Murphy's Law is Alive and Well:
Clausewitzian Friction on the Modern Battlefield

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Introduction

More Than You Ever Wanted to Know About Clausewitzian Friction
Or
Why War is Different From the Analysis of War?
Or
On the Battlefield, Is Murphy Still Alive and Well?

Why should you be interested in Friction on the battlefield?
Why examine Friction on the battlefield?
What is Friction on the Battlefield?
Can Friction be considered in analysis of the battlefield?

There is often considerable difference between our predictions (analyses) of the battlefield and the reality of the battlefield. Some reasons for the difference: We don't really understand the synergy among battle systems (weapons, communications, information, morale, etc.); Our tools for analyses—particularly combat models—are inadequate; We make due with incorrect or incomplete data; We interpret the data we have incorrectly; We focus on 'things' rather than people. Perhaps all these reasons combined in different ways.

Understanding the idea of Clausewitzian Friction may contribute to a better understanding of our analytic weaknesses and hence may lead to improvements in our analyses.

Why is it called Clausewitzian Friction? Probably because only Clausewitz, of all the strategists and contributors to the art of war from Sun Tzu through the 19th Century, identified and defined the concept as a significant characteristic of war. How did he come to do that? Perhaps because he was a very smart guy and he knew and learned from some other very smart guys.

He first introduced the idea of friction in war when discussing bureaucratic behavior in the Prussian military hierarchy. In a 29 September 1806 letter to his future wife, Marie von Brühl, Clausewitz said: "…three commanders-in-chief and two chiefs of staff…How much must the effectiveness of a gifted man [referring to Scharnhorst, his mentor] be reduced when he is constantly confronted by obstacles of convenience and tradition, when he is paralyzed by constant friction with the opinions of others."

How does the application of physical phenomenon 'friction' fit with Clausewitz's view of what really goes on during war? A suitable definition of the physical phenomenon is 'the resistance to motion which exists when a solid object is moved tangentially with respect

to the surface of another which it touches or when an attempt is made to produce such motion.' The first laws of the coefficients of friction were promulgated during the 17th and 18th centuries, so it is highly likely that Clausewitz, a well-read person, was aware of the physical concept and saw it as a suitable metaphor for the explanation of why actual war and theoretical war were so different.[1]

Following the first remarks on friction, Clausewitz continued to consider the concept; during a lecture in 1811 at the Berlin war college, he spoke about "the friction of the whole machinery" and referred to two sources of the friction: first, "the numerous chance events, which touch everything" and, second, "the numerous difficulties that inhibit accurate execution of the precise plans that theory tends to formulate."

In an April 1812 Essay to the Prussian Crown Prince (later Frederick William IV), Clausewitz listed eight major sources of 'tremendous friction'—things that make simplest plans and actions so difficult to execute in war:

- Insufficient knowledge of the enemy
- Rumors (information gained by remote observation or spies)
- Uncertainty about one's own strength and positions
- The uncertainties that cause friendly troops to tend to exaggerate their own difficulties
- Differences between expectations and reality
- The fact that one's own army is never as strong as it appears on paper
- The difficulty of keeping an army supplied
- The tendency to change or abandon well-thought-out plans when confronted with the vivid physical images and perceptions of the battlefield

"…Friction was not simply a notion that Clausewitz toyed with from time to time. Rather, the idea of 1806 grew over the course of more than two decades into a theoretical concept that lies at the very heart of his mature approach to the theory and conduct of war."[2] "By the time Clausewitz died in 1831, his original insight regarding friction's debilitating effects on the campaign of 1806 had grown into a central theme of the unfinished manuscript that his widow published as *Vom Kriege [On War]*."[3]

Clausewitzian Friction

Here is the full-blown concept in the version of *Vom Kriege*, published by his widow following his death, from Book One. On the Nature of War. Chapter 7. Friction in War (p. 119)[4] The following quotation is the complete version of Chapter 7.

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[1] Alan Gropman: "Friction comes from people." Visco: The physics of friction can be fully [?] described mathematically—once the materials in contact are known. Sometimes physical friction is desirable (e.g., drive belts and pulleys). Neither full mathematical description or desirability is true with the friction in war!

[2] Roger Ashley Leonard, ed., *A Short Guide to Clausewitz on War*, Capricorn Books, 1967.

[3] Barry Watts, *Clausewitzian Friction and Future War*, McNair Paper 52, Institute for National Strategic Studies, National Defense University, October 1996, 133 pp.

[4] The 'Fog of War' is not mentioned in Table of Contents.

