

Vol. 2, No. 1 (August 1997): Trevor N. Dupuy, Colonel, US Army 1916-1995; Technology and the Human Factor in War; History and Publications of TN Dupuy and HERO; The Quantified Judgement Model (Boeing version); A Rebuttal to "Force XXI and the Theory of Winning." 

Vol. 2, No. 2 (October 1997): Jutland: Beatty - Scheer; Should There Be a Naval QJM? Consistent Scoring of Weapons and Aggregation of Forces; Solving the AFV OLI Calculation Problems; Modeling World War I in Africa. 

Vol. 2, No. 3 (December 1997): Iranian Casualties in the Iran-Iraq War: A Reappraisal; Time and Breakpoints in the TNDM; A Look at the OLIs of APCs, ACs, IFVs, and CFVs; Some Thoughts on the Mobility Equation; The TNDM OLI Database. 

Vol. 2, No. 4 (December 1998): The Influence of T.N. Dupuy's Research on the Treatment of Ground Combat in RAND's RSAS and JICM Models; Iranian Casualties in the Iran-Iraq War, Part 2; More on the QJM/TNDM Italian Battles; How Advance Rates Are Calculated in the TNDM. 

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Trevor N. Dupuy
Colonel, US Army
1916 – 1995

Also in this issue:

- Technology and the Human Factor in War
- History and Publications of TN Dupuy and HERO
- The Quantified Judgement Model (Boeing version)
- A Rebuttal to "Force XXI and the Theory of Winning"

INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this seventh issue of our newsletter Christopher Lawrence, Dave Bongard, Richard Anderson, José Perez, Jay Karamales, and Susan Rich continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically-based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

(1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;

(2) Training, cultural and psychological profiles, and flow of information;

(3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in-house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically-based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.



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IN HONOR OF THE MEMORY OF THE LATE

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**International
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From the Editor...



The picture of Trevor N. Dupuy on the cover was taken on 4 June 1995. In addition to being a very good picture of Col. Dupuy, it is also the last picture taken of Col. Dupuy. It was taken, one day before his death, by Gary Schofield, a professional artist. You can see one of Mr. Schofield's paintings, *The Pentagon Full Honors Ceremony*, in the Hall of Heroes in the Pentagon.

At the suggestion of Dr. Paul Berenson, TRADOC, we have published an article written by Trevor N. Dupuy that was never before published called "Technology and the Human Factor in War." As you will read, this article again makes the forceful argument that you need to be able to model the human factors if you are going to model combat.

We have also included a series of background articles on Col. Dupuy. According to the best count we could assemble, he wrote or co-authored 86 books during his life. Granted, much of that count is inflated by three multi-volume series of thin books that accounted for 43 of those books, but that still leaves over 40 other full-length books. He wrote all but two of those books between 1956 and 1994, averaging well over two books a year. In the last ten years of his life he managed to publish ten books. We also have in our files three unfinished manuscripts. Just to provide a complete record, we also listed the 13 books authored or co-authored by his father,

During his tenure as President of TNDA/HERO/DMSI, Col. Dupuy's organizations produced more than 140 reports, some of which we have not been able to identify. The Dupuy Institute has produced more than 20 additional reports. We include in this issue a list of the 200 articles written by Trevor Dupuy. Many of these have not been published, and some were published but we don't know when or where. We suspect that there are some articles published that we are not aware of.

Just to assemble a "definitive" list of Trevor Dupuy's work was a major effort. All these writings are listed here thanks to the help of our "chief librarian," Susan Rich. I've also provided a brief history of Trevor's organizations in case someone is getting confused with all the "alphabet soup." This hopefully provides a concise summary of his life's work. It is as impressive a body of work as anyone has produced in recent times. If you have not done so already, I cannot stress the value of reading *Understanding War*. I consider it his best work, really a good compilation and explanation of all that he had done, and a very under-recognized book. Unfortunately, it is no longer in print.

We are also presenting here another article from outside the institute. The article is by Bill Buettell from Boeing Defense and Space Group and describes how and why Boeing has been using the QJM. Mr. Buettell heads up the modeling group at Boeing, and has been using a Boeing modified version of the QJM for their work for years.

The Quantified Judgement Model (QJM) is Trevor Dupuy's previous model of combat, from which the TNDM evolved. As the article points out, one of the advantages of the QJM is that it is quick and easy to run. While this "best bang for the buck" feature is a major advantage of the QJM/TNDM, our sense of pride often keeps us from stressing this feature. We would like to think that we are the best model, bar none.

We also have a "Letter to the Editor" from Niklas Zetterling in response to our last issue. He wrote it as a personal letter to me, not for publication, but I got him to agree to let us publish it even though he didn't have a chance to "polish" it up.

I have also included an internal memorandum (disguised as an article) that I wrote in preparation for responding to an article in *Army Times* magazine. Unfortunately, we did not see the article until a considerable time after it had been published, so writing a rebuttal letter would probably have been irrelevant, but I believe the reader will find the rebuttal interesting. Of course, we are not allowed to reprint the original article but it's in the June 1996 issue of *Army Times*.

In the next issue, I expect to include some more articles on our battalion-level validation. We have still to conduct our analysis of the advance rates and formulation of a summary conclusion. We also expect to include our TNDM analysis of the battle of Dom Bütgenbach, which we are currently working on. We are conducting an analysis as a multi-day division-level battle, and then we will fight the battle the way it actually occurred: as a

series of battalion-level engagements. We will then test the model results to the historical results. This test is part of our on-going validation effort. We also need to test all these changes to our second battalion-level validation data base of 123 battles (and growing) from 1914 through 1991. This will be filling in the back pages of the Newsletter for several more issues. I also expect to have some more “outside” articles for the next issue.

One of our customers has specifically requested that we look further into the issue of “Time” of battles. I intend to address that in some depth in the next issue. They are also interested in what we’ve done on a Naval TNDM, so I will address that in either the next issue or the one after that.

That is all for now. If you have any questions, please contact me. Addresses, E-mail addresses, and phone numbers are in the masthead. 



Technology and the Human Factor in War



by Trevor N. Dupuy

The Debate

It has become evident to many military theorists that technology has become increasingly important in war. In fact (even though many soldiers would not like to admit it) most such theorists believe that technology has actually reduced the significance of the human factor in war. In other words, the more advanced our military technology, these “technocrats” believe, the less we need to worry about the professional capability and competence of generals, admirals, soldiers, sailors, and airmen.

The technocrats believe that the results of the Kuwait, or Gulf, War of 1991 have confirmed their conviction. They cite the contribution to those results of the UN (mainly US) command of the air, stealth aircraft, sophisticated guided missiles, and general electronic superiority. They believe that it was technology which simply made irrelevant the recent combat experience of the Iraqis in their long war with Iran.

Yet there are a few humanist military theorists who believe that the technocrats have totally misread the lessons of this century’s wars! They agree that, while technology was important in the overwhelming UN victory, the principal reason for the tremendous margin of UN superiority was the better training, skill, and dedication of UN forces (again, mainly US).

And so the debate rests. Both sides believe that the result of the Kuwait War favors their point of view. Nevertheless, an objective assessment of the literature in professional military journals, of doctrinal trends in the US services, and (above all) of trends in the US defense budget, suggest that the technocrats have stronger arguments than the humanists—or at least have been more convincing in presenting their arguments.

I suggest, however, that a completely impartial comparison of the Kuwait War results with those of other recent wars, and with some of the phenomena of World War II, shows that the humanists should not yet concede the debate.

I am a humanist, who is also convinced that technology is as important today in war as it ever was (and it has always been important), and that any national or military leader who neglects military technology does so to his peril and that of his country. But, paradoxically, perhaps to an extent even greater than ever before, the quality of military men is what wins wars and preserves nations.

To elevate the debate beyond generalities, and demonstrate convincingly that the human factor is at least as important as technology in war, I shall review eight instances in this past century when a military force has been successful

because of the quality of its people, even though the other side was at least equal or superior in the technological sophistication of its weapons. The examples I shall use are:

- Germany vs. the USSR in World War II
- Germany vs. the West in World War II
- Israel vs. Arabs in 1948, 1956, 1967, 1973 and 1982
- The Vietnam War, 1965-1973
- Britain vs. Argentina in the Falklands 1982
- South Africans vs. Angolans and Cubans, 1987-88
- The US vs. Iraq, 1991

The demonstration will be based upon a marshalling of historical facts, then analyzing those facts by means of a little simple arithmetic.

Relative Combat Effectiveness Value (CEV)

The purpose of the arithmetic is to calculate relative combat effectiveness values (CEVs) of two opposing military forces. Let me digress to set up the arithmetic.

Although some people who hail from south of the Mason–Dixon Line may be reluctant to accept the fact, statistics prove that the fighting quality of Northern soldiers and Southern soldiers was virtually equal in the American Civil War. (I invite those who might disagree to look at Livermore’s *Numbers and Losses in the Civil War*). That assumption of equality of the opposing troop quality in the Civil War enables me to assert that the successful side in every important battle in the Civil War was successful either because of numerical superiority or superior generalship. Three of Lee’s battles make the point:

- Despite being outnumbered, Lee won at Antietam. (Though Antietam is sometimes claimed as a Union victory, Lee, the defender, held the battlefield; McClellan, the attacker, was repulsed.) The main reason for Lee’s success was that on a scale of leadership his generalship was worth 10, while McClellan was barely a 6.
- Despite being outnumbered, Lee won at Chancellorsville because he was a 10 to Hooker’s 5.
- Lee lost at Gettysburg mainly because he was outnumbered. Also relevant: Meade did not lose his nerve (like McClellan and Hooker) with generalship worth 8 to match Lee’s 8.

Let me use Antietam to show the arithmetic involved in those simple analyses of a rather complex subject:

The numerical strength of McClellan’s army was 89,000; Lee’s army was only 39,000 strong, but had the

multiplier benefit of defensive posture. This enables us to calculate the theoretical combat power ratio of the Union Army to the Confederate Army as 1.4:1.0. In other words, with substantial preponderance of force, the Union Army *should* have been successful. (The combat power ratio of Confederates to Northerners, of course, was the reciprocal, or 0.71:1.0.)

However, Lee held the battlefield, and a calculation of the actual combat power ratio of the two sides (based on accomplishment of mission, gaining or holding ground, and casualties) was a scant, but clearcut: 1.16:1.0 in favor of the Confederates. A ratio of the *actual* combat power ratio of the Confederate/Union armies (1.16) to their theoretical combat power (0.71) gives us a value of 1.63. This is the relative combat effectiveness of the Lee's army to McClellan's army on that bloody day. But, if we agree that the quality of the troops was the same, then the differential must essentially be in the quality of the opposing generals. Thus, Lee was a 10 to McClellan's 6.

The simple arithmetic equation¹ on which the above analysis was based is as follows:

$$CEV = (R/R)/(P/P)$$

When: CEV is relative Combat Effectiveness Value

R/R is the actual combat power ratio

P/P is the theoretical combat power ratio.

At Antietam the equation was: $1.63 = 1.16/0.71$.

We'll be revisiting that equation in connection with each of our examples of the relative importance of technology and human factors.

Airpower and Technology

However, one more digression is required before we look at the examples. Airpower was important in all eight of the 20th Century examples listed above. Offhand it would seem that the exercise of air superiority by one side or the other is a manifestation of technological superiority. Nevertheless, there are a few examples of an air force gaining air superiority with equivalent, or even inferior aircraft (in quality or numbers) because of the skill of the pilots.

However, the instances of such a phenomenon are rare. It can be safely asserted that, in the examples used in the following comparisons, the ability to exercise air superiority was essentially a technological superiority (even though in some instances it was magnified by human quality superiority). The one possible exception might be the Eastern Front in World War II, where a slight German technological superiority in the air was offset by larger numbers of Soviet aircraft, thanks in large part to Lend-Lease assistance from the United States and Great Britain.

The Battle of Kursk, 5–18 July, 1943

Following the surrender of the German Sixth Army at Stalingrad, on 2 February, 1943, the Soviets mounted a major winter offensive in south-central Russia and Ukraine which reconquered large areas which the Germans had overrun in 1941 and 1942. A brilliant counteroffensive by German Marshal Erich von Manstein's Army Group South halted the Soviet advance, and recaptured the city of Kharkov in mid-March. The end of these operations left the Soviets holding a huge bulge, or salient, jutting westward around the Russian city of Kursk, northwest of Kharkov.

The Germans promptly prepared a new offensive to cut off the Kursk salient. The Soviets energetically built field fortifications to defend the salient against expected German attacks. The German plan was for simultaneous offensives against the northern and southern shoulders of the base of the Kursk salient. Field Marshal Gunther von Kluge's Army Group Center, would drive south from the vicinity of Orel, while Manstein's Army Group South pushed north from the Kharkov area. The offensive was originally scheduled for early May, but postponements by Hitler, to equip his forces with new tanks, delayed the operation for two months. The Soviets took advantage of the delays to further improve their already formidable defenses.

The German attacks finally began on 5 July. In the north General Walter Model's German Ninth Army was soon halted by Marshal Konstantin Rokossovski's Army Group Center. In the south, however, German General Hermann Hoth's Fourth Panzer Army and a provisional army commanded by General Werner Kempf, were more successful against the Voronezh Army Group of General Nikolai Vatutin. For more than a week the XLVIII Panzer Corps advanced steadily toward Oboyan and Kursk through the most heavily fortified region since the Western Front of 1918. While the Germans suffered severe casualties, they inflicted horrible losses on the defending Soviets. Advancing similarly further east, the II SS-Panzer Corps, in the largest tank battle in history, repulsed a vigorous Soviet armored counterattack at Prokhorovka on July 12–13, but was unable to continue to advance.

The principal reason for the German halt was the fact that the Soviets had thrown into the battle General Ivan Konev's Steppe Army Group, which had been in reserve. The exhausted, heavily outnumbered Germans had no comparable reserves to commit to reinvigorate their offensive.

A comparison of forces and losses of the Soviet Voronezh Army Group and German Army Group South on the south face of the Kursk Salient is shown below. The strengths are averages over the 12 days of the battle, taking into consideration initial strengths, losses, and reinforcements.

A comparison of the casualty tradeoff can be found by dividing Soviet casualties by German strength, and German losses by Soviet strength. On that basis, 100 Germans inflicted 5.8 casualties per day on the Soviets, while 100 Soviets inflicted 1.2 casualties per day on the Germans, a tradeoff of 4.9 to 1.0

¹This calculation is automatic in analyses of historical battles by the Tactical Numerical Deterministic Model (TNDM).

Forces	Strengths		Losses			
	Troops	Tanks	Troops	%/Day	Tanks	%/Day
Sov Voronezh AG	400,000	2,000	195,000	4.06	2,100	8.75
Ger Army Gp South	280,000	1,500	57,000	1.70	700	3.89

The statistics for the 8-day offensive of the German XLVIII Panzer Corps toward Oboyan are shown below. Also shown is the relative combat effectiveness value (CEV) of Germans and Soviets, as calculated by the TNDM. As was the case for the Battle of Antietam, this is derived from a mathematical comparison of the theoretical combat power ratio of the two forces (simply considering numbers and weapons characteristics), and the actual combat power ratios reflected by the battle results:

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Sov Sixth Army	100,000	1,100	28,000	3.50	800	9.09	0.42
Ger XLVIII Pz Corps	68,000	700	8,900	1.64	280	4.00	2.40 ³

The calculated CEVs suggest that 100 German troops were the combat equivalent of 240 Soviet troops, comparably equipped. The casualty tradeoff in this battle shows that 100 Germans inflicted 5.15 casualties per day on the Soviets, while 100 Soviets inflicted 1.11 casualties per day on the Germans, a tradeoff of 4.64. It is a rule of thumb that the casualty tradeoff is usually about the square of the CEV.

A similar comparison can be made of the two-day battle of Prokhorovka. Soviet accounts of that battle have claimed this as a great victory by the Soviet Fifth Guards Tank Army over the German II SS-Panzer Corps. In fact, since the German advance was halted, the outcome was close to a draw, but with the advantage clearly in favor of the Germans.

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Sov 5th Gds Tk Army	95,000	800	7,700	4.05	340	21.25	0.38
Ger II-SS Pz Corps	50,000	400	1,900	1.90	85	10.63	2.60

The casualty tradeoff shows that 100 Germans inflicted 7.7 casualties per on the Soviets, while 100 Soviets inflicted 1.0 casualties per day on the Germans, for a tradeoff value of 7.7.

When the German offensive began, they had a slight degree of local air superiority. This was soon reversed by German and Soviet shifts of air elements, and during most of the offensive, the Soviets had a slender margin of air superiority. In terms of technology, the Germans probably had a slight overall advantage. However, the Soviets had more tanks and, furthermore, their T-34 was superior to any tank the Germans had available at the time. The CEV calculations demonstrate that the Germans had a great

²The initial tank strength of the Voronezh Army Group was about 1,100 tanks. About 3,000 additional Soviet tanks joined the battle between 6 and 12 July. At the end of the battle there were about 1,800 Soviet tanks operational in the battle area; at the same time there were about 1,000 German tanks still operational.

³The relative combat effectiveness value of each force is calculated in comparison to 1.0. Thus the CEV of the Germans is 2.40:1.0, while that of the Soviets is 0.42:1.0. The opposing CEVs are always the reciprocals of each other.

qualitative superiority over the Russians, despite near-equality in technology, and despite Soviet air superiority. The Germans lost the battle, but only because they were overwhelmed by Soviet numbers.

German Performance, Western Europe, 1943–1945

Beginning with operations between Salerno and Naples in September, 1943, through engagements in the closing days of the battle of the Bulge in January, 1945, the pattern of German performance against the Western Allies was consistent. Some German units were better than others, and a few Allied units were as good as the best of the Germans. But on the average, German performance, as measured by CEV and casualty tradeoff, was better than the Western allies by a CEV factor averaging about 1.2. and a casualty tradeoff factor averaging about 1.5. Listed below are ten engagements from Italy and Northwest Europe during that 1944.

Date	Engagement	Unit	--- Strength ---		----- Losses -----			
			Troops	Tanks	Troops %/Day	Tanks %/Day	CEV	
25-26 Jan 44	Aprilia I	Brit 1st ID	19,350	71	1,158	3.0	7	4.9
		Ger 3rd PzGrD	6,750	46	130	1.0	4	4.3
16-18 Feb 44	Bowling Alley	US 45th ID	20,946	106	1,018	1.2	35	9.0
		Ger LXXVI Pz C	41,974	201	2,238	1.3	56	7.0
11-13 May 44	S. Maria Infante	US 88th ID	18,702	249	531	1.4	9	1.8
		Ger 94th ID	9,250	34	1,035	5.6	20	29.4
22-25 May 44	Anzio Breakout	US 1st AD	22,374	424	710	1.1	93	7.3
		Ger 3rd PzGrD	12,815	89	1,035	3.5	51	19.1
28 May 44	Velletri	US 1st AD	20,683	462	767	3.7	18	3.9
		Ger 362nd ID	12,327	65	1,319	10.7	30	46.2
6-11 Sep 44	Moselle-Metz	US XX Corps	59,631	585	1,647	0.5	19	0.5
		Ger 1st Army	45,500	160	1,700	0.7	30	3.1
8-12 Nov 44	Seille-Nied	US XII Corps	99,583	764	4,265	0.9	89	2.4
		Ger LXXXIX Corps	23,584	71	4,880	4.1	14	3.9
16-17 Dec 44	Sauer River	US 4th ID (-)	8,634	40	1,035	4.0	3	3.8
		Ger 212th VGD	10,000	4	813	2.7	2	25.0
17-21 Dec 44	St. Vith	US 7th AD	10,375	152	1,485	3.6	56	9.2
		Ger LXVI Corps	23,800	251	1,884	2.0	60	6.0
21-26 Dec 44	Bastogne	US 101st AbnD	20,441	105	2,046	2.0	103	16.3
		Ger XLVII Pz Corps	36,678	351	1,662	0.9	50	2.8
Italic = Attacker		Bold = Successful				Average CEV: 1.16		

Technologically, German forces and those of the Western Allies were comparable. The Germans had a higher proportion of armored combat vehicles, and their best tanks were considerably better than the best American and British tanks, but the advantages were at least offset by the greater quantity of Allied armor, and greater sophistication of much of the Allied equipment. The Allies were increasingly able to achieve and maintain air superiority during this period of slightly less than two years.

The combination of vast superiority in numbers of troops and equipment, and in increasing Allied air superiority, enabled the Allies to fight their way slowly up the Italian boot, and between June and December, 1944, to drive from the Normandy beaches to the frontier of Germany. Yet the presence or absence of Allied air support made little difference in terms of either CEVs or casualty tradeoff values. Despite the defeats inflicted on them by the numerically superior Allies during the latter part of 1944, in December the Germans were able to mount a major offensive that nearly destroyed an American army corps, and threatened to drive at least a portion of the Allied armies into the sea.

Clearly, in their battles against the Soviets and the western Allies, the Germans demonstrated that quality of combat troops was able consistently to overcome Allied

technological and air superiority. It was Allied numbers, not technology, that defeated the quantitatively superior Germans.

The Six-Day War, 1967

The remarkable Israeli victories over far more numerous Arab opponents—Egyptian, Jordanian, and Syrian—in June, 1967 revealed an Israeli combat superiority that had not been suspected in the United States, the Soviet Union or Western Europe. This superiority was equally awesome on the ground as in the air. (By beginning the war with a surprise attack which almost wiped out the Egyptian Air Force, the Israelis avoided a serious contest with the one Arab air force large enough, and possibly effective enough, to challenge them.)

The results of the three brief campaigns are summarized in the table below:

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Egyptians	210,000	1,300	10,500	1.67	700	17.95	0.53
Israelis	150,000	800	1,764	0.39	122	5.08	1.90
Jordanians	55,000	288	3,117	1.89	179	20.72	0.60
Israelis	40,000	200	2,995	2.50	112	18.67	1.68
Syrians	63,000	750	1,870	1.48	160	10.67	0.42
Israelis	40,000	300	756	0.95	86	14.33	2.40

It should be noted that some Israelis who fought against the Egyptians and Jordanians also fought against the Syrians. Thus, the overall Arab numerical superiority was greater than would be suggested by adding the above strength figures, and was approximately 328,000 to 200,000.

It should also be noted that the technological sophistication of the Israeli and Arab ground forces was comparable. The only significant technological advantage of the Israelis was their unchallenged command of the air. (In terms of battle outcomes, it was irrelevant how they had achieved air superiority.) In fact this was a very significant advantage, the full import of which would not be realized until the next Arab–Israeli war.

The results of the Six Day War do not provide an unequivocal basis for determining the relative importance of human factors and technological superiority (as evidenced in the air). Clearly a major factor in the Israeli victories was the superior performance of their ground forces due mainly to human factors. At least as important in those victories was Israeli command of the air, in which both technology and human factors both played a part.

The October War, 1973

A better basis for comparing the relative importance of human factors and technology is provided by the results of the October War of 1973 (known to Arabs as the War of Ramadan, and to Israelis as the Yom Kippur War). In this war the Israeli unquestioned superiority in the air was largely offset by the Arabs possession of highly sophisticated Soviet air defense weapons.

One important lesson of this war was a reassessment of Israeli contempt for the fighting quality of Arab ground forces (which had stemmed from the ease with which they had won their ground victories in 1967). When Arab ground

troops were protected from Israeli air superiority by their air defense weapons, they fought well and bravely, demonstrating that Israeli control of the air had been even more significant in 1967 than anyone had then recognized.

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Egyptians	300,000	2,200	26,000	0.43	1,100	2.50	0.50
Israelis	150,000	1,200	8,500	0.28	560	2.33	2.00
Syrians, etc.	165,000	1,800	10,500	0.32	1,450	4.03	0.40
Israelis	70,000	600	3,650	0.26	290	2.42	2.50
Jordanians	12,000	400	80	0.33	50	6.25	0.56
Israelis	7,000	300	50	0.36	20	3.33	1.80
Iraqis	40,000	600	840	1.05	200	16.67	0.29
Israelis	15,000	400	200	0.67	30	3.75	3.40

It should be noted that the total Arab (and Israeli) forces are those shown in the first two comparisons, above. A Jordanian brigade and two Iraqi divisions formed relatively minor elements of the forces under Syrian command (although their presence on the ground was significant in enabling the Syrians to maintain a defensive line when the Israelis threatened a breakthrough around 20 October). For the comparison of Jordanians and Iraqis the total strength is the total of the forces in the battles (two each) on which these comparisons are based.

One other thing to note is how the Israelis, possibly unconsciously, confirmed that validity of their CEVs with respect to Egyptians and Syrians by the numerical strengths of their deployments to the two fronts. Since the war ended up in a virtual stalemate on both fronts, the overall strength figures suggest rough equivalence of combat capability.

The CEV values shown in the above table are very significant in relation to the debate about human factors and technology. There was little if anything to choose between the technological sophistication of the two sides. The Arabs had more tanks than the Israelis, but (as Israeli General Avraham Adan once told the author) there was little difference in the quality of the tanks. The Israelis again had command of the air, but this was neutralized immediately over the battlefields by the Soviet air defense equipment effectively manned by the Arabs. Thus, while technology was of the utmost importance to both sides, enabling each side to prevent the enemy from gaining a significant advantage, the true determinant of battlefield outcomes was the fighting quality of the troops. And, while the Arabs fought bravely, the Israelis fought much more effectively. Human factors made the difference.

Israeli Invasion of Lebanon, 1982

In terms of the debate about the relative importance of human factors and technology, there are two significant aspects to this small war, in which Syrians forces and PLO guerrillas were the Arab participants. In the first place, the Israelis showed that their air technology was superior to the Syrian air defense technology. As a result, they regained complete control of the skies over the battlefields. Secondly, it provides an opportunity to include a highly relevant quotation.

The statistical comparison shows the results of the two

major battles fought between Syrians and Israelis:

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Syrians	30,000	600	4,150	4.61	400	22.22	0.36
Israelis	35,000	800	1,082	1.03	30	1.25	2.75

In assessing the above statistics, a quotation from the Israeli Chief of Staff, General Rafael Eytan, is relevant.

In late 1982 a group of retired American generals visited Israel and the battlefields in Lebanon. Just before they left for home, they had a meeting with General Eytan. One of the American generals asked Eytan the following question:

“Since the Syrians were equipped with Soviet weapons, and your troops were equipped with American (or American-type) weapons, isn’t the overwhelming Israeli victory an indication of the superiority of American weapons technology over Soviet weapons technology?”

Eytan’s reply was classic:

“If we had had their weapons, and they had had ours, the result would have been absolutely the same.”

One need not question how the Israeli Chief of Staff assessed the relative importance of the technology and human factors.

Falkland Islands War, 1982

It is difficult to get reliable data on the Falkland Islands War of 1982. Furthermore, the author of this article had not undertaken the kind of detailed analysis of such data as is available. However, it is evident from the information that is available about that war that its results were consistent with those of the other examples examined in this article.

The total strength of Argentine forces in the Falklands at the time of the British counter-invasion was slightly more than 13,000. The British appear to have landed close to 6,400 troops, although it may have been fewer. In any event, it is evident that not more than 50% of the total forces available to both sides were actually committed to battle. The Argentine surrender came 27 days after the British landings, but there were probably no more than six days of actual combat. During these battles the British performed admirably, the Argentines performed miserably. (Save for their Air Force, which seems to have fought with considerable gallantry and effectiveness, at the extreme limit of its range.) The British CEV in ground combat was probably between 2.5 and 4.0. The statistics were at least close to those presented below:

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Argentines	6,500	0	1,116	2.86	0	0.00	0.36
British	3,200	0	599	3.12	0	0.00	2.80

It is evident from published sources that the British had no technological advantage over the Argentines; thus the one-sided results of the ground battles were due entirely to British skill (derived from training and doctrine) and determination.

South African Operations in Angola, 1987–1988

Neither the political reasons for, nor political results of, the South African military interventions in Angola in the 1970s, and again in the late 1980s, need concern us in our consideration of the relative significance of technology and of human factors. The combat results of those interventions, particularly in 1987–1988 are, however, very relevant.

The operations between elements of the South African Defense Force (SADF) and forces of the Popular Movement for the Liberation of Angola (FAPLA) took place in southeast Angola, generally in the region east of the city of Cuito–Cuanavale. Operating with the SADF units were a few small units of Jonas Savimbi’s National Union for the Total Independence of Angola (UNITA). To provide air support to the SADF and UNITA ground forces, it would have been necessary for the South Africans to establish air bases either in Botswana, Southwest Africa (Namibia), or in Angola itself. For reasons that were largely political, they decided not to do that, and thus operated under conditions of FAPLA air supremacy. This led them, despite terrain generally unsuited for armored warfare, to use a high proportion of armored vehicles (mostly light armored cars) to provide their ground troops with some protection from air attack.

Summarized below are the results of three battles east of Cuito–Cuanavale in late 1987 and early 1988. Included with FAPLA forces are a few Cubans (mostly in armored units); included with the SADF forces are a few UNITA units (all infantry).

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Battle of Lomba							
FAPLA	2,264	28	120	5.30	6	21.43	0.17
SADF	1,199	38	9	0.75	1	2.63	5.95
Battle of Cuatir							
FAPLA	2,329	33	150	6.44	10	30.30	0.17
SADF	2,706	104	23	0.85	1	0.96	5.88
Battle of Lipanda							
FAPLA	2,263	23	200	8.84	7	30.43	0.16
SADF	1,213	41	2	0.16	0	0.00	6.23

FAPLA had complete command of air, and substantial numbers of MiG–21 and MiG–23 sorties were flown against the South Africans in all of these battles. This technological superiority was probably partly offset by greater South African EW (electronic warfare) capability. The ability of the South Africans to operate effectively despite hostile air superiority was reminiscent of that of the Germans in World War II. It was a further demonstration that, no matter how important technology may be, the fighting quality of the troops is even more important.

The tank figures include armored cars. In the first of the three battles considered, FAPLA had by far the more powerful and more numerous medium tanks (20 to 0). In the other two, SADF had a slight or significant advantage in medium tank numbers and quality. But it didn’t seem to make much difference in the outcomes.

Kuwait War, 1991

The previous seven examples permit us to examine the results of Kuwait (or Second Gulf) War with more objectivity

than might otherwise have possible.

First, let's look at the statistics. Note that the comparison shown below is for four days of ground combat, February 24–28, and shows only operations of US forces against the Iraqis.

Forces	Strengths		Losses				CEV
	Troops	Tanks	Troops	%/Day	Tanks	%/Day	
Iraqi Forces	350,000	3,500	50,000*	2.86	2,000	14.29	0.27
UN Forces	300,000	3,000	965	0.08	5	0.05	3.70

* Ground combat killed, wounded, and captured in combat (estimate)

There can be no question that the single most important contribution to the overwhelming victory of US and other UN forces was the air war that preceded, and accompanied, the ground operations. But two comments are in order. The air war alone could not have forced the Iraqis to surrender. On the other hand, it is evident that, even without the air war, US forces would have readily overwhelmed the Iraqis, probably in more than four days, and with more than 285 casualties. But the outcome would have been hardly less one-sided.

The Vietnam War, 1965-1973

It is impossible to make the kind of mathematical analysis for the Vietnam War as has been done in the examples considered above. The reason is that we don't have any good data on the Vietcong–North Vietnamese forces.

However, such quantitative analysis really isn't necessary. There can be no doubt that one of the opponents was a superpower, the most technologically advanced nation on earth, while the other side was what Lyndon Johnson called a “raggedy–ass little nation,” a typical representative of “the third world.”

Furthermore, even if we were able to make the analyses, they would very possibly be misinterpreted. It can be argued (possibly with some exaggeration) that the Americans won all of the battles. The detailed engagement analyses could only confirm this fact. Yet it is unquestionable that the United

States, despite airpower and all other manifestations of technological superiority, lost the war. The human factor—as represented by the quality of American political (and to a lesser extent military) leadership on the one side, and the determination of the North Vietnamese on the other side—was responsible for this defeat.

Conclusion

In a recent article in the *Armed Forces Journal International* Col. Philip S. Neilinger, USAF, wrote: “Military operations are extremely difficult, if not impossible, for the side that doesn't control the sky.” From what we have seen, this is only partly true. And while there can be no question that operations will always be difficult to some extent for the side that doesn't control the sky, the degree of difficulty depends to a great degree upon the training and determination of the troops.

What we have seen above also enables us to view with a better perspective Colonel Neilinger's subsequent quote from British Field Marshal Montgomery: “If we lose the war in the air, we lose the war and we lose it quickly.” That statement was true for Montgomery, and for the Allied troops in World War II. But it was emphatically *not* true for the Germans.

The examples we have seen from relatively recent wars, therefore, enable us to establish priorities on assuring readiness for war. It is without question important for us to equip our troops with weapons and other materiel which can match, or come close to matching, the technological quality of the opposition's materiel. We must realize that we cannot—as some people seem to think—buy good forces, by technology alone. Even more important is to assure the fighting quality of the troops. That must be, by far, our first priority in peacetime budgets and in peacetime military activities of all sorts. 🌐

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by Susan Rich

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A Brief History of Trevor N. Dupuy's Organizations

by Christopher A. Lawrence



Trevor N. Dupuy was a career military officer and West Point graduate who had served a full 20 year career in the military and retired in 1958 as a full colonel. While serving as an active duty officer, Col. Dupuy authored/co-authored three books. His father had developed a reputation as an historian already, having eight books to his credit. They had both had extensive senior staff assignments in the US Army and had both developed strong professional reputations. Col. Dupuy then taught at University of Rangoon in Burma from 1958 to 1960. His desk from the University came back with him and became his desk for the rest of his life. This solidly built but somewhat worn desk is now used by General Krawciw as he continues Trevor Dupuy's work.

It was after he returned from Rangoon (and perhaps even towards the end of his tenure there) that Col. Dupuy started his prolific publication of books, adding four more books to his total (two of them with his father). His works at this time consisted mostly of general military and battle histories.

In 1962 he was contracted by Franklin Watts Publishing to prepare a general 18-volume history of World War II for younger readers. This eventually lead to two series of books on World Wars I and II and one on *Military Lives* that totaled some 42 books. These books were not scholarly works, but there were certainly influential. For example, when I was 12, I read the entire World War II series, unaware that this interest in history would grow to an obsession and later a profession. It is unfortunate, considering the almost complete dearth of military history for young people, that all of these series are currently out of print.

In 1962 Col. Dupuy went into business for himself, establishing the Historical Evaluation Research Organization (HERO). Its office was in the Georgetown area of Washington, D.C. This company conducted research for the US armed forces and produced military history books. It appears, in fact, from a review of the work the company performed that a significant part of the corporation's function was to write books, leading to a very prolific period from 1962 to 1970 where Trevor Dupuy wrote over 50 books on general military history. At this time, some of his books were being co-authored with his father, R. Ernest Dupuy. It was Trevor's claim that they shared their work by having Trevor do the research while his father did the writing.

It was clear that book writing was intended to be a major source of income for, and product of, HERO, but it was also clear from the beginning that Trevor was looking to make HERO an historically-based RAND. The first HERO report was *A Preliminary, Interpretive Survey of the History of Command and Control* for Sandia Laboratories. This report listed four staff members, including Charles B. MacDonald,

and 11 other consultants, advisors, and assistants, including Martin Blumenson. R. Ernest Dupuy edited the report.

The organization quickly moved into arms control issues, guerrilla warfare, effects of nuclear war, and a whole range of current relevant discussions. The second HERO report lists the company's board of directors as R. Ernest Dupuy, Trevor N. Dupuy, H. Struve Hensel, Charles T. Lanham, Jr., Louis Morton, Forrest Pogue, Theodore Ropp, and James Russell. It lists the chairman of the board as Louis Morton, the President and Executive Director as Trevor N. Dupuy, and Secretary

and Treasurer as Jean D. Brennan. It also mentions an "Associate Staff" of 52 members, including Charles MacDonald and Martin Blumenson, and a "professional permanent staff" of 12 people, including Trevor Dupuy, R. Ernest Dupuy, and two ladies who would be the backbone of HERO for the next two decades: Grace P. Hayes and Gay M. Hammerman. Grace Hayes already had two books on naval history to her credit. Also listed is Mary R. Mayo, who would remain a HERO research assistant until sometime in 1966. This mix of two experienced female military historians (Hayes and Hammerman) and a number of different retired military officers would serve as the backbone of HERO until the 1980s.

Early on came the first of a series of reports that started the analytical trend that later defined the organization, which was the four-volume report *Historical Trends Related to Weapons Lethality* prepared for the Combat Developments Command. The Combat Developments Command was one of the seed organizations for the US Army Concepts Analysis Agency (CAA). The report listed 29 study participants, including S.L.A. Marshall and Chester G. Starr. It appears that most were consultants, with the only people clearly listed as staff members being Trevor N. Dupuy, Grace Hayes, and



Trevor N. Dupuy (standing) and his father, R. Ernest Dupuy, watching US Army field exercises in Germany in 1960 while gathering information for one of their books.

Gay Hammerman. This work, published in October 1964, first used “Theoretical Lethality Indices” and was in essence the detailed analysis of weapons lethality over time that was used as the basis for the book *Evolution of Weapons and Warfare*.

In 1965, HERO produced a report on *US Alternatives in Vietnam*. Withdrawal was not one of them. It was based on a conference organized by HERO, and attendees included Henry Cabot Lodge, Robert L. Utley, and Dr. Daniel Ellsberg (later of Pentagon Papers fame). The HERO staff was listed in the back as six people, with Trevor N. Dupuy as Executive Director and Mr. Murray Dyer as Deputy Executive Director. This is the only report that mentions his name.

In 1965 and 1967, among a number of reports, Angus M. Fraser, Col, USMC, Ret. is listed as HERO Coordinator of Military Studies. There appear to have been a steady five or six staff members and a number of consultants in each study. S.L.A. Marshall is regularly used as a consultant, as was R. Ernest Dupuy. In 1966 there was a report on *Historical Analysis of Wartime Replacement Requirements: Experience for Selected Major Items of Combat Equipment* prepared for Research Analysis Corporation (RAC) that first extensively used primary source material gathered from the unit records in the National Archives. It also established the equipment loss rates relative to casualties rates for different postures. In 1967, HERO published under contract with RAC *Average Casualty Rate for War Games, Based On Historical Combat Data*. It was during this study that Grace P. Hayes replaced Col. Fraser as coordinator. Col. Fraser would still occasionally feature as a consultant in later reports. Mrs. Hayes continued in this role throughout her career with HERO, until she retired. At the same time HERO produced another report for RAC called *Developing a Methodology to Describe the Relationship of Mobility to Combat Effectiveness*. This report effectively worked out the difference between actual lethality and theoretical lethality, including dispersion. The elements that make up the QJM/TNDM were slowly being assembled: Dupuy and his associates had established TLIs, casualty rates, equipment losses based upon posture, dispersion, and detailed primary source research.

Sometime around 1970, the HERO office moved to Dunn Loring Virginia, where it remained until the 1980s. It was also around this time (actually 1967) that Trevor N. Dupuy and Associates (TNDA) was created as the corporate shell for HERO. It remained the corporate shell for HERO until it sold its stock and assets to Data Memory Systems, Incorporated, in 1983.

The QJM clearly had come into being by 1970, and is detailed in the HERO report *Use of Historical Data in Evaluating Military Effectiveness*. This report also marked the beginning of the process of researching and detailing the battles that served as the basis for validation of his models. Joining him in these efforts were Miss Lucille Petterson, and occasionally Dr. Robert McQuie, Col. Harold Quakenbush, USA retired, Dr. Janice Fain and her husband, Dr. Andrew Fain, among others. This report detailed 42 engagements, including 34 from the Italian Campaign and 8 from Okinawa.

These engagements were analyzed using the Quantified Judgement Method, or QJM. The QJM consisted of 13 equations measuring Combat Power, Force Potential, Force Strength, Mobility, Vulnerability, Exposure, Combat Power, Momentum, Combat Power (Expanded), Force Strength (expanded), Casualty Effectiveness, Spatial Effectiveness, and Result. OLIs had been developed and were being used. Twenty-eight factors were used for each engagement, including a factor for supply status, morale, leadership, and training and experience. These were usually rated at 1.0. The basic formulae for the TLI and the dispersion factors for OLIs existed. Tables for posture, morale, terrain, weather, season, and air superiority all existed in pretty much the form that was later published in *Numbers, Predictions and War*. At the end of the document is an appendix that evaluates the source of the quantitative data. In most cases the factors were based upon “professional judgement,” something that has often not been fully understood about the model, and has been a source of controversy. It is also an area where I feel the model could be improved, if properly budgeted and researched. I suspect that the report’s fourth volume, *Statistical Inference in Analysis of Combat*, was prepared by Robert McQuie. This was an attempt to provide some form of statistical analysis of the data used in the model. By this time, Trevor’s father had truly retired to do writing, and Grace Hayes had become his “right hand man.”

In 1971 and 1972, a series of large studies were funded primarily by the US Air Force but also by the United Kingdom on individual battles and on the effects of the air campaign as related to ground combat in WWII. This was sort of the end of the “general history writing phase” of HERO. This can be seen by the change in publishing that resulted in an end to general readership books like the *Military Lives* series and the publication instead of the *World Almanac of Military Power* every two years and the production of such periodicals as the *Combat Data Subscription Service*.

During this period HERO supported an analytical staff of at least a half dozen people, with the core consisting of Grace Hayes, Gay Hammerman, Paul Martell, and Col. John A. Andrews, USAF, Ret. Paul Martell provided the institute with its “sovietology” expert, as Mr. Martell, which was a pseudonym, was a Polish intelligence officer who had defected to the US.

This was also the period during which HERO began analysis of the Middle East wars. After the Yom Kippur War, Trevor N. Dupuy began to travel extensively in the Mideast and established strong personal contacts with many senior Israeli and Egyptian generals, and with some Syrian and Jordanian generals as well. Having developed the QJM from the extensive WWII data at the beginning of the decade, he then similarly tested the QJM to the 1967 and 1973 Arab-Israeli Wars, and clearly established the model was indeed applicable for modern combat (at least through 1973).

