**Slide 1: Publication Cover Page**

Everything I say today is based on and fully supported by this publication of the Military Operations Research Society, which appeared last year (2021). It is available from Barnes & Noble.

I’ll assume you are all familiar with the usual and traditional battle parameters   
such as FR (the force ratio),  
CX and FX (the number and fraction of casualties to side X),  
CY and FY (the number and fraction of casualties to side Y),   
the casualty exchange ratio (CER),   
the battle duration (T\_HOURS),   
and so forth.

But today most of my talk involves the parameters I introduced and have used for historical analysis for 60 years, ever since the early 1960’s.

**Slide 2: Battle Parameters**

In the early 1960’s, I discovered that the solution of the Lanchester-Osipov differential equations for simple battles not involving any reinforcements or detachments is best written in the form shown here, where *a* is the attacker’s remaining force fraction at the end of the battle, and *d* is the defender’s remaining force fraction at the end of the battle.

And three new parameters immediately command our attention,   
called mu, epsilon, and lambda. This talk will concentrate on mu and epsilon.

When is greater than one, the defender, side “”, is winning because the attacker’s remaining force fraction is decreasing faster than the defender’s.

When is less than one, the defender is losing, because side “*d”* is being drawn down faster than the attacker’s side “*a*”.

When is equal to one, it’s a draw or stalemate. Neither side is winning, and both sides are just spinning their wheels and generating casualties without gaining on their opponent.

Given each side’s initial and final strengths, values of the mu and epsilon parameters can easily be computed. Details are in the MORS publication.

It can be shown (both theoretically and empirically) that mu and epsilon are very closely approximated by the simpler expressions, as stated near the middle of the slide.

Here, *FX* is the casualty fraction for side *a* or *X*, and *FY* is the casualty fraction for side *Y* or *d*. See the book for details.

I often use the same words for both the raw parameters and their logarithms, and the logarithmic versions are in every case more appropriate for statistical and machine learning analyses.

So much for theory.

We now ask, “Are these Helmbold parameters actually valid measures of the things suggested by the names I’ve chosen for them?”

Well, as shown, bitterness, eps, is essentially equal to the geometric mean of the casualty fractions, and that certainly provides an objective and quantitative measure of what most folks mean when they say that a battle was bitterly fought.

We will not deal with “lambda” today, other than to remark that, because it is the average rate at which bitterness is accumulated during the battle, it measures the average intensity of the battle.

The next slide shows that historically, the probability that a side wins a battle is empirically given by a function of that side’s advantage parameter.   
So it is indeed the promised “Key To Victory”.

**Slide 3: Prob(WIND) vs logm(mu)**

Here is the probability that your side “” wins the battle.   
***Note that the abscissa is logmu.***

The red dots are a moving average of the fraction of battles won by side “” in the database.

The solid blue curve is a logistic fit to the empirical data.

So the Advantage parameter (mu or logmu) is indeed the key to victory.

When the Advantage parameter is zero, the probability that side “” wins is fifty percent.

If the defender can get logmu up to , they will have a 90% chance of winning.

So the advantage parameter provides an objective and quantitative measure of how much of an advantage the defender has in a given battle.

**Slide 4: Use The Key To Victory (Part A):**

Having the key to victory opens several doors to new advances in military science.

1. *The advantage parameter can be used to rapidly scan through large databases of battles to highlight those battles where the alleged winner disagrees with the Advantage parameter, prompting a closer examination of the data.*

This may sound trivial and a waste of time. Nothing could be further from the truth. Beware of Helmbold’s ***Iron Law Of Databases****:* ***“Any unedited database large enough to support statistical analysis contains so many errors that the statistical analysis is invalid!”***

I will digress a bit on databases. Military science is hampered by a lack of data. We desperately need bigger and better databases. Such databases must be available to all investigators. If I cannot access and use your database, then how are you gonna prove that your database even exists? You ***say*** it exists---***baloney, I don’t believe you!!!*** And since your database does not exist, all of your alleged conclusions are just a waste of time.