“If one has never personally experienced war, one cannot understand in what the difficulties constantly mentioned really consist, nor why a commander should need any brilliance and exceptional ability. Everything looks simple; the knowledge required does not look remarkable, the strategic options are so obvious that by comparison the simplest problem of higher mathematics has an impressive scientific dignity. Once war has actually been seen the difficulties become clear; but it is still extremely hard to describe the unseen, all-pervading element that brings about this change of perspective.

“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. Imagine a traveler who late in the day decides to cover two more stages before nightfall. Only four or five hours more, on a paved highway with relays of horses; it should be an easy trip. But at the next station he finds no fresh horses, or only poor ones; the country grows hilly, the road bad, night falls, and finally after many difficulties he is only too glad to reach a resting place with any kind of primitive accommodation. It is much the same in war. 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. Iron will-power can overcome this friction; it pulverizes every obstacle, but of course it wears down the machine as well. We shall often return to this point. The proud spirit’s firm will dominates the art of war as an obelisk dominates the town square on which all roads converge.

“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, every one of whom retains his potential of friction. In theory it sounds reasonable enough: a battalion commander’s duty is to carry out his orders; discipline welds the battalion together, its commander must be a man of tested capacity, and so the great beam turns on its iron pivot with a minimum of friction. In fact, it is different, and every fault and exaggeration of the theory is instantly exposed in war. A battalion is made up of individuals, the least important of whom may chance to delay things or somehow make them go wrong. The dangers inseparable from war and the physical exertions war demands can aggravate the problem to such an extent that they must be ranked among its principal causes.

“This tremendous friction, which cannot, as in mechanics, be reduced to 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. 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.

"We give these examples simply for illustration, to help the reader follow the argument. It would take volumes to cover all difficulties. We could exhaust the reader with illustrations along if we really tried to deal with the whole range of minor troubles that must be faced in war. The few we have given will be excused by those readers who have long since understood what we are after.

"Action in war is like movement in a resistant element. Just as the simplest and most natural of movements, walking, cannot easily be performed in water, so in war it is difficult for normal efforts to achieve even moderate results. A genuine theorist is like a swimming teacher, who makes his pupils practice motions on land that are meant to be performed in water. To those who are not thinking of swimming the motions will appear grotesque and exaggerated. By the same token, theorists who have never swum, or who have not learned to generalize from experience, are impractical and even ridiculous; they teach only what is already common knowledge: how to walk.

"Moreover, every war is rich in unique episodes. Each is an uncharted sea, full of reefs. The commander may suspect the reefs' existence without every 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. An understanding of friction is a large part of that much-admired sense of warfare which a good general is supposed to possess. To be sure, the best general is not the one who is most familiar with the idea of friction, and who takes it most to heart (he belongs to the anxious type so common among experienced commanders). The good general must know friction in order to overcome it whenever possible, and in order not to expect a standard of achievement in his operations which this very friction makes impossible. Incidentally, it is a force that theory can never quite define. Even if it could, the development of instinct and tact would still be needed, a form of judgment much more necessary in an area littered by endless minor obstacles than in great, momentous questions, which are settled in solitary deliberation or in discussion with others. As with a man of the world instinct becomes almost habit so that he always acts, speaks, and moves appropriately, so only the experienced officer will make the right decision in major and minor matters—at every pulsebeat of war. Practice and experience dictate the answer: 'this is possible, that is not.' So he rarely makes a serious mistake, such as can, in war, shatter confidence and become extremely dangerous if it occurs often.

"Friction, as we choose to call it, is the force that makes the apparently easy so difficult. We shall frequently revert to this subject, and it will become evident that any eminent commander needs more than experience and a strong will. He must have other exceptional abilities as well."[5]

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[5] Carl von Clausewitz, *On War*, edited and translated by Michael Howard and Peter Paret, Princeton University Press, 1976 and 1984 (indexed—names, places, wars, and campaigns only—version).

Clausewitz experienced war during the late 18th and 19th centuries; his philosophy derives from that experience. Is friction alive and well on today's battlefield? Or has technology—e.g., total battlefield awareness—done away with Clausewitzian friction?
A first observation is that friction is a two-way street; it affects the enemy as it does you—and that what counts is differential friction: the difference between the effects of your friction on you and the effects of his friction on him.

Historical Examples of Friction on the Battlefield
Before dealing with the question of change brought about by technology, let's look at some examples of friction on the battlefield in the past.

In January 1863, after a very bad command performance at Fredericksburg, VA, Burnside was replaced as commanding general, Army of the Potomac. 'Fighting Joe' Hooker was given command; the nickname came about by a typesetter's accident and Hooker didn't particularly like it. Hooker was an admirable staff man; during the winter quarters there were substantial improvements in food, clothing, equipment, training, and hygiene for the troopers of the Army of the Potomac. The same could not be said for the Army of Northern Virginia, also in winter quarters; shortages of clothing, shoes, food, and equipment persisted. By springtime, the Army of the Potomac was not only better equipped with positive changes in morale, but it was also considerably larger than the Army of Northern Virginia, about twice as big.