This was also the period during which Trevor N. Dupuy became widely introduced to the US Army analytical community. While most of his work was initially funded by the Air Force, its focus on ground combat made it mostly appli-

cable to the US Army. Trevor's attempts to get the QJM accepted by the Army's military operations research community met with limited success, although he received considerable support from the active duty military. Many professional military were embarrassed by the "unusual" and ahistorical results provided by many of the early combat models.

It was also in the early 1970s that many of the professional contacts were made that would later influence the work and direction of Trevor's companies in the 1980s and 1990s. These contacts included Col. John Brinkerhoff at CAA, who later would become co-founder and vice president of DMSI; Col. Nicholas Krawciw with the UN observer force in the Middle East, who would later become President of The Dupuy Institute; and Col. William A. Lawrence at CAA, who was already my father.

The study of the effects of air interdiction dominated HERO's activities from 1970 through 1972. This work allowed the development of the staff and the research capability to conduct a series of analyses of the basic problems of measuring combat. From 1973 through 1979, HERO published studies on ammunition expenditure, effects of barriers, effects of surprise in combat, studies of breakthrough operations, artillery effectiveness, Soviet combat performance, effects of smoke and dust on combat, effects of fatigue and losses, and effects of fortifications. These studies were all excellent "first steps" in the study of the problems of modeling land combat. Unfortunately, however, the pattern that would persist throughout the organization's history was developing. There was never a second step. The historians (and some OR people) would gather the data, do some preliminary analysis, and present the reports. The analytical community would then use it for further analysis and their own purposes, but HERO was not allowed to continue its analysis and work so that a more definitive and useful study could be made. All HERO reports tended to be "incomplete" because the commitment to long-term research, which is required to obtain a result, was not made by the contracting offices. As a result, a series of excellent in-depth studies were done for a wide range of customers, but no continuous research effort was underway that would produce a definitive and conclusive result. In my opinion, this lack of steady work and the "task" funded nature of the work was a major limitation to HERO's effort, and eviscerated many promising lines of research. Much greater material results could have been obtained from this historical research had there been a more far-seeing policy on the part of many DOD agencies.

During the early 1970s, Trevor Dupuy began publishing the results of his QJM work with the books *Numbers, Predictions, and War* and *Evolution of Weapons and Warfare*. The publication of *Numbers, Predictions and War* resulted in the "paper and pencil" version of the QJM being effectively public domain. His Middle East work produced the excellent *Elusive Victory* and later *Flawed Victory*. At this point, HERO was no longer a book writing and analytical house, but was now a historical analysis house that was publishing books culled from its analyses. This trend would con-

tinue until the establishment of The Dupuy Institute. Of course, HERO also produced a number of significant non-analytical historical works, including the massive *Encyclopedia of Military History*, but this type of work was clearly no longer the company's major thrust.

Unfortunately, in many people's minds, all of HERO's work was associated with the QJM. Even though from the early 1970s and on it does not appear that the QJM and QJM analysis ever made up over 25% of the organization's work, and often was much less than that, HERO, Trevor and the QJM became inseparable in the popular perception. This appears to have led many people to ignore the otherwise valuable research and analysis being performed, simply because they didn't like the model. They forget that the rest of the company's work was research and analysis not related to the combat model.

In the late 1970s, HERO added two staff members that would have a significant impact on the organization. These were Col. John Sloan, a sovietologist who was Vice President of TNDA from 1976 to 1979, and C. Curtiss Johnson, who was already an established author. Also in this period, a number of other historians worked for the organization, including Edward Oppenheimer and Richard G. Sheridan. By the early 1980s the HERO organization had an experienced and reputable staff, a considerable body of work, and an established reputation. In the early 1980s two more junior researchers were added to the staff who would play a role in the future of the organization. These were Arnold Dupuy, one of Trevor's nine children, and Brian Bader. In 1983 Grace Hayes retired and Curt Johnson became the Executive Director of Research. The organization was a mature established research and analytical house with around a dozen employees.

But HERO had reached its limit as a business. It had a uneven but steady flow of work coming in but was clearly not going to become any larger or more influential without some shift in direction. As a result of the QJM being rejected by the analytical community, the level of work in the organization declined in the early eighties, but it still maintained its core staff and capabilities.

In 1983 Col. John Brinkerhoff, now retired after a stint as the Deputy Assistant Secretary of Defense for Reserve Affairs, decided that HERO would serve as an ideal base to build up a large analytical house like Booz-Allen or BDM. This meant that the organization would have to expand beyond its historical work and go into a wide range of analytical and operations research work. It was also intended to expand the organization into more commercial work, including computerized wargames. Col. Brinkerhoff supported this vision with a major injection of funding from his own pocket and created a new corporate over-body called Data Memory Systems, Inc. (DMSI). Trevor N. Dupuy was President of DMSI with Col. John Brinkerhoff as Vice-President. HERO was maintained as a division within the organization, with Curt Johnson as the head. This led to a very dramatic, dynamic, and expansionist phase than eventually would lead to the overextension and demise of the organization. At this

point, the corporate entity TNDA was retired. HERO Books, a private publishing company, was also created and infused with cash, with Guy Clifton as its head. It was a separate business from DMSI.

HERO/DMSI began to start assembling its data into databases, including the Land Warfare Database (LWDB) and the QJM database. These databases were originally “paper” databases, but eventually several of them were computerized. The QJM was computerized, the original programming work completed in BASIC by José Perez in 1985. It was actually the BASIC programming code that was copyrighted, as the model was public domain. A Database Division was established under Col. Peter Clark, USAF, Ret. in 1984, and this division eventually became the Combat Analysis Division (CAD) which was responsible for running, maintaining, and using the QJM. The organization added a third division with the Professional Education Division (PED), leaving the organization staffed with HEROs, CADs and PED’ophiles.

Sadly, in 1985 Paul Martell died suddenly of a heart attack while on a trip. Before he died, he had co-authored two books with Trevor Dupuy—*Great Battles of the Eastern Front* and *Flawed Victory*—and had written on his experiences as a defector.

Much of the work of HERO and DMSI was never really completed due to the lack of follow-up work or steady funding from the government. So, for example, the Ardennes Campaign Simulation Database, the largest database of ground combat, was created by DMSI under contract from CAA, and then never further analyzed or explored by DMSI. No budget was provided to do so. It has been used for two other efforts—the model validation work of CAA, and an attempt by Dr. Jerome Bracken to find out whether Lanchester’s square law is visible. But the people who best knew and understood the data were never funded to do any further analysis with it.

At TDI, we have been using some of this untapped data for our analysis. For example, when we were tasked by the Joint Chiefs of Staff to provide an estimate of casualties for the Bosnia peacekeeping effort, we went back to an report called *Casualty Estimates for Contingency Operations*, again prepared under contract for CAA. Created in 1985, it was basically an unorganized paper database of incidents, skirmishes, battles, campaigns, and wars since 1945. As far as I know, it never really succeeded in answering any question that anyone was asking at the time, so this unstructured database was never used for any analytical purpose. But it turned out to be invaluable for starting the Modern Contingency Operations Database (MCOB) that was used to produce our historically-based estimate of US casualties in the Bosnia operation. We were able to create such a data base in ten days only because of the existence of this previous study. We also used some of the research to help develop our Battalion-Level Operations Database (BLODB). But as is typical with the nature of this effort, after completing our Bosnia estimate, no further budget was provided to develop and improve the database for future use. The Institute currently has a similar situation with the Kursk Database, which was

completed in March of this year. Again, no funding for any further analysis has been approved. TDI could easily spend a dozen man-years just “fleshing out” and analyzing the data that has been gathered over the last 35 years by HERO and its descendent organizations.

Unfortunately, this was the pattern throughout the history of HERO. Many of the studies produced were very good first steps, but the second step was never taken. In part, this appears because the analytical community wanted HERO to gather the data and they would provide the analysis. Operations researchers didn’t want to soil their hands researching operations. Apparently no one trusted the historians to think, or perhaps the fear was that they would produce the wrong answer. This unwillingness to listen to the students of history resulted in the DOD modeling community heading down a path over the last 40 years that has led to a complicated and expensive series of models that address only half the factors that make up combat, because they do not address human factors. Any combat model developed should start by addressing human factors. Unfortunately, Trevor N. Dupuy and HERO were never able to win this argument.

In 1986, the organization tried to expand even further afield with the addition of Andrew Wittner, also originally with CAA, as the VP of Business Development. It was also at this time that Trevor N. Dupuy published what I consider his most important work, *Understanding War*, which effectively encapsulated much of his work and knowledge developed over the last 25 years.

Unfortunately the organization had become a three-ring circus, with historical research, book writing, model development, and defense analysis work being done alongside various stock offerings, legal research services, international trade, commercial game design, magazine publications, and many other new business ideas, most which never generated any significant revenue. From 1986 through 1988 the staff expanded rapidly, with the noticeable additions being Vince Hawkins, Dave Bongard, myself (Chris Lawrence), Jay Karamales, and Richard Anderson. The largest project within HERO was the Ardennes Campaign Simulation Database, headed by me, and later by Brian Bader after my resignation. It was also at this time that the QJM was reprogrammed into Pascal, courtesy of one of our customers. This Pascal code was donated to DMSI.

By this time the cracks in the structure were quite visible. The organization had moved to large new offices in Fairfax, Virginia, and had built the staff up to over 20 employees. But it had acquired considerable debt to pay for the additional expansion and was vulnerable if there was a downturn in business.

Worse, the organization was at war with itself over its future and direction. It was being torn between the historians and the business development people. The historians were interested in conducting the core business of HERO, while the business development people were interested in rapid expansion into virtually any business area. The organizational structure had become top-heavy and confused, with a president and two vice presidents all heading in different direc-

tions, and the two divisions that actually did the work headed by managers who did not have the authority or clout of the VPs. The senior heads of the corporation had their pet projects, using staff and time, and these projects operated outside of the working divisions. This was all amplified by bitter management fights that took their toll. John Brinkerhoff left in early 1987, Andy Wittner left in early 1988, Chuck Hawkins came in as an investor and vice president, while Curt Johnson and Pete Clark moved up to fill the vice president slots. In 1988, the business of HERO/DMSI had peaked. Its best “year” was the second half of 1987 and first half 1988, when its revenue peaked above a million dollars.

The organization reached its peak size in 1988, when it had 25 full-time, part-time, and temporary employees, of which around 15 were full-time. Most of the people associated with this newsletter and with TDI were employed by DMSI during this time (Dave Bongard, Richard Anderson, Jay Karamales, José Perez, Curt Johnson and myself).

This period of growth was followed by a rapid period of decline, with a dizzying array of stock buy-outs, changes of management, and arguments on how the downsizing should occur. The marketing effort was diluted and work took second place to the management activities. The receipts began to decline. Of course the debt was still there, creating a major financial problem for the corporation. At this point the research staff started leaving, with Curt Johnson being the first out the door in late 1988. I was next in early 1989, followed by Jay Karamales, Richard Anderson, and others. In 1989 Col. Ken Moll, US Army, Ret. joined the corporation as the senior vice president, but he was unable to halt the decline. In 1990, Trevor Dupuy quit his own corporation in a management dispute with Col. Moll and Chuck Hawkins. Much of the remaining staff followed Trevor out the door to his new organization. Brain Bader remained, holding the dubious distinction of being the last Director of HERO.

At this point, Trevor N. Dupuy reactivated TNDA and went back into business. He quickly rebuilt the core business of HERO, bringing on Curt Johnson, Richard Anderson, Dave Bongard, Jay Karamales, Arnold Dupuy, and Guy Clifton. The stock in HERO books was traded for stock in DMSI so that HERO books went with Trevor to TNDA and Col. Dupuy no longer held stock in the organizations he had founded, HERO/DMSI. He also oversaw a major revision to the QJM. Dr. James Taylor of the Naval Post-Graduate School had been contracted by the Jet Propulsion Laboratory to do some work on applying differential Lanchester equations, using the QJM as a workhorse. This work was integrated with the old QJM formulae, programmed by José Perez in Pascal, and modified with additional work by Trevor and Chip Sayers.

But the disputes with DMSI continued, with arguments over “non-competition” agreements and ownership of property. DMSI filed two legal suits against TNDA. One of the suits even listed Trevor’s desk from Burma as a corporate asset taken from DMSI. Still, TNDA briefly flourished, producing the *Attrition Handbook* and the accurate predictions of the Gulf War published in *If War Comes* along with several other books. At this point Trevor was heading back to

his basic concept of using the organization to publish books along with doing DOD analytical work. This might even have succeeded had the Gulf War lasted longer. Some 500,000 paperback copies of *If War Comes* had been printed and the book climbed onto the *New York Times* best seller list just as the war ended. This period from mid-1990 to mid-1992 saw the production of five books, including the six volume *International Military and Defense Encyclopedia*.

By then, however, the Berlin Wall had fallen and the US defense industry was undergoing budget cuts, with studies and analysis taking the first hits. There were now two historical analysis organizations competing for a shrinking slice of the pie, and busily engaged in a legal dispute with each other. Too late the two organizations settled their differences out of court, but declining revenues, the accumulated debts, the costs of the legal fight, and the distractions caused by these disputes rendered both organizations no longer viable. They both closed their doors, with TNDA filing bankruptcy in 1992 and DMSI effectively shutting down that same year and filing bankruptcy in 1994, after they had sold off their remaining assets. From these ashes, Trevor started The Dupuy Institute in 1992 as a non-profit 501(c)(3) organization. It was literally operating out of his basement, and again started work on book contracts. Col. George Daoust was the executive director of TDI and Dave Bongard was its one employee. The advent of the Kursk Database contract in mid-1993, put together with the help of John Sloan, allowed me to come back to work for Col. Dupuy, increase our staff, and leave the basement. In 1993 HERO Books was reconstituted by Trevor’s son, Arnold Dupuy, as an independent for-profit venture. He currently operates it as a part-time business under the name NOVA Publications. In 1994 *Hitler’s Last Gamble* was published. It is the only book prepared by TDI and was Trevor’s last published book, co-authored by Richard Anderson and Dave Bongard. It was developed from the data gathered during the Ardennes project at DMSI.

In January 1995, aware of his declining health, Col. Dupuy brought in Major General Nicholas Krawciw, US Army, Ret., to take over as head of the institute. Trevor N. Dupuy died on 5 June 1995, and General Krawciw took over as President of the Institute. In the middle of 1996, we adopted our current management structure with myself as Executive Director and George Daoust as Chairman of the Board of Directors.

One of goals of HERO/TNDA/DMSI/TDI has been to learn lessons from history. There are many such lessons to be learned. There is obviously still a need, even if unrecognized, for an historical/analytical organization. Such an organization cannot exist off of book revenues. It must be funded by contractual defense work in order to survive with adequate and competent staff. The organization is stronger, and the caliber of the staff higher, if there is some continuous level of support over the years.

As I see it, the Dupuy organizations went through six stages of their existence. They are:

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| 1962—1970 | A book-writing and historical analysis organization |
| 1970—1983 | An historical/analytical organization that also wrote books (a RAND-like think tank) |
| 1983—1988 | An expanding “beltway bandit” based on a RAND-like think tank. |
| 1989—1990 | Collapse |
| 1990—1992 | An attempt to re-establish the original HERO based upon book writing. |
| 1992—present | An historical/analytical organization (a RAND-like think tank). |

TDI continues to operate with original HERO staff including Curt Johnson, Dave Bongard, Jay Karamales, Richard Anderson, José Perez, and myself. We have all been associated with Trevor’s companies and work for over a decade. Trevor left an organization that contained the corporate knowledge and the ideals for quality historical research that he had envisioned when he established HERO 35 years ago. TDI is the successor organization to HERO. 🌐



From first to last: Trevor N. Dupuy talks to Brian Bader, last director of HERO, on 4 June 1995.

List of HERO, DMSI, TNDA, and TDI Reports



by Susan Rich

I. HERO/DMSI REPORTS 1962 - 1990

1. A Preliminary, Interpretive Survey of the History of Command and Control (2 Volumes) (1963) (Sandia)
2. History and Urban Education: A Five-City Survey Plan, 1964-1965 (Encyclopedia Britannica) (1964)
3. Responses to Violations of Arms Control and Disarmament Agreements (Vols I-IV Unclassified; Vol V, Top Secret Appendix) (1964) (ACDA)
4. Historical Trends Related to Weapons Lethality (4 Volumes) (1964) (AVTAC of CDC)
5. Holidays: Days of Significance for All Americans (1964) (F.Watts)
6. Origins, History, and Accomplishments of the U.S. Army Reserve (1965) (Chief of Army Reserve)
7. US Alternatives in Vietnam (1965) (Conf. at IDCAF)
8. Military, Political & Psychological Implications of Massive Population Casualties in History (4 Volumes) (1965) (CDC)
9. Survey & Analysis of Implications of Current Chinese Communist Strategic Thinking (1965) (SRI)
10. Politico-Military Affairs Since World War I; The Historical Setting for Current & Future Strategy (1965) (SRI)
11. An Evaluation of Trends in Roles & Missions of the US Armed Services (1965) (Douglas)
- 11.1 A Quarterly Compilation of Legislative Abstracts on National Defense, Vol.0, No.0 (1965)
12. Isolating the Guerrilla (Vol. I, Confidential; Vols II-III, Limited Distribution) (1965) (ARO)
13. Development of a Public Information Program on Temporarily Incapacitating Chemical and Biological Agents (Confidential) (1966) (US Army)
14. Historical Analysis of Wartime Replacement Requirements: Experience for Selected Major Items of Combat Equipment (2 Volumes) (1966) (RAC)
15. National Strategic Concepts and the Changing Nature of Modern War (3 Volumes) (1966) (USAF)
16. Average Casualty Rates for Wargames, Based on Historical Combat Data (3 Volumes) (1967) (RAC)
17. Developing a Methodology to Describe the Relationship of Mobility to Effectiveness (2 Volumes) (1967) (RAC)
18. Military History of World War I (1967) (Franklin Watts)
19. The Reserve Story (1967) (Army Times Publishing Co.)
20. Comparative Analysis of Armored Conflict Experience (3 Volumes) (Secret) (1967) (PA&E)
21. The Nature of Military Power and its Application in the Future (2 volumes) (1967) (US Army)
22. A Study to Develop a Research Program for the Design & Development of Modern College Libraries (1968) (OE)
23. Report to Chairman on Conference of Smithsonian Institution Armed Forces Museum and Study Center Advisory Board (Belmont Report) (1967) (Smithsonian)
24. Historical Data on Tactical Air Operations: The Volturno Campaign, 13 Oct.-15 Nov. 1943 (3 volumes) (1969) (AFS&A)
25. German Evaluation of Allied Air Interdiction in World War II (1969) (AFS&A)
26. Target/Range Experience for Tank & Antitank Weapons (1969) (Batelle)
27. Historical Data on Tactical Air Operations: The Rome Campaign, 11 May-17 June 1944 (1970) (AFS&A)
28. Historical Data on Tactical Air Operations: Disruption in Combat (1970) (AFS&A)
29. Foreign Area Studies Handbook: Mongolia (1970) (AU)
30. American Revolutionary Bicentennial Commission: A Calendar of Events; American Revolution Commemorative List (1970) (ABC)
31. Historical Data on Tactical Air Operations—Interdiction from Falaise to Westwall, 1944 (1970) (AFS&A)

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32. Use of Historical Data in Evaluating Military Effectiveness (4 volumes) (1970) (AFS&A)
- 33A. Allied Air Interdiction Against Axis Forces in Tunisia, Feb-May, 1943 (1971) (AFS&A)
- 33B. Allied Air Interdiction for Operation HUSKY (Sicily), May-Aug, 1943 (1971) (AFS&E)
- 33C. Allied Air Interdiction Against Axis Forces Pre-Invasion, Northwest Europe, 1 March - 5 June, 1944 (1971) (AFS&A)
- 33D. Allied Air Interdiction in Support of OVERLORD, 6 June - 25 Aug, 1944 (1971) (AFS&A)
- 33E. Allied Air Interdiction from Falaise to Westwall, 14 Aug - 14 Sept. 1944 (1971) (AFS&A)
34. A Study of the Relationship of Tactical Air Support Operations to Land Combat (3 volumes) (1971) (DOAE)
- 35A. Tactical Air Interdiction, World War II: France (1972) (AFS&A)
- 35A1. Annex to 35A
- 35B. Tactical Air Interdiction, World War II: Germany (1972) (AFS&A)
- 35C. Tactical Air Interdiction, World War II: Italy (1971) (AFS&A)
36. Opposed Rates of Advance of Large Forces in Europe (ORALFORE) (1972) (DCSOPS)
37. Familiarization Program - The Founders Project
38. Historical Bibliography of Warfare in the Middle East (1972) (Battelle)
39. A Reporting System for Allied Command Europe (ACE) (1972) (SHAPE)
40. Manual of Historical Data for Input to & Development of Air and Ground Combat Simulation Models (1973) (AFS&A)
41. Rates of Expenditure of Ammunition in Relation to Posture (1973) (SHAPE)
42. Feasibility Study for Net Assessment of Effectiveness of NATO-Warsaw Pact Forces by Means of QJM (Secret) (1973) (DIA)
43. A Selective Historical Evaluation of the Qualitative-Quantitative Effectiveness of the Employment of Unconventional Forces and/or Resources in Support of National Policy (1973) (Braddock, Dunn & McDonald)
44. Analysis of Operational Criteria & User Requirements of a Naval Air Reporting System (1974) (CNA)
45. Historical Evaluation of Barrier Effectiveness (1974) (CAA)
46. The Terrorist & Sabotage Threat to US Nuclear Programs (1974) (Sandia)
47. A Small Data Base of Tactical Airport in Historical Combat (1975) (PA&E)
48. German & Soviet Replacement Systems in World War II (1975) (OASDM&RA)
49. The October War in the Middle East (October, 1973) in Historical Perspective (1976) (NA)
50. Combat Data Subscription Service, (2 volumes) (1975) (A quarterly publication)
51. A Survey of Quick Wins in Modern War (1975) (NA)
52. A Study of Breakthrough Operations (1976) (DNA/Sandia)
53. The Quantified Judgement Model of Analysis of Historical Combat Data; A Monograph (1976)
54. Comparative Analysis of Arab and Israeli Combat Performance, 1967 & 1973 Wars (1976) (OASDI)
55. Artillery Survivability in Modern War (Secret) (1976) (Sandia)
- 55A. Artillery Fire and Effect, US Ninth Army, Roer River Crossing, Feb 1945 (1977) (DNA)
56. Assessment of Arab & Israeli Combat Effectiveness: 1973 War (1977) (CIA)
57. Studies on Soviet Combat Performance (1977) (NA)
58. Assessment of the Danger of Surprise Attack in Europe, and NATO Vulnerability to Surprise (1977) (AFSA)
59. Historical Scenarios of Soviet Breakthrough Efforts in World War II (1977) (AFSA)
60. Availability of Historical Data Concerning Soviet Air Defense Experience (1978) (Sandia)
61. Analysis of the Implications of Surprise in Scenarios of Conventional and Tactical Nuclear Combat in Europe

(Secret) (1978) (DNA)	Strategic Forces
62. Search for Historical Records of High Rate Artillery Fire in Combat Situations (2 volumes) (1978) (HEL)	79B. Nuclear Concepts: The Deterrence Concept
63. Effects of Smoke & Dust on Combat Performance (AMSAA)	79C. Nuclear Weapons Proliferation: Impact and Response
64. Target Positioning Assessment (1978) (Batelle)	79D. The Concept of Stability
65. Effects of Combat Losses & Fatigue on Operational Performance (1978) (TRADOC)	79E. The Concept of Nuclear Threshold
66. Observations on Defense Against the V-1 Missile (1978) (Sandia)	80. Relevance of Selected Non-Nuclear Experience to Possible Future Employment of Nuclear Weapons (1980) (DNA)
67. The German General Staff; Institution of Demonstrated Excellence for National Command, Planning, Coordination, and Combat Performance (1978) (Pres. Com. on Natl. Cmd. Str.)	81. Soldier Capability: Army Combat Effectiveness (SCACE); Historical Combat Data and Analysis (1980) (Battelle)
68. Historical Trends in Artillery Vulnerability (1979) (Sandia)	82. The Factors of Combat (1980) (DNA)
69. Navy Nuclear Test Personnel Review	83. US Home Defense Forces Study (1981) (MRA&L)
70. Development of Soviet Air Defense Doctrine & Practice (1979) (Sandia)	84. Static Comparison of Combat Capabilities of NATO & Warsaw Pact Forces at Division Level in the European Theater of Operations in the Early 1980s (Secret) (1981) (CIA)
71. The Value of Field Fortifications in Modern Warfare (1979) (DNA)	85. Potential Military Aggression Against Jordan (QJM Analysis) (1981) (Keyadah)
72. A Historical Analysis of the Effectiveness of Tactical Operations Against and in Support of Armored Forces (1980) (Sandia)	86. Analytical Survey of Personnel Replacement Systems in Modern War (1982) (TRANSDNS)
73. The Impact of Nuclear Weapons Employment on the Factors of Combat (1980) (Sandia)	87. Mobilization in the Korean Conflict (1982) (MRA&L)
74. German and Allied Army Reserves in 1914 (1980) (MRA&L)	88. Performance of The 88th Infantry Division in World War II (1981) (MRA&L)
75. The Preparedness Debate: 1914-1916 (1979) (MRA&L)	89. Conventional Attrition & Battle Termination Criteria (1981) (MRA&L)
76. Comments on "Plumbbob" and "Shot Smoky" (1980) (JRB)	90. A Study of War Termination (1982) (DNA)
77. The Soviet Threat in the Middle East: Perceptions in the Region (1980) (ISA)	91. Naval QJM Feasibility Study (1982) (DNA)
78. Potential Warsaw Pact Invasion of Switzerland; Quantified Judgment Analysis (1980) (SGSO)	92. Modern Artillery Experience in Combat (2 volumes) (1983) (FAS)
79. Analytic Research on Strategic, Tactical & Doctrinal Military Concepts (1980) (DNA)	93. Physical Damage & Casualties in Modern Battle (1982)
79A. Nuclear Concepts: The Concept of the Equivalence of	94. Historical Summary of the Electronic Content of Federal Defense Expenditures (1982) (Washinghouse)
	95. HERO Land Warfare Data Base (6 volumes) (1983) (CAA)
	96. Unknown

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97. Toward an Overview of Modern Chemical/Conventional Combat: A Conference Based on Historical Experience
98. Contributing to the Reliability of the Army War College Model (3 volumes & preliminary report) (1983) (AWC)
99. Historical Survey of Casualties in Different Size Units in Modern Combat (1982) (TRASANA)
100. The QJM Data Base (3 volumes) (1985)
101. Implications of the Present Knowledge and Past Experience for a Possible Future Chemical/Conventional Conflict (1985) (IDA)
102. Impact of the Introduction of Lethal Gas on Combat Performance of Defending Troops (2 volumes) (1985) (DNA)
103. JESS Data Base (3 volumes) (1984) (JPL)
104. Unknown
105. Human Impact of Technological Innovation on the Battlefield (1984) (USAMRDC)
106. Casualty Estimates for Contingencies (2 volumes) (1985) (CAA & DCSPERS)
107. Historical Analysis of Reserve Components, Tank Bns Equipment Problems for Korean War Mobilization (1985) (LMI)
108. Cold Weather Combat, Analogy to Chemical Combat (1985) (OASDR&E)
109. Methodology for Extending Emergency Command Requirements for a Situation D Emergency (1985) (CCC Ac GP)
110. Mission Accomplishment by Divisions & Their Component Maneuver Elements (1987) (JPL)
111. Combat History Analysis, History Study Efforts (5 volumes) (CHASE) (1986) (CAA)
112. Representing Battle Termination in Combat Simulations: The Modeling of "Defeat Criteria" (1987) (Sandia)
113. Understanding Soviet Armed Forces (1987)
- 113A. Understanding the Fundamentals of Air-Land Combat (1987)
114. Handbook on Ground Force Attrition (1986) (CIA)
115. History of OTEA
- 115A. History of OTEA
116. Test Measures Catalogue (1987) (OTEA)
- 116A. Summary Listing, Test Measures, Conditions and Resources List (1987) (OTEA)
117. Forced Changes of Combat Posture (1988) (CAA)
- 117B. New Engagement Data for the Breakpoints Data Base (1988) (CAA)
118. The Relationship Between Technology Trends and the Size & Composition of Military Forces (1987) (Sandia)
119. Combat Data Base Survey for MAPPS (1987) (Oak Ridge)
120. Ardennes Data Base (1990) (CAA)
- 120.1 Ardennes Campaign Simulation Data Base (ACSDDB) User's Guide (Dec. 1989) (CAA)
- 120.2 The Ardennes Campaign Simulation Data Base (ACSDDB) Final Report (Feb. 1990) (CAA)
121. Comparison of Differences of Relative Combat Effectiveness of National Forces in Offensive & Defensive Posture (1988) (DOAE)
122. Examination of Historical Air Defense Performance (1988) (Sandia)
123. Armed Forces of the United States: Fundamentals (1988)
124. The Quantified Judgement Model in Low Intensity Conflict Application (1988) (CIA)
- II. TND A REPORTS 1990 - 1992**
125. Current Military Trends in Historical Perspective (1990) (Boeing)
126. Report on Pre-war Forecasting (1991)
127. Unknown
128. Unknown
129. Testimony of Col. T.N. Dupuy, USA, Ret. Before the House Armed Services Committee (1990)
130. The Tactical Numerical Deterministic Model Manual of Rules and Procedures (Provisional) (1991)
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III. TDI REPORTS 1992 - Present

A-1. Road Map for Developing a Comprehensive Wargame Utilizing Historical Experience and Data (Jun. 1993) (AFSC)

A-2. Air Model Historical Data Study Phase I Report (Jan. 1995) (AFSC)

A-3. Air Model Historical Data Study (Statement of Work) (Aug. 1995) (AFSC)

A-4. Air Model Historical Data Study Final Report (4 volumes) (Sept. 1995) (AFSC)

B-1. Peacekeeping in Bosnia: Fatality Estimates (Preliminary and Final Reports (Nov. 1995) (JCS)

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The Quantified Judgment Model

(Boeing Version): A Background and Utility Summary



by H.W. Buettel

Boeing Information and Defense Systems

Greetings to all QJM/TNDM users. This article provides the background on some highly successful uses and modifications of QJM that have been undertaken by Boeing Defense & Space Group (D&SG) Strategic Analysis organization over the last few years. QJM was originally acquired by Boeing Aerospace Company in the mid-1980s from Data Memory Systems Inc. This of course was the Pascal code of version 3.1. The model was used a number of times in analytical studies, but was not prominent in the Boeing stable of constructive models of military operations.

Things changed in the early 1990s. The general downsizing of the US defense industry with the end of the Cold War affected Boeing D&SG as it did other military contractors. As the personnel strength of organizations shrank many modeling tools became inactive. The times were also changing in other ways. There was a growing emphasis on deductive rather than inductive warfighting analysis. Simply put, the military wanted to know the effects of new products or weapon systems on joint warfighting at theater or campaign levels rather than their benefits at a one on one or few on few level of resolution. The latter was the province of large, detailed computer based simulations such as CASTFOREM or MIL-AASPEM. The other was entirely new and called for simple, rapid turn around, aggregated modeling.

The first test of this new analytical environment came in the US Air Force Multi-Role Fighter Request for Information (RFI) in 1991. This analysis required the modeling of three theater level combat scenarios and the generation of data not only on the air campaign, but also its effects on the ground war. While Boeing D&SG could well analyze the air component using the OME III (Optimal-Marginal Evaluator III) air campaign simulation model, the ground war representation was problematic. It was here that QJM entered the arena.

It was suggested that QJM could be modified to accept one of OME III outputs (basically a sortie/kill schedule) as an expected value for high performance ground attack aircraft. However, for various reasons, the Pascal version of the model was unsuitable for this. The modification was accomplished by rehosting QJM in an automated LOTUS spreadsheet environment where all battle dynamics would be highly visible. Specialized output files were also devised. To make a long story short, literally hundreds of runs were made in a batch mode reading DOS files from OME III output into the spreadsheet and then fighting the ground war under normal QJM methodology. MRF Program office personnel indicated that the resulting data was far more timely, detailed, and in-

sightful than results obtained by many Boeing competitors in the RFI using other models and methodologies.

As Boeing D&SG reorganized in the early 1990s, QJM came into more prominence as an analytical tool. Fast paced and rapid analysis became a requirement under the shrinking defense budget as a means of advocacy for weapon systems and defense programs. There was literally no time to run "big" models. In 1992, Boeing D&SG initiated its Combined Arms Study project. This was a broad brush, high level analytical effort focused on theater joint warfighting requirements under radically new scenario conditions. QJM assumed a premier role in this effort and was soon joined by a Boeing developed fast turn model—the Major Regional Conflict Air Campaign Model (MRC). Using these two models in harness, over five hundred "runs" were made during 1993 alone in support of Boeing efforts to focus product line emphasis, provide alternative analyses associated with the Bottom Up Review, and support of internal and external customers. During this time further modifications and improvements to the model were made. Special accumulators were devised to track data of interest such as "killed by ground" vs "killed by air" statistics. Artillery-delivered "smart munitions" effects were added as were modifications as to how attack helicopters were "played."

During this period the MRC-QJM team was used to quickly evaluate a wide variety of scenarios and effects of new weapon systems. Among these were the Conventional Air Launched Cruise Missile (CALCM), Advanced Airborne Command and Control (A2C2), Joint Direct Attack Munition (JDAM), Advanced Short Takeoff Vertical Landing (ASTOVL) fighters, bomber delivered sensor fused weapons (SFW), bomber fleet structure studies, and literally dozens of other topics.

In 1994 Boeing D&SG Strategic Analysis organization was called upon by Boeing Helicopters to assist in the analysis of the RAH-66 Comanche reconnaissance-attack helicopter. This led to the most extensive modification of the model to date. A major question as to the value of reconnaissance and the role Comanche and other reconnaissance, surveillance and target acquisition (RSTA) systems contributes to battle outcomes was being debated within the US Army. There was no methodology in place within models to assess this in general. Colonel Dupuy felt that "intelligence" was an "intangible; probably individually incalculable" factor in combat.¹ While this probably remains true due to the human cognitive processes involved in the perception of "intelli-

¹ Colonel T.N. Dupuy, *Numbers, Predictions and War*, New York: Bobs Merrill Company, Inc., 1979, p. 33.

gence,” we felt that he would agree that sensors and reconnaissance assets could be scored under QJM methodology much like weapons. This required a scoring methodology for sensors and recon platforms, the modification of input files to account for and track some twenty RSTA categories which include night vision devices, ground surveillance radars, airborne imagers, scouts, recon vehicles, recon helicopters, SIGINT collectors, and others. The sensor profiles of opposing forces are compared in a calculation that accounts for effects of weather, terrain, force size, command and control effectiveness, and camouflage and deception. There was then the question of how to apply the resulting factor. Embedded in the classic QJM historical Combat Effectiveness Value (CEV) are any number of intangible or hitherto uncalculated factors such as leadership, command and control and certainly the reconnaissance effectiveness of the force. It was felt that the reconnaissance factor could be most appropriately used in a manner similar to a Combat Effectiveness Value (CEV) influencing Combat Power and attrition rates.

The modification was highly successful in supporting the RAH-66 Comanche program and provided valuable insights as to the relative “worth” of various sensor profiles, army aviation force structure alternatives, and the influence of RSTA in battles pitting US forces against a diverse population of adversary forces in the near to far term.

Since then, the Boeing QJM continues to be a prominent tool for analytical studies. Most recently, QJM is again being called upon along with its partner MRC for a new series of campaign analyses. There are also preliminary plans for a Boeing “Super QJM” hosted in an advanced computing environment with graphical user interfaces and expanded capabilities. At the same time we are highly interested in the exciting new methodologies, databases, and capabilities inherent in the TNDM, and have been in dialogue with The Dupuy Institute regarding mutually beneficial relationships.

QJM is not the only model used for Boeing analytical studies. Many other tools of differing complexity, resolution, and purpose are required in Boeing D&SG studies. However, QJM remains one of the first and the last models run in many cases.

QJM has served Boeing Defense & Space Group well in providing rapid, detailed, and insightful data in support of a diversity of studies no other one model could have accomplished. Its inherently flexible and agile methodology is adaptable to change and growth with little expenditure of time and resources. Its historically validated database substructure provides a powerful tool for top level analyses of future warfighting situations. 

LETTERS TO THE EDITOR



SWEDISH WAR COLLEGE

The Dupuy Institute
Mr. Chris Lawrence

Date

1997-08-21

Niklas Zetterling
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Dear Mr. Lawrence,

I have received the new issue of the TDI newsletter and it was of course with great interest I read your comments on my article. I have only two remarks on your reply. The first is that I am glad you took up the differences in casualty reporting. The second is that I am not a professor. Probably my title, "senior researcher" is quite misleading. As you are aware of I previously worked at the Swedish National Defence Research Establishment (Foa). Since the War College is still in a transition period to a more academic organization, I have opted to retain my title from the Foa. That title is awarded if qualified scientific reports or articles have been published in sufficient quantity and quality.

To me titles have very little meaning, and I don't bother about it in what has been written, but in the future it might be good not to "overqualify" my titles.

It was very interesting to read the articles on armour. I have not been really satisfied with the way TNDM treats armour, but neither have I recognized any simple solutions to the problems. One problem which has bearing upon the CEV calculations is the low values for the German Panther tank (even though it has no effect on the engagements in Italy I discussed in my article since there were no Panthers there at that time). The OLI values given in the table on page 33 suggest that the T-34/85 was better than (using the old OLIs) or much better (using the new OLIs) than the Panther. This is a conclusion I believe few T-34/85 tank crews would agree upon.

I think there are several reasons for the problems with AFV OLIs. First of all a punishment factor based on the weight of the vehicle is a rather coarse method. But I think the fundamental problem is that "soft" and "hard" targets are different in important aspects. For modelling purposes "soft" targets, and weapons designed to hit such targets, are much more linear than "hard" targets. A 50% increase in armour protection on a Sherman tank would be practically no benefit at all if main enemy antitank system is the Pak 43 8,8 cm L71 gun. It would however make considerable difference if the main enemy is the Pak 40 7.5 cm L46 gun. This also hits upon another problem. Not only has AFV combat more step like functions if it is to be simulated in a computer program but the effects of systems tend to be more relative than absolute compared to "soft" targets. This results in a much more complicated problem, especially when trying to develop algorithms. I have been working on a program for WWII battalion level ground combat and I am working with separate capabilities and effects against armour and other weapons. It has proved quite complicated to combine these and I can well understand if you are reluctant to discontinue using a single OLI value for a system.

Sincerely

Niklas Zetterling

A Rebuttal to “Force XXI and the Theory of Winning Outnumbered”

by Christopher A. Lawrence



I was recently shown an article by Lt. Col Leonhard in the June 1996 issue of *Army* called “Force XXI and the Theory of Winning Outnumbered.” Unfortunately it was published more than a year before I saw it, so there was not much point to writing a letter to the editor. Instead, I will address it in this newsletter.

The author quoted Trevor, and then constructed a database of battles from some questionable secondary sources. From this database he discovered that 56.5% of the battles were won by the side with the smaller number of soldiers. He also discovered that the defense won 24.5% of the time. He therefore concludes that “...in battle, the smaller side wins more than half the time” and “Numbers were apparently not just irrelevant, but actually seemed harmful to the cause” and “...increased mass on a single battlefield simply increases friendly casualties” and “too often, we have accepted the received wisdom that large numbers win battles, despite evidence to the contrary” and finally “to divorce ourselves from attrition theory—demonstrably fictitious in its bloody conclusions—is a necessary step for the Army to take as an institution.”

The Land Warfare Database rates mission success for each side (attacker and defender) by a 10 point scale. I decided to use this database (which is developed from a combination of primary and secondary sources) to measure winners and losers based upon force ratios. Like Col. Leonhard, I used the aggregate personnel strengths for comparisons, and did not look at any other factors except whether the unit was the attacker or defender. I certainly didn't look at how the force was armed, trained, deployed, or led.

To calculate winner or loser, I assigned a value of “+1” to a battle if the attacker's mission accomplishment score was greater than the defender's score, a value of “0” if both scores were the same, and a value of “-1” if the defender's mission accomplishment score is greater than the attacker's.

I also created a second field which measured the difference between the two mission accomplishment scores, with the positive value being attacker wins and the negative values being defender wins. The larger the value, the greater the win.

I found that the attacker won in 367 out of 605 cases (61% of the time), the result was drawn in 41 cases (7%), and the defender won in 197 cases (33%).

Force ratios were calculated by dividing the defender's strength into the attacker's strength. Therefore, a force ratio greater than 1 means the attacker is stronger than the defender, while a force ratio less than 1 means the defender is stronger. There are eleven cases where the force ratio is 1.

The following matrix shows the results of the database:

	----- Force Ratio -----			Total
	> 1	1	< 1	
Attacker Won	271	7	89	367
Draw	35		6	41
Defender Won	126	4	67	197
Total	432	11	162	605

Overall, the larger side won 56% of the time (271 + 67) while the smaller side won 36% of the time (89 + 126). The sides were equal or the result was a draw in 52 cases (9%). Leaving out the draws and battles where the two sides were equal, then the larger side won 61% of the time over the smaller side. This matches Trevor's figures which Col. Leonhard quotes. This database was certainly the source of Trevor's figures as quoted in Col. Leonhard's article.

Looking further into these figures, in the 367 cases where the attacker won, he had superior numbers 74% of the time. This would indicate a strong bias in favor of numbers for the attacking force.

In the 193 cases where the defender won, 64% of the time they were numerically inferior. This would indicate that the defense is the stronger form of combat.