The database I used is and has for decades been publicly available on GitHub, as referenced in the book, and anybody in the world can access it. That database is, I believe, absolutely unique because along with its estimates of the number of personnel on each side and the losses on each side, it ***also*** gives the author’s estimate of how much error there might be in those numbers. On average the estimated error is around plus or minus 10 percent. In some cases, the estimated error is much larger. Regrettably, there is no explanation of how the errors were estimated. But future databases need to address the errors in their basic data. They can profitably use the physical sciences method of reporting the measured values and their estimated accuracy.

When an earlier analysis of this database used the advantage parameter to scan for anomalous values, it found that the data on the battles that occurred late in World War II in northern Italy was “anomalous”. Much later I discovered where those estimates came from. Their German strength and loss data were assumed to be accurate, although at that stage the German commanders were under immense pressure to falsify their reported losses and strengths. In any case, the German practice was to report strengths and losses once every ten days, yet the database cheerfully gave German strengths and losses midway between reporting days to five-and six-figure accuracies---with nary a word about how that was done. So all those data were not only anomalous---the historians just made them up out of whole cloth. That’s what I mean by saying that scanning the data for anomalous discrepancies between the advantage parameter and which side won can prompt penetrating inquiries.

Because of its historical significance, historians have studied and described in minute detail the famous Battle of Waterloo, fought on Sunday, 18 June 1815, so one would imagine that everything about it is firmly established fact down to the finest detail. So it may come as a bit of a surprise that nobody knows exactly when the battle started or when it ended. It started sometime after breakfast and before lunch, with most guesses putting it at around 1000 hours, give or take an hour or so. Wristwatches were unknown at the time. Even pocket watches not only weighed a lot but were notoriously inaccurate and delicate and cost so much one would hesitate to bring one to a battle. And every town kept its own time, for no “Standard” times were defined until railroad schedules made that necessary.

OK---Back to the present and the matter at hand.

**(Database Scan)** When I scanned my current database for cases where the conventional winner differed from the winner expected from the value of the Advantage Parameter, I found about 8 percent of the battle data had anomalous entries. Here are a couple of examples:

**White Plains:** Fought on October 28, 1776, near White Plains, New York. The British attackers are conventionally declared the winner, but the Advantage Parameter favors the defending Continentals. According to the narrative account of the action, after the Continentals fought off a British attack, the two sides remained where they were ***for two whole days***. Repeat ***“two whole days”!!*** Learning that British reinforcements were on the way, Washington stole away under cover of rain and darkness. When the British were finally prepared to act, they found that Washington had again eluded their grasp.  
So basically, ***after*** the British had lost the first battle, they said “Wait here while we get some reinforcements, and then we’ll fight a ***second*** battle.” But the Continentals said, “No thanks, old chaps, we’ll be on our way and see you again some other time and place.”

Soooo----When did the battle end????

When the fighting stopped, or when the British discovered the Colonials had vanished?

**Bunker Hill:** Next, consider Bunker Hill, fought on Saturday, June 17, 1775. Although the battle is traditionally known as Bunker Hill, most of the action took place on the adjacent Breeds Hill. The attacking British are conventionally declared the winner. But the narrative account of the battle sounds quite a bit different to me.

You see, the Colonials were so short of ammunition at the start that they couldn’t afford to waste a single shot. Hence the famous order "Don't fire until you see the whites of their eyes".

Two British assaults on the colonial positions were handily repulsed with significant British casualties. The colonials, now too low on ammunition, prudently decided to steal away to fight another day. The third time the British advanced they found an empty hilltop.

While the British achieved their tactical objective of eventually gaining possession of the heights, the Colonials also succeeded in their tactical objectives, which were to hold the heights while their ammunition lasted, and to then execute a successful withdrawal in the face of the enemy.

Soooo----When did the battle end???  
When the Colonials left, or when the British enjoyed their ***self-guided tour of an empty hilltop?***

Note that in these two battles, as in all battles, the Advantage Parameter’s value is known and fixed as soon as the casualty-production process ceases. In fact, for ***any and all*** parameters that depend only on the strengths and losses:   
***the battle ends when the casualty-producing process concludes. Because, at that point, the parameter value is fixed, and any subsequent maneuvers are irrelevant.***

The obvious recommendation is that military historians should be more careful, both about how they decide when a battle ends, and how they decide which side won. In particular, they should report the Helmbold Advantage and Bitterness Parameters, and then discuss how the choice of battle termination time affects the decision on who won.