Hooker's plan for the spring operations was a double envelopment or pincer attack, with roughly equal forces attacking Lee's army from the north (vicinity of Chancellorsville) and from the east (Fredericksburg). At the outset, the eastern prong was to be a holding force to pin down major elements of the Army of Northern Virginia.

Lee's counter was to recognize the limit of the holding force and thus provide only a minimal force to face the Union troops at Fredericksburg and to be more aggressive in facing the assault from the north.

Hooker then became hesitant, re-thinking and questioning the plan, which was still a good one. By being hesitant and second guessing himself, he lost the advantage.[6] The aggressiveness of the Confederate leadership, including the masterful splitting of the Army of Northern Virginia, in the face of the enemy, and the march across the enemy front of Jackson's Corps to the right flank of the Union force further degraded the Union effectiveness. As G. F. R. Henderson, a scholar of the tactical and operational level of war, points out (1895): 'The first thing is to realize in war we have to do not so much with numbers, arms and maneuvers, as with human nature.'[7]

Hooker 'lost the bubble,' as we say today. In addition, he also was wounded or at least stunned by a near-miss artillery round, and failed to allow others to take over command

[6] Refer to Clausewitz's eighth friction item in his 1812 essay.
[7] COL G.F.R. Henderson, CB, *The Science of War. A Collection of Essays and Lectures, 1891-1903*, edited by COL Neill Malcolm, DSO, Longman, Green & Co., 1933 (first edition 1903).

from him—or others failed to step forward and take responsibility. Whatever the case, an excellent plan failed because of loss of focus and will.

Another demonstration of friction came out of the same battle. Elements of Jackson's Corps, in the process of moving to the right flank of the Union force, were surprised by a Union cavalry unit—an unexpected meeting engagement. The word spread that Union cavalry were in the area. Jackson and others reconnoitered out in front of the Confederate force, when the flank attack slowed in the early evening; the forward elements of the Confederate force were not informed of the leadership moving in front of them. When Jackson's party began to return to their lines, the lead elements, hearing the horses coming through the brush, assumed the presence of Union cavalry and opened fire. Among others Jackson was seriously wounded (a casualty of friendly fire). After amputation of his left arm, while recuperating, Jackson took ill with pneumonia, a common occurrence of seriously wounded soldiers, and died. Fratricide is a significant example of and contributor to friction on the battlefield.

Moving forward to the Vietnam War and a present-day story—*We Were Soldiers Once*, the title of a popular movie—changed from the original title: *We Were Soldiers Once—And Young*.[8] The story covers two facets of the first fight of the 1st Air Cavalry Division in Vietnam—a fight that both the US Army and the North Vietnam Army were looking for, the former to see how the airmobile concept would really work and the latter to see if they could develop tactics to defeat the airmobile concept.

Ia Drang, morning of 14 November 1965, the first elements of the 1st Battalion, Seventh Cavalry, 1st Cavalry Division, LTC Harold Moore commanding, arrived at LZ X-Ray. Characteristics of the battalion: well-trained, well-schooled, with a solid plan for the air assault and a clear understanding of the commander's intent; high cohesion. Result: victorious in a Helluva fight; defeated a much larger, well trained enemy force.

Ia Drang, morning of 17 November 1965, the 2nd Battalion, Seventh Cavalry, 1st Cavalry Division, LTC Robert McDade, commanding was on a route march to LZ Albany. Characteristics: not well-trained (at least in air assault operations), poor cohesion, poor plan, new commander, not prepared for surprises, poor understanding of commander's intent. Result: Ambush; Helluva fight: defeat(?).

Another example from the same event. Bravo Company, 1st Battalion, was the first unit to land at X-Ray, with the Battalion Command group. Specialist 4 Galen Bungum, a 40 mm grenadier had 18 rounds (grenades). Prior to lift off from Plei Me, Moore reminded his company commanders to insure that all riflemen had at least 300 rounds of ammunition and two hand grenades plus as much additional ammunition as they could carry. Each M79 grenadier should have at least 36 of the 40 mm grenades. Why did Bungum, one of the first troopers on the ground, have only 18 rounds? Early on 14 November, Bungum had been told to pass out his grenades to others as he was going on R&R. After distributing his grenades, he was told that there were no choppers going to An Khe and

[8] LTG Harold G. Moore (US Army, ret) and Joseph L. Galloway, *We Were Soldiers Once…And Young*, Random House, 1992.

that he was to join the planned assault. He hustled around to gather back his basic load of grenades but was able to collect only 18 rounds. He quickly ran out of ammunition early in the fire-fight and had to scratch around to find a workable M16. What is the possibility that events such as that one are recognized in analysis? What influence do such events have on combat and the analysis of combat?