Col. Leonhard questions whether “defense is a stronger form of combat than the attack.” He assumed that this would be shown by the defense winning more often than not. But, as more often than not, the force with the inferior strength assumes the defense, one would expect is a law of numbers to be at play here and that the defense would lose more often than not. Both his database and the LWDB show this.

The point is that for the attacker to win, he had to outnumber the defender 74% of the time, while the defender was able to win while outnumbered 64% of the time.

Col. Leonhard's data goes from ancient times to around 1900, I gather. Needless to say, getting accurate data before 1800 gets a little difficult, and getting accurate data before 1600 is real tricky.

In the LWDB, 364 of the engagements (60%) are from this century. While I am not happy with the “representativeness” of the data in the LWDB, it is certainly better than what Col. Leonhard has gathered. While I also would like to improve the quality of the data in parts of the LWDB, again, its sourcing and work is superior to the various secondary source battle books that he has used.

Looking at the data over time shows the following:

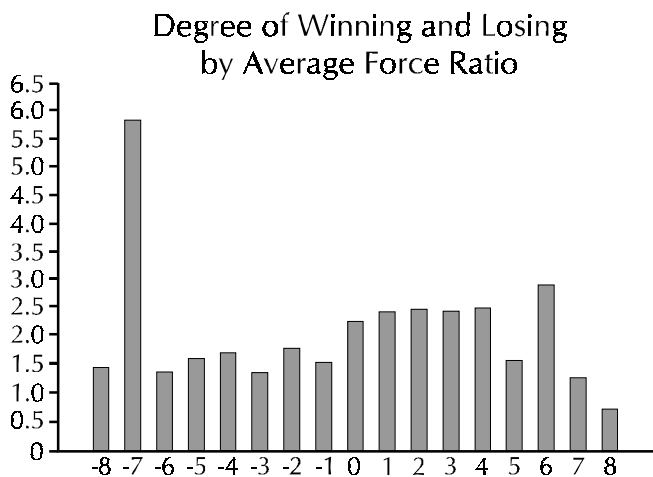
(continued on next page)

Attacker Won			
	Force Ratio ≥ 1	Force Ratio < 1	% Attacker Wins ≥ 1
1600-1699	16	18	47%
1700-1799	25	16	61%
1800-1899	47	17	73%
1900-1920	69	13	84%
1937-1945	104	8	93%
1967-1973	17	17	50%
Total	278	89	76%

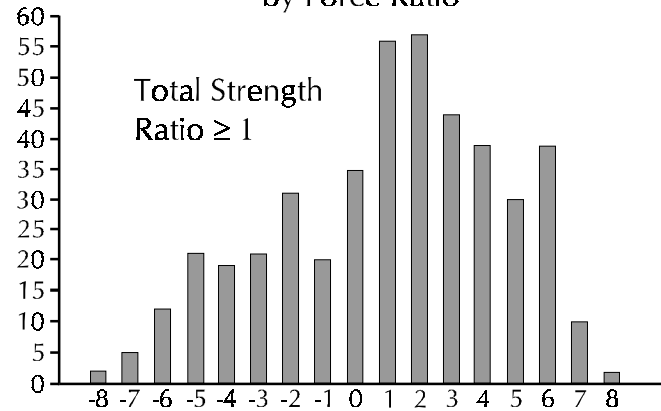
Draw		
	Force Ratio > 1	Force Ratio < 1
1600-1699	0	1
1700-1799	1	1
1800-1899	2	2
1900-1920	13	1
1937-1945	17	0
1967-1973	2	1
Total	35	6

Defender Won			
	Force Ratio ≥ 1	Force Ratio < 1	% Defender Wins ≥ 1
1600-1699	7	6	54%
1700-1799	11	13	46%
1800-1899	38	20	66%
1900-1920	30	13	70%
1937-1945	33	10	77%
1967-1973	11	5	69%
Total	130	67	66%

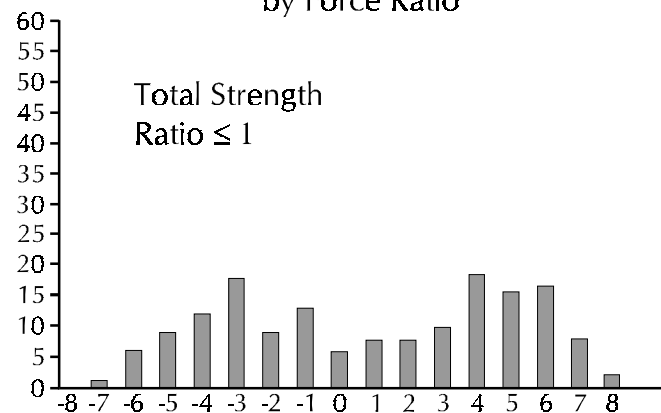
As each side was rated with a mission accomplishment score of 1–10, I created a series of graphs based upon that score as the X axis. This was done by subtracting the defender's score from the attacker's score. A positive value is an attacker win, a "0" is a draw, and a negative value is a defender win. The larger the absolute value of the score, the larger the victory.



**Degree of Winning and Losing
by Force Ratio**



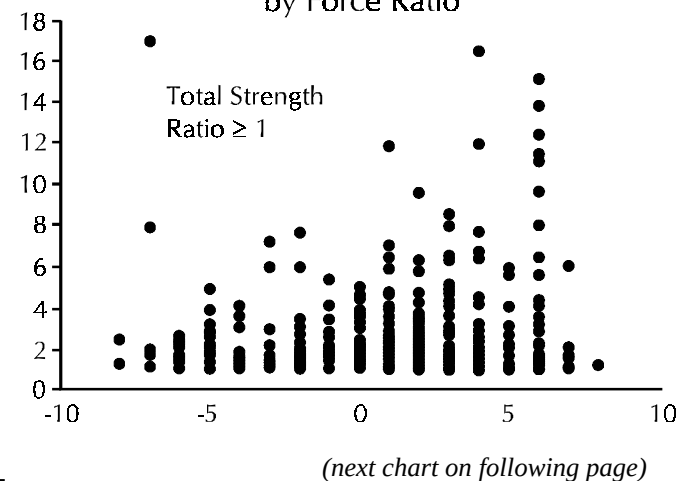
**Degree of Winning and Losing
by Force Ratio**



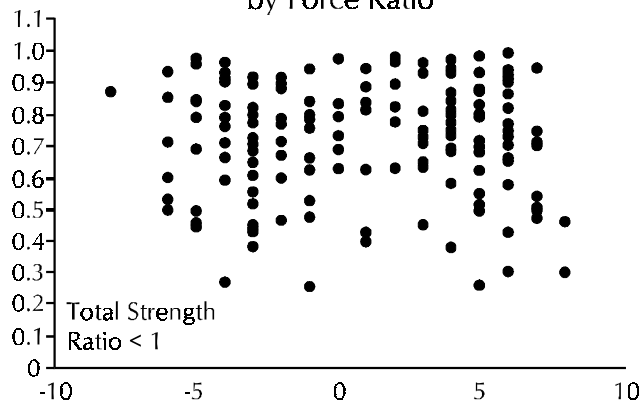
I think these make the point. They are even beginning to look like some form of distribution curve.

I have also used the computer to count the number of cases for each "degree of winning." These follow:

**Degree of Winning and Losing
by Force Ratio**



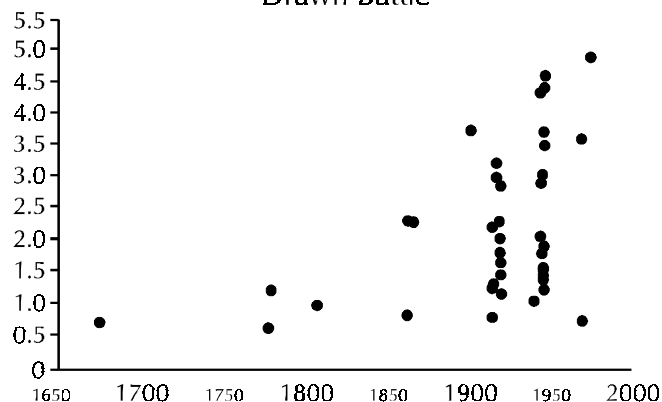
Degree of Winning and Losing
by Force Ratio



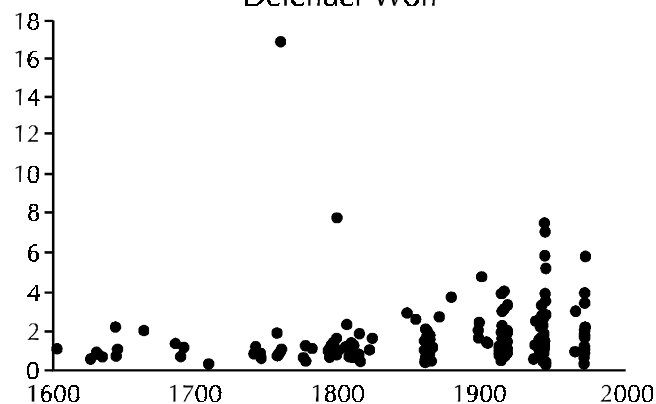
I put these both on the same scale, so the results are easy to compare. Only the area of truly great wins (value of 8) does the smaller force appear to do as well in the attack. In most of these cases, the winner was wearing kilts and swinging claymores. I do not propose that we make these changes for Force XXI.

Finally I have graphed the “Degree of Winning and Losing by Force Ratio, using the average of the total strength ratio,” as displayed in the following charts:

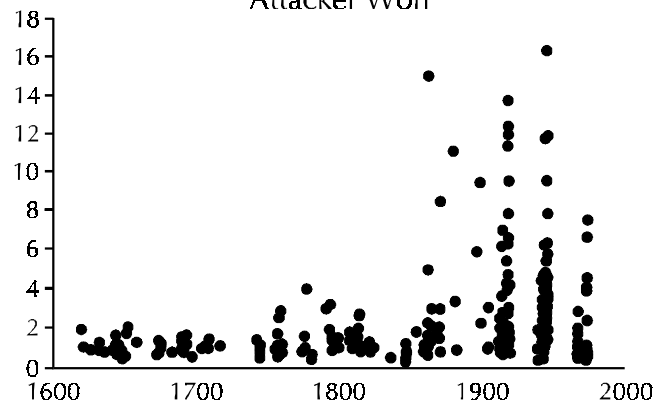
Strength Ratio Over Time
Drawn Battle



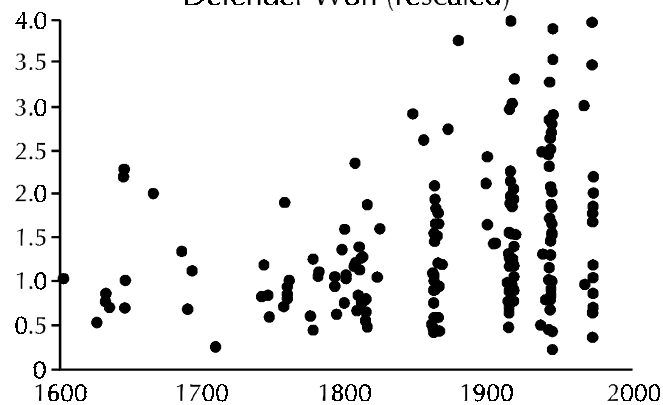
Strength Ratio Over Time
Defender Won



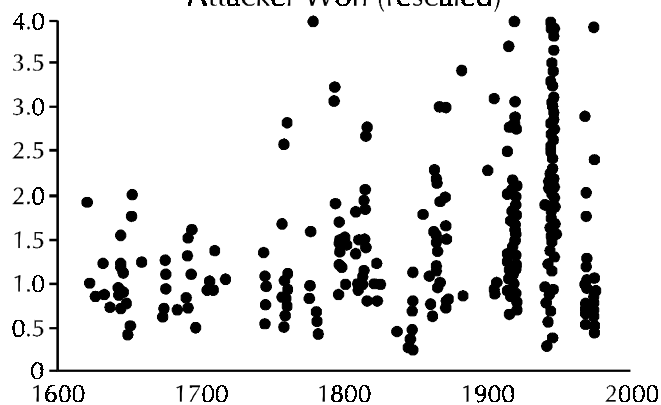
Strength Ratio Over Time
Attacker Won



Strength Ratio Over Time
Defender Won (rescaled)

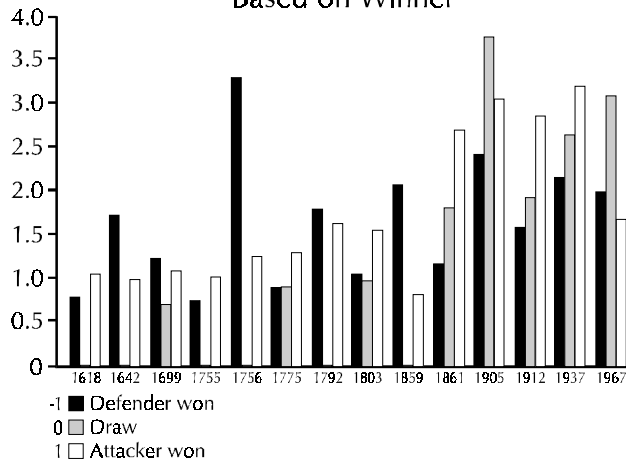


Strength Ratio Over Time
Attacker Won (rescaled)

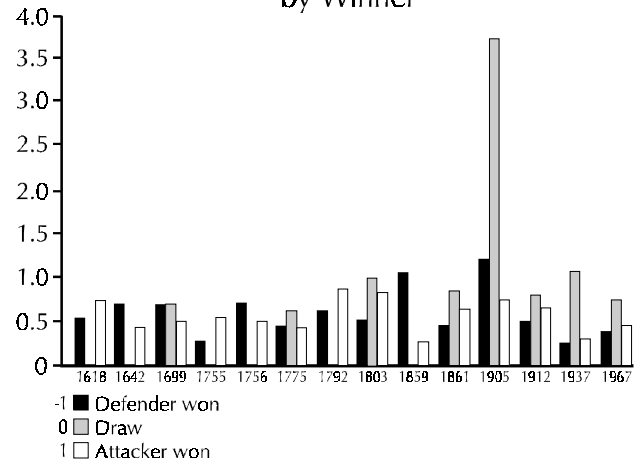


Finally, I printed out a collection of charts using the 14 “Wars” as I defined in my previous article. I also decided to play with all my various functions in the software, so you get the charts by averages, counts, standard deviation, etc. Improved software usually does not result in increased efficiency, merely an increase amount of paper produced. Remember, “-1” means the defender won, “0” is a draw, and “+1” is an attacker win. The charts appear on the following page.

Average Strength Ratio By War
Based on Winner

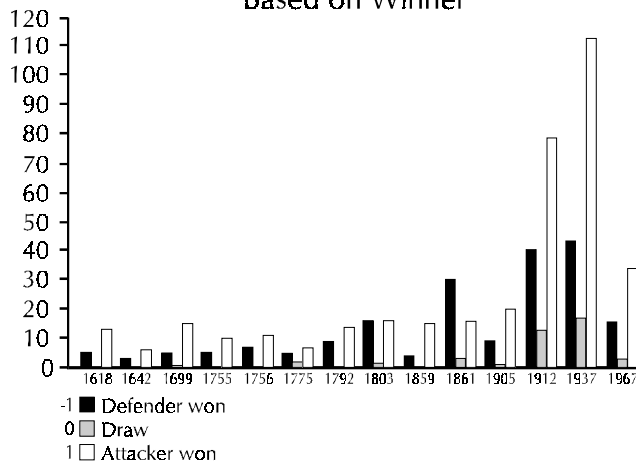


Minimum Strength Ratio
by Winner

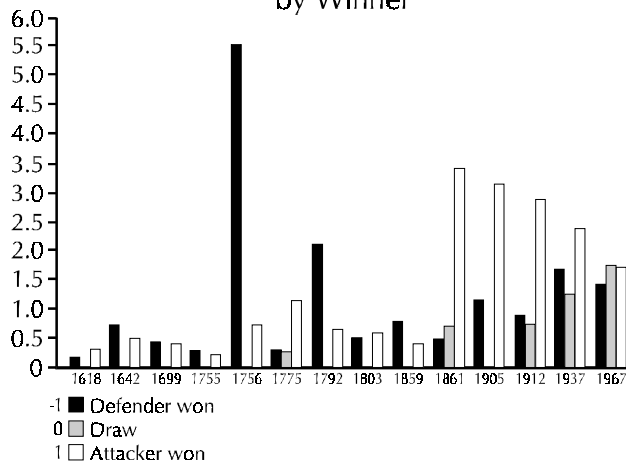


This last graph is interesting in that it shows that in no case is the winner less than $\frac{1}{4}$ the strength of loser. **This would clearly indicate that numbers count absolutely when you have less than $\frac{1}{4}$ the strength of the enemy.** 🌐

Number of Cases
Based on Winner



Standard Deviation of Ratio By War
by Winner



TDI Profile:

Trevor N. Dupuy

by Susan Rich



Trevor Nevitt Dupuy was born in New York on May 3, 1916. He attended the US Military Academy in West Point, graduating in the class of 1938. During WWII he commanded a US artillery battalion, a Chinese artillery group, and the artillery of the British 36th Division. He was always proud of the fact that he had more combat time in Burma than any other American, and received numerous decorations for valor from the US, British, and Chinese governments.

After the war Trevor served on the War Department General Staff, OPD from 1945 to 1947, and as military assistant to the Under Secretary of the Army from 1947 to 1948. He was a member of the original SHAPE staff in Paris under Generals Eisenhower and Ridgway from 1950 to 1952.

Between 1952 and 1956 Trevor was a member of the founding faculty of the Harvard Defense Studies Program. In 1956 he became Director of the Ohio State Military Studies Program. In 1958, after retiring from active military duty, he served as a visiting professor in the International Relations Program at Rangoon University in Burma.

Trevor came by his interest in military history through his father, who was a prominent military historian and a career army officer. Trevor wrote, "I was brought up by my father to be both a soldier and a military historian. To him the two were inseparable, and that is the way it has always been for me."

His writing career began in 1952, when the Army reinstated the teaching of military history in ROTC courses, and Trevor received a faculty appointment at Harvard University as a professor of Military Science and Tactics. Because there was no text, Trevor asked his father to help him write a textbook to be used by his students. They each wrote a chapter every two weeks, and each week Trevor mimeographed the new chapter to distribute to his students. By the end of the academic year, the father and son had completed the two-volume textbook, *Military Heritage of America*, the first of many such endeavors.

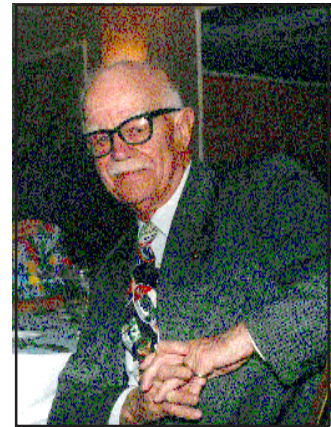
From 1960 to 1962 Trevor worked for the Institute of Defense Analysis. In 1962 he formed the first of his research companies, Historical Evaluation and Research Organization (HERO), of which he remained President and Executive Director until 1983. From 1967 to 1983 he was also President of T. N. Dupuy Associates Inc. (TNDA), which became the parent organization for HERO. In 1983, TNDA sold its assets (including HERO) to a new corporation he formed called Data Memory Systems, Inc. (DMSI). Trevor was the president and largest stockholder in DMSI. In 1990, he resigned from DMSI, sold his stock and reactivated TNDA.

In 1992 TNDA was closed out, and Trevor established the non-profit corporation The Dupuy Institute (TDI). The non-profit status was merely recognizing what had been the financial status of all his companies over the last 30 years.

During these years he became a prolific author and lecturer on many subjects, giving lectures at war colleges and official and private defense analysis agencies in more than 20 countries on five continents. His combat experience in the far East gave him a practical outlook, which tempered his theoretical orientation. He was a reflective and independent thinker who was enthralled by the political aspects of military power and who possessed unique energy, creativity, concentration and perseverance. He also had the uncanny ability to take some data and instantly derive a new meaning or relationship that was not obvious, but almost always turned out to be correct. He challenged conventional wisdom with a completely new outlook for the empirical study of combat.

Through the years his interest in military history analysis grew as he discovered continuous trends and patterns in the historical accounts he read and wrote. He believed the lessons of previous combat could and should be used as a basis for winning the next war. But he also recognized that analysis of military history was ignored in the US approach to almost all issues of national security and military problems, although it was relevant to most. He perceived that the current methodology and models used in the US failed because they lacked realism; they attempted to evaluate human behavior in combat according to theoretical design characteristics without consideration of how human beings actually behaved in real combat. He saw that it was futile to do accurate combat experiments in any controlled peacetime environment because it was impossible to recreate the very pervasive aspect of fear in a lethal environment. Therefore, he often said, military history must instead be considered the only real laboratory of the soldier.

The development of the Quantified Judgment Method of Analysis began in 1964, when HERO performed a study for the Army's Combat Developments Command called



“Historical Trends Related to Weapons Lethality.” The study involved developing a process to compare the lethality of weapons over the course of history. This resulted in a measurement scale providing “theoretical lethality indices.” Awareness of the dynamic interrelationship among dispersion, mobility, and firepower led to the development of further measurement scales, and subsequently to the QJM model, and later the TNDM.

In most fields of human endeavor, new developments are unlikely to receive immediate endorsement by the authorities in that field, and the QJM was no exception. One of Trevor’s greatest frustrations was his inability to get the US Defense establishment to pay more attention to the results of his historical analysis. He was impatient with people who did not recognize the wisdom of his insights, and his criticism tended to be explicit. In Europe and the Middle East he was considered an eminent person and became the confidant of chiefs of staff and defense ministers. In the US, while many agencies valued his research and insights, they often downplayed the value of his analysis, as it was not based on “traditional” operations research methods. In fact, he was often prevented from following his frequent creative urges by the pressure of meeting payrolls and deadlines. Yet although he could easily have sold out for the comfort of a stable job, he believed that his independence was a prerequisite for pursuing his work. Besides, he was not really interested in making money; what he really wanted was recognition of the validity of his theories about the historical analysis of combat. For over 30 years he persevered in this cause despite indifference, opposition and lack of reward, hoping to advance the use of history to protect both national and global security.

When Trevor died on June 5, 1995, he left many projects unfinished, but there were four that he had especially hoped to complete. These included a critical and comprehensive biography of Douglas MacArthur, and a book entitled *The Fighting Generals*, about the interaction of Stilwell and Chennault in East Asia in WWII. Another book project, *The Documented History of the US Armed Forces* was 90% complete when he died, and the manuscript now occupies four and a half linear feet of file cabinets in the office at TDI. The fourth unfinished project was his own autobiography, which he thought could be interesting in light of his very unusual combat experience in Burma during WWII, his work as a staff officer in high-level staffs which involved significant critical matters during the Cold War, and his travels and adventures as an author, lecturer and military analyst in later years. He had planned to call this book *A Footnote to History*.

Trevor has been characterized as a genius and a prophet. His contributions to the store of human knowledge in terms of the derivation of a theory of combat and philosophy of war are of outstanding value. He is the author or co-author of more than 80 books and more than 100 articles published in professional and military journals in many countries. The Departments of State and Defense sought his viewpoint when war broke out in the Persian Gulf, and he was asked to give

his advice to the US Congress on several occasions. The media also sought him, and he appeared on more than 30 television and radio shows, including the “Today Show,” the “Larry King Show,” the major networks, C-Span and Cable News Network. He was recognized as one of the very few people who was truly qualified to interpret international crises while they developed, and at the time of his death, was considered one of the world’s leading military historians. Those of us here at TDI, his loyal friends and employees, are continually aware of his influence. We retain a keen respect for the intricate quality and amazing quantity of catalogued historical knowledge he left under our care. We are challenged by what he left for us to fathom without him. 🌐

“My personal feeling is that if I have done anything worthwhile, it is in military theory and the relationship of the elements of historical experience to theory.”

—Trevor Dupuy



Beatty



Scheer

JUTLAND

Also in this issue:

- Should There Be a Naval QJM?
- Consistent Scoring of Weapons and Aggregation of Forces
- Solving the AFV OLI Calculation Problems
- Modeling World War I in Africa

INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this issue of our newsletter Christopher Lawrence, Dave Bongard, Richard Anderson, José Perez, Susan Rich, and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically-based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

(1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;

(2) Training, cultural and psychological profiles, and flow of information;

(3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in-house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically-based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.



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IN HONOR OF THE MEMORY OF THE LATE

Trevor N. Dupuy

Col., USA

**International
TNDM Newsletter**

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From the Editor...



Well, the last issue had a number of minor errors in it that I wanted to correct. First R. E. Dupuy (Trevor Dupuy's father) wrote or co-wrote 14 books. *The Encyclopedia of Military History* was listed on Trevor Dupuy's list of publications but not on R. E. Dupuy's list.

Second, some of Trevor's articles were written under the pseudonym of Alexander Ross. This was the case with the articles "Tactical Automation—Archilles Hell of the US Army" and "A Question of Professionalism in Today's Army." As Col. Dupuy was actively involved in contracting within the industry he was writing critical articles about, he occasionally felt it wiser to use a pseudonym. This is not unusual. I know of one general officer who wrote a critical article on combat modeling many years ago who also wrote it under a pseudonym.

Operations research is supposed to be an intellectual discipline that is objective and scientific. The fact that some people in the industry feel they cannot openly criticize the outputs of the industry, or feel that they must do so under a pseudonym, indicates that the discipline has become a "bureaucratic" discipline, with all the infighting, secretiveness, obscuration, and defensiveness that one often sees in bureaucracies. Of course, Col. Dupuy was well known for his open criticisms of some the methodologies that the community was using for its combat models. But there were always some models and aspects of the industry that he never publicly challenged, even though his opinions in private were quite clear. This is unfortunate, but necessary, if one is to remain employed.

The third error was in my article on "Fighting Outnumbered." The article I was responding to was in the June 1996 issue of *Army*, not *Army Times*. Hopefully, nobody lost any time trying to look up this article in the wrong magazine.

This issue focuses primarily on the Naval QJM. We have excerpted part of an old HERO report to show how they were looking at developing a Naval QJM from the Battle of Jutland. There is still an interest in the Naval QJM from some of our customers who are developing integrated air/land/sea modeling packages. While an integrated modeling package based upon the same concepts is a desirable goal, there are some problems with using the QJM methodology for Naval warfare. I briefly address those here, and would like to thank Dr. Brian McCue (Center for Naval Analysis) for his input, some of which was blatantly stolen for my article.

We also have an article from Dr. James Taylor, the Lanchester expert, on the need for a consistent scoring system for aggregate modeling. Obviously, the reason this article was written is that there are some models out there that are mixing the firepower scores from one system with the formulas from another system. One cannot validate firepower scores except as they are used in the body of the model for which they were designed. Mixing and matching components from different models is a conceptual mistake, unless one then carefully validates the final model. This last step is not being done.

We also have an article on the measurement of the Armor OLIs, presented in response to the articles in the Volume I, Issue 6 and Volume II, Issue 1 on the subject. José Perez has prepared a response to this problem, and I will have an additional response in the following issue. We are interested in comment from our other users.

Finally, we have started work on our second validation of the model, and as a result, immediately encountered some problems. This generated the article on modeling World War I in Africa.

The articles addressing a TNDM analysis of the Battle of Dom Bütgenbach have been delayed as both Jay Karamales and I have been distracted by other issues. We should hopefully have it ready for the next issue, or the issue after that. We intend to conduct it as an analysis of multi-day division-level battle, and then fight the battle the way it occurred as a series of battalion-level engagements. We then will test the model results to the historical results. This test is also considered to be part of our ongoing validation efforts.

Finally, for our "Who Is TDI?" column, we introduce Dr. James G. Taylor. Dr. Taylor is already familiar to some readers because of his position with the Naval Postgraduate School, his books on Lanchester, and his own work independent of TDI. He was also involved in the early development of the TNDM and he has worked with us on several projects. The Dupuy Institute is more than two guys and a telephone. The Institute makes extensive use of experts in the field when the work calls for it. Dr. Taylor's knowledge of the Lanchester equations was tapped in developing the TNDM.

For the next issue, we will have an article on casualties during the Iran–Iraq War (First Gulf War). I also expect to include some more articles on our battalion–level validation work. We have still to conduct our analysis of the advance rates and a summary conclusion from the first validation. We also need to test all these changes to our second battalion–level validation data base of 123+ battles from 1914 through 1991. This will be filling in the back pages of the Newsletter for several more issues. I also hope to look in greater depth at the issue of time and the TNDM.

That is all for now. If you have any questions, please contact me. Addresses, e-mail addresses, and phone numbers are in the mast head.



A handwritten signature in black ink, appearing to read "Chris Lawrence". The signature is fluid and cursive, with a large initial "C" and a long, sweeping underline.

The Development of a Naval Quantified Judgement Model



by Christopher A. Lawrence

In the 1970s Trevor N. Dupuy demonstrated to a number of people that his aggregated, top-down, historically validated modeling methods worked for land combat. Col. Dupuy and other people then began to explore whether this method would work for air or naval combat. To further investigate air combat modeling, the Air Command and Staff College issued a contract to The Dupuy Institute in 1994. A description of this first phase of developing an Air Campaign Model was provided to the readers in Volume I, Number 5 of the Newsletter. Unfortunately, due to budget limitations and, more significantly, lack of an interested sponsor this effort never got beyond the first phase. But we certainly proved, at least to ourselves, that such an effort could be made and would produce a useful model.

In the early 1980s the first exploratory attempts were made by HERO to develop a Naval Quantified Judgement Model (QJM). These efforts are documented in a report dated August 1982 for a contract done for the Defense Nuclear Agency. The report is called "Conventional Attrition and Battle Termination Criteria, Feasibility of a Naval QJM Methodology." The first two sections of that report cover the concept and methodology of a Naval QJM, while the third section actually tests some of the a proposed methodology, using the Battle of Jutland as an example. This section is excerpted in this issue.

This idea was never further developed. Col. Dupuy did perform a draft analysis of the Battle of Midway for the purpose of presentations and proposals, but basically there was no further development beyond this report.

In early 1988, Col. Dupuy intersected with a Mr. Richard Humphrey of the Naval Surface Warfare Center who had independently been developing his own Naval QJM. It was clearly inspired and based on Col. Dupuy's previous work. Mr. Humphrey was very correct in giving Col. Dupuy credit for this. For his analysis, Mr. Humphrey analyzed Trafalgar (1805), Lake Erie (1813), Tsushima Strait (1905), Coronel (1914), and the First Battle of the Falklands Islands (1914).

In his introductory presentations, he pointed out that two of the desired qualities of a Naval QJM are simplicity and transparency. These are important points. The simplicity and transparency of the QJM/TNDM approach makes the models easy to understand and use. This is very much in contrast to what is usually encountered in the modeling community.

Mr. Humphrey's work was presented at MORS in 1990, and by that time he had added the Battle of Midway in 1942 to the other five battles he had analyzed. But as far as I know, this was the end of any significant active work on this effort. It did result in a period of renewed interest by Col. Dupuy in

the Naval QJM and some attempts to find sponsorship, but this effort died due to a lack of interest in the US establishment and Mr. Humphrey's work disappeared in the cutbacks that occurred in the early Nineties at the Naval Surface Warfare Center.

There was also some exploration of the idea at the National Defense University. NDU at that time was developing a wargame for use by students in a crisis decision exercise. The QJM was being used for the ground portion of that effort, and a serious look was taken at developing a Naval QJM. But it appears that the concerns over the ability to project the results of a Naval QJM to the modern period ended this approach.

This desire to have an integrated air/land/sea package with a simple and transparent model (to borrow from Mr. Humphrey) is certainly what was motivating the National Defense University. I assume it is also why other people have expressed an interest in such a solution. Of course, there is a fully developed land model of combat with the TNDM. There is a first stage of the Air Campaign Model with the Dupuy Air Campaign Model (DACM). The question is whether there should be a naval QJM for modern naval combat. 

Application of Methodology to Surface Combat: The Battle of Jutland



[From the HERO report *Feasibility of a Naval QJM Methodology (Case Study: The Battle of Jutland)* prepared by T.N. Dupuy, Edward Oppenheimer, Brian R. Bader, Grace P. Hayes, and Denton W. West.]

Background

In the evening of 30 May 1916 Admiral Sir John Jellicoe, Commander of the British Grand Fleet, having received intelligence of unusual activity in the German ports, led his Battle Fleet out of Scapa Flow in anticipation of a long-awaited naval encounter with the German High Seas Fleet; Less than an hour later the British Battle Cruiser Fleet, under Vice Admiral Sir David Beatty, sailed from Rosyth. By the next morning almost all operational forces of the Royal Navy in the North Sea were at sea.

The activity reported by British intelligence was related to preparations by the German High Seas Fleet, commanded by Vice Admiral Reinhard Scheer, to put to sea, in execution of a plan to steam north toward the Skaggeurak, hoping to lure the British battle cruisers or some other element of the Grand Fleet out to their destruction. Unaware that most of the Grand Fleet was already at sea, the Germans set out at 0300 on 31 May. The scouting force of battle cruisers, commanded by Vice Admiral Franz Hipper, were in the lead, with Scheer and the main body following an hour and a half later.

At about 1415 Beatty, who had been proceeding on a course slightly north of east into the central regions of the North Sea, turned north for an assigned rendezvous with Jellicoe's force, which was then about 70 miles north-northeast, proceeding roughly southeast. Still unknown to each other, Hipper's flagship, the *Lützow*, was 45 miles to the east of Beatty's flagship, the *Lion*. Following the British turn, both battle cruiser forces were heading generally north on converging courses.

Within minutes British scouting destroyers sighted German cruisers, and the German fleet also received report of enemy ships. Hipper sighted the British battle cruisers at 1520, a few minutes before Beatty became aware of his approach. Hipper changed course at once to the southeast, to try to lead the British, then headed northeast, toward Scheer, who was still some distance away. At about 1530 Beatty, sighting the Germans, also changed course to the east and then southeast, so that the two battle cruiser fleets were soon on almost parallel courses, both heading toward the approaching Scheer.

Visibility was good on the surface, but low clouds and mist limited aerial observation. German gunners had a slight advantage over the British, for the brighter western sky made the British ships more clearly visible than the grey German ships against the grey sky to the east. And the westerly wind blew smoke across the line of sight of the British gunners.

The First Cruiser Engagement: 1538–1605 hours

Beatty deployed his battle cruisers in a line-ahead formation, with his flagship, the *Lion* (eight 13.5" guns), in the van, followed by her sister ship, the *Princess Royal*. Then in order steamed the *Queen Mary* (eight 13.5" guns), the *Tiger*, with similar armament, and finally the sister ships *New Zealand* and *Indefatigable*, each with eight 12" guns. Hipper's ships were deployed in the same type of formation, with the *Lützow* (eight 12" guns), the flagship, in the lead, followed by her sister ship, the *Derfflinger*. Then followed the *Seydlitz*, the *Moltke*, and the *Von der Tann*, each armed with 11" guns, the first two with ten and the last only with eight.

Initial fire distribution for the Germans covered every British battle cruiser except the *New Zealand*, Hipper preferring to keep all of a ship's guns on one target. The British ships should have been able to cover every German ship, with a double concentration on one. But a faulty fire distribution signal from Beatty left *Derfflinger* free from enemy fire until almost 1600 hours. This meant, however, that the *Lützow* and the *Moltke* were fired on by two British ships each.

The *Lion* was probably the first ship hit when, at 1551, two 12" shells from the *Lützow* scored. These were followed by as many as seven more in the next quarter hour, including one that permanently disabled a turret. The *Princess Royal*, immediately behind, was struck by five 12" shells from the *Derfflinger*. Two turrets were hit (one temporarily disabled), and her main fire control was put out of action for about twenty minutes. Other hits pierced a funnel and foremast. The *Tiger* received nine 11" hits, which caused serious damage amidships and temporarily knocked out two turrets. Of the first five British ships in line, only the *New Zealand* and the *Queen Mary* remained unscathed.

In a duel between the *Indefatigable* and the *Von der Tann*, neither ship scored a hit until around 1604 hours. Then, the German ship found the range and scored six hits. An explosion in a turret started fires that spread quickly to *Indefatigable's* magazine, which was not separated by an adequate fireproof barrier from the turret's ammunition handling room. A massive explosion followed, and the *Indefatigable* disappeared, taking all but two sailors with her to the bottom of the sea.

On the German side, the *Lützow* and *Derfflinger* were each hit once around 1600 by 13.5" shells which caused only minor damage. The *Seydlitz* received her first hits of the day when two 13.5" projectiles from the *Queen Mary* knocked out one main battery turret. These were the only hits on the German battle cruisers during the initial exchange of fire.

In the first 17 minutes, the British lost one battle cruiser and eight main battery turrets, and received a total of 29 hits

from heavy caliber shells. For the Germans, the damage was only four hits from heavy projectiles and one main battery turret out of action. Two defects in the British ships had much to do with the disproportionate damage. The British shells were equipped with defective fuzes which sometimes caused them to explode before penetration and practically without damaging their targets. One battle cruiser and her crew had been sacrificed to the inadequacy of screening in the connecting passageway between magazines and turrets.

As shown in Table 1, the total unmodified OLI of the six British battle cruisers was 556,252. Applying the factors in accordance with the conditions of battle, the force strength and combat power became 278,126. For the Germans these figures are 500,349 and 600,419. The ratio of OLIs, which is 1.11% in favor of the British, becomes a German advantage of 2.16 in combat power.

The damage done to each ship in the first engagement, lasting from 1545 to 1605, is shown in Table 2. Total damage suffered by the British ships, of inflicted by the Germans, is 205,029, while that suffered by the Germans, or inflicted by the British, is 25,715. The ratio of these gives a damage-inflicting capability of 7.97:1 in favor of the Ger-

man battle cruisers in line, the *Moltke* and the *Von der Tann*. Hit by three 15" shells, the *Von der Tann* shipped 600 tons of water through a hole caused by a shell penetration near the waterline. Two other hits pierced two turrets and put them out of action, and a third turret was disabled by a loss of power. The *Moltke* received one 15" hit from the *Barham*, and two 12" shells from the *Tiger*, sustaining substantial damage. Two hits on the *Derfflinger* brought the German sustained hit total to ten for the period between 1605 and 1630. Three main battery turrets (all on the *Von der Tann*) were disabled.

German fire continued to be effective in this second engagement. The *Lion* and the *Princess Royal* took two and three hits respectively from 12" shells. Substantial damage was caused to the *Lion*; damage to the *Princess Royal* was less severe. The *Tiger* also received minor damage when two 11" projectiles from the *Moltke* hit at about 1625. Fire from the *Von der Tann* scored one 11" hit each on the *New Zealand* and the *Barham*. And shells from the *Derfflinger*, now under fire after a brief respite at the beginning of the battle, hit the *Queen Mary* with eight 12" projectiles, smashing her decks, port broadside battery, and a main battery turret. In a catas-

Table 1: First Battle Cruiser Engagement at Jutland: 1545-1605 Hours, 31 May 1916

Ship (Armament)	OLI	x	Sun's Position	x	Wind	x	Sea Condition	x	Visibility	=	S	x	Leadership	x	Surprise	x	Training	=	P
Lützow (8 x 12")	106,546	x	1.2	x	1	x	1	x	1	=	127,855	x	1	x	1	x	1	=	127,855
Derfflinger (8 x 12")	106,546	x	1.2	x	1	x	1	x	1	=	127,855	x	1	x	1	x	1	=	127,855
Seydlitz (10 x 11")	103,878	x	1.2	x	1	x	1	x	1	=	124,654	x	1	x	1	x	1	=	124,654
Moltke (10 x 11")	99,878	x	1.2	x	1	x	1	x	1	=	119,854	x	1	x	1	x	1	=	119,854
Von der Tann (8 x 11")	83,501	x	1.2	x	1	x	1	x	1	=	100,201	x	1	x	1	x	1	=	100,201
German Total	500,349										600,419								600,419
Lion (8 x 13.5")	100,536	x	1	x	0.5	x	1	x	1	=	50,268	x	1	x	1	x	1	=	50,268
Princess Royal (8 x 13.5")	100,536	x	1	x	0.5	x	1	x	1	=	50,268	x	1	x	1	x	1	=	50,268
Queen Mary (8 x 13.5")	104,836	x	1	x	0.5	x	1	x	1	=	52,418	x	1	x	1	x	1	=	52,418
Tiger (8 x 13.5")	104,836	x	1	x	0.5	x	1	x	1	=	52,418	x	1	x	1	x	1	=	52,418
New Zealand (8 x 12")	72,754	x	1	x	0.5	x	1	x	1	=	36,377	x	1	x	1	x	1	=	36,377
Indefatigable (8 x 12")	72,754	x	1	x	0.5	x	1	x	1	=	36,377	x	1	x	1	x	1	=	36,377
British Total	556,252										278,126								278,126

Table 2: First Battle Cruiser Engagement Damage Assessment

Ship	Main Bty	Elsewhere	Factor	OLI	Damage
Seydlitz	2		5	753	3,765
		1	10	721	14,420
Lützow		1	5	753	3,765
Derfflinger		1	5	753	3,765
Total German Damage					25,715
Lion	2		10	753	15,060
		8	5	780	31,200
Princess Royal	2		10	753	15,060
		4	5	780	15,600
Tiger	4		10	753	30,120
		7	5	721	25,235
Indefatigable		sunk			75,754
Total British Damage					205,029

mans, exceeding the combat power ratio of 2.16 by a factor of 3.69.

The Second Battle Cruiser Engagement: 1605–1630 hours

Starting at about 1605, four battleships of the *Queen Elizabeth* class (in order, *Barham*, *Malaya*, *Warspite*, and *Valiant*) joined up with Beatty's battle cruisers. Fire from these ships' 15" guns was directed on the last two German

trophe similar to the one that befell the *Indefatigable* a few minutes earlier, a powder flash ignited the *Queen Mary's* inadequately protected magazine, and the ship blew up. Only 19 men managed to escape.