There are several additional cases where the data are suspect, and they are discussed in detail in my book. As just one example, the database says that in the Battle of Tippermuir in 1644 a force of 6,800 lost 3,000 while their opponent lost only one man. I don’t believe that. Even if the numbers are correct, this event surely is nothing like any of the other battles in the database.

1. ***(Raise Issues)*** *Military historians should consistently use the defender’s advantage parameter to prompt penetrating questions should the historical record award victory to the side that did not have the advantage parameter value in its favor.*
2. ***(Report)*** *Military historians should report Helmbold’s advantage and bitterness parameters for each battle (or phase of battle, when appropriate), take them into account in their analyses, and be much more careful about deciding when the battle actually ended and which side won.*
3. ***(Teach)*** *We certainly should teach commanders how to maximize their advantage parameter --- Tom Lucas’s efforts may contribute to that (if he uses the right criterion of victory).*
4. ***(Program)*** *A permanent program should be established and adequately funded to assemble larger and highly accurate databases of historical land, sea, and air battles to empirically test, evaluate, and further refine the relationship of the defender’s advantage parameter to victory in battle and to pursue other historical matters relevant to current military matters.*

We both need, and nowadays have, adequate statistical and computational power to analyze, very large and complex databases. We should find their secrets before our enemies do.

**Slide 5: Use The Key To Victory (Part B):**

1. ***(Use)*** *The advantage parameter should be used as the primary objective function or figure of merit to be optimized when designing a force’s equipment, organization, and tactics.*
2. ***(Score)*** *The advantage parameter should be used as the “score” of a trainee unit at Fort Irwin’s National Test Center (NTC). (Special awards could be issued for exceptionally high logmu scores, and each training unit should be told where its logmu and Probability of Win score stands relative to the other units that have been trained at NTC.)*
3. ***(DARP Effort)*** *A major DARPA effort should be started ASAP to provide our nation’s battlefield commanders with accurate, trustworthy, and timely intelligence regarding their logmu values------and to deny that to enemy commanders.*

**Slide 6: Use The Key To Victory (Part C):**

1. ***(Effect of Reinforcements)*** *Combined theoretical and empirical efforts should be initiated to better understand and take into account the effect of reinforcements and detachments during the course of a battle on the defender’s advantage parameter.*
2. ***(Improve Generalship)*** *Our initial suggestion for an objective and quantitative measure of the quality of “generalship” should be further studied and refined.* ***NPGS THESIS??***
3. ***(Deliberate defeat)*** *We should consider defining and using a new battle outcome category to cover cases where a tactical defeat is or was deliberately accepted because of its strategic benefits.*

I have in mind incidents like “Horatio at the Bridge”, and the Spartans at Thermopylae.

**Slide 7: logeps vs logmu:**

Are the bitterness and advantage parameters mutually independent?  
Yes. Very nearly so.

Intuitively, bitterness might be slightly higher near zero log-advantage, as each side may feel that if they just work a little harder, they’d win, and so they both keep slugging away.

Our 300-battle database is large enough to show that any such effect is small, but not large enough to prove that it is actually zero.

And if the defender’s advantage parameter is unusually high or low, bitterness may be low because one side or the other recognizes that they are so much weaker than the other that they find it prudent to extract themselves from the situation as expeditiously as possible.

**Slide 8:** **logmu vs. Year**

How did the advantage change with the passage of years?

Here, and in my other slides, the horizontal (year) axis is centered at the year 2000, as signaled by labeling the axis as “Year 2000”.

So the calendar year 1900 CE is at on the Year 2000 axis and the calendar year 1940 CE is at on the Year 2000 axis.