"I would lay special stress on the fact, which none can gainsay, that human nature, the paramount consideration of all questions of either tactics or strategy, remains unaltered. And the art of generalship, the art of command, whether the forces be large or small, is the art of dealing with human nature. Human nature must be the basis of every leader's calculations. To sustain the *moral* of his own men; to break down the *moral* of his enemy—these are the great objects which, if he be ambitious of success, he must always keep in mind.
"It is this aspect of war, then, that those who aspire to become real generals should study. This aspect remains unchanged, and nowhere can it be studied with more profit than in the campaigns of those great captains, who owe their greatness to the one fact, that was the mainspring of all their actions. It should be remembered, too, that while attack formations and development or avoidance of fire are a part of the soldier's daily training, taught in the drill books and practiced at manoeuvres, neither the drill-book nor manoeuvres throw much light on the way human nature is to be dealt with."[9]

More Recent Examples

What about today? Does modern technology eliminate or reduce friction on the battlefield? Barry Watts has attempted to provide some answers to that question.[10]

"American military officers today most often refer to Clausewitz's unified concept of a general friction…as the 'fog and friction' of war.[11] The diverse difficulties and impediments to the effective use of military force that those possessing military experience instinctively associate with this phrase are generally acknowledged to have played significant roles in most, if not all, of the wars since Clausewitz's time…."

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[9] Henderson, *op. cit.*, p. 101.

[10] Watts, *op. cit.* Watts' background: Senior analyst for Northrop Grumman Corporation (since 1986). Retired LtCol, USAF. Combat in SEA (F-4). USAF Academy instructor in philosophy and mathematical logic. Office of Net Assessment (Andy Marshall); two tours. USAF Air Staff: Soviet threat specialist on Project Checkmate. At Northrop Grumman: Corporate strategy; US military capabilities, doctrine and strategy; LRP. Gulf War Air Power Survey, 1991-93. Served in OSD, PA&E.

[11] Footnote accompanying the phrase 'fog and friction' of war: "The March 1992 edition of *Air Force Manual 1-I: Basic Aerospace Doctrine of the United States Air Force* states that war is characterized by 'fog, friction, and chance.' The reigning view in the U.S. Army is that '[a]mbiguity, uncertainty, fog, friction, danger, stark fear, and chance…continue to describe accurately the conditions with which military forces have to contend and will continue to contend' (GEN Gordon R. Sullivan and LTC James M. Dubrik, *Land Warfare in the 21st Century*, Strategic Studies Institute, US Army War College, 4th annual conference on strategy, February 1993). See also see U.S. Marine Corps, *Warfighting*, Fleet Marine Field Manual 1, 6 March 1989.

There is an alternative view, however. Watts says: "The historical persistence of friction, despite vast changes in the means of war since Clausewitz's time, suggests that his concept may reflect far more than a transitory or contingent feature of land warfare during the Napoleonic era. Yet, as we try to think about how war may change over the next couple of decades in response to technological advances, nothing precludes us from wondering whether the scope or overall magnitude of Clausewitzian friction may change. Some U.S. military officers who have grappled with how future wars may be fought have suggested that foreseeable advances in surveillance and information technologies will sufficiently lift 'the fog of war' to enable future American commanders to 'see and understand everything on a battlefield.' [12]

Continuing with Watts with observations from the Gulf War: "…as of 27-28 February 1991, US intelligence [believed that there were] only eight nuclear targets [in Iraq]…five were believed destroyed, two damaged, and one still operational."
"Postwar…inspections eventually uncovered some 39 nuclear facilities at 19 different… locations in Iraq."

"Adverse weather…offers another unambiguous example of the frictional impediments to the execution of plans and intentions in *Desert Storm*. Adverse weather conditions substantially disrupted operations, especially during the early days of the air campaign and the Coalition's ground offensive at the conflict's end. On the second and third nights of the war, more than half of the planned F-117 strikes were aborted or unsuccessful due to low clouds over Baghdad; on the second day of the ground campaign (25 February 1991), all F-117 sorties were cancelled due to weather."

Will GPS take care of the weather constraint? What does experience in Afghanistan show?