When the engagement ended at 1630, the results had continued to favor the Germans. Ten hits in all were made on German ships, with the loss of three main battery turrets and their six guns. Seventeen hits struck the British ships, and one battle cruiser, with eight 12" guns, was sunk.

As shown in Table 3, the OLI values for the two forces were altered by the damage and losses suffered in the first engagement and by the addition of four British battleships. The German OLI was 474,634, and the British 827,647, which gave the British a firepower advantage of 1.74. Modified by the sun and the wind, which had shifted slightly and so increased the factor to 0.6, the figures for combat power became British 496,588 and German 569,561, giving the advantage to the Germans at 1.15.

Table 4 shows the damage suffered by the ships of both sides in this engagement. The total suffered by the Germans is calculated at 68,760, while the British total is approximately twice as much, 138,516. This makes the damage-in-

Table 3: Second Battle Cruiser Engagement at Jutland: 1605-1630 Hours, 31 May 1916

Ship (Armament)	Sun's OLI	x	Position	x	Wind	x	Sea Condition	x	Visibility	=	S	x	Leadership	x	Surprise	x	Training	=	P
Lützow (8 x 12")	102,781	x	1.2	x	1	x	1	x	1	=	123,337	x	1	x	1	x	1	=	123,337
Derfflinger (8 x 12")	102,781	x	1.2	x	1	x	1	x	1	=	123,337	x	1	x	1	x	1	=	123,337
Seydlitz (10 x 11")	85,693	x	1.2	x	1	x	1	x	1	=	102,832	x	1	x	1	x	1	=	102,832
Moltke (10 x 11")	99,878	x	1.2	x	1	x	1	x	1	=	119,854	x	1	x	1	x	1	=	119,854
Von der Tann (8 x 11")	83,501	x	1.2	x	1	x	1	x	1	=	100,201	x	1	x	1	x	1	=	100,201
German Total	474,634										569,561								569,561
Lion (8 x 13.5")	54,276	x	1	x	0.6	x	1	x	1	=	32,566	x	1	x	1	x	1	=	32,566
Princess Royal (8 x 13.5")	69,876	x	1	x	0.6	x	1	x	1	=	41,926	x	1	x	1	x	1	=	41,926
Queen Mary (8 x 13.5")	104,638	x	1	x	0.6	x	1	x	1	=	62,902	x	1	x	1	x	1	=	62,906
Tiger (8 x 13.5")	49,481	x	1	x	0.6	x	1	x	1	=	29,689	x	1	x	1	x	1	=	29,289
New Zealand (8 x 12")	72,754	x	1	x	0.6	x	1	x	1	=	43,652	x	1	x	1	x	1	=	43,652
Barham (8 x 15")	119,106	x	1	x	0.6	x	1	x	1	=	71,464	x	1	x	1	x	1	=	71,464
Malaya (8 x 15")	119,106	x	1	x	0.6	x	1	x	1	=	71,464	x	1	x	1	x	1	=	71,464
Valiant (8 x 15")	119,106	x	1	x	0.6	x	1	x	1	=	71,464	x	1	x	1	x	1	=	71,464
Warspite (8 x 15")	119,106	x	1	x	0.6	x	1	x	1	=	71,464	x	1	x	1	x	1	=	71,464
British Total	827,647										496,588								496,588

flicting capability ratio 2.01 in favor of the Germans, exceeding the combat power ratio of 1.15 by a factor of 1.75.

The Destroyer Action: 1630–1648 hours

At about 1630 a brief lull took place in the firing between the capital ships. Destroyer commanders on both sides issued orders for torpedo attacks on the opposing battle cruisers. But what were planned as swift strikes against the larger ships rapidly disintegrated into fierce small ship skirmishes as the destroyers on each side found themselves face to face with enemy destroyers blocking the way to primary targets.

Eleven German destroyers, carrying on the average three 3.4" guns and six 19.7" torpedo tubes each, attacked Beatty's force. They were supported by gunfire from the light cruiser *Regensburg* and four large G-Type destroyers (each with four 4.1" guns and six 19.7" torpedo tubes). Simultaneously, eight British Admiralty M-Type destroyers, armed with three 4" guns and four 21" torpedo tubes, headed toward the German battle cruisers. Supporting the small destroyers were two ex-Turkish destroyers with five 4" guns and four 21" torpedo tubes, and the light cruiser *Nottingham*.

Ranges were so short that the position of the sun gave no advantage to the German destroyers, as it had earlier to the battle cruisers. The German ships fired ten torpedoes at the British battle cruisers at about 1635 hours. There were no hits. At about the same time a torpedo, one of five fired by British destroyers, struck the *V-29*, causing fatal damage. The *V-27* was hit by two 4" shells in her engine room, which cut her steam line and left her dead in the water. Both ships sank within minutes (one by fire from friendly destroyers to prevent capture), their crews rescued by other German destroyers.

The British destroyers suffered moderate damage. At 1635 the *Nomad* was hit by four 3.4" shells, one in her engine room, and she stopped dead in the water. Critically damaged, she still remained afloat. (Within an hour, the main battle lines had changed course from southeast to northwest, and German battleships steaming up from the south sank her.) At 1648 a sister ship, the *Obdurate*, was hit by two 4.1" projectiles which caused minimal damage.

At about 1632, after a two minute pause in the firing,

Table 4: Second Battle Cruiser Engagement Damage Assessment

Ship	Hits*	Factor	OLI	Damage
Lützow	1	5	753	3,765
Derfflinger	2	10	721	14,420
Seydlitz	1	5	753	3,765
Moltke	2	5	753	3,765
	1			
Von der Tann	6			
Total German Damage				25,715
Lion		10	753	15,060
	8	5	780	31,200
Princess Royal		10	753	15,060
	4	5	780	15,600
Tiger		10	753	30,120
	7	5	721	25,235
Indefatigable	sunk			75,754
Total British Damage				205,029
*no hits on main battery				

Hipper and Beatty started up another exchange of heavy gunfire. The four Queen Elizabeth battleships were too far out of range for the German guns, and even the British 15" shells were unable, for a while, to make their mark in the renewed fighting. The *Princess Royal* and the *Tiger* had minor damage from 11" shells between 1632 and 1634 hours, one striking the *Princess Royal* and three the *Tiger*. Six minutes later Beatty spotted Scheer's battleships steaming toward his battle cruisers, and ordered a reverse in course. The trap had been sprung, and he realized it, but at the same time he knew that, with luck, the German ships could be lured unaware to their doom at the hands of Jellicoe's main force. Just as Beatty's battle cruisers commenced their turn, the *Lion* and the *Tiger* were again hit. The *Lützow* landed two 12" shells on the *Lion*, starting fires in her sick bay. The *Tiger* was hit by two 11" projectiles from the *Seydlitz*, bringing her total in the renewed firing to five. In this exchange of gunfire, no German capital ships were hit.

Altogether, in the period between 1630 and 1648 the German forces lost one destroyer to enemy fire (a torpedo) and sank another one themselves after it had received two hits from British 4" guns. The British had one destroyer stopped by four 3.4" shells and another with minor damage from two 4" shells. The *Tiger* was hit by five 11" projectiles altogether, while the *Princess Royal* received one hit from a similar gun. And finally the *Lion*, already heavily hit, received

two 12" shells.

Again recognizing damage and losses in the earlier engagement and new ships joining the battle, the British total OLI value, as shown in Table 5, was 372,253. The German total was 623,951. Since neither wind nor sun was a factor in this engagement, the total combat power for each is the same as the total OLI, and the combat power ratio is 1.68 in favor of the Germans. One of the German destroyers was sunk and another suffered four hits (not considered sunk here, since she was still afloat when the engagement ended), making the total damage suffered by the German ships 14,325, as shown in Table 6. The British force totalled 35,925. Again the damage ratio favored the Germans, this time by a factor of 1.68. This exceeds the combat power ratio by a factor of 1.49.

Calculation of Outcome and Relative Combat Effectiveness

Application to Naval Methodology. A suitable means for calculating the outcome of a naval engagement has not yet been determined. However, we have developed a methodology for calculating combat power and relative combat power, and also for assessing damage, and calculating a relative damage–inflicting ratio. If it is assumed that the relationship of the ratio of damage–inflicting performance (DI) to the combat power ratio is an exponential relationship such as is found in land combat, then a CEV can be calculated, as follows:

$$DI_{red}/DI_{blue} = (PR_{red}/PR_{blue})^2$$

Once PR/PR is calculated, the CEV can be calculated as in the land simulation:

$$CEV = (PR/PR)/(P/P)$$

The Jutland Example. In reviewing the secondary sources on the Battle of Jutland, and before undertaking a quantitative analysis, the HERO researchers arbitrarily assessed the quality of British leadership (Beatty) as 0.7 on a scale of 0.1 to 1.0; German leadership (Hipper) was assessed as 0.8. Applying the same scalar measure to training, the British were assessed at 0.8, the Germans at 0.9. If leadership and training are the only bases for relative combat effectiveness (and

Table 6: Destroyer Action Damage Assessment

Ship	Hits*	Factor	OLI	Damage
V-27	2	5	235	2,350
V-29	sunk			11,975
Total German Damage				14,325
Nomad	4	5	185	3,700
Obdurate	2	5	250	2,500
Lion	2	5	780	7,800
Princess Royal	1	5	7800	3,900
Tiger	5	5	721	18,025
Total British Damage				35,925

they are certainly the most important) the combined value for the Germans would be 0.72; for the British 0.56. Thus the German CEV_g is 1.29, and for the British, CEV_b is 0.78. Thus, on the basis of a subjective, historical assessment, we should expect that the calculations for DI, and P/P, should provide a result approximately as follows:

$$(CEV)^2 = DI/DI = (1.29)^2 = 1.66$$

Returning to the analyses of the three engagements, the three DI/DI values were as follows:

First battle cruiser engagement: (1 BC)	3.68
Second battle cruiser engagement: (2 BC)	1.75
Destroyer engagement: (DD)	1.49

Applying the above formula of the relationship of damage to CEV, we can calculate CEV_s for the three engagements as follows:

1 BC:	$CEV = \sqrt{3.68} = 1.92$
2 BC:	$CEV = \sqrt{1.75} = 1.32$
DD:	$CEV = \sqrt{1.49} = 1.22$

The second and third of these CEV calculations compare very favorably with the judgmental CEV calculation of 1.29. The considerably higher German CEV value in the first battle cruiser engagement suggests that German performance was better than average, or British performance worse than average, or that the Germans were more favored by chance; or (which is more likely) some combination of all three. 🌐

Table 5: Destroyer Action at Jutland: 1630-1648 Hours, 31 May 1916

Ship (Armament)	OLI	Sun's x Position	Sea x Condition	Visibility	= S	x Leadership	x Surprise	x Training	= P
Lützow (8 x 12")	99,016	x 1	x 1	x 1	= 99,016	x 1	x 1	x 1	= 99,016
Derfflinger (8 x 12")	95,251	x 1	x 1	x 1	= 95,251	x 1	x 1	x 1	= 95,251
Seydlitz (10 x 11")	81,928	x 1	x 1	x 1	= 81,928	x 1	x 1	x 1	= 81,928
Moltke (10 x 11")	87,998	x 1	x 1	x 1	= 87,998	x 1	x 1	x 1	= 87,998
Von der Tann (8 x 11")	41,681	x 1	x 1	x 1	= 41,681	x 1	x 1	x 1	= 41,681
Destroyers (x 15)	194,665	x 1	x 1	x 1	= 194,665	x 1	x 1	x 1	= 194,665
Regensburg	23,412	x 1	x 1	x 1	= 23,412	x 1	x 1	x 1	= 23,412
German Total	623,951				623,951				623,951
Lion (8 x 13.5")	46,476	x 1	x 1	x 1	= 46,476	x 1	x 1	x 1	= 46,476
Princess Royal (8 x 13.5")	58,176	x 1	x 1	x 1	= 58,176	x 1	x 1	x 1	= 58,176
Tiger (8 x 13.5")	42,271	x 1	x 1	x 1	= 42,271	x 1	x 1	x 1	= 42,271
New Zealand (8 x 12")	69,269	x 1	x 1	x 1	= 69,269	x 1	x 1	x 1	= 69,269
Destroyers (x 15)	131,280	x 1	x 1	x 1	= 131,280	x 1	x 1	x 1	= 131,280
Nottingham	24,781	x 1	x 1	x 1	= 24,781	x 1	x 1	x 1	= 24,781
British Total	372,253				372,253				372,253

Should There Be a Naval QJM for Modern Naval Combat?



by Christopher A. Lawrence

First, let me state that I am ignorant of the current state of the art for naval combat modeling, nor did I have the time to educate myself before I wrote this article. In many respects, then, this is a discussion by a man who is wearing blinders, so please bear with me.

As discussed in the article earlier in this issue, the idea of a naval QJM has been floated around for the last 15 years. In addition to the usual advantages for developing an aggregated top-down model of naval combat (simplicity, transparency, etc.), the real advantage, and I suspect the primary reason, people are interested in a "Naval QJM" (or maybe we should now call this a "Naval TNDM") is the ability to use it in an integrated manner with the TNDM. The TNDM is supposed to be a model of air/land combat, but it is in fact a model of land combat that incorporates those elements of air and naval activity that directly impact on the tactical aspects of ground combat. As such, the TNDM is designed to address air and naval aspects in the following areas:

- By providing OLIs for Combat Helicopters that can be applied to the ground combat.
- By providing OLIs for Combat Aircraft that can be applied to the ground combat.
- By providing OLIs for the anti-aircraft weapons.
- By calculating separate aircraft loss rates based on the air defense OLI.
- By providing a table that accounts for the additional effects above and beyond the OLIs caused by having air superiority (see Table 5 in the User's Guide).
- By providing factors for Shoreline Vulnerability and casualties for amphibious operations (see Table 9 in the User's Guide).
- By adding a "Naval Gunfire Effect" to the OLIs of infantry and artillery weapons.

When we were developing the Dupuy Air Campaign Model (DACM), we were well aware that not only were we going to have to integrate the model with the TNDM, but that we needed to treat and address naval air. Accordingly, we put in such factors in the surface-to-air portion of the model under airbase survivability as Speed, Armor, Damage Control, and Displacement. These applied only to naval units. We also included a factor under Airbase repair of whether the platform was a carrier. Under anti-aircraft defense, we also had a factor for fire from supporting ships. By so doing, we were conceptually preparing for some airbases that would be modeled as ships. Theoretically, it would have been relatively simple to use the air campaign model to address carrier engagements with land targets or other carriers. As such, the fully articulated DACM would have been able, in the

most basic sense, to fight the Battle of Midway.

Basically, modern naval combat operates in three dimensions. These are:

- Air
- On the surface
- Under the sea

But the equation is far more complicated than that. From a modeling point of view, one must address:

- Air-to-air
- Air-to-surface
 - a. versus ground units
 - b. versus naval units
- Surface-to-air (AAA)
 - a. from ground units
 - b. from naval units
- Surface-to-surface
- Air/Surface-to-underwater (anti-submarine warfare)
- Underwater-to-surface
- Underwater-to-underwater
- Underwater/Surface-to-ground
- Ground-to-surface

I assume we do not need to seriously address ground-to-undersea and undersea-to-air yet.

Currently, the TNDM handles air-to-surface versus ground units (item 2a), surface-to-air from ground units (item 3a) and underwater/surface-to-ground (item 8). If the DACM had been completed, then we could have also addressed air-to-air (item 1), and as a natural extension of the model, we would certainly have been able to address air-to-surface versus naval units (item 2b) and surface-to-air from naval units (item 3b). Therefore, assuming we have first created DACM, this would leave the "naval QJM" covering surface-to-surface (item 4), the submarine warfare (items 5, 6, and 7), and ground-to-surface (item 9).

For naval combat from 1600 to 1945, I am comfortable that a "QJM" type aggregate methodology would have worked for surface-to-surface combat between fleets. I will not attempt to argue that it is the best approach, as it may not be, but it is a "doable" approach. There are several problems with surface-to-surface combat after 1945. They are:

- Small number of ships involved
- Importance of "critical hits"
- Effects of ECM, ECCM, and intelligence
- First fire is important (surprise)
- Lack of recent historical examples

Gone are the days of Jutland-like battleship engagements. Surigao Strait in late 1944 was the last great battlefleet engagement. Surface-to-surface actions since then have been brief affairs of only a few ships involved, or in many cases one or two ships versus various light craft and torpedo boats. Quite simply, we are reaching the point where only one nation has any significant sized surface fleet. Therefore, most likely surface engagements are going to be between small craft, boats, and maybe a few ships. With a small number of maneuver elements (one to five on a side), then the variability of the results are going to be significant. Small differences in capability may have major effects. Aggregate modeling requires a large number of platforms to aggregate, and future naval combat is not going to have this anytime in the next 50 years. Even the largest carrier battles of World War II really only involved a few ships. Midway was essentially a fight between three American and four main Japanese carriers.

As a result of the modern ship designs being unarmored or lightly armored, and many of the weapons being smart ("missiles"), the importance of getting the single "critical" hit tends to be heavily emphasized. While these "critical" hits have always been important in naval combat (witness the *Bismarck* versus the *Hood*), it seems to have become even more important now. This, considered in conjunction with the small number of platforms, makes the modeling of these critical hits even more important. Furthermore, it may make the results of modern naval combat perhaps far more variable than ground combat.

ECM and ECCM have now become critical, as they help determine the effectiveness of the single magic bullet (like an Exocet missile) to take out a single ship. The "paper, scissors, stone" tendency in electronic warfare makes it more difficult to model using any method. Furthermore, intelligence is also critical as the effects of surprise can be a much larger multiplier of combat power than what we see on land.

Getting the first shot in is always important in warfare, but in the case where one bullet (i.e., an Exocet missile) can sink one ship, then the first fire develops critical dimensions. With a small number of platforms, one could easily see a scenario in which one side fires and the other side sinks—end of battle. We have had premonitions of this with the Battle of Savo Island in 1942, where effectively half of the US fleet was taken out by Japanese torpedoes before they really knew there was a general engagement. The "first shot" was also the critical factor in Midway, leading to a very lopsided exchange (basically one for four), and this came about due to an intelligence advantage the US had.

Finally, we don't have much in the way of good modern ship-vs-ship engagements from which to create a database. Therefore, the factors would be speculative and could not be validated. So the surface-to-surface portion of the model would be a well validated gun and torpedo model, extended forward over 50 years, with a significant selection of "un-validatable" factors included. The TNDM has been validated through 1991. I am considerably less comfortable with a model validated through 1945, and extended forward 50

years.

Getting into submarine warfare is a real tricky exercise (air/surface-to-underwater, underwater-to-surface, underwater-to-underwater). Actually, for ASW, this might be modeled well on an aggregate-level if one scores the various search systems over an area of water, and then determines a probability of finding a sub in that area. But basically, in all these cases, you pretty much have a classic weapon-vs-weapon duel that traditional operations research methods are best able to answer. In the case of underwater-vs-underwater, we have one historical case to work from, unless one considers the US subs in WWII who sunk themselves with their own torpedoes. As a curiosity, we also have one historical case of a boarding action versus a sub. There is a considerable body of experience with the "cat and mouse" games that US and Soviet submarines played during the cold war, but of course, no shots were fired. But, having begun my professional career working with submarine sonar systems, I have a good layman's knowledge of the environment, and I am not comfortable with an aggregate modeling method here. Basically, he who hears the other side first, wins.

Ground-to-surface combat is not that common. One could handle it as a form of surface-to-surface and that would primarily be based upon missile systems. This would have all the problems of modeling a surface-to-surface engagement using missiles.

So, I remain skeptical that using a QJM-type approach for naval combat is the best solution for modeling naval combat. It can be done, but first one would have to fully develop the air campaign model (DACM), and then from there develop a Naval model. At some point, one would have to ask whether using classic OR techniques might be simpler and better for such a model. 🌐

List of Naval Engagements

by Dave Bongard



Pre-World War I	Date	Combatant Notes
Yalu River	17 Sep 1894	
Weihaiwei Operations	2-12 Feb 1895	
Manila Bay	1 May 1898	
Santiago de Cuba	3 Jul 1898	
Torpedo Boat Attack on Port Arthur	8 Feb 1904	
Chemulpo	9 Feb 1904	
Yellow Sea	10 Aug 1904	
Ulsan	14 Aug 1904	
Tsushima	27 May 1905	
World War I		
Heligoland Bight	28 Aug 1914	Cruisers
Coronel	1 Nov 1914	
SMS <i>Emden</i> vs HMAS <i>Sydney</i>	9 Nov 1914	
Falklands	8 Dec 1914	
Dogger Bank	24 Jan 1915	
Rufiji Delta	11 Jul 1915	SMS <i>Konigsberg</i> vs HMS <i>Mersey</i> & <i>Severn</i>
Jutland	31 May-1 Jun 1916	
Valona	15 May 1917	Austria vs UK, France, Italy
Interwar		
Straits of Gibraltar	29 Sep 1936	DD
Yangtze River	27 Sep 1937	Air vs DD
USS <i>Panay</i>	12 Dec 1937	Air vs ship
Cabo Palos	6 Mar 1938	DD
World War II		
Rio de la Plata	13 Dec 1939	
HMS <i>Rawalpindi</i> vs <i>Scharnhorst</i> and <i>Gneisenau</i>	8 Jun 1940	BB
Norwegian Coast	8-10 Apr 1940	
Narvikfjord	10-12 Apr 1940	DD and BB
HMS <i>Glorious</i> vs <i>Scharnhorst</i> and <i>Gneisenau</i>	8 Jun 1940	BB
Calabrian Coast	9 Jul 1940	BB
Northwest Crete	19 Jul 1940	
<i>Scheer</i> vs HMS <i>Jervis Bay</i>	5 Nov 1940	
Taranto Raid	11 Nov 1940	CV
Gulf of Siam	16-17 Jan 1941	
Cape Matapan	28 Mar 1941	BB
Denmark Straits	24 May 1941	BB
Pursuit/Shadowing of <i>Bismarck</i>	25-28 May 1941	CV
<i>Bismarck</i>	27-28 May 1941	BB
Pearl Harbor	7 Dec 1941	CV
Macassar Strait	23 Jan 1942	DD
Gilberts and Marshalls Raid	1 Feb 1942	CV

continued on next page...

Madoera Strait	4 Feb 1942	
Palembang	13-14 Feb 1942	
Attempt on Rabaul	20 Feb 1942	CV
Raids on Wake and Marcus	24 Feb-4 Mar 1942	CV
Java Sea	27 Feb 1942	
Banten Bay	28-29 Feb 1942	
Raids on Lae and Salamaua	10 Mar 1942	CV
Indian Ocean	2-8 Apr 1942	CV
Doolittle Raid	18 Apr 1942	CV
Coral Sea	7-8 May 1942	CV
Aleutians/Dutch Harbor	3-4 Jun 1942	CV
Midway	4-6 Jun 1942	CV
Savo Island	9 Aug 1942	
Eastern Solomons	22-25 Oct 1942	CV
Cape Esperance	11-12 Oct 1942	
Santa Cruz Islands	26-27 Oct 1942	CV
Casablanca	8 Nov 1942	BB
Guadalcanal I	12-13 Nov 1942	BB
Guadalcanal II	13-14 Nov 1942	Air vs ships
Guadalcanal III	14-15 Nov 1942	BB
Tassafaronga Point	30 Nov 1942	DD
Bismark Sea	2-4 Mar 1943	Air vs DD and Tpts
Komandorski Islands	26 Mar 1943	
Kula Gulf	5-6 Jul 1943	
Kolombangara	12-13 Jul 1943	
Vella Gulf	6-7 Aug 1943	DD
Vella Lavella	6-7 Oct 1943	DD
Empress Augusta Bay	2 Nov 1943	
Strikes on Rabaul	5 & 11 Nov 1943	CV
Cape St. George	23 Nov 1943	DD
Nordkapp	26 Dec 1943	<i>Schamhorst vs Prince of Wales</i>
Philippine Sea	19-21 Jun 1944	CV
Battle off Formosa	13-16 Oct 1944	CV
Sibuyan Sea	23-24 Oct 1944	CV air vs BB
Surigao Strait	24-25 Oct 1944	BB
Samar	25 Oct 1944	BB vs DD and CV air
Cape Engano	25 Oct 1944	CV
East China Sea	7 Apr 1945	CV air vs BB

Post-World War II		
Off Dutch New Guinea	16 Jan 1962	
Tonkin Gulf	1965	
Port Said	5 Jun 1967	Missile
Sharm-el-Sheik	7 Jun 1967	
USS <i>Pueblo</i>	23 Jan 1968	
Latakia I	6 Oct 1973	Missile
Latakia II	7-8 Oct 1973	Missile
Damietta	8-9 Oct 1973	Missile
Tartus-Latakia	12-13 Oct 1973	Missile
Nile Delta	15-16 Oct 1973	Missile
Aboukir Bay-Alexandria	21-22 Oct 1973	Missile
US-Libyan Air Clash	19 Aug 1981	CV
Swedes vs Soviet Sub	27 Oct-6 Nov 1981	
Falklands War	22 Apr-14 Jun 1982	Air/CV, Missile
Attack on USS Stark	17 May 1982	Air/Missile vs Ship
Tanker Clashes; Boghammars, etc.	1983-1985	
"Line of Death" US vs Libya	4 Jan 1989	CV
Second Gulf/Kuwait War Naval Air Ops	17 Jan-27 Feb 1991	CV

Consistent Scoring of Weapons and Aggregation of Forces



The Cornerstone of Dupuy's Quantitative Analysis of Historical Land Battles

by James G. Taylor, PhD, Dept. of Operations Research, Naval Postgraduate School

Introduction

Col. Trevor N. Dupuy was an American original, especially as regards the quantitative study of warfare. As with many prophets, he was not entirely appreciated in his own land, particularly its Military Operations Research (OR) community. However, after becoming rather familiar with the details of his mathematical modeling of ground combat based on historical data, I became aware of the basic scientific soundness of his approach. Unfortunately, his documentation of methodology was not always accepted by others, many of whom appeared to confuse lack of mathematical sophistication in his documentation with lack of scientific validity of his basic methodology.

The purpose of this brief paper is to review the salient points of Dupuy's methodology from a system's perspective, i.e., to view his methodology as a system, functioning as an organic whole to capture the essence of past combat experience (with an eye towards extrapolation into the future). The advantage of this perspective is that it immediately leads one to the conclusion that if one wants to use some functional relationship derived from Dupuy's work, then one should use his methodologies for scoring weapons, aggregating forces, and adjusting for operational circumstances; since this consistency is the only guarantee of being able to reproduce historical results and to project them into the future.

Implications (of this system's perspective on Dupuy's work) for current DOD models will be discussed. In particular, the Military OR community has developed quantitative methods for imputing values to weapon systems based on their attrition capability against opposing forces and force interactions¹. One such approach is the so-called antipotential-potential method² used in TACWAR³ to score weapons. However, one should not expect such scores to provide valid casualty estimates when combined with

historically derived functional relationships such as the so-called ATLAS casualty-rate curves⁴ used in TACWAR, because a different "yard-stick" (i.e. measuring system for estimating the relative combat potential of opposing forces) was used to develop such a curve.

Overview of Dupuy's Approach

This section briefly outlines the salient features of Dupuy's approach to the quantitative analysis and modeling of ground combat as embodied in his Tactical Numerical Deterministic Model (TNDM) and its predecessor the Quantified Judgment Model (QJM). The interested reader can find details in Dupuy [1979] (see also Dupuy [1985]⁵, [1987], [1990]). Here we will view Dupuy's methodology from a system approach, which seeks to discern its various components and their interactions and to view these components as an organic whole. Essentially Dupuy's approach involves the development of functional relationships from historical combat data (see Fig. 1) and then using these functional relationships to model future combat (see Fig. 2).

At the heart of Dupuy's method is the investigation of historical battles and comparing the relationship of inputs (as quantified by relative combat power, denoted as P_a/P_d for that of the attacker relative to that of the defender in Fig. 1)(e.g. see Dupuy [1979, pp. 59-64]) to outputs (as quantified by extent of mission accomplishment, casualty effectiveness, and territorial effectiveness; see Fig. 2) (e.g. see Dupuy [1979, pp. 47-50]). The salient point is that within this scheme, the main input⁶ (i.e. relative combat power) to a historical battle is a derived quantity. It is computed from formulas that involve three essential aspects: (1) the scoring of weapons (e.g. see Dupuy [1979, Chapter 2 and also Appendix A]), (2) aggregation methodology for a force (e.g. see Dupuy [1979, pp. 43-46 and 202-203]), and (3) situational-adjustment methodology for determining the

¹ For example, see Taylor [1983a, Section 7.18], which contains a number of examples. The basic references given there may be more accessible through Robinson [1993].

² This term was apparently coined by L.B. Anderson [1974] (see also Kerlin et al. [1975, Chapter I, Section D.3]).

³ The Tactical Warfare (TACWAR) model is a theater-level, joint-warfare, computer-based combat model that is currently used for decision support by The Joint Staff and essentially all CINC staffs. It was originally developed by the Institute for Defense Analyses in the mid-1970s (see Kerlin et al. [1975]), originally referred to as TACNUC, which has been continually upgraded until (and including) the present day.

⁴ For example, see Kerlin and Cole [1969], GRC [1973, Fig. 6-6], or Taylor [1983b, Fig. 5] (also Taylor [1983a, Section 7.13]).

⁵ The only apparent difference between Dupuy [1979] and Dupuy [1985] is the addition of an appendix (Appendix C "Modified Quantified Judgment Analysis of the Bekaa Valley Battle") to the end of the latter (pp. 241-251). Hence, the page content is apparently the same for these two books for pp. 1-239.

⁶ Technically speaking, one also has the engagement type and possibly several other descriptors (denoted in Fig. 1 as reduced list of operational circumstances) as other inputs to a historical battle.

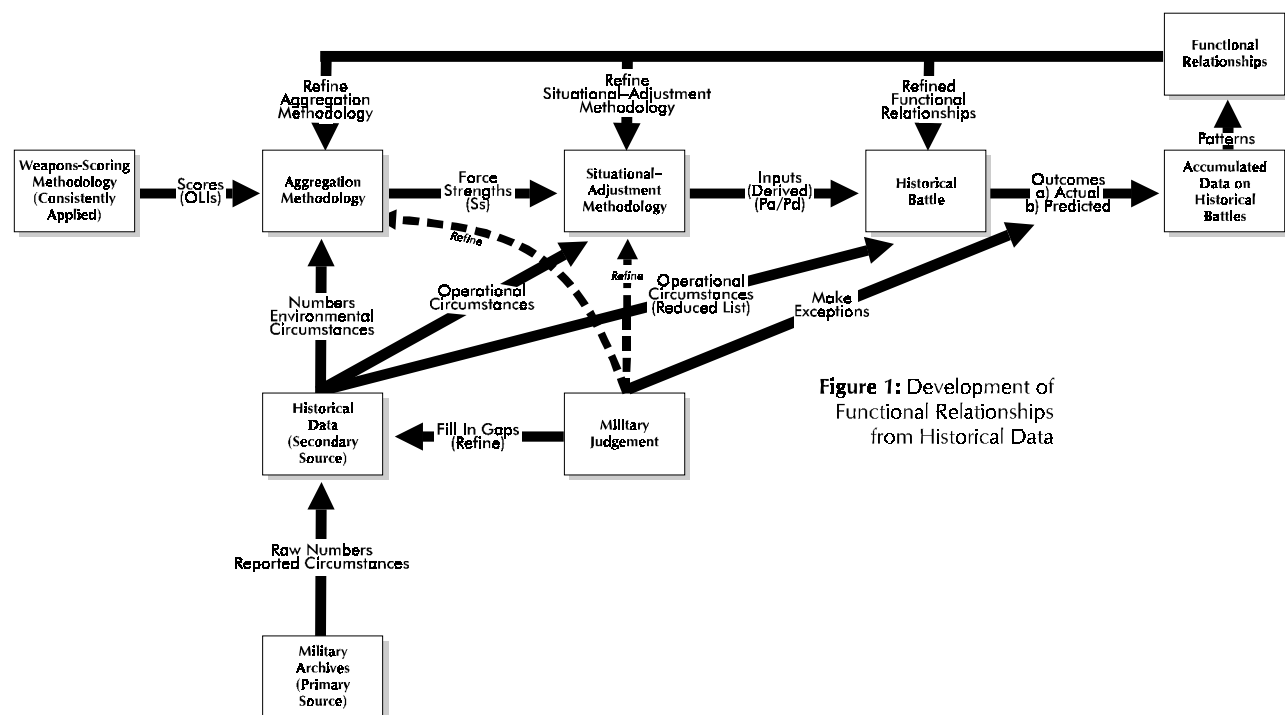


Figure 1: Development of Functional Relationships from Historical Data

relative combat power of opposing forces (e.g. see Dupuy [1979, pp. 46-47 and 203-204]). In the force-aggregation step the effects on weapons of Dupuy's environmental variables and one operational variable (air superiority) are considered⁷, while in the situation-adjustment step the effects on forces of his behavioral variables⁸ (aggregated into a single factor called the relative combat effectiveness value (CEV)) and also the other operational variables are considered (Dupuy [1987, pp. 86-89]).

Moreover, any functional relationships developed by Dupuy depend (unless shown otherwise) on his computational system for derived quantities, namely OLIs, force strengths, and relative combat power. Thus, Dupuy's results depend in an essential manner on his overall computational system described immediately above. Consequently, any such functional relationship (e.g. casualty-rate curve) directly or indirectly derivative from Dupuy's work should still use his computational methodology for determination of independent-variable values.

Fig 1 also reveals another important aspect of Dupuy's work, the development of reliable data on historical battles. Military judgment plays an essential role in this development of such historical data for a variety of reasons. Dupuy was essentially the only source of new secondary historical data developed from primary sources (see McQuie [1970] for

further details). These primary sources are well known to be both incomplete and inconsistent, so that military judgment must be used to fill in the many gaps and reconcile observed inconsistencies. Moreover, military judgment also generates the working hypotheses for model development (e.g. identification of significant variables).

At the heart of Dupuy's quantitative investigation of historical battles and subsequent model development is his own weapons-scoring methodology, which slowly evolved out of study efforts by the Historical Evaluation Research Organization (HERO) and its successor organizations (cf. HERO [1967] and compare with Dupuy [1979]). Early HERO [1967, pp. 7-8] work revealed that what one would today call weapons scores developed by other organizations were so poorly documented that HERO had to create its own methodology for developing the relative lethality of weapons, which eventually evolved into Dupuy's Operational Lethality Indices (OLIs). Dupuy realized that his method was arbitrary (as indeed is its counterpart, called the operational definition, in formal scientific work), but felt that this would be ameliorated if the weapons-scoring methodology be consistently applied to historical battles. Unfortunately, this point is not clearly stated in Dupuy's formal writings, although it was clearly (and compellingly) made by him in numerous briefings that this author heard over the years.

In other words, from a system's perspective, the functional relationships developed by Colonel Dupuy are part of his analysis system that includes this weapons-scoring methodology consistently applied (see Fig. 1 again). The derived functional relationships do not stand alone (unless further empirical analysis shows them to hold for any weapons-scoring methodology), but function in concert with computational procedures. Another essential part of this

⁷ In Dupuy [1979, e.g. pp. 43-46] only environmental variables are mentioned, although basically the same formulas underlie both Dupuy [1979] and Dupuy [1987]. For simplicity, Fig. 1 and 2 follow this usage and employ the term "environmental circumstances."

⁸ In Dupuy [1979, e.g. pp. 46-47] only operational variables are mentioned, although basically the same formulas underlie both Dupuy [1979] and Dupuy [1987]. For simplicity, Fig. 1 and 2 follow this usage and employ the term "operational circumstances."

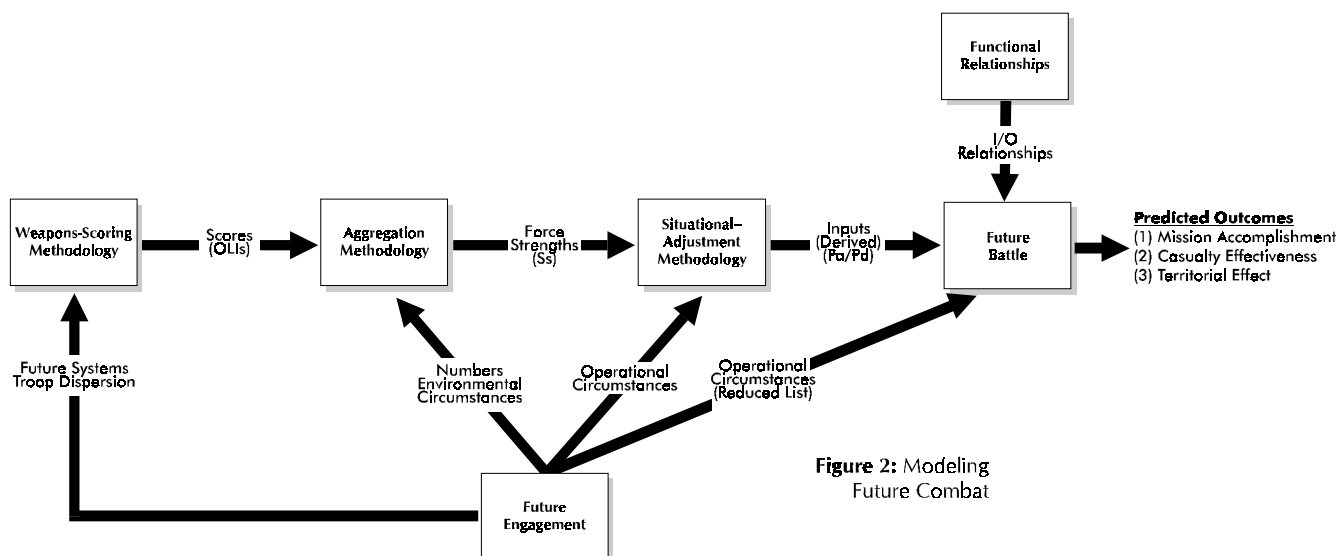


Figure 2: Modeling Future Combat

system is Dupuy's aggregation methodology, which combines numbers, environmental circumstances, and weapons scores to compute the strength (S) of a military force. A key innovation by Colonel Dupuy [1979, pp. 202-203] was to use a nonlinear (more precisely, a piecewise-linear) model for certain elements of force strength. This innovation precluded the occurrence of military absurdities such as air firepower being fully substitutable for ground firepower, antitank weapons being fully effective when armor targets are lacking, etc. The final part of this computational system is Dupuy's situational-adjustment methodology, which combines the effects of operational circumstances with force strengths to determine relative combat power, e.g. P_a/P_d .

To recapitulate, **the determination of an Operational Lethality Index (OLI) for a weapon involves the combination of weapon lethality**, quantified in terms of a Theoretical Lethality Index (TLI) (e.g. see Dupuy [1987, p. 84]), **and troop dispersion**⁹ (e.g. see Dupuy [1987, pp. 84-85]). **Weapons scores** (i.e. the OLIs) **are then combined with numbers** (own side and enemy) **and combat-environment factors to yield force strength**. Six¹⁰ different categories of weapons are aggregated, with nonlinear (i.e. piecewise-linear) models being used for the following three categories of weapons: antitank, air defense, and air firepower (i.e. close-air support). **Operational**, e.g. mobility, posture, surprise, etc. (Dupuy [1987, p. 87]), **and behavioral variables** (quantified as a relative combat effectiveness value (CEV)) **are then applied to force strength to determine a side's combat-power potential**.

⁹ Chris Lawrence has kindly brought to my attention that since the same value for troop dispersion from an historical period (e.g., see Dupuy [1987, p. 84]) is used for both the attacker and also the defender, troop dispersion does not actually affect the determination of relative combat power P_a/P_d .

¹⁰ Eight different weapon types are considered, with three being classified as infantry weapons (e.g. see Dupuy [1979, pp. 43-44], [1987, pp. 85-86]).

Requirement for Consistent Scoring of Weapons, Force Aggregation, and Situational Adjustment for Operational Circumstances

The salient point to be gleaned from Fig. 1 and 2 is that the same (or at least consistent) weapons-scoring, aggregation, and situational-adjustment methodologies be used for both developing functional relationships and then playing them to model future combat. The corresponding computational methods function as a system (organic whole) for determining relative combat power, e.g. P_a/P_d . For the development of functional relationships from historical data, a force ratio (relative combat power of the two opposing sides, e.g. attacker's combat power divided by that of the defender, P_a/P_d is computed (i.e. it is a derived quantity) as the independent variable, with observed combat outcome being the dependent variable. Thus, as discussed above, this force ratio depends on the methodologies for scoring weapons, aggregating force strengths, and adjusting a force's combat power for the operational circumstances of the engagement. It is *a priori* not clear that different scoring, aggregation, and situational-adjustment methodologies will lead to similar derived values. If such different computational procedures were to be used, these derived values should be recomputed and the corresponding functional relationships rederived and replotted.

However, users of the Tactical Numerical Deterministic Model (TNDM) (or for that matter, its predecessor, the Quantified Judgment Model (QJM)) need not worry about this point because it was apparently meticulously observed by Colonel Dupuy in all his work. However, portions of his work have found their way into a surprisingly large number of DOD models (usually not explicitly acknowledged), but the context and range of validity of historical results have been largely ignored by others. The need for recalibration of the historical data and corresponding functional relationships has not been considered in applying Dupuy's results for some important current DOD models.

Implications for Current DOD Models

A number of important current DOD models (namely, TACWAR and JICM discussed below) make use of some of Dupuy's historical results without recalibrating functional relationships such as loss rates and rates of advance as a function of some force ratio (e.g. P_a/P_d). As discussed above, it is not clear that such a procedure will capture the essence of past combat experience. Moreover, in calculating losses, Dupuy first determines personnel losses (expressed as a percent loss of personnel strength, i.e., number of combatants on a side) and then calculates equipment losses as a function of this casualty rate (e.g., see Dupuy [1971, pp. 219-223], also [1990, Chapters 5 through 7]¹¹). These latter functional relationships are apparently not observed in the models discussed below. In fact, only Dupuy (going back to Dupuy [1979]¹²) takes personnel losses to depend on a force ratio and other pertinent variables, with materiel losses being taken as derivative from this casualty rate.