***On the average***, logmu hasn’t changed since 1600 CE ( on the Year2000 scale).

As far as the Advantage Parameter goes, there has been no “revolution in military affairs” over the last 400 years, even though it has a very large scatter about the average trend line. It would be nice to know more about what causes the scatter, and perhaps other investigators will accept that challenge. ***NPGS THESIS??***

Note the slight, but persistent negative value of the average. Since in all cases I computed the Advantage favoring the Defender, that negative bias translates into a persistent slight advantage to the Attacker. However, we cannot put much faith in any such Attacker advantage, for this database has only 300 battles, and it just happens to contain five battles with a defender’s advantage less than . We’d need a database of at least 3,000 battles before declaring any supposed Attacker Advantage a reliable “Law Of War”.

**Slide 9: How Did The Other Parameters Change With The Passage of Time?**

Most of the other battle parameters changed so gradually with time that over the course of a 50-year military career, only the most observant would notice any change.

***(Read a few example rows and pause to allow the audience to peruse.)***

The striking exceptions are the ***post-WWII*** casualty fractions and , and the bitterness parameter, . This is shown graphically on the next slide.

**Side 10:** **Pre-WWII and Post-WWII logeps vs Year2000**

This graph shows that after 1939AD ( on the Year2000 scale), the trendline of bitterness versus battle started on a new and extremely steep decline, quite different from the pre-1939 gradual slope.

As far as I know, this behavior at the battle level was previously unknown.

I note that some social scientists, using the *Correlates of War* Databases, have found a similar change in the lethality of ***wars*** (not battles) before and after 1939 or so.

I can imagine and hypothesize as many potential reasons for this behavior as anybody else, but right now nobody knows what’s really causing it.

I suspect that figuring out what is really going on here is a very difficult long-term research project, and I’ll leave that to the future. ***NPGS THESIS??***

**Slide 11: WWII Battle of Kursk**

This slide shows the day-by-day values of the advantage favoring Russia during the battle or campaign on Kursk’s southern front, based on data provided to the US Army Concepts Analysis Agency by the Dupuy Institute.

We can read a complete summary of the campaign from his graph.

The Russians were initially at a serious disadvantage, and that disadvantage increased day by day until around 12 or 13 July, at which point the tide turned ---it was no longer running out---instead, it began to flow back in.

From then to 20 July Russia’s advantage increased to the point of parity. After 20 July Russia’s advantage increased and soon became overwhelming.

This provides additional empirical evidence that the Advantage parameter is a valid objective and quantitative measure of a side’s advantage in combat.

By the way, ***this means that the Lanchester-Osipov parameters changed during the Kursk campaign***. Therefore, all attempts to fit those equations to the campaign data that ***also*** assume that the relevant parameters are constants in the sense that they are fixed ***during the course of the campaign***, are doomed to failure. Of course, if the coefficients change during the course of the campaign, then the whole Lanchester-Osipov approach is no longer applicable to the entire campaign and are a waste of time.

**Slide 12: RAF Advantage in Battle of Britain (Adlerangriff)**

So far, all our data has been for land combat battles.

It would be amazing if air battles were anything like ground battles, for air battles are quintessentially machine versus machine.  
Here we are using sorties and losses instead of manpower strengths and losses.

This figure shows the RAF’s day-by-day advantage parameter during the so-called “Adlerangriff” or “Eagle Attack” phase of the World War II Battle of Britain. In that phase, the German objective was to destroy the Royal Air Force in order to gain air superiority over Britain, threaten an invasion, and thus force Britain to negotiate a peace treaty.

The German Adlerangriff did not succeed, and so Germany turned to a different approach, namely heavy night bombing of ports and industrial cities, including suburbs of London, with the strategic aim of destroying Britain’s supply chain and civilian morale.

The horizontal red and green lines mark the values . Points that fall between them are essentially draws, with the probability of victory ***between 45 and 55 percent.***

I point out that of the 18 days in the *Adlerangriff* phase:   
There were only 4 days on which the RAF’s advantage (logmu) was less than 0.05, i.e., was below the red line;  
There were 7 days on which the RAF’s advantage (logmu) was greater than +0.05, i.e., was above the green line; and   
On the remaining 7 days the RAF’s advantage (logmu) was between the red and green lines, in other words essentially a draw with neither side having a very strong advantage.

So, just by looking at the graph, we can conclude that the whole campaign was nearly even, that on balance the stubborn and skillful RAF defense certainly was not in any danger of losing the campaign, and that therefore the Luftwaffe, having no clear prospect of destroying the RAF, was fully justified in ending that campaign and seeking another approach.