Situation Awareness

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[12] Accompanying footnote: 'Admiral William A.] Owens Says Technology May Lift "Fog of War": Breakthroughs Could Give Forces total Command of Future Battlefield,' *Inside the Navy*, 23 January 1995, 3. See also, Admiral William A. Owens in *Dominant Battlespace Knowledge: The Winning Edge*, eds. Stuart E. Johnson and Martin C. Libicki, Washington, DC: National Defense University Press, October 1995, 14-15; and Owens, 'System-Of-Systems: US "Emerging Dominant Battlefield Awareness Promises to Dissipate the "Fog of War",' *Armed Forces Journal International*, January 1996: 47. The meaning initially associated with Admiral Owens' notion of Dominant Battlefield Awareness was that, by connecting largely existing sensors and shooters together via appropriate information and command-and-control systems, it should be possible to detect, track, and classify most (or all) of the militarily relevant objects moving on land, the surface of the ocean, through the air, or in space within a cube of battlespace some 200 nautical miles on a side. Nor are visionary military officers alone in this speculation. In a 6-month assessment conducted by a Washington, DC, defense-policy institute on the prospects for a 'Military Technical Revolution' (MTR), the participants concluded that "what the MTR promises, more than precision attacks or laser beams, is…to imbue the information loop with near-perfect clarity and accuracy, to reduce its operation to a matter of minutes or seconds, and, perhaps most important of all, to deny it in its entirety to the enemy." [Footnote: Michael J. Mazarr, Jeffrey Shaffer, and Benjamin Ederington, *The Military Technical Revolution: A Structural Framework*, Center for Strategic and International Studies (CSIS), Washington, DC, final report of the CSIS study group on the MTR, March 1993, 58.p. 3]

Watts, p. 92: "Air combat experience going at least back to the Second World War suggests that surprise in the form of the unseen attacker has been pivotal in three-quarters or more of the kills…Lieutenant Colonel Mark Hubbard [P-38 pilot, Eighth Air Force] stressed that '*90% of all fighters shot down never saw the guy who hit them*.' Hubbard was by no means alone in observing that friction the form of the unseen attacker from six o'clock played a dominant role in engagement outcomes. The American P-47 pilot Hubert Zemke (17.75 air-to-air kills…) stressed that '*few pilots are shot down by enemies they see*.' Similarly, the German Me-109 pilot Erich Hartmann, whose 352 kills during World War II made him the top scorer of all time, later stated that he was 'sure that eighty percent of kills never knew he was there before he opened fire.'"[13]

A series of air-to-air experiments, tests, and simulations were conducted by the US Air Force in the late 1970s.[14] ACEVAL (Air Combat Evaluation) and AIMVAL (Air Intercept Missile Evaluation were major air-to-air heavily instrumented tests carried out in Nevada. The forces were Blue: F-15s and F-14s vs Red: F-5Es (resembled MiG-21s); the combat area was a 40 nautical mile radius region. Weapons for Blue: guns, short-range infrared missiles, and medium-range, radar-guided AIM-7F Sparrow; for Red: guns and IR missiles. AIMVALwas focused on the operational utility of five IR concepts. ACEVAL was focused on factors affecting engagement outcomes when multiple aircraft are involved, with force size, force ratio, and initial ground controlled intercept condition (Red advantage, neutral, or Blue advantage variables). The trials consisted of 360 valid engagements; 1,488 sorties were needed by the design. One interesting exampleof the results: "…perhaps the most famous single engagement of both tests was the ACEVAL 'Towering Inferno' 4-v-4 in which all eight participants were shot down after a minute and 52 seconds, was not a valid trial." One observation coming out of the trials: "…in AIMVAL incremental hardware advantages had tended to wash out in the long run as opponents adapted, and that in ACEVAL human interactions had been five times as influential on outcomes as test variables like force ratio or the initial GCI condition."

A major simulation effort was carried out in 1981: the AMRAAM (Advanced Medium Range Air-to-Air Missile) OUE (Operational Utility Evaluation), conducted with McDonnell Douglas flight simulators.[15] There were 1,200 engagements involving 10,000 simulator sorties. Participants were from operational units. Fighter-sweeps and Blue fighters facing Red fighters escorting strike aircraft. Blue weapons: medium-range, radar-guided AMRAAM; half the trials were run with beyond visual range (BVR) rules of engagement. Expectation for the BVR trials was that hardware advantages would drive outcomes. "The bottom line from the test, however, turned out to be otherwise. Situation awareness proved to be 'the single most important factor affecting engagement outcomes.' For both sides, being aware of adversary weapons' envelopes and keeping outside them to avoid being 'shot,' while trying to maneuver adversaries into their own weapons envelopes, proved as important and dominant as it had been in ACEVAL…[S]uperior Blue hardware conferred building blocks or baseline elements of

[13] Watts, *op. cit.*
[14] Watts, *op. cit.*
[15] Watts, *op. cit.*

advantage that the Red side had to work hard to overcome and, in the aggregate, Blue hardware advantages were reflected in superior Blue exchange ratios. Statistically, though, the outcome of any particular engagement most often hinged on very small differences here or there across a large set of interrelated human and hardware factors, and the dominant of these factors was situation awareness."