For example, TACWAR determines personnel losses¹³ by computing a force ratio and then consulting an appropriate casualty-rate curve (referred to as empirical data), much in the same fashion as ATLAS did¹⁴. However, such a force ratio is computed using a linear model with weapon values determined by the so-called antipotential-potential method¹⁵. Unfortunately, this procedure may not be consistent with how the empirical data (i.e. the casualty-rate curves) was developed. Further research is required to demonstrate that valid casualty estimates are obtained when different weapon scoring, aggregation, and situational-adjustment methodologies are used to develop casualty-rate curves from historical data and to use them to assess losses in aggregated combat models. Furthermore, TACWAR does not use Dupuy's model for equipment losses (see above), although it does purport, as just noted above, to use "historical data" (e.g., see Kerlin et al. [1975, p. 22]) to compute personnel losses as a function (among other things) of a force ratio (given by a linear relationship), involving close air support values in a way never used by Dupuy. Although their force-ratio determination methodology does have logical and mathematical merit, it is not the way that the historical data was developed.

Moreover, RAND (Allen [1992]) has more recently developed what is called the situational force scoring (SFS) methodology for calculating force ratios in large-scale,

aggregated-force combat situations to determine loss and movement rates. Here, SFS refers essentially to a force-aggregation and situation-adjustment methodology, which has many conceptual elements in common with Dupuy's methodology (except, most notably, extensive testing against historical data, especially documentation of such efforts). This SFS was originally developed for RSAS¹⁶ and is today used in JICM¹⁷. It also apparently uses a weapon-scoring system developed at RAND¹⁸. It purports (no documentation given [citation of unpublished work]) to be consistent with historical data (including the ATLAS casualty-rate curves) (Allen [1992, p.41]), but again no consideration is given to recalibration of historical results for different weapon scoring, force-aggregation, and situational-adjustment methodologies. SFS emphasizes adjusting force strengths according to operational circumstances (the "situation") of the engagement (including surprise), with many innovative ideas (but in some major ways has little connection with previous work of others¹⁹). The resulting model contains many more details than historical combat data would support. It also is methodology that differs in many essential ways from that used previously by any investigator. In particular, it is doubtful that it develops force ratios in a manner consistent with Dupuy's work.

Final Comments

Use of (sophisticated) mathematics for modeling past historical combat (and extrapolating it into the future for planning purposes) is no reason for ignoring Dupuy's work.

¹⁶ The RAND Strategy Assessment System (RSAS) is a multi-theater aggregated combat model developed at RAND in the early 1980s (for further details see Davis and Winnefeld [1983] and Bennett et al. [1992]). It evolved into the Joint Integrated Contingency Model (JICM), which is a post-Cold War redesign of the RSAS (starting in FY92).

¹⁷ The Joint Integrated Contingency Model (JICM) is a game-structured computer-based combat model of major regional contingencies and higher-level conflicts, covering strategic mobility, regional conventional and nuclear warfare in multiple theaters, naval warfare, and strategic nuclear warfare (for further details, see Bennett et al. [1994]).

¹⁸ RAND apparently replaced one weapon-scoring system by another (e.g. see Allen [1992, pp. 9, 15, and 87-89]) without making any other changes in their SFS System.

¹⁹ For example, both Dupuy's early HERO work (e.g. see Dupuy [1967]), reworks of these results by the Research Analysis Corporation (RAC) (e.g. see RAC [1973, Fig. 6-6]), and Dupuy's later work (e.g. see Dupuy [1979]) considered daily fractional casualties for the attacker and also for the defender as basic casualty-outcome descriptors (see also Taylor [1983b]). However, RAND does not do this, but considers the defender's loss rate and a casualty exchange ratio as being the basic casualty-production descriptors (Allen [1992, pp. 41-42]). The great value of using the former set of descriptors (i.e. attacker and defender fractional loss rates) is that not only is casualty assessment more straight forward (especially development of functional relationships from historical data) but also qualitative model behavior is readily deduced (see Taylor [1983b] for further details).

¹¹ Chris Lawrence has kindly informed me that Dupuy's work on relating equipment losses to personnel losses goes back to the early 1970s and even earlier (e.g. see HERO [1966]). Moreover, Dupuy's [1992] book *Future Wars* gives some additional empirical evidence concerning the dependence of equipment losses on casualty rates.

¹² But actually going back much earlier as pointed out in the previous footnote.

¹³ See Kerlin et al. [1975, Chapter I, Section D.1].

¹⁴ See Footnote 4 above.

¹⁵ See Kerlin et al. [1975, Chapter I, Section D.3]; see also Footnotes 1 and 2 above.

One would think that the current Military OR community would try to understand Dupuy's work before trying to improve and extend it. In particular, Colonel Dupuy's various computational procedures (including constants) must be considered as an organic whole (i.e. a system) supporting the development of functional relationships. If one ignores this computational system and simply tries to use some isolated aspect, the result may be interesting and even logically sound, but it probably lacks any scientific validity.

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Solving the AFV OLI

Calculation Problems, Pt I

Lightweight/Lightly Armed Vehicles

by José Perez

In the June 1997 issue of this newsletter, articles by David Bongard and Christopher Lawrence discussed some of the weaknesses of the current algorithm used to calculate OLI values for Armored Fighting Vehicles (AFV). In the August 1997 issue, Niklas Zetterling's letter to the editor mentioned several other criticisms of the AFV algorithm. The points discussed were:

- Light AFVs (armored cars, APCs, etc.) are undervalued.
- Lightly armed AFVs are undervalued.
- The algorithm emphasizes the antiarmor role.
- Only modern main battle tanks and heavily armed AFVs receive favorable scores.
- The German Panther tank receives a lower OLI score than the T-34/85.
- The punishment factor is rather coarse because it is based on the weight of the vehicle.
- Linear models cannot be applied to "hard" targets, such as AFVs.
- The effects of AFVs are more relative than absolute compared to "soft" targets.

These problems can be boiled down into several groups:

- Lightweight and lightly armed AFVs.
- OLI scores that go against expert judgment.
- The punishment factor calculation is too simple.
- The AFV algorithm relies heavily on linear models.

In this article, I will attempt to address the first problem: lightweight and lightly armed AFVs. The remaining topics will be addressed in future articles, but I invite everyone to join in the discussion and to propose ideas. A fully developed solution is not essential; at this point, ideas are needed to spark the discussion.

Several solutions for the problem of lightweight and lightly armed AFVs were proposed by Bongard and Lawrence:

- Use the old armor OLI algorithm for light and lightly armed AFVs.
- Develop an alternate algorithm for this class of AFVs.
- Develop an algorithm that balances the general combat value of an AFV with its antiarmor role.
- Give an AFV two different OLI scores—one for its

antiarmor role and one for its general combat role.

- Put the armor algorithm into a separate engagement module using SSPKs.

Three additional solutions are:

- Make the algorithm more flexible.
- Move IFVs, APCs, etc. to the Infantry category.
- Calculate multiple OLIs for each weapon.

Bongard and Lawrence's second and third solution can be combined with my first. Their fourth and my second can be folded into my third, which is more general. Their first and fifth ideas are unique. The eight solutions can be boiled down to:

- Use the old armor OLI algorithm for light and lightly armed AFVs.
- Make the algorithm more flexible by developing a method balances the general combat value of an AFV with its antiarmor role.
- Calculate multiple OLI scores for each weapon: one for each weapon category used in the TNNDM.
- Put the armor algorithm into a separate engagement module using SSPKs.

Use the old armor OLI algorithm: To evaluate each of these ideas, consider their individual strengths and weaknesses. The old armor algorithm overrated some AFVs (see pp. 32–33, Bongard, "AFV Values in the TNNDM", TNNDM Newsletter, vol. 1, no. 6). It also does not reflect improvements in technology and armor. Thus, using the old method would undervalue modern IFVs, APCs, armored cars, etc. Of all the approaches listed, this one would be the simplest to implement. This change would have no impact on TNNDM, but it would require that the eligible AFVs be identified somehow. That identification would have to be stored. These changes would require a minor to modest effort.

A more flexible algorithm: This would add complexity to the algorithm and increased complexity usually leads to increased errors/problems. However, one can argue that the current method is too simple—it emphasizes the antiarmor role of AFVs at the expense of the more general roles of IFVs, APCs, etc. True flexibility would require that some "judgment" be built into the algorithm. Some form of expert knowledge would be needed in order for this algorithm to recognize which AFVs (light and/or lightly armed) need to

be scored differently. Changing the algorithm would have no impact on the rest of the TNDM. Also, more flexibility could make the algorithm more easily adaptable to changes in AFVs. These changes would require a modest to medium effort.

Multiple OLI scores: This has the potential of changing how all weapon OLIs are calculated. If multiple OLIs are created for AFVs, why not do it for other weapons? Some air defense weapons, for example, can be used against ground targets. Munitions are being developed for mortars for antiarmor use. The TNDM currently does not have the ability to automatically handle dual purpose weapons. This might be a way to solve two problems with one solution, but it could require changing the model to accommodate this capability. This approach could have an extensive impact on the model. If the model is changed, it would have to be revalidated before this change could be evaluated. These changes would require a modest to major effort.

A separate armor module: As Chris Lawrence pointed out in his article (p. 34, Lawrence, "How Would We Correct Armor OLIs?", TNDM Newsletter, vol. 1. no. 6), using SSPKs requires creating an armor battle model. With that comes all the problems associated with creating a model—analysis, development, testing, validation, etc. This solution would lead to changes to the model, as it was not designed for this type of input. However, this could be a basis for re-evaluating how close air support (and artillery) are modeled in the TNDM. These changes would require a medium to major effort.

After evaluating the pros and cons of each approach, I prefer the "more flexible algorithm" solution. For the amount of effort involved it presents the fewest obstacles with the quickest results.

The weaknesses identified by Lawrence and Bongard contain three elements:

- Weight
- Weapons
- General combat value

The current algorithm evaluates AFVs on the basis of:

Weapon OLIs
 Battlefield Mobility Factor (BMF)
 Radius of Action Factor (RAF)
 Vehicle Punishment Factor (VPF)
 Vehicle Attack Factor (VAF)
 Vehicle Supply Factor (VSF)

The elements of BMF are: Horsepower, Weight, Speed and Ground Pressure.

The RAF is based on: Range.

The VPF is based on: Armor Type, Weight, Height and Length.

The VSF is calculated from: Load (rounds for primary weapon) and Firing rate of primary weapon.

Being lightweight and lightly armed are the most com-

mon reasons for why an AFV receives a low OLI score (see pp. 30–31, Perez, "Calculating an OLI Score for Armored Fighting Vehicles", TNDM Newsletter, vol. 1, no. 6 and Bongard, op. cit.). These tend to be characteristics of IFVs, APCs and armored cars/trucks. What is needed is a set of rules that adequately identifies these characteristics and applies a General Combat Factor to increase the AFV's score.

In terms of weight, possible categories are:

Light:	1 to 30 tons
Medium:	20 to 50 tons
Heavy:	30 or more tons

These categories overlap because, over time, the weight of AFVs has tended to move up. It is worth noting that the US Marine Corps' LVTP-7 Amphibious Assault Vehicle weigh 26 tons while the US Army's M-3A1 Stuart, a light tank, weighed 14.2 tons fully loaded; and the M-4 Sherman, a medium tank, weighed 35 tons. These ranges will have to be adjusted to fit as this algorithm is developed.

In terms of armament, possible categories are:

Lightly armed:	1 to 60 total weapons' OLI
Well armed:	40 to 150 total weapons' OLI
Heavily armed:	90 or more OLI

Again, the ranges overlap because of the increasing lethality of weapons mounted on AFVs.

The General Combat Factor (GCF) is intended to represent the general utility of an AFV that otherwise would have a low OLI score. Therefore, the GCF for main battle tanks should be almost nil. The rules for evaluating an AFV's General Combat Value could then be:

If Light and Lightly armed, then the GCF is High.
 If Light and Well armed, then the GCF is Medium.
 If Light and Heavily armed; then the GCF is Low.
 If Medium and Lightly armed, then the GCF is High.
 If Medium and Well armed, then the GCF is Low.
 If Medium and Heavily armed, then the GCF is Very Low.
 If Heavy and Lightly armed, then the GCF is Medium.
 If Heavy and Well armed, then the GCF is Very Low.
 If Heavy and Heavily armed, then the GCF is Nil.

GCF categories are:

Nil:	1.0
Very Low:	1.0 to 1.2
Low:	1.1 to 1.3
Medium:	1.2 to 1.5
High:	1.4 to 3.0

To calculate the exact value of the GCF for an AFV, each of these rules would be evaluated and the degree to which they apply would determine the GCF value. For ex-

ample, rules 1 and 2 might both apply to an AFV. If rule 1 applies to a degree of 60% and rule 2 40%, then .6 and .4 will be used as weights to calculate the GCF. To generate OLIs that are acceptable, an expert would have to evaluate the performance of this algorithm and then adjust the range of values of each category until satisfactory results are obtained. Once this task is accomplished, the expert's knowledge will have been built into the AFV algorithm.

I do not consider myself an expert on AFVs; therefore, it is almost certain that someone else might devise a different set of rules using these categories. In order for this solution to work successfully, it requires an expert to develop the appropriate categories and then the rules for evaluating them.

The approach which has just been described is based on a branch of mathematics called "fuzzy logic." Fuzzy logic attempts to solve the problem of how to evaluate "fuzzy" concepts like Light, Medium and Heavy which have a numerical component, but cannot be defined precisely. Credit for originating this concept is generally given to Lotfi Zadeh, an electrical engineer at the University of California at Berkeley. For an overview of fuzzy logic, I recommend one of the following books:

Kosko, Bart, *Fuzzy Thinking. The New Science of Fuzzy Logic*, New York, Hyperion, 1993.

McNeil, F. Martin and Thro, Ellen, *Fuzzy Logic: A Practical Approach*, Boston, MA, AP Professional, 1994. 

Modeling World War I in Africa



by Christopher A. Lawrence

The first battalion-level validation of the TNDM consisted of 76 engagements from 1918 through 1989. The model required no special efforts, except to account for short engagements (less than four hours), engagements where one side was “casualty insensitive” (like the Japanese in WWII), and a special attrition multiplier for WWI engagements. We got good fits for most of the battles, but our fits for the WWI data (especially winner/loser predictions) were the weakest. As of the result of this effort, I became concerned about the use of the model for WWI data. First, the casualty multiplier of four that was used was not systematically derived. It had evolved as a custom of the person who regularly ran the model. Based upon his years of experience, he always put a multiplier of four in the model for WWI engagements. The only documentation on this procedure was in Trevor N. Dupuy’s original *Numbers, Predictions and War* in which he used an attrition multiplier of two for WWI engagements. Col. Dupuy always explained that this was the adjustment necessary to account for the tactics having not yet adjusted to the increase lethality of the weapons.

While this appears to be a perfectly valid hypothesis, a hypothesis it remains. When I was conducting the first validation, I began to wonder if the increased attrition could not be entirely explained by these WWI armies being “casualty insensitive.” This would produce a multiplier of 2.5, but far more significantly, this multiplier would be based upon an entirely different theoretical construct. Furthermore, if this construct was correct, this would have some direct implications for those trying to model and predict the effects of a revolution in military affairs (as the previous revolution occurred between WWI and WWII).

Therefore, let’s look at the effects of the two different multipliers. In Tables 1 and 2, we list the original casualty results predicted by the model, those same results adjusted for time (no engagements longer than four hours were adjusted), and then the casualty results modified by “casualty insensitive” vice the WWI multiplier. In all cases we are dealing with “percent losses.” The averages and standard deviations of the errors from the historical result are summed at the end of each chart.

Therefore, if we consider that the increased casualties for WWI combat are caused by “casualty insensitive” systems, this would result in the average attacker losses being underpredicted by 3.14 (vice 0.07%) and the standard deviation of the errors being 4.61 (vice 4.87). For the

defenders, the average defender losses would be underpredicted by 3.294 (vice being overpredicted by 10.234) and the standard deviation of the errors is 16.92 (vice 23.44). At this point, I am not willing to reach a conclusion based upon this data. But as I noted in Volume 1, Number 5 of the Newsletter:

“One could postulate that the WWI attrition multiplier of four that we used also incorporates the 2.5 ‘casualty insensitive’ multiplier. This would imply that there was only a multiplier of 1.6 to account for other considerations (like adjusting to the impact of increased firepower on the battlefield).”

Table 1

Engagement	Length (hours)	Attacker % Loss	CEV-Predicted Att % Loss	Adjusted by Time Factor	Revised to be Casualty Insensitive
Essen Hook	0.5	9.86	0.49	3.92	2.45
Cantigny	2	3.46	0.24	0.48	0.30
St. Amand	2	10.43	1.04	2.04	1.28
Mediah Farm	2	12.86	4.89	9.78	6.11
Boursches II	3	3.74	2.01	2.68	1.68
Yvonne-Odet	3.5	2.31	1.89	2.16	1.35
Berzy le Sec	3.75	5.25	2.40	2.56	1.60
N. Wood III	4	10.59	9.24		5.78
Beaupre Farm	4	2.79	1.18		0.74
Bouzancy River	4	6.60	1.51		0.94
N. Wood II	4.5	11.31	19.62		12.26
W. Wood I	6	20.75	23.22		14.51
Boursches I	6	12.46	10.79		6.74
Hill 142	8	13.15	9.03		5.64
Hill 252	8	5.53	5.68		3.55
N. Wood IV	11	6.13	3.35		2.09
W. Wood II	12	8.33	6.42		4.01
N. Wood I	12	9.60	20.57		12.86
Chaudun	12	8.07	19.43		12.14
La Neuville	12	6.34	6.49		4.06
Remilly	12	2.07	7.27		4.54
Exermont	14	6.60	7.10		4.44
Mayache	14	6.93	7.54		4.71
Average		8.05	7.45	7.92	4.95
Std Deviation			5.42	4.87	4.61

Table 2

Engagement	Length (hours)	Defender % Loss	CEV-Predicted Def % Loss	Adjusted by Time Factor	Revised to be Casualty Insensitive
Essen Hook	0.5	55.56	10.19	81.52	50.95
Cantigny	2	53.24	24.14	48.28	30.18
St. Amand	2	100.00	53.25	100.00	66.56
Mediah Farm	2	53.55	13.55	27.10	16.94
Boursches II	3	4.07	2.02	2.69	1.68
Yvonne-Odet	3.5	10.92	32.46	37.10	23.19
Berzy le Sec	3.75	33.14	35.43	37.79	23.62
N. Wood III	4	1.21	1.98		1.24
Beaupre Farm	4	32.04	90.62		56.64
Bouzancy River	4	49.82	40.07		25.04
N. Wood II	4.5	1.26	5.74		3.59
W. Wood I	6	4.82	14.18		8.86
Boursches I	6	13.76	15.24		9.53
Hill 142	8	19.16	21.81		13.63
Hill 252	8	11.00	18.67		11.67
N. Wood IV	11	28.27	23.67		14.79
W. Wood II	12	30.09	27.53		17.21
N. Wood I	12	15.01	28.53		17.83
Chaudun	12	62.50	100.00		62.50
La Neuville	12	3.14	12.27		7.67
Remilly	12	10.14	81.08		50.68
Exermont	14	5.90	8.62		5.39
Mayache	14	6.00	15.43		9.64
Average		26.29	29.41	36.52	23.00
Std Deviation			27.74	23.44	16.92

Battle	Side	Posture	Strength	Historical Losses	Model Prediction	Prediction x 4	Prediction at OLI = 1
Agbeluvoe Station	German	Attacker	236	45	6	26	7
	UK	Defender	150	10	8	32	7
Khra	UK	Attacker	429	75	47	188	127
	German	Defender	460	13	138	460	55
Tepe	UK	Attacker	120	6	10	40	10
	German	Defender	53	8	4	16	4
Garua	UK	Attacker	594	63	67	269	50
	German	Defender	425	21	30	121	40
Nsanakang I	UK	Attacker	240	3	9	35	8
	German	Defender	43	3	5	21	5
Nsanakang II	German	Attacker	500	126	52	210	24
	UK	Defender	251	158	15	61	37
Susa	German	Attacker	300	40	16	66	18
	UK	Defender	180	9	13	53	12
Kake	German	Attacker	120	10	4	16	4
	UK	Defender	60	20	15	59	14
Lisoka	UK	Attacker	15	0	1	4	1
	German	Defender	50	3	5	20	6
Average	Attacker			40.89	23.56	94.89	27.67
	Defender			27.22	28.59	93.67	20.00

With this in mind, we started looking for additional sources of good World War I battalion-level engagements. We found these in Africa—a very interesting theater indeed, as most battles were fought with European-led colonial troops. We have good secondary source data on battalion-level engagements in this theater because virtually every engagement in Africa was battalion-level or lower. We examined a large number of engagements, and performed some preliminary analysis on nine engagements, all from the campaigns in Togo and the Cameroon in 1914 and 1915. All the data comes from secondary sources, and while we have considerable confidence in the British data, we have much less in the German data.

We tested this data using an attrition multiplier of one and also using a multiplier of four. As we noticed that we were having problems with accurately predicting the winner and loser, we decided to rerun the engagements with every person having an OLI of 1—in effect, ignoring the weapons and just counting the people. The question we were trying to answer here is whether the OLIs are improving the predictive capability of the model or decreasing it.

For these engagements there were only three basic weapons systems in use: rifles, .30cal machine guns, and light field howitzers. In only one engagement did both sides have artillery. I suspect that the model does not properly balance the weighted value of the weapon systems relative to each other for the environment in which they are used. This may also mean that the model does not correctly

balance the weighted value of the weapons systems for this period. It could also mean that the model doesn't correctly balance the value of the weapons for any period or environment. The results are shown in Tables 3 and 4.

What is quite clear here is that the attrition multiplier of four doesn't work here. It appears to be far too high. If one inserted an attrition multiplier of 1.6, one would get an equally good fit for both the regular model prediction run and the runs where OLI=1. Just out of interest, the figures from such a manipulation are shown below. Again, I am not willing to reach any conclusions from this limited data.

Of course the implied assumption here is that one could not develop a “casualty insensitive” system using colonial troops. There were probably a lot of factors in the nature of the fighting in Western Europe that forced both sides to develop a very bloody and high casualty mode of fighting (Falkenhayn was basically basing his strategy on bleeding the French army to death in 1916). Certainly the motivation,

recruitment, effect of nationalism, mode of fighting and combat environment was very different in Africa than in Western Europe, and there is no reason that one would expect to see a “casualty insensitive” system develop in these African battles. Of course it could be that the natives of Africa were just a whole lot smarter than those Europeans.

But this does leave us with the anomalous scenario of using an attrition multiplier of four for WWI engagements in Europe, and no attrition multiplier for the other WWI

Battle	Side	Posture	Strength	Historical % Losses	Model Prediction	Prediction x 4	Prediction at OLI = 1
Agbeluvoe Station	German	Attacker	236	19.07	2.54	11.02	2.97
	UK	Defender	150	6.67	5.33	21.33	4.67
Khra	UK	Attacker	429	17.48	10.96	43.82	29.60
	German	Defender	460	2.83	30.00	100.00	11.96
Tepe	UK	Attacker	120	5.00	8.33	33.33	8.33
	German	Defender	53	15.09	7.55	30.19	7.55
Garua	UK	Attacker	594	10.61	11.28	45.29	8.42
	German	Defender	425	4.94	7.06	28.75	9.41
Nsanakang I	UK	Attacker	240	1.25	3.75	14.58	3.33
	German	Defender	43	6.98	11.63	48.84	11.63
Nsanakang II	German	Attacker	500	25.20	10.40	42.00	4.80
	UK	Defender	251	62.95	5.98	24.30	14.74
Susa	German	Attacker	300	13.33	5.33	22.00	6.00
	UK	Defender	180	5.00	7.22	29.44	6.67
Kake	German	Attacker	120	8.33	3.33	13.33	3.33
	UK	Defender	60	33.33	25.00	98.33	23.33
Lisoka	UK	Attacker	15	0.00	6.67	26.67	6.67
	German	Defender	50	6.00	10.00	40.00	12.00
Average	Attacker			11.14	6.95	28.00	8.16
	Defender			15.98	12.20	46.80	11.33
Std Deviation	Attacker				8.73	21.17	10.36
	Defender				21.5	46.76	17.16

engagements for no better reason than that it appears to work. The proposed alternative approach is that there is a multiplier of 1.6 to account for the increased lethality of weapons that accounts for all WW I era engagements, and a multiplier of 2.5 that accounts for the “casualty insensitive” systems that was used on the Western Front in WWI. I would have to collect and test a whole lot more data before I committed myself to any hypothesis on this. (Table 5)

Table 5								
Battle	Side	Posture	Strength	Historical % Losses	Model Prediction	Prediction x 1.6	Prediction at OLI = 1	OLI = 1 Prediction x 1.6
Agbeluvoue Station	German	Attacker	236	19.07	2.54	4.06	2.97	4.75
	UK	Defender	150	6.67	5.33	8.53	4.67	7.47
Khra	UK	Attacker	429	17.48	10.96	17.54	29.60	47.36
	German	Defender	460	2.83	30.00	48.00	11.96	19.14
Tepe	UK	Attacker	120	5.00	8.33	13.33	8.33	13.33
	German	Defender	53	15.09	7.55	12.08	7.55	12.08
Garua	UK	Attacker	594	10.61	11.28	18.05	8.42	13.47
	German	Defender	425	4.94	7.06	11.30	9.41	15.06
Nsanakang I	UK	Attacker	240	1.25	3.75	6.00	3.33	5.33
	German	Defender	43	6.98	11.63	18.61	11.63	18.61
Nsanakang II	German	Attacker	500	25.20	10.40	16.64	4.80	7.68
	UK	Defender	251	62.95	5.98	9.57	14.74	23.58
Susa	German	Attacker	300	13.33	5.33	8.53	6.00	9.60
	UK	Defender	180	5.00	7.22	11.55	6.67	10.67
Kake	German	Attacker	120	8.33	3.33	5.33	3.33	5.33
	UK	Defender	60	33.33	25.00	40.00	23.33	37.33
Lisoka	UK	Attacker	15	0.00	6.67	10.67	6.67	10.67
	German	Defender	50	6.00	10.00	16.00	12.00	19.20
Average	Attacker			11.14	6.95	11.13	8.16	13.06
	Defender			15.98	12.20	19.52	11.33	18.13
Std Deviation	Attacker				8.73	8.11	10.36	13.48
	Defender				21.5	24.19	17.16	15.94

All of these runs are done with the CEV for both sides equal to 1. From the literature, this is clearly incorrect, as in the early parts of the Togo and Cameroon battles the German colonial troops were better trained. As the campaign continued, the Germans relied heavily on native levies, and it would be expected that the quality of the troops then declined down to the level of the French and British troops, if not below it. When we have looked at the CEVs we have been getting virtually any type of number for both sides. For examples, the CEVs for these nine engagements are shown in Table 6.

While I have no problems with the CEVs of five of the engagements (Tepe, Garua Nsanakang I, Kake, and believe it or not, Lisoka), there are four engagements whose CEVs I simply cannot justify (Agbeluvoue Station, Khra, Nsanakang II, and Susa). When it came to predicting the casualties, the engagements in which the model had problems were Agbeluvoue

Engagement	British CEV	German CEV
Agbeluvoue Station	2.70	0.37
Khra	0.19	5.10
Tepe	0.91	1.10
Garua	0.71	1.40
Nsanakang I	0.59	1.70
Nsanakang II	0.15	6.80
Susa	2.30	0.43
Kake	0.77	1.30
Lisoka	6.50	0.15
Average	1.65	2.04

Station, Khra, Nsanakang II and Susa, so the “deviant” CEVs certainly reflect the engagements where the model was having a problem. Significantly, where we gave an OLI of 1 per man, it fundamentally corrected the losses for Khra to be a better prediction, reversing which side lost the most, and it did the same for Nsanakang II. The model also correctly predicted the outcome of these two engagements with this adjustment. In six of the remaining cases there were no

significant differences in the model run with or without OLIs and in the case of Garua, not using the OLIs made the prediction worse.

If one looks at the weapons at those battles, then the reasons for the concerns over the OLIs becomes apparent (Table 7).

It is obvious that two of our problem engagements are ones in which only the British had guns (Khra and Nsanakang II). These were our two worst prediction problems. Agbeluvoue Station was a confused night action that the Germans had really sort of botched with a series of unorganized piecemeal attacks. We also don’t have very good German data, so this may be “excusable error.” I cannot explain the problems with Susa, but again, here the German data is weak, as it is with all engagements in which the Germans were the attackers. If one looks at the win/loss predictions, one sees a similar pattern (Table 8).

As can be seen, the model predicted the correct winner in four of the cases, and with a proper CEV, would have predicted the correct winner in five out of nine cases. The four cases in which it was wrong were Agbeluvoue Station, Khra, Nsanakang II, and Susa. Where we assigned the OLI as equal to 1 per person, the model predicted the winner in eight out of nine cases, with only Agbeluvoue Station being a problem. Clearly, in the case of these engagements, the OLIs are causing problems with the model. Let’s look at this issue in more detail.

The first noticeable point is that the OLI of a British rifle is 1.363, the French rifle is 1.364, while the OLI of the German rifle is 1.661. The OLIs for UK and German machineguns were about the same (7.53 vs 7.485). This automatically gives the German a 22% advantage in any engagement with pri-

Engagement	British MGs	British Guns	German MGs	German Guns
Agbeluvoue Station	1			
Khra	3	3	9	
Tepe	2			
Garua	5	2	5	3
Nsanakang I	3			
Nsanakang II	5	2	6	
Susa	1		3	
Kake	1			
Lisoka			1	

Table 8					
Engagement	Attacker	Defender	Winner	Predicted Winner	OLI = 1 Predicted Winner
Agbeluvue Station	German	UK	UK	German	German
Khra	UK	German	German	UK	German
Tepe	UK	German	UK	-- draw --	UK
Garua	UK	German	German	German	German
Nsanakang I	UK	German	UK	UK	UK
Nsanakang II	German	UK	German	UK	German
Susa	German	UK	UK	German	UK
Kake	German	UK	German	German	German
Lisoka	UK	German	German	German	German

marily riflemen. This is certainly what caused the model to predict that the Germans would win Susa. When the OLIs were set at 1, then the UK was correctly predicted as the winner, although in both versions of the engagement, the attacker casualties were underpredicted. This engagement, like Agbeluvue Station, may have also had poor data for the Germans. Since our primary sources of data are British secondary sources, they tend to have good data for the British side, good data when they defeat the Germans and capture some people, and poor data when they are attacked by the Germans because they rarely capture anyone and certainly do not overrun the German positions. The other two engagements are certainly influenced by the unilateral presence of guns. A look at the OLIs of the engagements

Table 9							
Engagement	----- British Force -----			----- German Force -----			
	Weapon	Number	OLI	Weapon	Number	OLI	
Khra	Rifles	429	584.885	Rifles	460	764.060	
	MGs	3	22.590	MGs	9	67.365	
	Guns	3	2079.000	Guns	0	0.000	
Nsanakang II	Rifles	251	342.113	Rifles	500	830.500	
	MGs	5	37.650	MGs	6	44.910	
	Guns	2	1386.000	Guns	0	0.000	
Garua	Rifles	594	809.622	Rifles	425	705.925	
	MGs	5	37.650	MGs	5	37.425	
	Guns	2	1386.000	Guns	3	1383.000	

where guns are present is revealing (Table 9).

As can be seen here, at Khra and Nsanakang II, the artillery makes up 77% and 78% of the UK's OLIs respectively, while the machine guns make up 1% to 2% of the OLIs. This brings up one of the weaknesses of using an OLI, which is that it is a type of firepower score. You are really measuring two things with a single score. One is combat power, meaning its utility in forcing your will upon the enemy. The second is attrition capability, with attrition also being a primary tool of forcing your will on the enemy. The OLI is used to determine who wins and loses and also how many losses each side takes. One score for both purposes is clearly a compromise solution, but it is a compromise solution that works when both sides have forces of significant size that are mixed in a balanced manner. Keep in mind that the TNDM was designed to fight division-level engagements. As the model tries to resolve combat results at lower levels, this dual purpose use of the firepower score starts showing up as more of a problem.

No one doubts that mortars and artillery cause at least 50% to 60% of the casualties in ground combat, as this has been documented over and over again. It is quite clear that the OLIs for the artillery pieces are based upon this documentation, and one will note that in the three

engagements with significant artillery that they do indeed account for 60% to 80% of the OLI. But they clearly do not account for 60% to 80% of the combat power, for at Khra the Germans certainly didn't think that they were outgunned by 3 to 1 or they wouldn't have tried to hold that position. As it was, they held that day but they did withdraw the following day, and later surrendered without combat. By the same token, at Nsanakang II they attacked, even though the British had the guns, giving the British a 2-to-1 advantage according to the firepower score. The Germans obviously knew something about the utility of artillery that the model does not reflect.

Of course, there was not a problem with the modeling of the Garua engagement, as the artillery on each side conveniently cancels each other out, having almost the same scores.

At this point, we decided to take a step back on the original validation. We have contacted one of our consultants in Germany, Dr. Arthur Volz, and are getting better German data. This data may provide some adjustment to our modeling of the battles of Agbeluvue Station and Susa, among others. I have also decided to put the OLIs through the "acid test," so to speak. This will consist of us re-running all 76 engagements in the first validation with all the OLIs set at 1 per person. We will then compare those results with the original results and see which does better, and where one method predicts much better than the other.

Of course, I would be very interested in seeing how any other model performs with the engagements I've been using here. I've been deliberately picking "model busters" like the engagement at Lisoka just to see how the model acts in the extreme. If the TNDM gives reasonably good outputs with odd and unusual engagements, then we certainly will have more confidence in its ability to handle all engagements.



TDI Profile:

Dr. James G. Taylor



James G. Taylor is a professor of Operations Research at the Naval Postgraduate School (NPS), where he has twenty-nine years of teaching experience in various fields of operations research relating to military (particularly combat modeling) problems. He possesses a unique combination of both theoretical and practical military operations research, command-and-control, and intelligence experience, teaching experience, and research experience, all related to defense planning problems. He has specialized in a number of different areas, including the quantitative evaluation of combat operations and systems (in particular, combat models and systems effectiveness evaluation) and other defense planning problems. He has also specialized in Soviet military affairs, especially the Soviet control of systems and operations (military cybernetics), and he both speaks and reads Russian. Before the ending of the Cold War, he taught several courses at NPS concerning various aspects of Soviet military affairs at the SCI level.

Dr. Taylor's research interests include all aspects of combat models (from models of micro-combat processes such as target detection, fire assessment, etc. to detailed one-on-one simulations to aggregated theater-level models) and modelling of combat processes (including model architecture, systems analysis, and development of computer programs). His interests also include hierarchical considerations (i.e., hierarchies of combat models with "up links" and "down links"), model development (including systems analysis (e.g., system decomposition, functional analysis, system architecture), interface requirements, mathematical modeling, computer implementation, etc.), and use of models for the evaluation of weapons and tactics, exercise assessment, etc.

Dr. Taylor developed the prototype for the computer model of the Tactical Numerical Deterministic Model (TNDM), as a result of which he is thoroughly familiar with the late Col. (US Army Ret.) T.N. Dupuy's work. This prototype computer model evolved out of consulting work for Dr. Joseph Feary of the Jet Propulsion Lab (JPL) of the California Institute of Technology. Dr. Feary wanted a sounder basis for attrition in the Joint Theater-Level Simulation (JTLS), then under development by JPL, and thought that Col. Dupuy's work would provide this. Dr. Taylor is currently doing research on the so-called attrition calibration (ATCAL) methodology for assessing casualties in aggregated models for a number of DoD organizations, including the US Army Concepts Analysis Agency (CAA) and the Simulation and Analysis Center (SAC) of OSD PA&E.

Dr. Taylor has received international recognition for his research on the Lanchester theory of combat: he was awarded

the 1975 MAS Prize by the Military Applications Section (MAS) of the Operations Research Society of America (ORSA) and has frequently been invited to deliver assessments about the state of the art of combat modelling at both national (e.g., ORSA meetings, Military Operations Research Symposia, etc.) and international meetings. He was an associate editor of *Operations Research*, the journal of the Operations Research Society of America, from 1976 to 1978. He has been a Councilman of the Military Applications Section (MAS) of ORSA (1976–1978) and was the MAS Program Chairman for the San Francisco ORSA/TIMS meeting held in May 1977. Dr. Taylor is also a faculty member of Omega Rho (the International Honorary Society for Operations Research). He also served as an Associate Editor for *Naval Research Logistics Quarterly* from 1976 until 1983.

Dr. Taylor has written two books on combat models, *Force-on-Force Attrition Modelling* and *Lanchester Models of Warfare*, vol. 1 & 2, both published by MAS of ORSA. His various theoretical interests (including the mathematical properties of combat models and the optimization of combat dynamics) have resulted in numerous (over fifty) publications in various technical journals. His educational background includes a B.S. (with Great Distinction), M.S., and Ph.D., all in Petroleum Engineering from Stanford University in 1961, 1962, and 1966 respectively. The latter degree includes a Ph.D. minor in mathematics. Recipient of numerous academic honors, he was a National Science Foundation Cooperative Fellow for three years at Stanford University. He was elected to Phi Beta Kappa in 1960 (in his junior year of college) and Sigma Xi. Dr. Taylor speaks and reads French, German, and (particularly) Russian. Currently he is learning Japanese. ☎



Dr. Taylor is an admirer of the famous mathematician David Hilbert.



Iranian Casualties in the Iran-Iraq War: A Reappraisal



Also in this issue:

- Time and Breakpoints in the TNDM
- Some Thoughts on the Mobility Equation
- A Look at the OLI of APCs, ACs, IFVs, and CFVs
- The TNDM OLI Database

INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this issue of our newsletter Christopher Lawrence, Richard Anderson, José Perez, Susan Rich, and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically-based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

- (1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;
- (2) Training, cultural and psychological profiles, and flow of information;
- (3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in-house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically-based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.



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IN HONOR OF THE MEMORY OF THE LATE

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From the Editor...



The lead article in this issue comes from Bill Beuttel at Boeing. In addition to his work using the QJM, which he discussed in Volume 2, Number 1, Mr. Beuttel has done some private research on the Iran–Iraq War. This war is the largest conventional conflict since WWII. I find it significant that this war produced a stalemated military situation using modern weapons. The impression is often given that all modern warfare is dramatic campaigns like The Gulf War or the 1967 Arab–Israeli War. Modern warfare can also achieve stalemated situations as happened in the Iran–Iraq War and as almost happened in the Arab–Israeli War of 1973. “Blitzkrieg” is not created by weapons and technologies, it is created by a combination of the proper application of those weapons and technologies by one side and military incompetence by the other side.

The article on “Time and Breakpoints in the TNDM” is a result of a request by one of our users to look into the way his organization is using the TNDM. They are using the TNDM as an attrition calculator in a larger model they have, and have come up with a novel way for determining battle length and breakpoints. This article tries to address whether this is really a valid approach.

Next there are four articles related to the problems created by the revised armor OLIs. I suspect the solution to the problem now is that we need to revise the armor value formula to adjust the weight tables by historical period, as it appears the primary problem with the revised armor values is that they were done for modern weapons, and no attempt was made to address the WWII period. This is discussed in “The Current Status of OLIs” article and will be addressed in more depth in the next issue.

We have also included a request for help from our readers to fill our HERO files. There are 29 “reports” that we do not have copies of. Of those, three are books, three we do not know the names of, and at least six are classified (we are not set up to store classified material). We are hoping that people may have copies of some of these other reports and will forward copies to us. Can’t hurt to ask.

Finally, for our “Who is TDI” profile, it is time to properly introduce Dr. George A. Daoust, the Chairman of our Board. Col./Dr. Daoust has been with the Institute since the beginning (1992), when he and Trevor N. Dupuy, operating out of Col. Dupuy’s basement, set up TDI from the ashes of his previous for–profit company (which obviously didn’t make a profit). I think of it as “re–establishing HERO” as a realistic entity (meaning non–profit, which was the case of all the previous for–profit companies). Col. Daoust has had a varied career ranging from leaping out of perfectly operating airplanes to being an Assistant Secretary of Defense. Col. Daoust has been one of the mainstays of this organization over the last six years.

We have assembled two deliverables for our annual support contract subscribers. One is the latest version of the TNDM, version 2.03, which is a minor update that corrects some small programming errors. The most important change it that is now allows one to properly use the multiple directory option. We have set up our OLI database so that there is a separate directory of weapons for each era. José Perez is already working on version 2.04 (we’ve spotted a few more minor errors). The other deliverable is the disk of all 1,644 OLIs that we have assembled. It is described in the article “The Current Status of OLIs”. We now keep them in separate files for Pre–WWI, WWI, WWII, 1970s, and modern weapons. It is delivered to the customer as five separate files. We expect to update these OLI files further as we continue the battalion–level validation and we will provide these updates to our support contract holders. Hopefully our users will find them useful.

For the next issue, we will have another article from Bill Beuttel called “Causes of Casualties in the Iran–Iraq War (1980–1988).” It is effectively a continuation of the article in this issue. Also, one of our TNDM users has promised me an article on how he is using the model.

The articles addressing a TNDM analysis of the Battle of Dom Bütgenbach have been yet further delayed as both Jay Karamales and I have been distracted by other issues. We should hopefully have it ready for the next issue. We intend to conduct it as an analysis of a multi–day division–level battle, and then fight the battle the way it occurred: as a series

of battalion-level engagements. We will then compare the model results to the historical results. This test is also considered to be part of our ongoing validation effort.