I believe that this agrees with, and supports, most historians’ assessment of this phase of the Battle of Britain.

I consider that this also supports the view that the advantage parameter really does measure a side’s advantage---for air battles as well as for land battles.

**Slide 13: Naval Battles**

Naval battles are quintessentially battles between machines, and in that way are quite different from land battles. It would be silly to think that Naval battles would in any way resemble land combat battles, but I’m bold enough—or crazy enough---to try it.

I usually don’t like to use data from dictionaries of battles, for I have found them untrustworthy and very suspect.

However, sometimes I’ve had no choice. So, in this case, I have used the data on 77 naval battles that occurred between 1639 and 1905 as given in Gaston Bodart’s *Kriegslexicon*. As an aside, I note that all too often Bodart’s figures are suspect, because they consistently add to a very nice round number. For example, Bodart may report 1,300 killed, 6,700 wounded, adding to a nice round number of 8,000 bloody losses. Too many nice round numbers of total losses.

Now, as 77 is a relatively small sample we must be very cautious about interpreting the findings.

As for land combat battles I used only the personnel strengths and casualties to compute the parameter values.  
Although Bodart also reports the number and size of the ships involved on each side, the number and size of their cannon, and many other details, I used just the personnel strengths and losses, just as I did for land combat battles.

Bodart states which side is considered the winner. But, unfortunately, Bodart does not report which side was the attacker and which the defender. In order not to contaminate Bodart’s data with my judgment of naval tactics, I computed the advantage favoring Bodart’s winning side.

As shown on this graph, the sign of the advantage parameter agreed with the winner about 90 percent of the time. In other words, you just tell me which side had the higher advantage, and I’ll tell you which side won, and I’ll be correct 90 percent of the time.

Note that almost all of the points fall above or not far below the horizontal axis at logmu = 0.

Note, also that there is little or no systematic variation with battle date—no statistically significant trend of Advantage with the battle date. However, the sample size of 77 may be too small to detect a sight systematic trend.

We conclude that the advantage parameter is a good indicator of superiority in naval battles, just as it is in land combat battles.

We also see that in naval battles the advantage has not changed significantly with the passage of time, which is confirmed by statistical tests of significance.

**Slide 14: Bodartship logeps vs. logmu**

In naval battles, as in land battles, bitterness does not depend upon advantage.

We conclude that bitterness and advantage measure two separate and independent aspects of naval battles, just as they do for land battles.

**Slide 15: Use The Key To Victory (Part A)**

Here is where we stand today:

* Military historians need to be a lot more careful about which side won, and they should tell us what ***objective*** ***and quantitative*** criteria they used for that. They should also report the value of the winner’s advantage parameter when the shooting stopped (and if they wish, also at the end of the battle, although that will be the same as when the shooting stopped).
* Quickly screening large databases for oddities and other potential errors during the data wrangling phase is greatly simplified by comparing the database’s claimed winner against the side that has the highest advantage parameter.
* DoD should establish a permanent agency or office to construct, data, and quantitatively analyze the lessons implied by larger, more varied, more complete, and up-to-date databases. To be specific, I have in mind an office of one or two dozen analysts, plus an appropriate number of computers and support personnel, with a guaranteed consistent operating budget of about four or five million a year, with the authority to contract out whatever work they consider extends their expertise. At least two of their researchers should be experienced experts in practical statistics and applied machine learning. Steady funding is necessary because some of their most important projects will span many years. Its mission would include:
  + Assembling large and highly accurate databases of historical land, sea, and air battles
  + Empirically testing, evaluating, and further refining the relationship of the advantage parameter to victory in battle.
  + Examining and extrapolating trends in the data to support DoD planning.
* Military historians should consistently use the defender’s advantage parameter to prompt penetrating questions should the historical record award victory to the side that did not have the advantage parameter value in its favor.
* Every historical battle account or analysis should report the battle’s historical advantage parameter and describe how it was computed.