"This test result obviously reinforces historical air-to-air combat data rather than contradicting them. It also supports the Clausewitzian hypothesis that friction is a structural feature of combat interactions with humans 'in the loop.' Finally, it lends concrete empirical support—at least at the tactical level—for the proposition that eradicating friction in some permanent way through hardware improvements is, at best, unlikely."

"…Could information technology be used to mitigate this longstanding pattern of very low sorting efficiencies [timely and effective targeting of enemy aircraft] in complex engagements arising from seemingly small lapses in situation awareness? Early experience…with the recently fielded Joint Tactical Information Distribution System (JTIDS) indicates the answer is 'Yes.' JTIDS not only provides integrated, all-aspect identification of friendlies and hostiles…but even displays targeting decisions by others in one's flight. The aggregate gains in air-to-air effectiveness resulting from these improvements in SA and sorting have been nothing less than spectacular…[reference to *Desert Storm* performance] Hence technology…can certainly manipulate the differential in friction between opposing sides to one's advantage at the tactical level…The implication that *cannot* be drawn from JTIDS experience…is that friction has been permanently eliminated. If adversary forces fielded a system comparable to JTIDS, then the burden of achieving superior situational awareness and sorting in air-to-air would fall back on the 'manual' abilities of human brains to absorb, interpret, and act upon automated information about who is where and doing what more quickly or more effectively that the opponents (or both). Exactly how frictional imbalances might ultimately manifest itself [sic] in this 'technologically altered' set of conditions is hard to anticipate. What can be said with confidence, though, is that by reducing the aspects of friction we have been discussing with improved information systems, friction will probably manifest itself in other ways or in areas that we may not even be able to predict. There are two reasons for this conclusion. First new technology amounts to introducing novelty into the combat area, and the indirect and second-order consequences of novelty within the context of human interactions are seldom, if ever, fully predictable. Second, if both sides have access to the novelty or innovation…then transforming the resulting SA and targeting data into knowledge and action better or quicker than the opponents will still ultimately be taking place in the same sort of 'gray matter' that members of our species have been carrying around in their skulls for the last 45,000-90,000 years. Both sides will have improved compared to where they were without [the novel technology], but the relative margin of advantage will fall back to differences between the men in the machines."[16]

[16] Watts, *op. cit.*

One can put ground operations in the same context. Visualize combined arms teams (armor and infantry) in the assault. 'Sorting,' in the sense of selecting and engaging targets, both fixed (positions) and mobile (armored vehicles, for example), is complex—perhaps even more than in air-to-air combat, although reaction times may be longer in ground operations. There is much evidence from the first Gulf War of multiple weapons firing at the same targets—even after the targets had been killed. Coordination of fires in ground operations is complex. Are there data on SA regarding the sources of killing fire from the enemy; that is, how often are friendly units targeted by un-detected or un-noticed enemy?

US Army doctrine covering urban operations cites conditions relating to friction.[17] Included are: structures affecting observation, firing ranges and fields of fire; small and isolated units engaged in fire-fights; logistic (re-supply) difficulties, particularly ammunition and food; communications difficulties, included GPS functioning; increased stress on soldiers as a function of isolation, poor communications and poor logistics; presence of non-combatants and neutrals, coupled with shorter engagement and target recognition ranges and times, compounding targeting and rules of engagement compliance.

From *The Washinton Post*, Thursday, March 21, 2002:
Soldier Dies as Mess Tent Is Hit in Artillery Drills. Fort Drum, N.Y.—Two artillery shells fell short during an Army firing exercise and exploded near a mess tent where soldiers were eating breakfast yesterday. One soldier was killed and 14 were injured.
The soldiers, from the 10th Mountain Division's 110th Military Intelligence Battalion, were about 200 yards from the edge of the 90-square-mile target area when the shells hit at 7:20 a.m., the Army said. "These guys had major shrapnel wounds," Maj. Kenneth McDorman, a spokesman for the 10th Mountain Division, which has scores of soldiers in Afghanistan. An Army team from Fort Rucker, Ala., was sent to determine what went wrong. The dead soldier was identified as Pfc. William Hamm, 34, of Ocala, Fla.
The howitzers are capable of firing several kinds of rounds and have a range of up to 12.2 miles. [Note: a second soldier died of wounds, as reported in *Post*, 22 March.]

Summation and Conclusion
Elements that form the atmosphere of war from Clausewitz (two variants in Book One)

Chapter 3: Danger, Exertion, Uncertainty, Chance
Chapter 8: Danger, Physical Exertion, Intelligence, Friction

Watt's provides a composite list of five sources of general friction:

- Danger's impact on the ability to think clearly and act effectively in war
- The effects on thought and action of combat's demands for exertion
- Uncertainties and imperfections in the information on which action in war is unavoidably based
- Friction in the narrow sense of the internal resistance to effective action stemming from the interactions between the many men and machines making up one's own forces

[17] FM 90-10-1, *An Infantryman's Guide to Urban Combat*, 1982.