As always, I expect to include some articles in the next issue on our battalion-level validation work. We have still to conduct our analysis of the advance rates and to compile a summary conclusion from the first validation. We also need to test all these changes to our second battalion-level validation data base of 123+ battles from 1914 through 1991. Right now, though, we are going back through the TNDM and running the initial 76 battles not using the OLIs (i.e., every man has a OLI of 1 and no weapons are counted). We are then going to compare them to the runs using the OLIs and see which predicts better. While this will not “validate” the OLIs *per se*, if the runs using the OLIs predict better than the runs without them, then we must conclude that the OLIs are helping to improve the predictive capability of the model. If the reverse is the case, well...

That is all for now. If you have any questions, please contact me. Addresses, E-mail addresses, and phone numbers are in the masthead. 



Iranian Casualties in the Iran–Iraq War: A Reappraisal

by H.W. Beuttel



The Iran–Iraq War was the longest sustained conventional war of the 20th Century. Lasting from 22 September 1980 to 20 August 1988, the seven years, ten months, and twenty–nine days of this conflict are some of the least understood in modern military history. The War of Sacred Defense to the Iranians and War of Second Qadissiya to Iraqis is the true “forgotten war” of our times. Seemingly never ending combat on a scale not witnessed since WWI and WWII was the norm. Casualties were popularly held to be enormous and, coupled with the lack of battlefield resolution year after year, led to frequent comparisons with the Western Front of WWI. Despite the fact that Iran had been the victim of naked Iraqi aggression, it was the Iraqis who were viewed as the “good guys” and actively supported by most nations in the world as well as the world press.

Studying the Iran–Iraq War is beset with difficulties. Much of the reporting done on the war was conducted in a slipshod manner. Both Iraq and Iran tended to exaggerate each other’s losses. As oftentimes Iraqi claims were the only source, accounts of Iranian losses became exaggerated. The data is highly fragmentary, often contradictory, usually vague in particulars, and often suspect as a whole. It defies complete reconciliation or adjudication in a quantitative sense as will be evident below.

There are few stand alone good sources for the Iran–Iraq War in English. One of the first, and best, is Edgar O’Ballance, *The Gulf War* (London: Brassey’s, 1988). O’Ballance was a dedicated and knowledgeable military reporter who had covered many conflicts throughout the world. Unfortunately his book ends with the *Karbala -9* offensive of April 1987. Another good reference is Dilip Hiro, *The Longest War: The Iran–Iraq Military Conflict* (London: Paladin Books, 1990). Hiro too is a careful journalist who specializes in South Asian affairs. Finally, there is Anthony Cordesman and Abraham Wagner, *The Lessons of Modern War Volume III: The Iran–Iraq War*, (Boulder, CO: Westview Press, 1990). This is the most comprehensive treatment of the conflict from a military standpoint and tends to be the “standard” reference. Finally there are Iranian sources, most notably articles appearing since the war in the *Tehran Times*, *Iran News*, the Islamic Republic News Agency (IRNA) and others.

This paper will approach the subject of losses in the conflict from the Iranian perspective. This is for two reasons. First, too often during the war Iraqi claims and figures were uncritically accepted out of prejudice against Iran. Secondly, since the war the Iranians have been more forthcoming about details of the conflict and though not providing direct figures, have released related quantified data that al-

lows us to extrapolate better estimates.

The first installment of this paper examines the evidence for total Iranian war casualties being far lower than popularly believed. It will also analyze this data to establish overall killed to wounded ratios, MIA and PoW issues, and the effectiveness of chemical warfare in the conflict. Later installments will analyze selected Iranian operations during the war to establish data such as average loss rate per day, mean length of engagements, advance rates, dispersion factors, casualty thresholds affecting breakpoint and other issues.

Casualties as Reported and Estimated

Too often incorrect formulae were applied to calculate casualties or the killed to wounded ratio. The standard belief was that Iran suffered two wounded for every killed—a ratio not seen since the ancient world. Colonel Trevor N. Dupuy established that the average distribution of killed to wounded in the 20th Century warfare is on the order of 1:4 and in fact this relationship may be as old as the year 1700.¹ In Operation Peace for Galilee of 1982 the Israeli ratio of killed to wounded was on the order of 1: 6.5 while the Syrian was 1: 3.56.² At the same time in the Falklands UK casualty ratio was 1: 3. For Argentine ground forces it was 1: 4.85.³ Also it was assumed that Iran must have suffered 3–4 times the casualties of Iraqi forces in many given engagements on the basis of no good evidence this author can find.

Typical western estimates of Iranian losses in the war are given below:⁴

	Low End	High End
KIA	450,000	730,000
WIA	600,000	1,200,000
Total	1,050,000	1,930,000
PoW		45,000

The lowest estimate of Iranian KIA was from the Pentagon which estimated the killed (military and civilian) at 262,000.⁵

At the end of 1980 the Iraqis claimed 4,500 Iranian KIA and 11,500 WIA.⁶ Iraqi claims as of 22 September 1981 were 41,779 Iranian KIA.⁷ By the end of August 1981 other estimates placed it as 14,000–18,000 KIA and some 26,000–30,000 WIA.⁸ Alternate estimates placed this at 14,000 KIA

and 28,000 WIA.⁹ Still others claimed 38,000 KIA.¹⁰ During the first half of 1982 estimate was 90,000 Iranians killed.¹¹ Iran's casualties in its 1984 offensives resulted in 30,000–50,000 more KIA.¹² In mid-1984 Iran's KIA were 180,000–500,000 and WIA 500,000–825,000.¹³ By 23 March 1985 Iranian KIA may have been 650,000 with 490,000 “seriously” wounded.¹⁴ In September 1986 the count of Iranian dead was 240,000.¹⁵ By April 1987 Iran had 600,000–700,000 KIA and twice that number wounded.¹⁶ Iraq claimed 800,000 total Iranian KIA at the time of the cease-fire.¹⁷ Figure 1 graphically depicts this reporting.

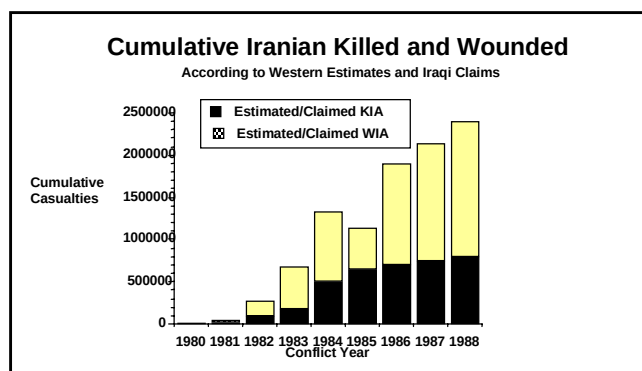


Figure 1: Western Estimates and Iraqi Claims

Official Iranian statistics released on 19 September 1988 immediately after the cease fire listed the following casualty figures:

Killed in Action: 123,220
 Regular Army: 35,170 (29%)
 Pasdaran: 79,644 (65%)
 Paramilitary: 8,406 (6%)

Died of Wounds: No Official Figures, Assumed Contained in Above

Wounded in Action: No Official Figures

“Missing in Action”: 60,711 (actually included possible MIA and PoW)

PoWs: ~ No precise figure for status. Included in “Missing in Action”

Non-Battle Deaths, Injuries etc.: No figures

Civilian Deaths Due to Enemy Action: ~ 11,000

Civilian Wounded Due to Enemy Action: ~ No Official Figures but > 34,000

Chemical Casualties: ~ 100,000
 Chemical KIA: “25,000” (sic, 2,500 see below)
 Military: ~ 45,000
 Civilian: ~ 45,000
 “Other” (Probably friendly Kurds): ~ 10,000

Iranian Missing in Action: Wanted Dead or Alive

By 1995 Iran had conducted seventeen dedicated MIA retrieval operations from wartime battlefields. Approximately 80% of the MIAs are believed to lie in Iraqi territory. In that year Iran proposed a joint Iranian–Iraqi accord to retrieve the missing of both sides.¹⁸ Brigadier General Mir Feisel Baqerzadeh and IRGC Brigadier General Behahim Safaie head the Special Commission for MIA Retrieval. Iran claimed to have recovered or settled some 21,000 cases by early 1995. In that time 2,505 MIAs had been retrieved by joint search operations in Iraq and another 12,638 in Iranian territory, the latter representing 85% of those estimated missing in Iranian held ground. Back calculating these figures indicates total Iranian missing was now regarded as 72,753, up 20% from the original figure of 60,711. By October 1996 the count was 24,000 retrieved.¹⁹ By June of 1997 the number of MIA cases resolved had risen to 33,000 including 6,000 death certificates issued at family request for individuals of whom no trace had ever been found.²⁰ As of September 1997 the total number of MIA bodies recovered stood at over 37,000 according to Brigadier General Baqerzadeh.²¹ “Martyr” (i.e. killed in action) status entitles the family to a \$24,000 lump sum death benefit as well as a \$280 monthly pension with provision for \$56 a month for each dependent child from the Foundation for the Martyrs.²²

The rate of actual forensic identification of the remains is unknown. One source mentions a positive identification of some 900. The standard practice seems to be determination of the operation in which they were martyred and the provincial origins of units in that engagement. Wartime operations which have yielded large numbers of MIA remains are *Beit ol-Moqqadas-4*, *Kheiber*, *Karbala-4*, *Karbala-5*, *Karbala-6*, *Karbala-8*, *Karbala-10*, *Ramazan*, *Badr*, *Kheiber*, *Muslim Ibn-e Aqil*, *Wal Fajir Preliminary Operation*, *Wal Fajir-1*, *Wal Fajir-2*, *Wal Fajir-6*, *Wal Fajir-8*, *Fath-5*, and the Iraqi attacks on Majnoon and Shalamech. The retrieval operations are often dangerous and occur in former minefields. As of 1995 eleven IRGC personnel had been killed and fourteen seriously wounded in MIA retrieval operations. Individual military units often recover their own MIAs. In a speech at Gurgan, Ali Mirtaheri, head of the committee in charge of search teams for MIAs of the 27th *Hazrat-e Rasul Pasdaran* Infantry Division, stated in November 1997 that divisional teams had recovered 1,610 MIA bodies. Forty-two team members from the division have been killed and another eighty maimed in the operations (probably from leftover mines).²³

Due to the number of cases and the vigorous retrieval operations MIA funerals tend to be mass affairs. Burials in Tehran alone tell the story. In October 1993 208 were buried in Tehran and 360 in other locations. In October 1994 1,000 martyrs were buried in Tehran; in April 1995 another 600 of 3,000 just recovered MIAs and the following month 405 more in Mashad; in October 1995 600 were interred; 750 in October 1996; 1,000 more in January 1997; in July 1997 another 2,000 including 400 from Tehran Province were

interred nationwide; in September 1997 200 of 1,233 interred nationwide, including 47 in Qazvin, 34 in Khuzistan, 5 in Shustar and 5 in Sistan–Baluchistan. Of these only 118 were unknowns.²⁴ Unrecovered Iranian MIAs are carried as active soldiers on their unit personnel rolls with their current status listed simply as “still at the front.” Iran has also recovered Iraqi MIAs, returning up to 400 bodies at a time in a mutual exchange program usually accomplished at the Khosrawi border station in Kermanshah Province.²⁵ A total of 31,000 Iraqi bodies have been so returned compared to 2,500 Iranian dead returned by Iraq as of January 1997.²⁶ In January 1997, in conjunction with the Iraqi return of the remains of sixty Iranian MIAs of the *Wal Fajir* Preliminary Operation, Brigadier General Mir Feisel Baqerzadeh stated that Iran was willing to assume all search responsibilities and associated costs for both Iraqi and Iranian MIAs on Iraqi territory should Iraq not wish to continue recovery operations.²⁷ In May 1997 Brigadier General Mohammed Balar, spokesman for the Commission for Iranian PoWs, called on international organizations to pressure Iraq to clarify the status of 20,000 Iranian MIAs.²⁸

Actual Numbers of PoWs and Missing in Action

By January 1982 Iran held some 28,423 Iraqi PoWs to Iraq’s 5,285 Iranian captives.²⁹ In early 1984 Iran held 50,000 Iraqis to Iraq’s 7,300 Iranian PoWs.³⁰ In August 1986 Iran claimed to hold some 52,000 Iraqi PoWs.³¹ Just before the cease–fire in 1988 the International Commission of the Red Cross (ICRC) estimated 49,285 Iraqi PoWs in fifteen Iranian camps and 12,747 Iranians in ten Iraqi camps.³²

On 9 August 1988 the ICRC count was 50,182 Iraqi PoWs held in Iran to 13,526 Iranians in Iraqi captivity.³³ Iran had at least 8,500 captured in the final Iraqi offensives of July 1988 and another 700 on 23 August 1988 immediately after the cease–fire went into effect.³⁴ PoW release had begun long before the war ended. In August 1986 Iran had released 200 Iraqi PoWs and had unilaterally released some 620–650 previously.³⁵ By 18 October 1988 Iran and Iraq had agreed to begin PoW exchanges. Beginning 30 October 1988 each side exchanged 25 PoWs. Eight of the 25 Iranians were civilian internees captured early in the war.³⁶

On 10 November Iran and Iraq agreed again to the exchange of 1,118 Iraqi and 411 Iranian PoWs who were badly wounded or ill.³⁷ However, after 156 Iraqis and only 57 Iranians had been released the exchange broke down by 27 November over 63 Iraqis who refused repatriation.³⁸ In January 1989 Iran released 131 sick and wounded Iraqis and Iraq reciprocated by releasing 124 Iranians.³⁹ In February Iran offered to release another 260 ill Iraqi PoWs. One hundred fifty–eight were released, but 27 refused to return.⁴⁰ In March 1989 the more or less official count of PoWs was 50,000 Iraqi to 18,902 Iranians.⁴¹ Iran, on 10 April, released 70 disabled and sick Iraqi PoWs and on 23 May a further 49 plus 15 other PoWs of varied nationalities who fought for Iraq.⁴² No further activity occurred until December when Iran proposed more sick and disabled PoWs be exchanged and sug-

gested that a substantial number of Egyptian nationals were among the PoWs it held.⁴³ Eventually on 14 March 1990 Iran released twenty Egyptians captured fighting for Iraq.⁴⁴

It was not until after Iraq’s invasion of Kuwait that the PoW issue came alive again. On 15 August 1990 Saddam Hussein offered to release all Iranian PoWs. He further allowed 17,000 Iranian nationals in Kuwait to return home. By 23 August PoW exchanges were running at 6,000 a day and some 21,000 Iraqi and Iranian PoWs had been repatriated.⁴⁵ By 4 September 23,798 Iranian and 24,250 Iraqis had been released.⁴⁶ On 16 November the two countries agreed to another exchange of 100 PoWs a day and a group of 200 Iraqis was released on 4 December, another group of 200 on 10 December 1990.⁴⁷ There is no record of Iranian PoW releases by Iraq in this time period. However, a total of 39,043 Iranian PoWs were eventually released.⁴⁸

On 1 June 1991 Iran claimed Iraq was still holding at least 5,000 Iranian PoWs, an assertion Iraq denied. When Iran repeated the claim in October, Iraq admitted it had 400 who refused repatriation.⁴⁹ During the 1991–92 time frame another 64 Iranian soldiers became PoWs during fighting with the NLA and Kurdish groups supported by Iraq.⁵⁰

Then in early 1991 some 5,000 Iraqi soldiers crossed into Iran to evade coalition forces in the Desert Storm War. Beginning in November 1992 Iran released 400, followed by releases of 1,000 (April 1993), 400 (May 1993), 450 (June 1993) and 459 (July 1993). Eventually 4,115 were released in fourteen intervals with the last known release bringing the total to 4,574.⁵¹ At the same time Iran released 100 Iraqi PoWs from the War of Sacred Defense in May 1993.⁵²

At that time the ICRC claimed to have had overseen the repatriation of over 80,000 PoWs held by both Iran and Iraq.⁵³ This figure is not borne out by the published numbers. At this time the maximum number of Iranian and Iraqi PoWs released from both the Iran–Iraq and Desert Storm wars stood at about 92,267, a discrepancy of 12,000. Some of the 17,000 repatriated civilian internees of the Iraqi invasion of Kuwait may have been counted. The ICRC still had some 19,000 Iraqis and 4,000 Iranians on its books as active PoWs.⁵⁴

By July 1992 the only exchanges were those of 101 MIA bodies.⁵⁵ In December 1993 Iran complained Iraq was still holding 8,000 Iranian PoWs. The proof was that 26 Iranian civilian internees from the war had escaped and made it back to Iran that same month.⁵⁶

In January 1994 Iran conceded that many of the personnel it listed as PoWs may have been KIA/MIA.⁵⁷ Then in July 1994 Iran accused Iraq of holding 16,000 Iranian PoWs.⁵⁸ According to the Red Cross Iran continued to hold as many as 19,000 Iraqi PoWs as of 1994.⁵⁹ In 1994 the ICRC calculated 4,168 confirmed Iranian PoWs still in Iraq and some 475 other unaccounted for Iranian PoWs.⁶⁰

In August 1995 the Iraqis complained Iran still held 7,000 of their PoWs.⁶¹ That same month Iran released 100 PoWs. The ICRC claimed at that time it had overseen the repatriation of 82,000 of 100,000 known PoWs of the war.⁶² MIA exchanges continued with Iraq returning 144 dead and Iran 200 in June 1996.⁶³ Since then Iran released 150 of Iraqi

PoWs as late as 28 October and 724 on 27 December 1996 making a total of 974 that year.⁶⁴ Iraq insisted there were still 20,000 Iraqis captive in Iran.⁶⁵

In January 1997 the two nations exchanged 60 Iranian and 70 Iraqi MIA remains, but Iraq again insisted Iran held 17,000 of its PoWs.⁶⁶ In August 1997 Saddam Hussein claimed Iran still held 20,000 (1997 ICRC figures about 13,000) Iraqi PoWs. He also claimed that all 39,000 Iranian PoWs held by Iraq had been freed except for a pilot downed during the early part of the war who was still being held as proof Iran started the whole thing.⁶⁷ The Iranians countered that 5,000 Iraqi PoWs had requested and been granted asylum in Iran which more or less agrees with 1994 ICRC figures for total remaining Iraqi PoWs (19,000 – 5000 = 14,000).⁶⁸ In September 1997 47 more Iraqi PoWs were released.⁶⁹ In total Iran has released some 48,650 Iraqi PoWs.⁷⁰ In November 1997 Iran approved release of another 500 Iraqi PoWs.⁷¹

Speaking in September 1997 Brigadier General Abdullah Najafi, chairman of the Iranian PoW commission, stated that “not even a single Iranian PoW has been released by the Iraqi regime in the past five years.”⁷² This suggests that some may have been released as late as 1992, but this author can find no record of this. The cold fact remains that since 1990 (or 1992 at the latest), no known living Iranian PoW has been recovered. 27,000 remains of MIAs have with another 39,000 estimated. A chronology of this confusing and somewhat contradictory chain of events is given below.

August 1988 ~ Official Iranian “missing”: 60,711

August 1988 ~ Known Iranian PoWs at Cease-fire (ICRC): 13,526

Aug 88- Jan 89 ~ Known Iranian PoWs Released: 206

Mar 1989 ~ Known Iranian PoWs Still Held (ICRC): 18,902

Mar 1989 ~ Possible Maximum Iranian PoWs Held: 18,902 + 206 (released) + 9,200 (captured at very end and after) = 28,308.

Jan 1990 ~ Maximum Known Iranian PoW ~ 18,902 + 206 = 19,108

Sep 1990 ~ Known Iranian PoW Release: 23,798

Sep 1990 ~ Total Iranian PoW Release: 23,798 + 206 = 24,004 (26% more than known in Jan 89)

Jan 1991 (?) ~ Total Iranian PoW release 39,043. (50% more than known in Jan 89)

Jun 1991 ~ Iran claims 5,000 still held. If so, total PoW was 5,000 + 39,043 = 44,043.

Dec 1993 ~ Iran Claims 8,000 PoW still held. If so, total PoW was = 39,043 + 8,000 = 47,043.

Jan 1994 ~ Iran admits “many” PoWs may be MIA/KIA.

Jul 1994 ~ Iran claims 16,000 PoWs still held. If so, total PoW was 39,043 + 16,000 = 55,043.

Jun 1995 ~ 21,000 MIAs recovered. Iran estimates total missing (and presumed dead) at 72,753, leaving 51,753 missing in action unrecovered.

Oct 1996 ~ 24,000 MIAs recovered. Revised Iranian hopeful estimates list 20,000 more MIA (dead) and 30,000 PoWs still unreleased. If so, total PoW was 39,043 + 30,000 = 69,043.

May 1997 ~ 27,000 total MIA recovered. 33,000 total cases resolved. Residual missing now 39,753. Iran calls on Iraq to clarify status of “20,000 PoW/MIA.”

Jun 1997 ~ Iran again claims 5,000 PoW still held.

Oct 1997 ~ Remains of over 37,000 MIAs recovered.

This author’s figures (admittedly incomplete) indicate the release of 92,267 PoWs (plus 547 more Iraqis as of November 1997) by both sides resulting from the Iran-Iraq and Desert Storm conflicts. If ICRC figures for “PoWs” (which seems to include PoWs and CIs from both conflicts) are correct 18,000 are still unreleased. Their own figures list 13,000 Iraqis and 5,000 Iranians still unreleased which makes up the difference.

It is the opinion of this author that, aside from the 400 expatriates Iraq admitted, that the “5,000” Iranian PoW and “20,000 PoW/MIA” still unaccounted for will be shown to be KIA (dead on the battlefield or died in captivity) as recovery operations proceed (20 more were delivered to Iran in June 1997 and another 15 in August). The alternate possibility is that some or most of these personnel now serve in the NLA or other Iraqi supported resistance groups and their identities and existence are concealed for this reason. There is no real evidence that such a large number of living Iranian PoWs are still being held by Iraq. Another chilling possibility recently raised is that some Iranian PoWs may have disappeared into the Iraqi biological weapons programs as human guinea pigs.⁷³

[Author’s note: As this article went to press I uncovered a small piece of information from 1988. In reference to some of the Iranian MIAs being defectors to the Iraqi-sponsored NLA, the Iranians estimated that as many as 3,000 of their troops may have defected while PoWs in Iraq. They have never mentioned this since. Also 136 Iranian soldiers were arrested and shot for desertion.]

The continued Iranian insistence on 5,000 possible remaining PoWs may also be related to the 6,000 missing de-

clared dead at family request without recovery of a body. In an interesting turn to usual practice, the families seem to have given up hope before the government has lost interest.

Further complicating the matter, Iran seems to have lost control of its accounting procedures. Originally listing 60,711 “missing” in 1988, this increased to 72,753 estimated MIA by 1995. If we combine the 39,048 released PoWs with 72,753 estimated MIA, Iran actually had some 111,801 PoW/MIA during the war or 84% more than they first thought. If there are 5,000 Iranian PoW still held by Iraq then the total would be 116,801 or 92% higher than estimated.

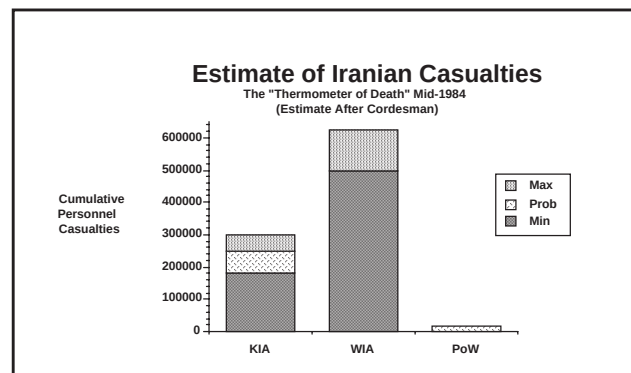
The answer to this poor accounting probably lies in the overall organization for combat employed by Iranian forces during the war. In addition to the regular army and *Pasdaran*, Iran employed a third component called the *Baseej*. The *Baseej al Mostafazim* (Mobilization of the Oppressed) was founded as a wartime expedient to augment the IRGC and formally placed under their control in January 1981. *Baseej* formations comprised 300-man battalions divided into 100-man companies with 22-man platoons armed with light weapons.⁷⁴ Their functions were IRGC reinforcement in the war. *Baseej* units fought extensively in the War of Sacred Defense (1980–88). However, their availability was only episodic as their tour of duty was normally only three months, usually from January to March. At this time most *Baseej* were rural peasants, often very young (some only 10) or very old and illiterate, who had to return for spring planting and fall harvests. As a result their training was rudimentary, often as little as two weeks of small arms and hand grenade practice. It was the *Baseej* who were given plastic keys to hang around their necks with the promise these would unlock the gates of paradise if they were killed in action.⁷⁵ As many as two million *Baseej* forces saw combat in the imposed war with Iraq.⁷⁶

When the Iranian government offered its original tally of dead and missing in 1988 the *Baseej* losses were not mentioned separately and assumed to fall under the category of *Pasdaran*. It was only after the war when most (if not all) Iranian PoWs had been released and the magnitude of the MIA issue became evident that Iran realized it had suffered far more losses than originally thought. It is likely the degree of *Baseej* unit administration and accountability was far below regular army or established *Pasdaran* formations. Given the episodic nature of their participation, widespread personnel illiteracy and their poor level of training (and the fact they were used as temporary human “fill” for *Pasdaran* formations), it is unlikely that unit returns were maintained in anything like a proper or organized manner.

This author believes that the bulk of the additional true MIAs claimed since the end of the war are represented by primarily *Baseej* fallen who were simply not originally accounted for in established *Pasdaran* or regular army unit returns. *Baseej* units made up to 40% of Iranian force strength during the war. The 73,000 now-claimed missing (and presumed dead) of the war represent 38% of the total known and presumed combat dead (circa 188,000—see below). This is too close to be accidental.

Killed and Died of Wounds.

As early as 1984—only half way through the war—estimates of Iranian casualties were wildly exaggerated as equally as wildly divergent. Figure 2 illustrates this so-called “Thermometer of Death” widely believed in the West.



Of 72,753 currently estimated MIAs virtually all are probably KIA. When this is added to the official KIA count of 123,230 we arrive at a total of 195,983 fallen.

Another clue for total KIA total comes from the *Behesht-e Zahra* Military Cemetery in Tehran. In this cemetery rest 36,000 fallen from Tehran Province alone.⁷⁷ The Iranian Army was (and is) a territorially based and mobilized entity. Depending on population base, the regions and provinces support various numbers and echelons of operational units. For example, the entire 1st Sarollah Corps is mobilized in Region 10 (Tehran) which has the largest population base. Kerman province, which is far less populous, is home to only the 41st Sarollah Division and the Zulfiqar Brigade.⁷⁸ Given this fact we may postulate that total casualties of all provinces are proportional to their populations. If so, the 36,000 KIA from Tehran Province (about 20% of Iran’s total population) represents about 20% of total KIA. This leads us to the calculation Total KIA = 36,000 * 5 = 180,000. This proportion is also confirmed by the mass ceremony for 3,000 recovered MIAs in February 1995. Six hundred of these were from Tehran Province, 20% of the total count in this instance.⁷⁹ Again when 1,200 martyrs were buried nation wide in October 1997, 112 (or 17%) were from Tehran Province.

If we do a simple average of the two figures we arrive at somewhere in the vicinity of 188,000 KIA. The minimum is too low as all MIAs are not yet accounted for. I use the average rather than the maximum as I feel that probably several thousand of the missing were defectors or collaborators who joined the ranks of the Iraqi sponsored National Liberation Army of Iran. Iran recruited at least 10,000 Iraqi PoWs into their “Badr” Army of Iraqi expatriates to fight against Saddam Hussein.

The Moshen Rezai Excursion

In September of 1997, outgoing commander of the *Pasdaran*, Major General Moshen Rezai, cited some compelling statistics on Iranian casualties in the War of Sacred

Defense. Speaking of the IRGC, he claimed some 2,000,000 *Pasdaran* served in combat over the course of the war. Of these 150,000 were martyred, 200,000 permanently disabled.⁸⁰ Taken at face value, these figures suggest KIA totals far higher than released in 1988. The *Pasdaran* are cited as taking some 90% more KIA than disclosed at war's end. If the proportion is the same for the regular army, then it must have suffered some 66,000 KIA and paramilitary deaths were on the order of 16,000. The total KIA would stand at 232,000. Another question is whether Rezai counted the MIAs, and if so how many were *Pasdaran* (and *Baseej*)? If he did and the proportion is constant (69%) then some 23,000 of 33,000 cases recovered or settled were *Pasdaran* (or *Baseej*). This in turn boosts the count by at least 11,000 (counting regular army and paramilitary recovered MIAs) to about 243,000. As there are at least 39,000 still missing (and presumed dead) the final tally would be on the order of 282,000 military and paramilitary dead.

On the other hand Major General Rezai may have been speaking somewhat loosely to exaggerate his component's contribution. He has been known to exaggerate before. The number of 150,000 KIA matches the sum of the announced dead (123,220) at war's end plus officially announced recovered MIA *bodies*—27,000 as of June 1997—(remember: 6,000 MIAs have been simply declared dead at family request). $123,220 + 27,000 = 150,220$. The remaining estimated 39,000 residual MIAs would bring the total count of military combat dead to 189,000 in line with above estimates.

Possible Clues to Non-Battle Deaths

Another piece of indirect evidence comes from the vast quantities of Iranian equipment captured by Iraqi forces between March and July 1988. These losses included 1,298 tanks, 155 infantry fighting vehicles, 512 armored personnel carriers, 365 pieces of artillery, 300 anti-aircraft guns, 6,196 mortars, 5,550 recoilless rifles, 8,050 RPG-7s, 60,164 assault rifles, 322 pistols, 501 engineer vehicles, 6,156 radios, 2,054 trucks and light vehicles, 16,863 items of NBC defense equipment and 24,257 caskets.⁸¹ It is the caskets which are of interest.

These were obviously intended for Iranian dead. For an army that popular imagination saw as taking 10,000 dead in a single battle this was a paltry number. In early 1988 Iran had 600,000 troops on the battle front. 24,000 represents only 4% of this number. Interestingly, if this author's

calculation of Iranian KIA at circa 188,000 is correct, annual average war deaths would be roughly $188,000 / 8$ or 23,500, almost the exact number of caskets. However, the Iranians did not know they were actually taking this many dead. They listed only 123,220 KIA at war's end, not realizing how many "missing" (PoW/MIA) they really had and that over half of these were, in fact, dead. Expected annual war dead under their original figures would have been $123,000/8 = 15,000$. This figure is 40% less than the casket cache total, but probably represented an Iranian planning factor for annual graves registration requirements at the front, but with a 60% hedge?

Sixty percent seems somewhat excessive. 10–25% is a more normal "fudge" factor. It may, however, provide a clue to the rate of Iranian non-battle deaths which would require caskets too. In the latter case this would indicate a non-battle to (then known) battle deaths ratio of roughly .6. This would represent something like 74,000 non-battle deaths (accident, disease etc). Ground truth ratio (with now known MIA dead) would be .39. This is almost identical to US experience in WWII (.36) and does not approach the WWI experience (1.43).⁸²

Wounded

No official Iranian figures of overall wounded have been released to this author's knowledge. Major General Rezai in the interview cited above mentioned some 200,000 permanently disabled. For reasons given above, this probably represents all components, not just *Pasdaran* forces. Given the standard 4:1 wounded to killed ratio, Iranian wounded must have been about 752,000. This gives a total battle casualty sum of right at 940,000. A problem is we have no data on Died of Wounds (DoW) as a category. Also the war was one of general chemical release which biases figures somewhat as the experience of WWI shows.

If the official Iranian figures are only rigorous KIA (death within one hour and counting 72,754 MIAs as KIAs) then using a "WWI w/gas" planning factor the ratio of wounded to killed would be 5.96 indicating about 1,120,480

"wounded." This is probably high as the blanket Iranian casualty figures for deaths probably include both KIA and DoW.

If we consider the Iranian figures to indicate both KIA and DoW the "WWI w/gas" ratio of surviving wounded to KIA and DoW of 4.1 yields 770,800 "surviving



Pasdaran soldiers on the march.

wounded.”

The average of these latter two figures is on the order of 945,440 wounded. This produces a ratio of 5:1. It seems reasonable that this average is closest to the truth.

Another clue to total Iranian wounded comes from the statistics of the Khuzistan Blood Transfusion Center. During the war the center provided 736,284 units of blood and blood products for both combatants and civilian patients in the province. The center itself produced 501,639 of the units.⁸³ In WWII 10–12% of wounded were transfused with an average usage of 4.3 units of blood per patient.⁸⁴ It is likely the center used the majority of its blood products for combatants. If the 501,639 units it produced itself was so used with the remainder procured for the civilian population, applying WWII standards the total number of wounded transfused would be: $501,639 / 4.3 = 116,660$. This in turn might represent 12% of total wounded. Back calculating gives $116,660 / 0.12 = 972,168$. This is very close to the above estimate of 945,000 surviving wounded. It, however, may be high as it would probably include a substantial number who received transfusion, but died of wounds

One last observation—the Iranians tried to make extensive use of Medevac helicopters during the war similar to US Army practice in Viet Nam. In the latter conflict the ratio of KIA and DoW to surviving wounded was 4.16 very close to the “WWI w/gas” planning factor of 4.1.⁸⁵ However, the Medevac solution was not completely feasible as it did not suit Iranian climatic and geographic situations. As a result the Iranians built a series of underground clinics immediately behind the front lines which offered the best and most expeditious medical service to their wounded according to Brigadier General Abolqasem Musavi, chancellor of the Iranian Army Medical University. This system allowed speedy evacuation and treatment of wounded even in mass casualty situations.⁸⁶

Given that the Iranian Army suffered on the order of 1,133,000 casualties in the War of Sacred Defense what else does this tell us about the conflict?

First, the average annual “theater” battle casualties would be approximately 28% or 141,000 battle casualties per year (given that the Iranians had about 500,000 troops committed at any one time). This rate is only little over half that of WWI although about 50% higher than that of WWII. As far as US wars are concerned it most resembles that of the US Civil War (24.6%).

The distribution of casualties is also in accordance with modern experience since 1945. The dead (188,000) represent about 17%, severely wounded (200,000) about 18% and other wounded (745,000) about 65%. This matches closely with T.N. Dupuy’s historically derived distribution of modern war casualties of 20% KIA, 15% severely wounded and 65% other wounded.⁸⁷

Chemical Casualties

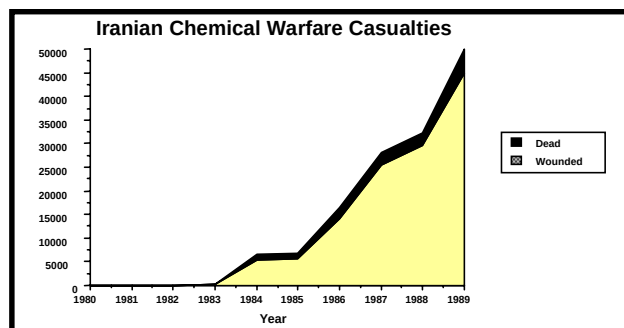
The War of Sacred Defense was the only conflict of the 20th Century other than WWI fought under conditions of

general chemical release. The Iranian ground forces were generally ill-prepared for chemical defense. During the course of the war much NBC defense gear was purchased from the UK, Germany, and Czechoslovakia, but there was never enough and NBC defense training was insufficient. Many Iranian soldiers became gas casualties because they did not have often enough to allow their protective masks to make a tight seal.⁸⁸

Throughout the war Iraq employed chemical weapons against Iranian forces 195 times. After the chemical attack on Halabja in March 1988 killed some 4,000–5,000 civilians and maimed 7,000 others, the IRGC sent a video crew to document the atrocity. The video was used as a training film for Iranian recruits. Instead of instilling hatred for Saddam’s brutality, the film demoralized its viewers and exaggerated the power of Iraqi chemical weapons.⁸⁹ Iranian troops later panicked under gas attack conditions at Fao and Majnoon and abandoned their positions. However, this phenomenon was widespread in the First World War.⁹⁰ Further, chemical attacks were usually not significantly lethal. This is again in accord with WWI experience. Gas inflicted 70,552 casualties on the American Expeditionary Force in 1917–18. Of these only 1,221 died (2% lethality). The British Army suffered 185,706 gas casualties of which only 5,899 died (3% lethality). Total British battle casualties for WWI were 677,515 KIA and 1,837,613 WIA. Gas accounted for only 7% of all British casualties and only 1% of all KIA. The Russian Army suffered an amazing 600,000 gas casualties with a lethality rate at times as much as 12%.⁹¹

Iraq may have first used gas in late 1980 near Salamchek. Iran reported its first chemical casualty in fighting near Hoveyzeh in early 1981. These early attacks seem to have been limited to the riot control agent CS. On 27 October 1982 near Musain four Iranian soldiers died from toxic chemical exposure, probably mustard gas. In mid August 1983 Iran suffered 318 casualties from mustard and arsenic agents. On November 7, 9, and 13 1983 Iraq used mustard in the Panjwin area. Four seriously wounded Iranian soldiers later died in European hospitals.⁹² Between May 1981 and March 1984 Iran claimed Iraq had employed chemical weapons on forty nine different occasions. This had resulted in 1,200 Iranian dead and 5,000 wounded.⁹³ Mycotoxins may also have been used.⁹⁴ On 17 March 1984 Iraqi forces employed gas which caused 400 Iranian casualties, 40 of which were from nerve agents.⁹⁵ In the *Badr* operation (1–18 March 1985) Iraq used chemical weapons five times, but inflicted only 200 Iranian casualties, none apparently fatal.⁹⁶ In one unnamed 1985 attack Iran claimed 11,000 troops were exposed to Iraqi chemical agents.⁹⁷ In *Wal Fajir*–9 (15 February–11 March 1986) Iran claimed 1,800 chemical casualties from a total of about 30,000.⁹⁸ Up to 8,500 Iranian soldiers were gas casualties by the end of *Wal Fajir*–8 and *Wal Fajir*–9 (15 February–19 May 1986) with about 700 killed or seriously wounded.⁹⁹ In attacks on 27 and 30 January, 9, 10, 12, and 13 February 1986 reportedly 8,500 Iranian gas casualties were suffered of which 35 died and 2,500 had to be hospitalized.¹⁰⁰ In *Karbala*–4 (24–26 December 1986) only five Iranian

troops died from toxic gas out of 10,000 battle casualties.¹⁰¹ By early 1987 chemical weapons had inflicted at least 10,000 Iranian casualties.¹⁰² In all Iran had suffered 25,600 gas casualties by April 1988 of which 260 (sic 2,600?) died. Iraq's extensive use of chemical agents in the final months before the August 1988 cease-fire may have raised the casualty count to as much as 45,000.¹⁰³ In the Iraqi "In God We Trust" offensive of June 1988 against Majnoon Iran claimed sixty soldiers killed and 4,000 wounded by Iraqi chemical weapons which included nerve and blood agents.¹⁰⁴ A small UK article on mustard gas from the Internet cites 5,000 Iranian troops killed by gas and 40,000-50,000 injured during the war.¹⁰⁵ The overall cumulative wartime pattern of Iranian military chemical casualties is illustrated in the below figure.



Speaking in 1996 Abdollah Mazandarani, Secretary General of the Iranian Foundation for Chemical Warfare Victims, claimed 25,000 Iranian soldiers were "martyred" (killed?) by Iraqi use of chemical weapons in operations *Wal Fajir*-8, *Karbala*-8, *Badr*, *Fao*, and *Majnoon*. 45,000 civilians were also affected by chemical weapons.¹⁰⁶ Iran claims at least 100,000 wounded by chemical weapons during the imposed war with Iraq. 1,500 of these casualties require constant medical attention to this day. Since 1991, 118 have died as a result of their toxic chemical exposure according to Hamid Sohrab-Pur, head of the Foundation of the Oppressed and Disabled's Center for Victims of Chemical Warfare.¹⁰⁷ One of these was Reza Alishahi who died in September 1994 after suffering 70% disability when he was gassed during the *Wal Fajir* offensives of 1987.¹⁰⁸ Another pathetic story is that of Magid Azam, now a 27-year-old medical student, who was a 16-year-old *Baseej* fighter gassed with mustard in the *Karbala*-5 offensive of January 1987 with no apparent permanent effects. In 1995 his health suddenly began to deteriorate so rapidly he required intensive care. His lungs are now so damaged that only a transplant can save his life. He is one of 30,000 Iranian veterans who have received treatment for recurring or delayed reactions to chemical weapons. It is estimated that up to 100,000 Iranian soldiers were exposed to toxic agents during the war¹⁰⁹

In the First World War toxic chemical agents accounted for only 4-5% of total casualties. Of 1,296,853 known chemical casualties in that conflict, 90,080 died (7%), 143,613 were badly wounded (11%) and the remaining 1,053,160 (82%) not seriously affected.¹¹⁰ 25,000 Iranian military dead out of 45,000 chemical casualties gives an incredible chemical lethality rate of 56%, higher than that for land mines. This claim

of 25,000 Iranian troops "martyred" is not an exaggeration, but rather a probable misprint.¹¹¹ Elimination of an extraneous zero makes the number 2,500 in line with previously released figures. This would give a chemical lethality rate of 6% per chemical casualty, remarkably close to WWI general rate although somewhat higher than individual US or British experience. Further, 45,000-55,000 military chemical casualties out of 1,133,000 total combat casualties yields a 4% casualty total for chemical weapons, again in line with overall WWI experience. 2,500 dead from chemical weapons is only 1% of total Iranian KIA. If 5,000 cited above is correct, about 3%. A representative sample of 400 chemical warfare casualties treated at the Labbati-Nejad Medical Center in Tehran in early 1986 yielded 11 deaths (3%) and 64 (16%) very seriously injured.¹¹²

Civilian Casualties

The Iran-Iraq War produced remarkably few civilian casualties compared to WWI or WWII rates. UNICEF data suggests that prior to WWI that civilians accounted for only 5% of all deaths in a given war. This rose to 15% in WWI and an astounding 65% in WWII.¹¹³ Iran claims 11,000 civilian deaths as a result of the war primarily through Iraqi air and missile strikes. The author's own study of Iranian civilian deaths places it at about 8,800 known deaths indicating this number is probably very close to the true figure. If so, civilian deaths accounted for just 5% of total war dead, a turn of the century standard. The number of wounded has not released, but this author figures can account for over 34,000 civilian wounded by air and missile strikes. Further, Iran claims 45,000 civilian "chemical" casualties. If all claims are true then approximately 90,000 civilians became casualties of the war.