**Slide 16: Use The Key To Victory (Part B)**

* Every cost-benefit analysis of proposed changes in equipment, organization, and operations should use our side’s advantage parameter as the analysis’s figure of merit and should report how our side’s advantage parameter changes when the recommended course of action is and is not adopted.
* All current and future combat commanders and their staffs should be taught the significance of the advantage parameter and how to improve our side’s advantage parameter
* Ongoing combat operations should base operational plans on the current and anticipated value of our side’s advantage parameter. (To further that, DARPA and our intelligence agencies should institute a program to provide field commanders with operationally useful reports of their current advantage parameter.)
* We should deny our enemy all knowledge of his, as well as our, advantage parameter.
* The advantage parameter should be used as the “score” of a trainee unit at Fort Irwin's National Test Center (NTC). (Special awards could be issued for exceptionally high logmu scores, and each training unit should be told where its logmu score stands relative to the other units that have been trained at NTC.)

**Slide 17: Use The Key To Victory (Part C)**

* Combined theoretical and empirical efforts should be initiated to better understand and account for the effect of reinforcements and detachments during the course of a battle on our side’s advantage parameter. ***NPGS THESIS??***
* One of the first tasks of the proposed DoD historical analysis office should be to confirm or disprove the occurrence of a sudden break in bitterness and its constituent casualty fractions around 1939, and to make better projections to the year 2100 CE.

**Slide 18: After Words**

* Rating Commanders Objectively and Quantitatively:

About 30 years ago, at a conference much like this one, I asked why Napoleon was a “great general” and was told that it was because he won so many battles. And when I asked how he won so many battles, I was told “Why, because he was a great general, you dummy.”

Another participant noted that to break out of this fallacious circular argument, we need some separate and independent criteria of “generalship” As no such criteria have been suggested in the intervening thirty years, I took a stab at it, using my Advantage Parameter as the base, and then subtracting a penalty based on my Bitterness Parameter to penalize “Pyrrhic victories.”

Obviously, more work is needed to thoroughly test it out and improve it, but at least it is well-defined and specific, so you know ***exactly*** what it is. Furthermore, it is a totally objective and quantitative scale for assessing generalship. See my book for details. ***NPGS THESIS??***

* In my book I also raise the question of how we should measure a side’s personnel strength.

Specifically, I suggest that instead of using the number of men present to measure a side’s personnel strength, we instead measure it by the number of man-hours of effort expended, as is traditionally done in industry.

When the number of personnel engaged in the battle changes significantly during a battle, as may be due to reinforcements, attachments, and detachments, then measuring the effort in man-hours may be more appropriate.

My book contains an example of how this might work out for the battle of Waterloo, which seems to provide additional insight.

However, the whole notion is just the germ of an idea, and a lot more thought and effort are needed to determine whether, and in what circumstances, it might be appropriate.

I hope someone will take up the challenge. ***NPGS THESIS??***

Thank you. I hope I have given you some interesting and important things to think about.

**XXX End of Speech---Don’t use anything below XXX**

**Slide 4: The Database and Lessons Learned**

I used a database of land battles that is publicly available on GitHub.

It is identical to a land battle database specially prepared by the Dupuy Institute for the US Army Concepts Analysis Agency and vetted by the US Army Center of Military History.

All things considered, it is clearly the best and most appropriate database for our purposes---despite its shortcomings.

Here, “missing data” means that at least one side’s initial or final strength is missing.

While the database gives the number of reinforcements, it contains no information on when they entered the battle, so we dropped those battles.

***Law of Nature:*** All databases extensive enough for analytical work contain numerous errors, and rigorous data wrangling is required to assure that only valid data are used in the analysis.

I probably was not critical enough in my data wrangling, but in outline this is what I did:

First, list all battles with winning side in conflict with the advantage parameter, and subject each of them to critical analysis

To our surprise and dismay, we found several battles where the side that really won the fight is ***NOT*** the side that the database (as well as most military historians) claims won the battle.