- The play of chance, of good luck and bad, whose consequences combatants can never fully foresee.

Taxonomy for Clausewitz's 'unified concept' of a general fiction;

- Danger
- Physical exertion
- Uncertainties and imperfections in the information on which action in war is based
- Friction in the narrow sense of the resistance within one's own forces
- Chance events that cannot be readily foreseen
- Physical and political limits to the use of military force
- Unpredictability stemming from the interaction with the enemy
- Disconnects between ends and means in war.

Watts' reconstruction of general friction in modern terms. His presumption: general friction ultimately arises from three elementary sources:

Human beings and their purposes
The spatial-temporal inaccessibility of key information in military affairs
The unpredictability of chaotic processes.

The hypothesis leads to the following list of general friction's sources as a late-20th-century alternative to the eight Clausewitzian sources:

- Constraints imposed by human physical and cognitive limits, whose magnitude or impact are inevitably magnified by the intense stresses, pressures, and responsibilities of actual combat.
- Informational uncertainties and unforeseeable differences stemming, ultimately, from the spatial-temporal dispersion of information in the external environment, in military organizations, and in the mental constructs of individual participants.
- The structural nonlinearity of combat processes which can give rise to the long-term unpredictability of results and outcomes by magnifying the effects of unknowable small differences and unforeseen events (or, conversely, producing negligible results from large inputs).

Where do we go with this?

<u>Some Possibilities for Analysis</u>

Improved robustness by considering wider ranges of situations ('mission-system' approach at RAND; example *Measuring Interdiction Capabilities in the Presence of Anti-Access Strategies*, Davis, McEver and Wilson, 2002).

Agent-based modeling, providing human characteristics (particularly weaknesses) to agents and making large numbers of runs (Marine Corps at Quantico).

Improved 'Red teaming' with emphasis on identifying possible but unexpected behaviors, both friendly and enemy.

Other?

Other Miscellaneous Questions
Is fratricide an aspect of friction?
What about intelligence, non-radiating enemy, asymmetry, battle damage assessment…?
Is friction non-linear?
Is it inside the head, fright, second guessing (see Chancellorsville and Hooker)

Summary of challenges:

- Focus on the human behavioral capabilities and limitations
- Look for the similarities & differences among a range of operations--analogies.
- If you can't get field experience, read!
- Accept the trite observation that models of combat are not combat and may not be useful representations of war

Supporting Material

Barry D. Watts, Table of contents:

1. The Once and Future Problem of General Friction
2. Clausewitz's Development of the Unified Concept of a General Friction (*Gesamtbegriff Einer Allgemeinen Friktion*)
3. Scharnhorst's Clarity About War as it Actually In (*Eigentliche Krieg*)
4. Clausewitz's Mature Concept of General Friction
5. Friction Before, During, and After Desert Storm
6. The Intractability of Strategic Surprise
7. The Inaccessibility of Critical Information
8. Evolutionary Biology as a Source of Friction and Exemplar for Theory
9. 'Situational Awareness' in Air-to-Air Combat and Friction
10. Nonlinearity and a Modern Taxonomy of General Friction
11. Implication for Future War, Its Theory, and Its Conduct

Roger Ashley Leonard, ed., *A Short Guide to Clausewitz on War*, Capricorn Books, 1967
"War moves in an atmosphere composed of danger, physical effort, uncertainty and chance. Everything is war is very simple, but even the simplest thing is difficult, and these difficulties, largely unforeseen or unpredictable, accumulate and produce a friction, a retarding brake on the absolute extension and discharge of violence. These difficulties consist of 'danger,' 'bodily exertion,' 'information' or the lack of it, and innumerable other small and incalculable circumstances and uncertainties originated by chance. These are some of the inevitable things that always prevent war in reality from ever approaching war on paper and in plans.

"War is the province of chance…From this uncertainty of all intelligence and supposition, this continual interposition of chance, the actor in War constantly finds things different from his expectations…

"…if it [the mind] is to get safely through this perpetual conflict with the unexpected, two qualities are indispensable: in the first place an intellect which, even in the midst of this

intense obscurity, is not without some traces of inner light, which leads to the truth and then the courage to follow the faint light…[in other words] *resolution*…
Resolution is an act of courage in single instances, and if it becomes a characteristic trait, it is a habit of the mind. But here we do not mean courage in face of bodily danger, but in the face of responsibility.