This yields a military to civilian casualty ratio of 11:1. This is far better than the ratio claimed in recent wars of 1:9. This suggests that despite the hysteria surrounding "War of the Cities" the Iranian civilian population was not severely at risk during the war. Compare this to WWII England where the one year German V-1/V-2 campaign killed 8,588 and wounded 46,838.¹¹⁴ Then contrast it to total English civilian casualties during WWII at 60,000 dead and 86,800 wounded due to the blitz and buzz bombs. UK military killed, wounded and missing (excluding PoW) were 582,900 in WWII giving a military to civilian casualty ratio of 4:1.¹¹⁵ Of course the WWII German bombing and missile campaigns against England were far more severe than that experienced by Iran at the hands of Iraq.

Civilian chemical casualties match military in magnitude. At first this might seem strange. I have found no WWI data on military to civilian casualty ratios as regards chemical agents so there is no point of comparison or contrast here. The high number of civilian chemical casualties seems to be a function of several factors. First some 2,000 Iranian towns and villages lay in areas where Iraqi forces employed chemical weapons.¹¹⁶ Secondly, Iraqi chemical strikes were often delivered deep into Iranian rear areas to attack reinforcements

and support troops. Casualties were often high as the rear echelon troops were less well equipped and prepared to cope with chemical attacks.¹¹⁷ In these rear area attacks the civilian population density must have been much higher than on the front line. Further, civilians probably had no means of chemical defense. Witness the chemical attack on Halabja in March 1988 with mustard, nerve and cyanogen chloride which killed some 4,000–5,000 civilians and maimed 7,000 others. This may explain the 1:1 relationship between overall Iranian military and civilian chemical casualties.

Summing Up

If we estimate that at least 5,000,000 troops (about 12% of Iran's then population) served in the war zone then the military casualty distribution is not less than the following (**Bold** indicates the author's choice from ranges).

Killed in Action/Died of Wounds: **188,000** (156,000 – 196,000) (17%)

Wounded in Action: **945,000** (754,000 – 1,110,000) (83%)

Severely Wounded/Disabled: **200,000** (18%) (Note: carve out of total wounded)

Missing in Action: **73,000** (6%) (Note: Carve out of total KIA plus several thousand possible defectors/collaborators)

PoW: **39,000** – 44,000

Total Military Battle Casualties (KIA + WIA): **1,133,000** – 1,302,000 (28% theater rate)

Possible Non-Battle Military Deaths: **74,000**

Non-Battle Military Injuries: No idea.

With Civilian KIA (11,000) and WIA (34,000) and “chemical” (45,000) Total Hostile Action Casualties: **1,223,000**

With Possible Military Non-Battle Deaths (74,000): **1,297,000**

Total Deaths Due to the Imposed War: **273,000** (104% of Pentagon Estimate of 262,000)

Of **5,000,000** estimated Iranian combatants (1 million regular army, 2 million *Pasdaran*, 2 million *Basceej*) ~

4% were Killed in Action/Missing in Action

4% were Disabled

13% were Wounded

1% were Non-Battle Deaths

1% were PoWs

Total military losses all known causes ~ 27%

The military battle casualty total percentile (27%) is

intermediate between that of WWI (50% ~ British Army) and WWII (13% ~ US Army/USMC, 22% British Army).¹¹⁸

The author acknowledges the highly speculative nature of much of the data and argument presented above. It is offered as a preliminary starting point to further study. As such, the author would appreciate hearing from anyone with additional data on this subject. In particular he would invite the Government of the Islamic Republic of Iran to provide any information that would corroborate, correct or expand on the information presented in this article. 

Mr Beuttel is employed as a military analyst by Boeing Information, Space & Defense Systems. The views and opinion expressed in this article are not necessarily those of the Boeing Company.

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Time and Breakpoints in the TNDM



by Christopher A. Lawrence

I have written two articles previously about the use of time in the TNDM. This was in Volume 1, Issue 4, “Looking at Time Using the BLODB” and in the following issue “The Second Test of the TNDM Battalion–Level Validations: Predicting Casualties.” To briefly summarize the problem, the TNDM treats time as a constant factor, so that if an engagement is 1 hour, casualties and advance rates are 1/24th of a 24 hour engagement. When this was tested using in the battalion–level validation and using the Battalion–Level Operations Database, this appeared to be a reasonable construct except for the really short engagements. I was unable to use the Land Warfare Database for such a test because all the engagements are longer than 8 hours, most being over 20 hours.

The tentative solution that I came to was that all engagements of less than 4 hours should be calculated as a 4 hour engagement.

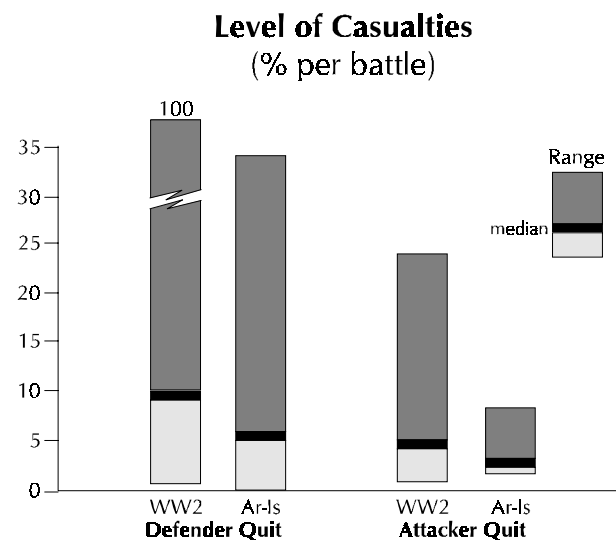
One of our TNDM users became concerned about this solution because of the way he is using the model. He uses the model as the attrition calculator for a larger model which is used for training. During an exercise, the “judge” will ask both the attacker and the defender how many casualties they are willing to suffer to take or hold a position. They then run the model for the number of hours necessary to achieve that casualty level for one side, and then give the two commanders an opportunity to change their orders.

This is a fundamentally different method of using the model. It very much touches on two issues, time and breakpoints. Let’s discuss breakpoints for a moment.

A breakpoint is a change in posture. It is when the defender quits defending and starts withdrawing, or when the attacker quits attacking. When people think of breakpoints, they tend to envision people panicking, streaming to the rear, etc. This is an *involuntary breakpoint*. There are also *voluntary breakpoints*, which is when the commander orders that the attack cease or the unit should withdraw. The voluntary breakpoints are more common than the involuntary ones.

The breakpoint methodology used in many US simulations, which is simply a wrong methodology, is to set the breakpoint at some percentage level of casualties (30% or 40% are popular figures). In the real world (meaning history), breakpoints are usually decided by the commander or the situation, not the men. The commander (though maybe not the top commander) decides that the objective is no longer worth holding or the attack is not going to succeed, so he gives an order to withdraw or cease attacking; or the situation has clearly changed so that it does not make sense to continue attacking or holding that position. Command–driven breakpoints, usually driven by the situation, are the norm.

Let me refer you to Trevor N. Dupuy’s book *Understanding Defeat*, which came out of a study on breakpoints for the US Army Concepts Analysis Agency. On page 210, Col. Dupuy shows from the Land Warfare Database that the median casualty rate for the attacker in a defeat during WWII was around 9% and during the Arab–Israeli Wars more like 6%, while for the defender the median casualty rate in defeat in WWII was around 4% while for the Arab–Israeli Wars it was around 3%. This chart is included below:



On page 214, Col. Dupuy asks the question

Perhaps now is the time to pose a question to the reader: “If you were fighting a losing battle, at what level would casualties make you quit?” Would you call off an attack, or withdraw from a defense, with casualties as low as many battles in the charts just presented? The casualty levels they show are certainly much lower than the ones that are seen as a matter of course in most current military planning and analysis studies. There does not appear to have been any research about unacceptable losses in combat. Until very recently, the last examination of breakpoints, for example, was published more than thirty years ago. Before the most recent study, and lacking a casualty guideline, a consensus of professional judgement was sought. A group of combat–arm officers ranging from major to lieutenant general were asked individually: “If you were a division commander, how high would casualties have to be in your division for you to quit?” Their answers, while qualified, suggested that most of them would recognize defeat on taking perhaps 50 percent casualties.

Col. Dupuy then analyzed 52 battles for which he could determine the reasons for the breakpoints, and published the following tabulation:

Reasons for a Force Abandoning an Attack or a Defense

Maneuver by Enemy			
Envelopment, Encirclement, Penetration	33		
Adjacent Friendly Unit Withdraw	13		
Enemy Occupied Key Terrain	6		
Enemy Achieved Surprise	8		
Enemy Reinforced	4	64%	
Firepower by Enemy			
Casualties or Equipment Losses	10		
Heavy Enemy Artillery/Air Attacks	2	12%	
Shortages of Resources			
No Reserves Left	12		
Supply Shortages	2	14%	
Conditions External to the Battle			
Truce or Surrender	6		
Change in Weather	2		
Orders to Withdraw	2	10%	

In effect, what this user has done is create a casualty-driven breakpoint methodology, with the commander (as opposed to some rule of thumb) determining what those breakpoints are. While I think this is an improvement over a “40% rule,” I would be very interested in finding out what is the average or median percent casualties (at division-level or battalion-level combat) that the commanders take during these exercises?

There is a second problem here, which is what to do about really short engagements. I suspect this is not a real problem for this user as I doubt if any commander gives a breakpoint of less than 1% at the division-level or less than 10% for the battalion-level engagements. For most situations, it is difficult to get casualties above those thresholds in less than 4 hours of combat using the model. Therefore, I suspect this problem has not come up very often.

The problem with using the model for hourly casualty rates is that of course, the average hourly figure will be very wrong for any given hour. Over several hours it will be just fine. The problem the model had with predicting casualties in brief engagements (less than 4 hours) was, in fact, that we were using an average hourly figure to try to account for hours that were clearly not average, but indeed quite intense. This led to the interim fix of all engagements of less than 4 hours being treated as 4 hours. I do intend to test this fix in the second validation, When I get the time to complete it.

Hopefully, this begins to answer the questions of our user. My gut reaction when told of his methodology was that there was something wrong with so different an approach. My reaction now is that the user needs to first look at what casualty levels the commanders are setting. In his case, the user does have the advantage of working with officers who have had recent combat experience, so their figures may be tempered by a high degree of reality. Furthermore, the country was very “casualty sensitive” during its operations. If the casualty levels set by the commanders are resulting in battles that are producing casualties that are higher than the historical norms (or the norms from their last war), then in fact he has just created another type of “40% rule” and this is fundamentally flawed.

Perhaps the best way to use the model in his training environment is to simply provide periodic combat reports to the commander, say every four hours, and at that point the commander can then intervene and determine if they need to make a change. For example, if after four hours of engagement, it is clear that the mission is not going to succeed, there is no reason to continue the engagement past that point until you reach 10, 20, 40, or whatever percent level you have previously decided was acceptable. 🌐

A Look at the OLIs of APCs, ACs, IFVs, and CFVs



by Christopher A. Lawrence

There are five potential problems with the revised scoring methodology for the Armored Fighting Vehicles (AFVs). They are:

1. The value of the vehicle as an “infantry” weapon is under-represented.
2. The value of the certain tanks relative to each other is not correctly represented.
3. The overall value of the armored forces within a combat unit is not correctly represented.
4. The effects of making infantry mobile is not fully represented.
5. The revised OLIs have not been properly validated.

While this article is intended to only look at the first and fourth problem, let me briefly address all five issues.

The value of the vehicle as an “infantry” weapon is under represented. To me, this is the most clearly identifiable problem to correct in the new AFV OLI methodology. Quite simply, we have a situation where some machine gun armed APCs (Armored Personnel Carriers) have a lower OLI than the same machinegun, man-portable. This is what this article will address.

The value of the certain tanks relative to each other is not correctly represented. This is the issue that seems to be first one that most people look at. Everyone seems to have a clear opinion as to which tank is better than which, and some of the OLIs do not match their opinion. In fact, much of the criticism I’ve heard related to the QJM seemed to be over whether one tank was better than another. While I agree with some of these criticisms, the predictive accuracy of the model is not going to hinge on whether a Panther is 1.5 times or 1.8 times better than a Sherman. While this is worth taking a look at, the original reason for the new OLI methodology was to correct this problem among modern weapons. I believe this has been reasonably done, and do not intend to address this further.

The overall value of the armored forces within a combat unit is not correctly represented. This concerns me greatly and will be addressed at some point in the future. When the new AFV values were created, when compared to the old values, they ended up overall increasing the OLIs for new tanks and decreasing them for WWII tanks. This fundamentally reduces the overall contribution of armor to the total OLIs for WWII engagements and the value of a tank in WWII compared to other weapons systems (like artillery and aircraft).

The effects of making infantry mobile is not fully represented. This is not a problem, although it may first appear

to be one. The OLIs measures the operational combat power of each weapon. It does not measure their combat power when one mobilizes the infantry weapons within the unit. But the TNDM does separately measure the overall effect of mobility on the unit. This point is sometimes missed when looking at the model. Combat mobility is a major force multiplier in the model and is calculated using the mobility equation. How this is done is briefly demonstrated below and in more depth in the following article. The actual value of the APC, beyond its value as an independent weapon system, is measured in the mobility equation.

The revised OLIs have not been properly validated. When the new OLIs were created, they needed to be validated back to the original QJM database. This was not done due to time and money constraints. While the current battalion-level validation is being done using these new values, there is no comparison to the old values that allows one to determine if the change in OLI values provides an improvement or a degradation to predictive accuracy. Of course, the new battalion-level validation database did not exist when the OLI changes were done, and the QJM database has never been computerized.

The obvious solution is the computerize the old QJM database and run the engagements using the current TNDM. As the final outputs for the old QJM database runs were never fully published, this still leaves us no means for direct comparison to the QJM runs short of running the engagements again using the old QJM values. The model has mutated enough from the original validation done 20 years ago, that this may not be an issue. But the model does need to be re-validated to its original engagements, even though its performance as a predictor of the Gulf War was good and validation using the battalion-level operations data base was also good.

APCs, ACs, IFVs and CFVs

There are six basic classes of weapons in the TNDM. They are:

1. Infantry
2. Anti-armor
3. Artillery
4. Air Defense
5. Armor
6. Air Support

OLIs are calculated for either “single weapons” or “mobile fighting machines.” Mobile fighting machines consist of Combat Vehicles (AFVs), Combat Helicopters, and Combat

Aircraft. It is in the calculation of the AFV factors that a significant change has occurred since the original model.

In World War II, AFVs consisted of many platforms. These included tanks and many vehicles that are effectively treated as tanks by the model ("heavily armored" tank destroyers, assault guns, etc.). Self-propelled anti-tank guns are classified as anti-tank. There are also self-propelled artillery, which are treated the same as artillery except they are multiplied by the self-propelled factors. This self-propelled factor is applied to artillery pieces, mortars (otherwise classified as an infantry weapon), air defense weapons, and lightly armored or unarmored anti-tank guns. It is multiplied by 1.05 for self-propelled weapons, and 1.10 for self-propelled weapons with crew armor.

Finally there is everything else. These include half-tracks, armored personnel carriers (APCs), and armored cars (ACs). In WWII, most half-tracks served as armored personnel carriers and most armored personnel carriers were half-tracks. Most armored cars were wheeled. All were lightly armored and usually mounted a 20mm gun or less. Of course, there were a large number of exceptions, with the Germans in particular mounting 75mm guns on armored cars and on half-tracks.

Since that time, the half-track has pretty much disappeared and replaced by fully tracked or fully wheeled APCs. The armored cars have begun to look more like modified versions of the APCs, with the US versions being modified fully-tracked APCs. Finally, in recent times, all these vehicles have become more muscular (and more expensive) with better armor and bigger guns (and often less ability to carry infantry) and have become IFVs (infantry fighting vehicles) and CFVs (cavalry fighting vehicles). Some of these IFVs are looking more like light tanks that also carry infantry (and of course, Israel has a main battle tank that also carries infantry).

So the problem from a modeling perspective is how do you count these vehicles? The solution was to count APCs as infantry weapons (but using the armored OLI formula) while counting IFVs and CFVs as armor. A listing of what is being counted in these categories is provided in the two adjoining sidebars.

As discussed in the sidebar on mobility (and in more depth in the following article), the mobility advantage of APCs is accounted for in the mobility equation. Therefore, the only thing we need to look at is the additional combat value of an APC above and beyond its value as a transport. Looking at modern weapons, the obvious case among the US weapons is the M-113 with an OLI of 1.08, while the M-2 MG which is mounted on it, independently has an OLI of .981. As pointed out in Dave Bongard's article in the June 1997 issue, the BRDM-2 has an OLI of .424, or a fraction of the value of its two weapons, the 14.5mm HMG (1.165) and the 7.62mm MG (.460).

The easiest solution to this adjustment might be to simply adjust the formula to account for the weapon. This could consist of a rule that the value of an AFV can never be less than the value of its weapons times the self-propelled factor for armor (1.1). In the case of the M-113, the M-2 MG mul-

tiplied by 1.1 equals 1.079, so it would keep its current value. In the case of BRDM-2, its value would become 1.788. From the lists below, the value of all the APCs and armored cars with 7.62mm MGs would be raised slightly to .506. The value of APCs and armored cars with 14.5mm MGs would be raised to 1.282, which is curiously enough, the value of the BTR-60s and BTR-70s armed with a 14.5mm MG. The adjustment in OLIs for the few odd cases (like BRDM-2) may not be significant enough to justify a change to the model. At this point, I am considering taking no action on this part of the issue, and just consider the APCs and other lightly armored vehicles to be adequately addressed due to the mobility formula. As this still only addresses points 1 and 4 as outlined in the beginning of this article, there is still problem of the value of tanks relative to each other, the overall value of tanks, and the validation of armor engagements (points 2, 3, and 5) to be considered. 🌐

MOBILITY

As always, in this "simple" model, whenever one peels back the first layer of simplicity, one discovers considerable complexity. Mobility is addressed as the total mobility of the force. This is done by a formula that measures the mobility of the attacker as a ratio of the mobility of the defender. The mobility calculation consists of number of people, plus a weighted count of vehicles other than tanks (multiplied by 12), plus the TLI of the armor vehicles, all multiplied by the a constant for air superiority divided by numbers of troops. The defender is calculated in the same way, then the attacker's number is divided by the defender's number, and the resulting fraction is used at its square root value. This gives a mobility factor for the attacker. The mobility factor for the defender is always 1. The attacker's mobility factor is further influenced by terrain and weather. This mobility number is used as a multiplier of the combat power, and reflects the effect of mobility on combat power.

For example, let's look at the effect of the formula if one force 10,000 truck mounted infantry (assume one truck for 12 people) engages a force of 10,000 "leg" infantry. Just to simplify the math, we will assume no armored vehicles, no air superiority and the terrain and weather "equals" 1. This would result in the attacker (the numerator) set at 20,000, while the defender (the denominator) is still 10,000. This results in a multiplier of 1.41 for the attacker. This is a straight multiplier in the combat power formula. Of course, the ratio of combat power between the attacker and defender is used to determine win and loss (and as a factor in casualties and advance rates).

If you had everyone in APCs instead, then the attacker's values would be 30,000 resulting in a combat multiplier of 1.73 to 1.

Therefore, I can honestly state that the transport and mobility benefit of trucks and APCs is accounted for in the mobility formula. It does not need to be counted for in OLIs (except as applied to SP artillery). Therefore, the armor OLIs of APCs need only account for their additional combat value above and beyond their use as transport for the infantry.

SLIGHT DOCUMENTATION PROBLEM

Note that there is a slight problem with the clarity of the documentation here. If one looks at the rules and procedures manuals, one will discover under the discussion of anti-armor and artillery, that the self-propelled factor is used (as opposed to making them mobile fighting machines). If one reviews the text on the self-propelled equation, the self-propelled factor is applied to standard artillery pieces, mortars and air defense. No mention is made of anti-tank. In fact, by a review of the weapons in the data base, it is clear that the self-propelled factor is applied to all self-propelled artillery, lightly armored or unarmored AT weapons, mortars, and air defense weapons. For example the German WWII 20mm Flak 38 SP and Flak 43 SP AA guns have an OLI 5% greater than their towed counterparts. Similarly, the HOT-2 ATGM on AMX-10, the HOT-2 ATGM on VAB, the SU-60 Tank Destroyer, the LOSAT Bradley/HVM TD, the TOW Hummvee w BGM-71B ITOW, and the AT-3/Sagger 9414 ATG on BRDM-2 are all considered self-propelled AT guns. From WWII, the 4.7mm Pak auf Pzkw 1B, the Marder-III, the Nashorn, and the US GMC w/M3a1 37mm ATG are also listed as self-propelled AT guns.

Also, in the original QJM, the self-propelled factor of 1.1 applied if there was overhead cover. Now it applies to any SP weapons with armor.

WHAT IS MAKING THE BRDM A REAL WIMP?

The combined OLIs of the 14.5mm HMG and the 7.62mm MG is 1.625, yet the OLI of the BRDM-2 is .424, or almost one quarter the value of its component weapons. Looking at the calculations for this weapon, one sees that the TLI of the 14.5mm is 4,369.65 while the TLI of the 7.62mm is 1,598.44. When divided by the dispersion factor, this produces a combined OLI of 1.19. This is lower than the expected value of 1.625. In fact—this is part of the problem—is that the MGs we've been comparing this to have an OLI of 1.165 and .460, while the OLIs for these same weapons used on the vehicles is .87 and .32, for a total of 1.19.

This value is then modified by the AFV. This produces a battlefield mobility factor of .85, the radius of action factor is 1.64, the punishment factor is .32, and armor factor of 1.00, a vehicle mobility factor of 1.00, a vehicle supply factor .79 and a vehicle attack factor of 1.02. These multiplied together results in a multiplier of .36, or the final OLI of .426 (with a little rounding). If the higher combined OLI was used of 1.625, then the final value would be .584, which of course is still very low compared to the value of the weapons.

Unfortunately, the difference in the OLIs between the vehicle weapons and the single weapons is because they were calculated by different analysts, most likely using different data. This is not a good justification and forces us to look at the calculations made by those analysts. Yet another task to be added to the list of "to be done" tasks.

Selected List of Post-WWII APCs and Armored Cars in the OLI Database

Country	Name	OLI	Category
S. Africa	Buffel APC	0.411	Inf
	Casspir wheeled APC	0.767	Inf
	Ratel 12.7mm 6x6 command veh	1.020	Inf
	Eland lt armd car (AMC)	55.000	Armor
	Ratel 60 6x6 IFV	53.000	Armor
S. Korea	KIFV (FMC)	1.080	Inf
	KIFV 25mm gun carrier	97.000	Armor
USA	AAV-7A1 Amph Aslt Veh (LVTP7)	1.080	Inf
	M-113 APC	1.080	Inf
	Recon HMMWV (M19 AGL, M60)	77.000	Inf
	LAV-25 25mm 8x8 IFV (Bradley)	65.000	Armor
	M-2HVB HMG	0.981	Inf
USSR/ Russia	BTR-152 6x6 APC	0.450	Inf
	BTR-50PA 14.5mm APC	1.282	Inf
	BTR-60P 7.62mm 8x8 APC	0.450	Inf
	BTR-60PB 14.5mm 8x8 APC	1.282	Inf
	BTR-70 14.5mm 8x8 APC	1.282	Inf
	BTR-80 14.5mm 8x8 APC	1.282	Inf
	MT-LB 7.62mm APC	0.682	Inf
	BMD-1 Airborne IFV	59.000	Armor
	BMP-1 73mm IFV	71.000	Armor
	BRDM-2 armd car	0.424	Armor
	BRM-1 recon veh (BMP)	54.000	Armor
	PRP-3 battlefied radar veh (BMP)	0.769	Armor
	SMG 7.62mm MMG	0.582	Inf
	PKV 14.5mm HMG	1.165	Inf

Part of the reason for the low values for the APCs is because the area of the vehicle relative to its weight is so high.

List of All WWII APCs and Armored Cars in OLI Database

Country	Name	OLI	Category
France	AMXUE It tracked APC	1.293	Inf
	Lorraine hvy tracked APC	7.081	Inf
	Hotchkiss M1914 MG	0.541	Inf
	AMC-29 HT AFV	27.000	Armor
	AMC-35 tracked AFV	38.000	Armor
	AMR-33 lt AFV	4.707	Armor
	AMR-33 tracks ca. AFV	37.000	Armor
	Laffly 50 armd car	29.000	Armor
	Laffly s15 TOE lt armd car	4.495	Armor
	Panhard 165/175 armd car	45.000	Armor
	Panhard 178-P armd car	29.000	Armor
Germany	SdKfz 250/1 lt HT APC	1.230	Inf
	SdKfz 251/1 Med HT APC	8.627	Inf
	MG 34 7.92mm as HMG	1.211	Inf
	SdKfz 231/232 armd car	39.000	Armor
	SdKfz 233 armd car w/75mm L24	96.000	Armor
	SdKfz 250/10 HT lt armd car	31.000	Armor
	SdKfz 250/9 HT armd car	31.000	Armor
	SdKfz 222 (4 rad)	36.000	Armor
	SdKfz 234/1 armd car w/20mm	71.000	Armor
Italy	AB.40 scout car	6.782	Armor
	AB.41 armd car	47.000	Armor
Japan	Model 01 Ho-Ki tracked APC	12.000	Inf
	Model 99 Ho-Ha HT APC	7.330	Inf
	Model 92 7.7mm HMG	0.999	Inf
Poland	wz.34 armd car	25.000	Armor
UK	Bren gun carrier	1.839	Inf
	Bren .303 LMG	0.545	Inf
	Bren "Universal Carrier"	2.953	Armor
	Marmon-Herr. Mk II armd car	7.868	Armor
	Marmon-Herr. Mk IV armd car	53.000	Armor
USA	DUKW amphib truck	0.322	Inf
	LVT-1 amphib APC	9.380	Inf
	LVT-2 amphib APC	15.000	Inf
	LVT-3 amphib APC	17.000	Inf
	LVT-4 amphib APC	18.000	Inf
	M-3 HT (APC, etc.)	8.600	Inf
	M-3A1 HT (APC, etc.)	10.000	Inf
	M2HB .50cal HMG	1.344	Inf
	LVT(a)-1	29.000	Armor
	LVT(a)-2	62.000	Armor
	M-20 armd car	7.635	Armor
	M-3A1 white scout car	5.187	Armor
USSR	M-8 armd car	73.000	Armor
	BA-10 armd car	37.000	Armor
	BA-32 armd car	45.000	Armor
	BA-64 armd car	3.312	Armor

Some Thoughts on the Mobility Equation

by Christopher A. Lawrence



The formula for the mobility equation is:

$$M = \frac{(N_a + 12J_a + W_i_a + 15Wg_a + 15Wy_a) * ym_a / N_a}{(N_d + 12J_d + W_i_d + 15Wg_d + 15Wy_d) * ym_d / N_d}$$

where

N	=	Number of troops
J	=	Number of vehicles*
W_i	=	Total OLIs for all armored weapons
Y_m	=	Air Superiority Factor from Table 5

*This figure is the sum of 1 per truck, 2 per track laying support or non-armor combat vehicle (APC, self propelled carriage or tractor), 10 per available organic aircraft, ½ per motorcycle.

See pages C-38 and C-39 of the *Manual of Rules and Procedures* for more details.

While this is intended to measure the effect of the superior mobility of one force over the other, it also does several other things:

1. Measures the effect of motorization and mechanization.
2. Measures the “maneuver” value of armor.
3. Measures the effect or air superiority.
4. Measures the effect of terrain and weather on mobility.

One must remember in this equation that both the numerator and the denominator are effectively divided by N (the number of people in the force). Actually, it is multiplied by the air superiority factor divided by N, but in the air superiority table, four of the six possible choices is equal to 1, so for many purposes the equation is simply divided by the number of people. This is obviously in the equations so that the mobility adjustment is not affected by the ratio of the number of people on a side.

Let’s look at each of these four functions in a little more depth. As discussed in the previous article on OLIs, the measurement of the transport and mobility effect of APCs is covered in the mobility equation. If one force is totally motorized relative to another force, there will get a 1.41 force multiplier. If they are armored (mechanized) they will get force multiplier of 1.73. A mechanized force versus a motorized force will get a force multiplier of 1.22.

But the mobility equation also sums up the total armor for each side, so if all other factors are equal (say for example, each side had a fully motorized infantry force of 10,000 men, which puts a value of 20,000 in both the numerator and denominator), then the side with 100 main battle tanks (M1A2s) would have an additional 143,600 points. This

totals up to 163,600, divided by 10,000 which equals 16.36. The defender is still 20,000 divided by 10,000, which results in a final ratio of 8.18, resulting in a force multiplier of 2.86. Obviously significant multipliers can occur if one side is heavily armored.

While it is never discussed what this is intended to represent, as it is in the mobility formula, it is assumed to represent the combat advantage gained by “maneuver” (from J.F.C. Fuller’s principles of war). As maneuvering 100 tanks allows one to obtain considerable mass and surprise, then this might be a reasonable interpretation of the output.

Of course, if it is measuring the “maneuver” value of the weapons, this does raise the question of why air weapons are not included in this equation (although aircraft are included in the “J” part of the equation at 10 points per aircraft).

All this is multiplied by air superiority, which is the air superiority factor for the force divided by number of people in the force. The factor is from Table 5, page B-6, and driven first by whether it is wet or dry. If wet, the factor is 1.0. The factor is also 1.0 if neither side has air superiority. So the final number ends up being multipliers by 1/N, or the inverse of the number of people. In effect, the entire equation for each side is divided by the number of people for each side. This of course, results in the equation not favoring any side because of superior numbers of people.

If the weather is dry, then the side with air superiority gets a multiplier of 1.1, and the side with air “inferiority” gets a multiplier to their mobility of .9. How this really works (lets take two Motorized forces of 10,000) is:

$$(10,000 + 10,000 + 0) \times 1.1/10,000 = 2.2$$

$$(10,000 + 10,000 + 0) \times .9/10,000 = 1.8$$

$$2.2/1.8 = 1.22 \text{ and the square root of } 1.22 \text{ is } 1.106.$$

So, the end result is that air superiority usually results in around a 10% improvement in the mobility score, which amounts to a 10% improvement in OLIs. If the defender had air superiority, then the final score for the attacker is .905. If the mobility situation is really lopsided (say the attacker has 100 tanks), the force multiplier effect of air superiority remains constant with the air superiority still being a bonus of 1.106. A simpler structure for the equation might be:

$$\sqrt{\frac{(N_a + 12J_a + W_i_a) / N_a}{(N_d + 12J_d + W_i_d) / N_d}} * ym_a$$

At least the effect of the air superiority factor would be clearly understood to be 1.1 as opposed to 1.1055416 that it currently is.

ALL THE MOBILITY MULTIPLIERS AT PLAY IN THE REAL WORLD: THE BATTLE OF LOMBA RIVER

Lets look at how this all applies to a real world problem. In 1994, when Trevor N. Dupuy was in South Africa, he was presented with three recent historical battles to run on the TNDM to see how they fit. All had a smaller number of South African forces attacking brigade size forces in Nimibia. Just to look at how the mobility equation functions in one of these engagements, we selected the first one he did, the Battle of Lomba River. This engagement occurred March 10, 1987 between the Republic of South African and Angolan government forces. The South African forces consisted of 3 motorized infantry companies, 2 mechanized companies, 1+ armored car squadrons and supporting mortars, AA and artillery. Angolan forces consisted of most of the 47th Armored Bde, with 3 motorized infantry battalions, an armored car-recon company, two tank companies (with T-54/55s) and supporting mortars, AA and artillery. The South Africans had 1,199 troops versus the 47th Brigades 2,264 troops. The South African's were the attackers. South African armor consisted of 38 vehicles with a combined OLI of 10,268. Angolan armor consisted of 28 vehicles (mostly T-55 tanks) with a combined OLI of 9,726.412. The South Africans had 119 trucks vs 141, and Angola also had 3 other tracked vehicles and 3 motorcycles. Terrain was flat—heavily wooded, weather was dry—sunshine—extreme heat. The defender had air superiority. The mobility calculation for this would be:

Attacker

$$(1199 + 12(119) + 10,268) * .9/1199 = 9.68$$

Defender

$$(2,264 + 12(141) + 12(3)(2) + 12(3)(1/2) + 9,726.412) * 1.1/2264 = 6.69$$

The value of M is then $\sqrt{\frac{9.68}{6.69}} = 1.20$

The 20% advantage multiplier is then further degraded by weather conditions:

$$m = 1.2 - (1 - .6 \times .9)(1.2 - 1) = 1.11$$

This 1.11 multiplier is multiplied by the entire score, making this a fairly significant force multiplier.

MICRO ANALYSIS, LOOKING AT A SQUAD

Of course, this all relates back to the discussion on the combat values of APCs. While Trevor Dupuy always stressed that one should not use the TNDM for “weapons trade-off” analysis, let’s just look at the effects of mechanization on a squad of infantry.

Let’s take a squad of infantry—say 12 men, even though US doesn’t use this squad size anymore (squad size in the US now is determined by FMC, vice DOD). Assuming armed

QUALITY SIGNIFICANCE OF QUANTITY

The multiplicative effect of quantity, beyond the benefit of raw numbers, is shown in the table for the “Qualitative Significance of Quantity (q).” This is a table new to the TNDM, and was not in the original QJM (as outlined in *Numbers, Predictions and War*). The table (see page B-9, Table 7 of the *Manual of Rules and Procedures*) ranges for a force multiplier of 1.0 for ratios of 1.5 to 1 or less, to a force multiplier of 1.2 for ratios of 7 to 1 or greater. This quantity factor is used the same way in four different places. It is used in the calculations of the total OLI for infantry and armor as a multiplier of each of those categories of weapons. Meaning that when adding up the total OLI for each of these forces, it looks at the ratio of OLIs for these weapons and adds this multiplier. According to the documentation, there is a similar factor for artillery and air support, but there is no place in the equations where it fits.

with 11 M-16s and a M-60, this would give them and OLI of 2.591. Put the same 12 men in a M-113 (they won’t fit in a Bradley) with its OLI of 1.080, plus the following multiplier from the mobility equation

$$\sqrt{(12 + 12(2) + 0)/12} = 1.73$$

resulting in the OLI of the mechanized infantry squad effectively becoming 6.358, while a motorized squad would be 3.664 and foot infantry is rated at 2.591. Now if you only use seven guys (OLI of 1.576) in a Bradley (OLI of 249) you come up with an OLI of 250.576 and a multiplier from the mobility equation of 4.6636895 for a final figure of 1168.609. Of course, the mobility multiplier went “out of control” because of the addition of the armor OLI to it. A US division has one Bradley per 50 men, not per seven. Still the impact is significant.

The mobility equation is then adjusted by weather and terrain. Operational factor for terrain (rm, see Table 2 in manual) and weather (hm, see Table 3 in manual) affects the attacker’s mobility. This is done by the following formula:

$$m = M - (1 - rm \times hm)(M - 1)$$

In effect, the value of M remains the same if the terrain is “Rolling Gentle–Bare” and the weather is “Dry–Overcast–Temperate.” The only value above “1” is the terrain value of “Flat–Bare–Hard” which results in a value of 1.05. The lowest value is for something like fighting in “Swamp–Jungle” in “Wet–Heavy Rain–Extreme Heat,” which would result in a combined value for rm and hm of .15, which in most cases would serve to cancel any advantages from mobility.

If M = 1 or the value of the terrain equals 1, then M = m. If M is greater than 1, then the reduction effect of terrain and weather on mobility is the “percentage” of the value over one. For example, if the mobility multiplier is 1.414 (square root of 2), and the terrain is “Rolling–Gentle–Heavily Wooded” and the weather is “Wet–Light Rain–Temperate” then the result would be:

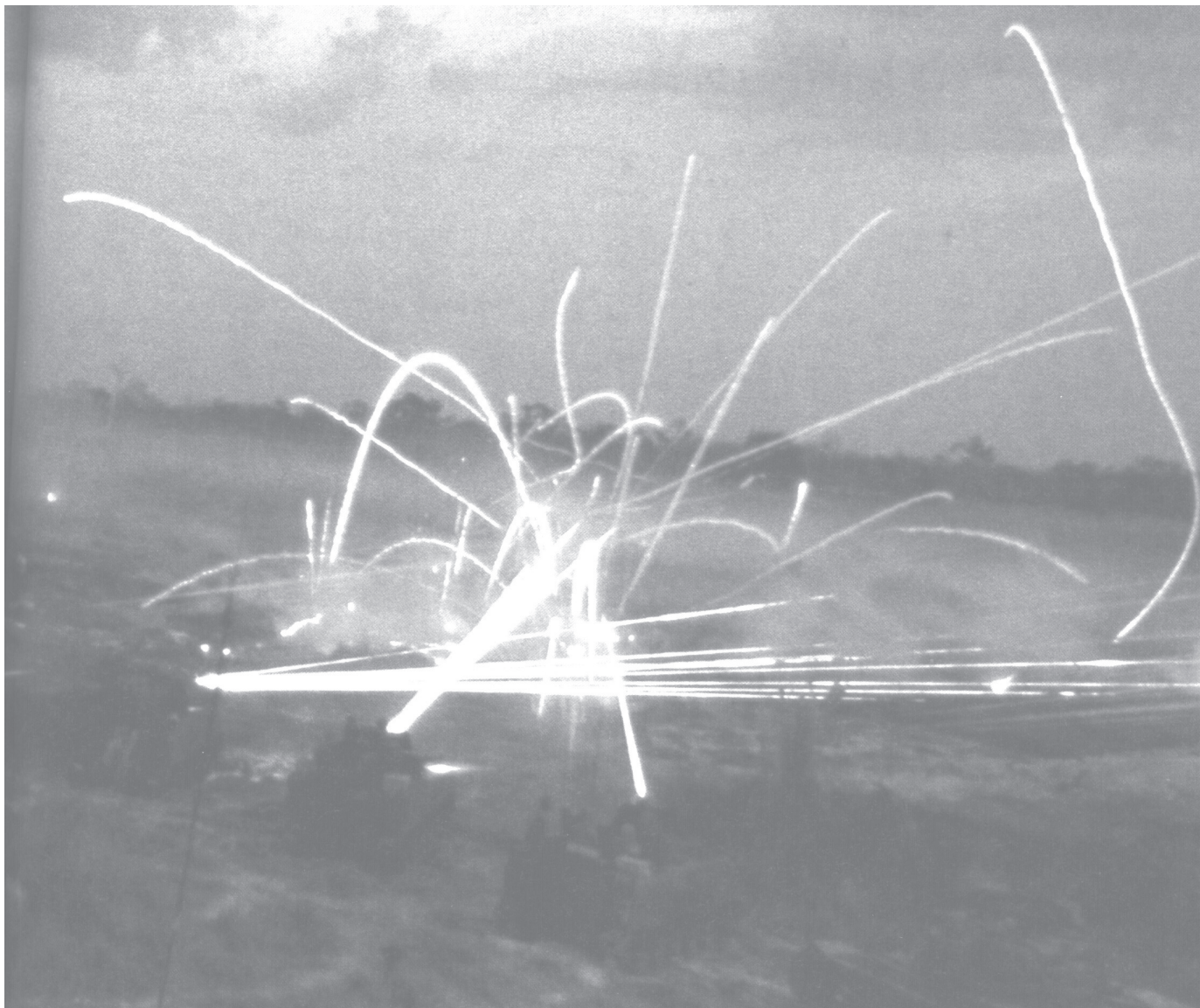
$$1.232 = 1.414 - (1 - .7 \times .8)(1.414 - 1)$$

Another way of looking at this is .7 times .8 equals .56. This multiplied by the mobility bonus of .414 equals .232. If the value of M is less than 1, meaning the defender is more mobile, then the equation increases the value of the attacker as the weather and terrain degrade mobility of the defender. Say if we set the attacker at .707 (square root of .5) under the same weather conditions, the result would be .83592. This effectively increases the attacker's values by difference between .707 and 1 by 44%. This accounts for the effect of the poor terrain and weather decreasing the mobility of the defender (whose value is always 1).

Keep in mind that the weather also affects the OLI of the attacker, artillery, air, and tanks, as well as the casualty rates. The terrain also affects the velocity (advance rate), defense, infantry weapons, artillery, air, tanks, and the casualty rate.

Of course, all this relates back to whether the value of an APC is now too low. Because of the mobility formula, the

value of the APC is not only its OLI, but also its addition to the mobility multiplier for the force. This bonus can be as high as a multiplier of 1.73, and this multiplier affects the OLIs of the entire force. Therefore, at this juncture, I am not uncomfortable with the values of APCs (as I used to consider them to be "overrated" in the OLI system). This does not mean that I am comfortable with the values of the IFVs, as they not only have a much higher value (249 vs 1.08), but also have a major impact on the mobility equation, especially if the armor OLI is high relative to the numbers engaged. An M-113 adds 24 to the mobility equations, while a Bradley adds more than 10 times that amount (all this of course is "depressed" by taking the square root of the value). At this point in time, my tendency is not to look towards changing the OLIs for APCs to correct the perceived "imbalance" in armor value problems. I do intend to look at the armor values of IFVs and MBTs though. 🌐



11th Armored Cavalry troops fire machine guns from their M-113 ACAVs and M48 tanks during a nighttime "mad minute" in the Iron Triangle, War Zone C, northwest of Saigon.