The Battle of Bunker Hill is a familiar example. Fought on 17 June 1775, and mainly on Breed’s Hill, it involved an attack by British Regulars against the Colonials. The database says the attackers won the ***battle***, which is the conventional military historian’s call. I beg to differ and argue that the Colonials won the ***fight***. Consider the following. The Colonials were short of ammunition, hence the order to “not fire until you see the whites of their eyes”.  
The British attacked uphill twice. Each time they met devastating fire from the Colonials and were forced to retreat after taking heavy casualties. The Colonials realized that they didn’t have enough ammo to beat back a third British assault, so they just up and left---to fight again under more favorable conditions.  
When the British went up the hill for the third time, there was no one there. As I said, the Colonials won the ***fight***, while the fight lasted.

Notice that ***who*** won depends critically on ***when*** the fight ended---did it end when the shooting stopped (i.e., when the Colonials left their positions), or when all tactical movement ceased (i.e., when the British reached the top of the hill)?

***So*** my first recommendation is that military historians be a lot more careful about which side won, that they tell us what ***objective*** criterion they used for that, and that they also report the value of the winner’s advantage parameter when the shooting stopped (and if they wish, also at the end of the battle, if that differs from when the shooting stopped).

I note that screening large databases for oddities and other potential errors during the data wrangling phase is greatly simplified by comparing the database’s claimed winner against the side that has the highest advantage parameter.

I also recommend that DoD establish a permanent agency or office to construct, data wrangle, and quantitatively analyze the lessons implied by larger, more varied, more complete, and up to date databases. To be specific, I have in mind an office of about a dozen analysts, plus an appropriate number of computers, microfilm readers, and support personnel, with a guaranteed operating budget of about four or five million a year, with the ability to contract out whatever work they consider extends their expertise. At least two of their researchers should be experienced experts in practical statistics and machine learning. Steady funding is necessary, for some of their most important projects will require many years. It’s mission would include:

* Assembling large and highly accurate databases of historical land, sea, and air battles
* Empirically testing, evaluating, and further refining the relationship of the defender’s advantage parameter to victory in battle.
* Examining and extrapolating trends in the data to support DoD planning.

I suppose we could call it the Historical Evaluation and Research office.

**Slide 5: The Probability of Winning**

The data show that the probability of side Y winning a battle (PWIN) depends on its advantage parameter (logmu) as follows:   
 where  
 is the standard logit function,   
,   
where is the log-advantage parameter, and  
.

The red dots are the database values, smoothed by averaging over a moving window.

*Reminder:*

The logit function is zero when ,   
one-half when ,   
and when .

This proves that the advantage parameter does indeed measure what most folks mean by advantage.

The obvious recommendations are that:

* Military historians consistently use the defender’s advantage parameter to prompt penetrating questions should the historical record award victory to the side that did not have the advantage parameter value in its favor.
* Every historical battle account or analysis should report the battle’s historical advantage parameter and describe how it was computed
* Every cost-benefit analysis of proposed changes in equipment, organization, and operations should use our side’s advantage parameter as the analysis’s figure of merit and should report our side’s advantage parameters when the proposed change is implemented, and when it is not adopted.
* All current and future combat commanders and their staffs should be taught the significance of the advantage parameter and how to improve our side’s advantage parameter
* Ongoing combat operations should base operational plans on the current and anticipated value of our side’s advantage parameter. (To further that, DARPA and our intelligence agencies should institute a program to provide field commanders with operationally useful reports of their current advantage parameter.)
* We should deny our enemy all knowledge of his advantage parameter.
* The advantage parameter should be used as the “score” of a trainee unit at Fort Irwin's National Test Center (NTC). (Special awards could be issued for exceptionally high logmu scores, and each training unit should be told where its logmu score stands relative to the other units that have been trained at NTC.)
* Combined theoretical and empirical efforts should be initiated to better understand and take into account the effect of reinforcements and detachments during the course of a battle on our side’s advantage parameter.

**Slide 6: Influence of Advantage on KMDA**

This figure displays the distance in kilometers that the ***attacker*** advances, depending on the size of the ***defender’s*** advantage.

We offer the following observations.

Whenever the ***defender’s*** advantage is substantial (logmu > ), the attacker’s advance tends to be less than 5 km. Indeed, the attacker’s “advance” is often negative, i.e., the ***attacker loses*** ground and the defender advances.