"The diverse sources of general friction are things that render action in war 'like movement in a resistant element' and 'span the gap between the pure concept of war and the concrete form that, as a general rule war assumes.'

"From the inner light and resolution we are naturally led to speak of its kindred quality, *presence of mind*, which in a region of the unexpected like war must act a great part, for it is indeed nothing by a great conquest over the unexpected.
If we take a general view of the four elements composing the atmosphere in which war moves, of *danger*, *physical effort*, *uncertainty*, and *chance*, it is easy to conceive that a great force of mind and understanding is requisite to be able to make way with safety and success amongst such opposing elements, a force which, according to the different modifications arising out of circumstances, we find termed by military writers…as *energy*, *firmness*, *staunchness*, *strength of mind and character*.
Firmness denotes the resistance of the will in relation to the force of a single blow, *staunchness* in relation to a continuance of blows.

"By the word 'information' we denote all the knowledge which we have of the enemy and his country; therefore, in fact, the foundation of all our ideas and actions…
A great deal of the information obtained in war is contradictory, a still greater part is false, and by far the greatest part is of a doubtful character."

Other Literature
Michael I. Handel, *Sun Tzu and Clausewitz Compared*, US Army War College, Professional Readings in Military Strategy, No. 2, 1991, compares *The Art of War* and *On War*. A discussion of friction is found on p. 56.

Michael Howard, *Clausewitz*, Oxford University Press, 1983, see particularly p. 24 ff.

Samuel B. Griffith, trans. & ed., *Sun Tzu The Art of War*, Oxford University Press, 1963.
No citation to friction (index)

Homilies

"To be a successful soldier, you must know history...what you must know is how a man reacts. Weapons change, but man who uses them changes not at all. To win battles you do not beat weapons—you beat the soul of the enemy."

George S. Patton, writing to his son while a cadet at USMA
cited in *Field Artillery*, Aug 88, p.2

"If I had time and anything like your ability to study war, I think I should concentrate almost entirely on the actualities of war—the effects of tiredness, hunger, fear, lack of sleep, weather....The principles of strategy and tactics, and the logistics of war are really absurdly simple: it is the actualities that make war so complicated and so difficult, and are usually so neglected by historians."

Field Marshall Lord Wavell to Basil Liddell Hart
(cited by Richard Holmes, *Acts of War*, 1985, p. 7)

"The smallest detail taken from an actual incident in war is more instructive to me, a soldier, than all the Thiers and Jominis in the world. They speak for the heads of states and armies, but they never show me what I wish to know—a battalion, company, or platoon in action. The man is the first weapon of battle. Let us study the soldier, for it is he who brings reality to it."

COL Charles Ardant du Picq
(*Etudes sur le Combat*, 1860)
(cited by Richard Holmes, *Acts of War*, 1985, p. 18)

"The white heat of ideology or the burning zeal of religion may sustain the few, or even, at particular moments in the world's history, inspire the many. But to the infantryman crouched behind a hummock of peat and heather while bullets snap over his head, or to the tank driver nudging through a hedge with the thrum of armour-piercing shot in his ears, neither ideology nor religion give much incentive for the one to get up and sprint to the next cover, or for the other to drive steadily across a field already scorched by his comrades' oily cremations. For the key to what makes men fight—not enlist, not cope, but fight—we must look hard at military groups and the bonds that link the men within them."

Richard Holmes, *Acts of War*, 1985, p. 291

"It is unrealistic—and, in political terms, probably dangerous—to expect an army, especially one which contains conscript soldiers, not to mirror the society which produces it. None the less, however great our belief in rational discipline, *Inhere Fürhrung* or comradely spirit, we should not lose sight of an inescapable fact. For all that military sociologists have identified a 'narrowing skill differential' between the soldier and the civilian, the former still includes hazarding his life as an essential part of his job description. General Sir John Hackett called it 'the clause of unlimited liability.' There may come a moment in even the best-conducted, most democratic of armies, when a leader gives an order which will result in the certain death of his subordinates, and a

framework of discipline which does not prepare for this eventuality does both army and society a disservice. As Major J. P. Isenhower put it: 'There is no doubt that current affection for the occupational model has contributed significantly to this problem [that of cohesion], for discipline is applied in the business world according to a different ideology from that in the military."

Richard Holmes, *Acts of War*, 1985, p. 335-336

I think the essential prerequisite of sound military advice is that the giver must convince himself that, if he were responsible for action, he would himself act so.

P. M. S. Blackett, 1960

Philosophers and scientists have shown that adaptation is the secret of existence. History, however, is a catalogue of failures to change in time with the need. And armies, which because of their role should be the most adaptable of institutions, have been the most rigid - to the cost of the causes they upheld.

Sir Basil Liddell Hart, 'Thoughts on War,' 1944

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