; *Washington Post,* May 25, 2002.

Hanson, Victor Davis: *The Dogs of War,* in: http://www.nationalreview.com/hanson/hanson110601.shtml, November 6, 2001.

Keegan, John: *The Face of Battle.* Jonathan Cape, London 1976.

Popper, K. R.: *The Open Society and its Enemies.* 5th. rev. ed., Routledge & Kegan Poul, London 1966. (OSE)