On the other hand, when the ***attacker*** has a substantial advantage (logmu < ), he can almost always advance, and in fact can often advance more than 10 km.

In other words, when the ***attacker*** has some advantage (logmu < 0), the ***defender*** usually has to retreat, and finds it practically impossible to gain ground.

These observations support the finding that the advantage parameter does indeed measure what most folks would consider to be a side’s advantage or degree of superiority in combat.

**Slide 7: Is Bitterness Affected By Advantage?**

This graph shows the historical relation between bitterness and advantage.

A careful statistical analysis found no effect of advantage on bitterness.

If further data and analysis confirm that bitterness is unaffected by advantage,   
then I, for one, would be a bit surprised, because common-sense tells me that battles in which the sides are evenly matched are likely to be more bitter than those where one side has a considerable advantage over the other.

On the other hand, when the two sides differ greatly in advantage, the weaker side is more likely to break off the engagement to fight again under more favorable conditions.

But when the two sides are about even, each side will tend to believe that if they just hold on a bit longer the other side will yield.

In fact, that belief may be irrational and mistaken, but humans are not always rational and objective.

Setting aside these musings and subjective speculations about how the sides might behave when nearly evenly matched, we are left with the finding that, at least for the actual combat data analyzed, bitterness is not affected by the size of the advantage.

Therefore, as far as we know bitterness and advantage are essentially independent quantities.  
Each quantitatively measures the feature for which it is named.

~~Although it would be desirable to include some analysis of intensity (lambda or loglambda), too few battles in the database have enough information to support an analysis of intensity.~~

**Slide 8: Long-Term Trends – Part I**

This slide shows that, on average, the advantage parameter has stayed absolutely constant for at least the past 400 years.

The horizontal axis is shifted so that the origin is at year 2000 of the Current Era. This was done so that the extrapolation to the year 2100 would show on the graph.

This is an entirely new finding.  
Nobody else knows this.  
It is a shocking result.  
Defender’s advantage a Constant since the age when firearms were still in the process of replacing longbows and crossbows?!  
Constant despite the enormous changes in equipment, organizations, and tactics?!

Note that the trend line lies very slightly below the zero-level, indicating that on balance neither the attacker nor the defender really has a much of a persistent edge or advantage over the other, despite Clausewitz’s claims to the contrary.

**Slide 9: Long-Term Trends – Part II**

This table shows the average rate of change of each parameter or feature per 50 years, listed in order of ***decreasing*** percent change over 50 years.

The battle duration, T\_HRS is ***not a percentage*** change per 50 years. Instead, it is the increased battle duration in hours over an average 50-year period, which amounts to about 7/10 of an hour per 50 years, or a little less than a minute per year.

The first finding is that almost all these features or parameters change so slowly over a 50-year period that only the most acute observer would notice their slow drift, hidden as it is beneath the wide variability from one battle to the next.

The second finding is that around the start of WWII there was a “Revolution in Military Affairs” that drastically altered the way the bitterness (eps) and its constituent casualty fractions (FY and FX) changed with time.

The following graphs show this “Revolution in Military Affairs” in striking form.

**Slide 10: Long-Term Trends – Part III**

This slide shows one graph for bitterness (at the top) and two (below it)   
for its constituent casualty fractions.

On each of these graphs, the trendline in blue uses only the pre-WWII data and   
the separate trendline in yellow uses only the WWII and post-WWII data.

The main point is that a startling “Revolution in Military Affairs” occurred in 1939. Before 1939 the bitterness parameter and its constituent casualty fractions declined rather slowly with the passage of time, but around 1939 they went into a steep dive.

If this rate of decrease persists the extrapolation to the year 2100 CE is astonishing.

I note for the record that sociologists using the Correlates of War databases have discovered a similar decline in the lethality of wars since around 1939, so the steep decline in bitterness appears to hold for both battles and wars. Their findings and mine are mutually consistent, although nobody has the slightest clue as to what is causing this phenomenon. Surely it is in our national interest to figure that out what is going on here.

Therefore, one of the first tasks of the proposed DoD historical analysis office would be to confirm or disprove the occurrence of a sudden break in bitterness and its constituent casualty fractions, and to make better projections to the   
year 2100 CE.