The Current Status of OLIs

by Christopher A. Lawrence



The revised armor OLI formulas were created by William Sayers with some minor tweaking and revision by Richard Anderson and Trevor Dupuy. Mr. Sayers became concerned that the armor values reflected in the model did not reflect the combat capabilities of the armored weapons well. He independently created a revised OLI formula for armor (mobile fighting machines in TNDM parlance) and presented this to Col. Dupuy. Col. Dupuy accepted the fact that this formulation was a better construct, and after some testing and minor revisions, incorporated it into the TNDM.

Mr. Sayers was careful to maintain the “balance” of the OLI values. As such, when he was developing his revised formula, he compared a sample mix of his weapons using the new OLIs with a sample mix of the weapons using the old OLIs. He made sure that the new formula, while perhaps dramatically reappraising individual weapons, maintained the same overall average value in the new mix when compared to the old mix. This being the case, it was not really necessary to validate the new values, as in the aggregate, they were the same as the old values. If Mr. Sayers can locate his notes on this, we may eventually talk him into writing an article on exactly how this was done.

But Mr. Sayers only carried out this evaluation for modern weapons, as that is all that he was concerned with. Of course, the QJM was validated to the old formulas using engagements from WWII, the 1967 Arab–Israeli War, and the 1973 Arab–Israeli War. Therefore we ended up with a situation where the new OLI values were not calibrated to the old OLI values for 1970s and earlier data.

As pointed out in the article by Dave Bongard in Volume 1, Issue 6 of the newsletter, the armor values for WWII weapons using the new OLI calculations almost always resulted in a lower set of values. This led to my concern, as discussed in this issue, that the new OLI methodology is not good as applied to WWII weapons. When I discussed this with William Sayers, he clearly stated that his formula could not be applied to WWII without revising it to maintain the same average value across a typical mix of weapons. This was never done, nor was the model ever validated using the new values in the old engagements.

The person maintaining the OLI databases instinctively knew that the new values were not good for the earlier engagements, so he continued to use the old armor OLI formula for all the engagements from the 1970s and earlier. This led to our OLI database being calculated by two completely different formulas for mobile fighting machine (MFM). The formula for “single weapons” has never changed, just the formulas for AFVs, Planes and Helicopters. Therefore, the TNDM is operating from three different weapons calculation formulas: one for single weapons for all years, one for MFMs pre–1980, and one for MFMs post–1980. When we performed the validation for the 76 battalion–level engagements, these were the values used. So, after publishing the

wonderful article from Dr. James Taylor about how the one of the strengths of the QJM methodology was the consistent application of scores, we have in fact been inconsistently applying them.

We currently have:

1. A set of scores for single–weapons that have been consistently applied. They were validated within the QJM using WWII, 1967, and 1973 data. They have also been validated within the TNDM using 76 battalion–level engagements from 1918 to 1989.
2. A set of scores for MFMs for before 1980 that have been consistently applied for engagements before 1980. They were validated within the QJM using WWII, 1967, and 1973 data. They have also been validated within the TNDM using 64 battalion–level engagements from 1918–1973.
3. A set of scores for MFMs for after 1980 that have been consistent applied for engagements after 1980. They were constructed so that an average mix of weapons under the new scoring system was the same overall value of an average mix of weapons under the old scoring system. They have also been validated within the TNDM using 12 engagements from 1982–1989.

At this point, I believe the following needs to be done:

1. We need to revise the MFM formula to consistently apply to all periods so we are only using one formula for MFMs.
2. We need to re–run the 64 engagements that were done using the old QJM MFM formula using the revised new MFM formula.
3. We need to then conduct a whole new validation using the new 121+ battalion–level engagement data.

This last step has already been begun using WWI African data and was published in the last issue. The work done on this, of course, has not been affected by the problem of the two different MFMs formulas due to the lack of any such vehicles in these conflicts. As a result of running the African engagements, the next step in the validation is to run all the 76 battalion–level engagements with an OLI of 1 per person (meaning using numbers of people, vice weapons values). This we already have done, and now only need to analyze the results. This will be the next step in the continuing validation effort.

As I do wish to have one OLI formula for all Mobile Fighting Machines in all eras, I will be revising the formula so as to keep the current values but allow reasonable values for pre–1980s armor. I will have a proposed formula in the next issue.



The TNDM OLI Database

by Susan Rich



The Dupuy Institute recently reviewed the status of its OLI's, and separated them out into five databases based on period. A total of 1644 weapons are currently stored in the TNDM OLI database. The OLI's for Pre-WWI (1600 to 1913), WWI, WWII and 1970s (including the 1960s) all use the old QJM formula for Mobile Fighting Machines. The Modern OLI's use the new TNDM formula for Mobile Fighting Machines. All databases use the same formula for single weapons. A copy of this OLI database has been provided to all of the subscribers to our annual support contract.

We have structured the database so that the weapons for each period are stored in a different directory. The numbers of weapons in each directory is:

PRE-WWI	=	49
WWI	=	70
WWII	=	576
1970S	=	35
MODERN	=	914
-----		-----
		1644

The count of weapons by nationality includes:

PRE-WWI (49):

24 INFANTRY WEAPONS:

7 ANY	2 UK
2 FRANCE	2 USA
1 PRUSSIA	8 USA/CSA
2 RUSSIA	

22 TOWED ARTILLERY:

3 ANY	3 RUSSIA
2 CSA	1 UK
4 FRANCE	7 USA/CSA
2 PRUSSIA	

3 MFM COMPONENT (i.e. for Cavalry):

3 ANY

WWI (70):

6 ARMOR:

2 FRANCE	3 UK
1 GERMANY	

27 INFANTRY WEAPONS:

1 ANY	9 GERMANY
2 AUST/HUN	2 RUSSIA
1 BELGIUM	4 UK
3 FRANCE	5 USA

31 TOWED ARTILLERY:

4 AUST/HUN	3 RUSSIA
1 BELGIUM	5 UK

5 FRANCE	4 USA
9 GERMANY	

4 FIXED-WING AIRCRAFT

1 FRANCE	2 USA
1 GERMANY	

2 MFM COMPONENT:

1 FRANCE	1 UK
----------	------

WWII (576):

133 ARMOR:

16 FRANCE	7 POLAND
37 GERMANY	8 UK
9 ITALY	24 USA
13 JAPAN	19 USSR

82 INFANTRY WEAPONS:

1 ANY	1 POLAND
6 FRANCE	8 UK
13 GERMANY	23 USA
5 ITALY	11 USSR
14 JAPAN	

47 ANTI-TANK WEAPONS:

2 FRANCE	1 POLAND
16 GERMANY	6 UK
3 ITALY	8 USA
5 JAPAN	6 USSR

94 TOWED ARTILLERY:

8 FRANCE	10 UK
17 GERMANY	1 US/France
5 ITALY	17 USA
21 JAPAN	12 USSR
3 POLAND	

12 SELF-PROPELLED ARTILLERY:

5 GERMANY	1 US/UK
3 JAPAN	2 US
1 UK	

37 AIR DEFENSE WEAPONS:

11 GERMANY	8 USA
8 JAPAN	4 USSR
6 UK	

87 FIXED-WING AIRCRAFT:

39 GERMANY	15 USA
4 JAPAN	18 USSR
11 UK	

84 MFM COMPONENT:

6 ANY	13 UK
32 GERMANY	11 USA
3 ITALY	1 USA/UK
6 JAPAN	12 USSR

1970s (35):**13 ARMOR:**

3 FRANCE	5 USA
2 ISRAEL	3 USSR

11 INFANTRY WEAPONS:

1 FRANCE	5 USA
1 ISRAEL	3 USSR
1 UK	

6 ANTI-TANK WEAPONS

1 UK	5 USA
------	-------

2 TOWED ARTILLERY:

2 USA	
-------	--

1 AIR DEFENSE WEAPONS:

1 USA	
-------	--

2 MFM COMPONENTS:

1 FRANCE	1 USSR
----------	--------

1 ITALY	
---------	--

9 PRC	
-------	--

21 USSR	
---------	--

5 YUGOSLAVIA	
--------------	--

68 SELF-PROPELLED ARTILLERY:

1 BRAZIL	1 N KOREA
1 CZECH	10 PRC
1 EGYPT	2 S AFRICA
3 FRANCE	1 S KOREA
2 GERMANY	3 UK
2 IRAQ	10 USA
5 ISRAEL	18 USSR
3 ITALY	1 YUGOSLAVIA
4 JAPAN	

97 AIR DEFENSE WEAPONS:

1 CZECH	2 SWEDEN
4 FRANCE	1 SWISS
1 GERMANY	8 UK
1 INTERNAT	1 UK/ITALY
1 JAPAN	13 USA
19 PRC	36 USSR
2 S AFRICA	4 YUGOSLAVIA
3 S KOREA	

MODERN (914):**137 ARMOR:**

2 ARGENTINA	18 PRC
2 BRAZIL	8 S AFRICA
1 CANADA	4 S KOREA
7 FRANCE	1 SAUDI ARABIA
11 GERMANY	4 SPAIN
1 IRAN	2 SWEDEN
1 IRAQ	10 UK
5 ISRAEL	24 USA
2 ITALY	25 USSR
5 JAPAN	3 YUGOSLAVIA
1 N KOREA	

220 INFANTRY WEAPONS:

1 AU	10 JAPAN
2 BELGIUM	1 N KOREA
1 BRAZIL	35 PRC
3 CZECH	15 S AFRICA
1 EGYPT	8 S KOREA
2 FINLAND	1 SAUDI ARABIA
10 FRANCE	10 UK
11 GERMANY	35 USA
2 INTERNAT	1 USA/INTL
3 IRAQ	35 USSR
5 ISRAEL	28 YUGOSLAVIA

91 ANTITANK WEAPONS:

3 FRANCE	1 SWEDEN
4 INTERNAT	5 UK
4 JAPAN	17 USA
13 PRC	33 USSR
3 S AFRICA	8 YUGOSLAVIA

59 TOWED ARTILLERY:

1 AU	3 S AFRICA
4 FRANCE	3 S KOREA
1 GERMANY	2 UK
1 INTERNAT	8 USA

47 FIXED-WING AIRCRAFT:

1 ARGENTINA	4 PRC
5 FRANCE	1 S AFRICA
3 INTERNAT	3 UK
1 ISRAEL	15 USA
1 ITALY	13 USSR

26 ROTARY-WING AIRCRAFT:

2 FRANCE	1 UK
1 GERMANY	11 USA
1 S AFRICA	10 USSR

169 MFM COMPONENT:

1 ANY	5 S AFRICA
16 FRANCE	2 SWEDEN
9 GERMANY	4 SWISS
2 INTERNAT	11 UK
2 ISRAEL	1 UK/FRANCE
3 JAPAN	51 USA
2 N KOREA	46 USSR
12 PRC	2 YUGOSLAVIA

We expect to continue updating and improving this database and plan on revising it at least once a year. If any user has values calculated for any weapons that we do not have, we would be happy to incorporate them into our database, as long as we have a reference for the sources used for the calculation. 

The Complete Library of HERO Reports

by Susan Rich



While TDI maintains the most complete collection of HERO reports in existence, our collection is incomplete. Of the 130 reports prepared, the 29 listed below are missing from our library. In some cases the missing reports are classified and were destroyed when DMSI closed down. These include reports 12, 13, 20, 42, 61, and 84.

Three of the projects (18, 19, and 29) are books, and we do not have copies of them. Although Trevor wrote over 80 books, they were always considered his personal property

and as such were not part of the company project list. A number was assigned to three projects, 104, 127, and 128, but there is no evidence that a report was actually written corresponding to these numbers.

The remaining 17 reports are ones that are simply missing. We ask our readers that if you have a copy of any of these reports in your files, please make a copy and forward it to us so that our collection can be complete. 

MISSING HERO/DMSI/TNDA REPORTS 1962-1992

- | | |
|---|--|
| 12. Isolating the Guerrilla, Vol. 1 (Confidential)(1965) (ARO) | 56. Assessment of Arab and Israeli Combat Effectiveness: 1973 War (1977) (CIA) |
| 13. Development of a Public Information Program on Temporarily Incapacitating Chemical and Biological Agents (Confidential) (1966) (US Army) | 60. Availability of Historical Data Concerning Soviet Air Defense Experience (1978) (Sandia) |
| 18. Military History of World War 1 (1967) (Franklin Watts) | 61. Analysis of the Implications of Surprise in Scenarios of Conventional and Tactical Nuclear Combat in Europe (Secret) (1978) (DNA) |
| 19. The Reserve Story (1967) (Army Times Publishing Co.) | 69. Navy Nuclear Test Personnel Review |
| 20. Comparative Analysis of Armored Conflict Experience (3 Volumes) (Secret) (1967) (PA&E) | 79C. Analytic Research on Strategic, Tactical and Doctrinal Military Concepts: Nuclear Weapons Proliferation: Impact and Response (1980) (DNA) |
| 21. The Nature of Military Power and its Application in the Future (2 Volumes) (1967) (US Army) | 79E. Analytic Research on Strategic, Tactical and Doctrinal Military Concepts: The Concept of Nuclear Threshold (1980) (DNA) |
| 26. Target/Range Experience for Tank and Antitank Weapons (1969) (Batelle) | 84. Static Comparison of Combat Capabilities of NATO and Warsaw Pact Forces at Division Level in the European Theater of Operations in the Early 1980s (Secret) (1981) (CIA) |
| 27. Historical Data on Tactical Air Operations: The Rome Campaign, 11 May-17 June 1944 (1970) (AFS&A) | 85. Potential Military Aggression Against Jordan (QJM Analysis) (1981) (Keyadah) |
| 29. Foreign Area Studies Handbook: Mongolia (1970) (AU) | 89. Conventional Attrition and Battle Termination Criteria (1981) (MRA&L) |
| 30. American Revolutionary Bicentennial Commission: A Calendar of Events; American Revolution Commemorative List (1970) (ABC) | 96. Artillery Fire and Effect, US Ninth Army, Roer River Crossing, Feb. 23, 1945 (1977) (DNA) |
| 33D. Allied Air Interdiction in Support of OVERLORD, 6 June-25 August 1944 (1971) (AFS&A) | 97. Toward an Overview of Modern Chemical/Conventional Combat: A Conference Based on Historical Experience (1983) |
| 37. Familiarization Program - The Founders Project | 104. Unknown |
| 42. Feasibility Study for Net Assessment of Effectiveness of NATO-Warsaw Pact Forces by Means of QJM (Secret) (1973) (DIA) | 115. History of OTEA |
| 43. A Selective Historical Evaluation of the Qualitative-Quantitative Effectiveness of the Employment of Unconventional Forces and/or Resources in Support of Unconventional Forces and/or Resources in Support of National Policy (1973) (Braddock, Dunn & McDonald) | 127. Unknown |
| | 128. Unknown |

TDI Profile:

George A. Daoust, Jr.

by Susan Rich



George Daoust is Chairman of the Board of Directors of The Dupuy Institute, which he assisted Trevor Dupuy in establishing in 1992. They shared similar backgrounds and experiences as career Army officers, and maintained a close friendship and business association throughout the years.

Dr. Daoust was born on October 10, 1922 in Oakland, California. He graduated from the United States Military Academy in 1945 as an infantry officer. After graduation from parachute school he served in the 508th Parachute Infantry Regiment in Germany, followed by staff, intelligence, and other troop assignments. From 1949 to 1952 he was an instructor in the Airborne Department of the Infantry School, where he developed new courses and taught classes in Pathfinding, Aerial Delivery, and special operations. In 1952 he was assigned as Chief of Physical Security on the task force conducting the first test of the hydrogen bomb on Eniwetok.

Following staff and troop assignments in Washington, D.C., Japan, and Fort Bragg, Dr. Daoust attended Georgetown University from 1956 to 1958. Continuing his studies there while assigned to the Army General Staff, he received a Ph.D. in International Relations. He was chief of the Communist China General Intelligence Branch during the Taiwan Strait crisis and shelling of Quemoy, and served as Assistant Secretary of the General Staff in 1959–1960.

From 1962 to 1966 Dr. Daoust was Berlin Action Officer in U.S. European Command during the Berlin Wall and autobahn crises. The following year he was responsible for the coordination of political and military activity in Berlin and Germany in the Department of Defense, and was a member of the Berlin Task Force in the State Department.

After being selected for promotion to Colonel, Dr. Daoust retired from the Army as a Lieutenant Colonel in 1967. Upon retiring, he joined Stanford Research Institute in Washington, D.C., where he organized and was Director of the Political/Policy Analysis Department. During the next four years he was project director and editor of several studies, including US–Soviet Interaction Models, U.S. Military Bases in Spain, and a Political, Economic, and Military Evaluation of Japan in the 1970s. During this period he developed a program to adapt the principles and techniques of international crisis management to domestic and urban problems.

Dr. Daoust became a member of the International Institute for Strategic Studies in London, England. He was appointed to the European Advisory Committee in the Department of State. He was also an occasional lecturer and consultant to the National War College and the Industrial College of the Armed Forces.

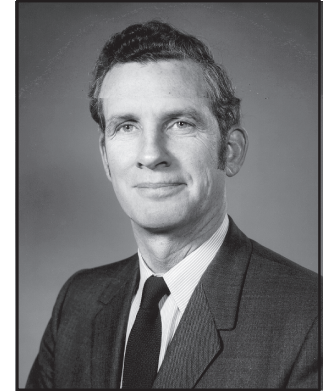
In 1971 Dr. Daoust was appointed Deputy Assistant Secretary of Defense for Manpower Research and Utilization. In this position he was responsible for the All–Volunteer program during the transition from the draft. He also coordinated the DOD Manpower Research program and monitored manpower utilization. Dr. Daoust served as the manpower representative on the DOD Pro-

ductivity Steering Committee in 1972–1973 and headed the U.S. Interagency committee on the future of Selective Service. He undertook numerous highly classified, sensitive manpower studies, and directed research to assure more effective utilization of both military and civilian personnel in supporting the DOD's various national security objectives.

As an early supporter of Equal Opportunity in the Armed Forces, Dr. Daoust worked to develop support for a model day care system for military installations. This would have allowed mothers to continue a full time career in the military, and would have made a major impact on the early education field, as well as on the individual lives of the participants. Now, 25 years later, this concept is becoming a reality.

After leaving DOD in 1973 Dr. Daoust wrote extensively and participated in numerous hearings and conferences on manpower in the Armed Forces. He was Dean of the International University of Communications, where he taught graduate seminars in Political Geography and Systems Analysis. He was a consultant on manpower and political/military issues until 1975 when he joined Planning Research Corporation (PRC) as Director of Government Relations. This led to his selection in 1981 as Executive Director of the National Council of Technical Service Industries (NCTSI), an association of major defense service contractors. During his years at PRC and NCTSI he was a registered Congressional Lobbyist.

Dr. Daoust left NCTSI in 1985 to take an extended three year vacation with his wife Lucy. They had a van and trailer built to their specifications, and toured throughout the U.S., with side trips to Hawaii, Alaska and Canada. Since returning to their home which Dr. Daoust built 23 years ago in Great Falls, Virginia, they have taken several lengthy trips to

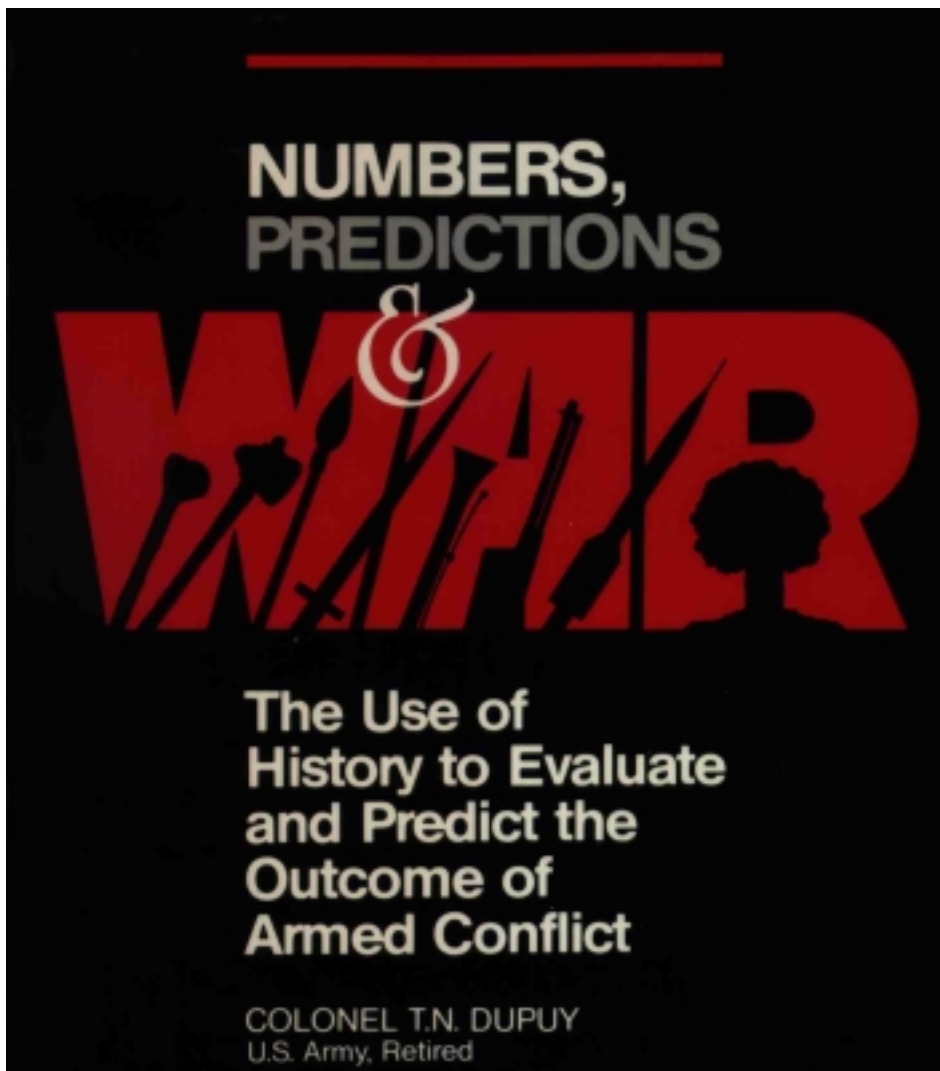


The most recent photo (c. 1975) of the man reputed to be Dr. George Daoust.

Europe and the Middle East.

Although retired since 1985, Dr. Daoust has remained overcommitted to work. Since 1992 he has published and edited the magazine *Current World Affairs*, which is a quarterly bibliography of current events. He and Lucy share an interest in genealogy, and together spent several long years transcribing, printing and binding 15 volumes of diaries written by Lucy's grandfather, who served in the 7th Regiment, US Colored Troops, in the Civil War and who published the history of their service in 1878.

Dr. Daoust has retained strong ties forged 50 years ago with his classmates at West Point and their families, and enjoys spending time with his daughter (the author of this page) and her children. He maintains that "Life gets better with each passing year, but they sure pass quickly now!" 🌐



The Influence of T.N. Dupuy's Research on the Treatment of Ground Combat in RAND's RSAS and JICM Models

Also in this issue:

- **Iranian Casualties in the
Iran-Iraq War, Part 2**
- **More on the QJM/TNDM
Italian Battles**
- **How Advance Rates Are
Calculated in the TNDM**

INTRODUCTION

In tribute to what Trevor Dupuy pioneered and in an effort to pursue what he wanted to achieve, TDI continues to amass historical data and strives to refine the combat variables which go into the TNDM. In this issue of our newsletter Christopher Lawrence, Richard Anderson, José Perez, Susan Rich, and Jay Karamales continue to provide information on these efforts.

As you, our readers, survey the pages of this issue, you may be curious about the total scope of work of TDI. The paragraphs below outline what is missing in applied military history and what TDI is doing to shore up that deficiency. In other words, here is *our core capability*:

1. TDI provides independent, objective, historically-based analyses of modern military campaigns. Operations research, as developed during and right after World War II, was based on recorded, detailed data from battles. It is now nearly extinct. It has been supplanted by weapons and systems effects and performance analyses totally devoid of human factors considerations. As a result the Services, particularly the Army, have only partial answers for the development of operational concepts, battle doctrine, weapons requirements, and organizations. Similarly, because they were not historically validated, the Service models and simulations are skewed. Striving for only measured weapons effects and technical systems capabilities, they miss (or significantly distort) the impact of leadership, training, organization, and psychological factors (such as fear of death) on military units in contact.

2. Over the years, TDI, a successor organization to the Historical Evaluation and Research Organization (HERO), both founded by the late Colonel Trevor N. Dupuy, has compiled a large database from modern military campaigns and battles. Using Colonel Dupuy's methodologies and some new techniques, TDI has developed the following capabilities:

a. Comparison of fighting capabilities of opposing forces (systemic strengths and weaknesses) based on:

- (1) Command and organizational arrangements, leadership, force structure, intelligence, and logistics;
- (2) Training, cultural and psychological profiles, and flow of information;
- (3) Doctrinal flexibility or constraints in utilizing new weapons and technologies.

b. Validation of models or simulations and of scenarios for field exercises. Validation is a process, based on historical data and trends, that assists in determining whether a scenario, model, or simulation is an accurate representation of the real world. TDI has the capability to do this independently or to provide primary source historical data for agency in-house validations.

c. Estimating casualties for combat or other operations.

d. Providing lessons learned from studies of cause and effect chains among responsible players at the political, theater, operational, and tactical levels.

e. Analysis of group behavior (impact of various combat activities on units) and other human factors (historically-based aggregate measure of leadership, training, morale, organizational capacity, and cultural characteristics) in modern battles.

f. Studies, based on historic trends and experiential data, of the specific impact on combat caused by new technology and the improvement in weapons. This enables projections of ways in which future wars should be fought and understanding of what elements constitute "force multipliers."

3. The capabilities listed above merge operations research with historical trends, actual combat data, and real world perspectives creating applied military history in its most useful sense.



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IN HONOR OF THE MEMORY OF THE LATE

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Col., USA

International TNDM Newsletter

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From the Editor...



Just in case you have been watching your mail box closely, you may have noticed that it has been almost 10 months since you saw the last issue of *The International TNDM Newsletter*. There are several reasons for this. First and foremost was that we were not doing any work using the model during that period. Second, the Institute was overloaded with its current project work and a number of new significant marketing efforts. As such, our last issue, the December 1997 issue, came out in late February 1998. We have not produced a new issue since then. As such, this December issue picks up where we left off. For those of you who have a subscription, the subscription is considered to be for 6 issues, vice a calendar year. The original plan was to produce the *Newsletter* every two months. We almost held to that plan for the first nine issues, and then had this extended break. During that time, with the Suppression Contract, Bosnia Studies, Mine Studies and our ongoing support contracts, we were making extensive use of the TNDM and systematically making improvements and updates to it. The nature of our studies over the last year have changed with us temporarily making much less use of the model, so work with the TNDM stopped for a while. We now expect to resume more work with the model. It's uncertain whether it will be at the same level as before, so we are not sure the *Newsletter* will remain bi-monthly or be spaced out further. For those who hold annual support contracts, we intend to extend the dates of the support contract to account for this "blank" period. We will address this to you in private correspondence.

Last month, I gave an extended four-hour TNDM lecture and presentation to a company in East Asia looking to purchase the model. If this occurs, we may be doing some significant additional work on the model, especially if they are looking for some changes to fulfil their specific needs. Again, after reviewing other models, they came to review the TNDM because the other models seems to produce "non-historical" casualty and advance rates and do not measure the impact of human factors on combat. As such, the TNDM still retains a place in the modeling community for those who are interest in real-world representation of combat and wish to address all the major factors that influence battle outcomes, including the human factor.

The lead article of this issue is an informal paper from Paul Davis of RAND on the influence of the QJM on RSAS/JICM. This article was an unsolicited response to a casual phone call I made to him one evening. I am very thankful that Mr. Davis took the time to prepare this article. It was an effort above and beyond the call of duty.

As Mr. Davis was so kind as to prepare an eleven-page article for me, I took the time to compose an article that answers his question on how advance rates are calculated in the TNDM.

Also, for this issue, we are finishing the article from Bill Beuttel at Boeing on the Iran-Iraq War. His original article was long enough that we took the liberty of breaking it into two parts. This article addresses the causes of casualties by weapons effects. We did send copies of the previous issue to the Iranian Embassy in Canada and to Dr. Cordesman of Georgetown University for comment, but to date, neither have chosen to respond. But since the original article was published, the Iranians have issued out a press release stating that they suffered 181,000 people killed in the war (85% of 213,000 during the Revolution and the War). This certainly matches well with Mr. Beuttel's average-based estimate of 188,000 dead. We have yet another article in hand from Mr. Beuttel on chemical weapons and Iranian casualties in the Iran-Iraq War. We will be publishing this in the next issue.

We will be presenting two articles related to Salerno, one in this issue and the other in the next. Back in Volume 1, Issue 6, we published an article by Niklas Zetterling of the Swedish War College on some errors in the original QJM validation database. This article poses two questions: first, was there an error in the original data HERO assembled on Sicily; and second, did this error result in TDI calculating too low a CEV advantage for the Germans. As a result of some other contract work we are doing, we have had the opportunity to review the Salerno engagements, and of course Dr. Zetterling was quite correct. So we have included an article that identifies those corrections that we have made.

The second part of the question will be answered in the next issue. As part of our TNDM demonstration that we did last month, we ended up modeling a part of the Salerno landing as a series of incremental engagements. We will have Mr. Anderson write up what was done and how the results measure with history in the next issue. Like most of our runs (I believe Darwin/Goose Green is the only exception), we ran these engagements only once. We do not tweak the engagements to perfection. This engagement directly points to the issue of time as used in the TNDM, for we have been discussing this some in past issues. As such, there will be a brief postscript to the issue of time in the TNDM that partially adjusts and corrects what I wrote in Volume 2, No. 3 of the *Newsletter*. I hope this provides a clarification to our South African users.

As such, we have made a few small adjustments and corrections to the model, primarily being able to turn “the short engagement” function on and off as needed. This is version 2.05 and will be sent out to our users next month.

We still need to address the issue of the revised armor OLIs, but that will have to wait until the next issue or the one after that. As the OLIs are balanced for current weapons, and validated for WWII weapons, for now we are guardedly comfortable with the situation. However, this is not a problem that we intend to let sit uncorrected. I suspect the solution to the problem now is that we need to revise the armor value formula to adjust the weight tables by historical period, as it appears the primary problem with the revised armor values is that they were done for modern weapons, and no attempt was made to address the WWII period.

Finally, for our *Who is TDI* article, it is time to introduce the President of TDI, General Nicholas Krawciw (ret. USA). General Krawciw joined the Institute in January of 1995, and it was intended that he take over the Institute at the end of the fiscal year. This process was unfortunately hastened by Col. Dupuy’s untimely death in June 1995, but Gen. Krawciw has been at the helm since that time.

The articles addressing a TNDM analysis of the Battle of Dom Bütgenbach have been yet further delayed as both Jay Karamales and I have been distracted by other issues, including the need to meet contractual deadlines. We will have it in a future issue, perhaps the next one. We intend to conduct it as an analysis of multi-day division-level battle, and then fight the battle the way it occurred as a series of battalion-level engagements. We then will test the model results to the historical results. This test is also considered to be part of our on-going validation efforts.

As always, I expect to include some articles in the next issue on our battalion-level validation work. We have still to conduct our analysis of the advance rates and a summary conclusion from the first validation. We also need to test all these changes to our second battalion-level validation data base of 123+ battles from 1914 through 1991. Right now, though, we are going back through the TNDM and running the initial 76 battles not using the OLIs (i.e., every man has a OLI of 1 and no weapons are counted). We are then going to

compare them to the runs using the OLIs and see which predicts better. While this will not “validate” the OLIs *per se*, if the runs using the OLIs predict better than the runs without them, then we must conclude that the OLIs are helping to improve the predictive capability of the model. If the reverse is the case, well.....

On a final note, The Dupuy Institute and I have signed a contract with Westview Press, a division of Harper-Collins, to write a book entitled *Prokhorovka: The Battle of Kursk*. It will be based on the research we did for the Kursk database. Our old Russian research team has already started gathering participant interviews. It is expected that I will be working on this book “in my spare time” over the next year and hope to complete it by the end of 1999. If anyone knows of a source of funding for TDI to do a “lessons learned” study of the battle, this would go a long way in helping to complete this book.

That is all for now and it is good to be back writing (although I hate editing). If you have any questions, please contact me. Addresses, email addresses, and phone numbers are in the masthead. 



Influence of Trevor Dupuy's Research on the Treatment of Ground Combat in RAND's RSAS and JICM Models

by Paul K. Davis



This paper is about how Trevor Dupuy's research affected RAND's work on a series of combat models from 1982 onward. The paper begins with background on the RAND models, notes Dupuy's broad influence, and then describes how RAND's close-combat models were formulated and calibrated. The next part of the paper addresses points raised in a recent *TNDM Newsletter* article by James Taylor and also corrects some misimpressions.

Background

The RAND Strategy Assessment System (RSAS) was in continuous development from 1982 until about 1992, after which it was succeeded by a post-Cold War version called the Joint Integrated Contingency Model (JICM).¹ The RSAS was an analytical wargaming system describing joint and combined operations in theater and global conflict for the spectrum from conventional through general nuclear war. It represented commanders and political leadership with knowledge-based models. The RSAS could be used as a closed model or as a game with some higher level decisions made by players. The combat model, called CAMPAIGN, could also be used alone, either closed or as a game.² It decomposed into portions for air, ground, naval, and strategic-mobility operations.

The JICM resulted from a substantial reprogramming that improved overall coherence, combined features of alternative theater models contained within the RSAS, and provided a single interface. Regrettably, the political and commander-level models were not updated for the post-Cold War period and withered away, but the JICM has an improved treatment of combat and mobility and uses conditional logic to describe adaptive plans. These plans can be seen as minimal commander models. The JICM is used heavily by RAND in studies and exercises for Air Force, Army, OSD, and Joint Staff sponsors. It is also used directly in some war colleges, by OSD(PA&E), by the Korean Institute for Defense Analyses (KIDA), and by the Korean armed forces. RAND also uses START, a more simplified spreadsheet model that draws heavily on the JICM for its ground combat algorithms.³

With this background, what follows focuses on ground combat modeling in the RSAS and JICM. It is here that Trevor Dupuy's work had the most effect.

The RSAS/JICM Ground-Combat Models

We began brainstorming the RSAS combat model in 1982.⁴ From early on, we set the objective of representing

diverse factors that had previously been given short shrift. These included treating maneuver concepts and other aspects of strategy explicitly and representing the Soviet style of theater warfare. We also put a great deal of emphasis on reflecting qualitative factors such as fighting effectiveness and surprise, using history as a source of lessons learned and rough numbers, and being willing to add factors and processes to the model as needed to connect with what military experts really believed to be important at the operational level of warfare.

We were never going to use the RSAS to do weapon system tradeoffs such as those involving alternative tanks, but we were going to be doing studies related to the conventional balance, higher-level defense planning, arms control, multi-theater war, various force-improvement proposals, and potential nuclear escalation (Davis and Winnefeld, 1993). In some of these studies, qualitative factors would be crucial.

Two other considerations were important. First, the RSAS was to be fast-running and suitable for extensive uncertainty analysis.⁵ Second, we sought to understand results over time and what underlay our assumptions. In part because of this, we did not use the mathematically elegant matrix-equation approaches. Although they had much to recommend them, we were not persuaded that they were so correct as to justify slower run speed and the great delays and complications involved in establishing killer-victim scoreboards.⁶ Instead, we started down a path of using unit and weapon-category strengths or scores, and then taking situational factors into account before estimating attrition and movement.⁷ This approach remained controversial, but I believe it was correct for our purposes.

Influence of Dupuy's Work

As the reader should have inferred by now, I was strongly influenced from the outset (as my colleagues were later) by Trevor Dupuy's writings (Dupuy, 1979). Indeed, at the invitation of me and Milt Weiner, Trevor visited RAND as a consultant, probably in 1985. We talked subsequently on a number of occasions until his death. We even served together on a panel reviewing modeling issues for the now-defunct Office of Technology Assessment. I made a point of citing Trevor's work in many papers and talks, which he appreciated because so many people in the analytic community failed to take his work as seriously as it deserved. He in turn commented thoughtfully from time to time on our work at RAND. Not surprisingly, he particularly liked a paper critical of DoD modeling (Davis and Blumenthal, 1991). In any case, Trevor

understood my appreciation for his work enough to ask me for a letter expressing it when he was building support for the Dupuy Institute. I was delighted to respond.⁸

Against this background, it seems to me looking back that Trevor Dupuy's work affected RSAS development in four ways: (1) by strongly influencing our overall philosophy, particularly with respect to the need to recognize a vast range of factors, including controversial qualitative and even subjective factors such as national fighting effectiveness; (2) by convincing us that historical information was a valuable source of both insight and rough numbers (always controversial); (3) by providing some of those numbers, which we could use along with other information to define and calibrate the baseline models; and (4) by providing history-based "verities" that we could use as challenges, assessing whether the emerging RSAS could generate results consistent with historical tendencies.⁹

The proof of the pudding in modeling, of course, is whether it proves useful. Thinking back, I see many ways in which Dupuy's influence on RAND affected later policy-level work for the DoD. In particular, a number of our studies for OSD and the Joint Staff have highlighted issues and suggested solutions that simply were not on the table of those reluctant to use qualitative and subjective factors.¹⁰ Also, we have used historical examples heavily in our discussion with military officers, which often is valuable in finding common ground, establishing credibility, and communicating complex ideas.

Important Limits of Influence

What did *not* happen is also worth discussing. Although we read *Numbers, Predictions and War* in some detail, my colleagues and I did not see the QJM itself as being useful for our purposes. We had many reasons.

First, the QJM was a static model, whereas we needed a simulation generating behavior over time, including the action-reaction behavior of modeled commanders. Further, even the close-combat model used for a time period's fight in a given sector should, in a good combat simulation, be quite different from a static model describing results of an entire battle as calibrated from history. For example, even over relatively short periods such as a day or so, simulation should represent tactical- and operational-level reinforcement, decisions of commanders to withdraw to more defensible positions or reduce flank exposure, and so on. A static model such as the QJM, in contrast, must somehow represent the effects of averaging such events over time. It should not be surprising, then, that Dupuy's historically-based model shows less dramatic dependences on force ratio and other factors than might be found in a strictly local calculation of a simulation.

Second, the original QJM was closely tied to a ground-force-centric image of war and historical data from an era that preceded precision guided weapons (PGMs) for tactical air forces, attack helicopters, and what became missile systems such as MLRS/ATACMS. As a result, it greatly oversimplified and reduced visibility of much of what we were

interested in. We did not believe that OLI (or WEI/WUV) methods worked adequately for these matters—especially as we looked ahead.¹¹

Third, a central credo of our approach to analysis was appreciation of uncertainty, including recognition that most of the key parameters of combat models are highly uncertain—especially for future battles, but even when looking to past battles, except in special instances (Ardennes? Kursk?) where historians have gone to great lengths to collect information. This meant that we never took seriously the precise numbers we used as baseline values in attrition or other equations. Instead, we planned to do extensive sensitivity analysis (or what we now call exploratory analysis) in which, for example, we would be varying attrition intensities and even qualitative fighting effectiveness substantially. In this context, readers should not be surprised that we saw claims for the early-80s QJM as much too good to be true. It seemed evident that Dupuy had greatly "overused" the available data in a statistical sense.¹² Further, those of us who knew him observed that in his actual work, Trevor went through much more extensive campaign analysis than one might naively think hearing about the QJM. Although the QJM was static, he would identify different phases of a campaign and treat them separately, having noted when reserves were committed or some such, etc. That is, as a good analyst he was doing "off line" much of what we were trying to do explicitly in an analytic war game or simulation.

A fourth factor was the analytical character of the original QJM model. It had been built up from a series of incremental patches with many buried interrelationships and nonlinearities. When at one point we attempted to calibrate using QJM data, we generated curves from the model and found behaviors that made no sense to us phenomenologically.¹³

Fifth and finally, we disagreed with the QJM on theoretical grounds, believing that it mistreated some very phenomena—not only the ones mentioned above in connection with modern warfare such as attack helicopters or tactical air forces with PGMs, but also classic close-combat considerations involving large-scale operational maneuver, force-to-space ratio,¹⁴ combined-arms imbalances, deep battle, and the need to disaggregate so as to estimate attrition separately to different weapon classes (e.g., with artillery being reduced primarily by other artillery).¹⁵ Thus, we were taking Dupuy's research quite seriously, but attempting to move beyond it in many ways.

I have elaborated on these matters to explain why we were at once strongly influenced by Dupuy's insights and historical data, but not motivated to use or calibrate to the QJM *per se*. James Taylor grumps in a recent *TNDM Newsletter* article (Taylor, 1997) about the failure of us and others to do so, but we had good reasons.

Many Sources of Information Were Used

A related consideration here was that we were drawing on *many* sources of information simultaneously, even for historical data. In sketching our original approach to attrition

modeling, I personally drew on work of Wainstein (1973) from IDA, Yengst and Smolin (1981) from SAIC, General Chaim Herzog of Israel (Herzog, 1984), David Rowland of the UK's DOAE (now DERA), and others.¹⁶ Bruce Bennett drew on earlier Army reports and models studies associated with the Quick Game developed by Ed Kerlin and others at RAC and the ATLAS model.¹⁷ We also had a fair amount of quantitative information from unclassified Soviet sources regarding rates of advance, repair rates of damaged tanks, durations of operations, and so on. Alan Rehm, who had worked on these matters while at CIA, provided further information on Soviet thinking (e.g., Rehm and Sloan, 1984), as did John Hines working in the Office of Net Assessment and two Afghan officers who had studied in the Soviet Union (Sloan, Jalali, and Wardak, 1985).¹⁸

There was a large variance in data, both within individual studies such as that of Wainstein, and even more so across authors, who had made different assumptions about orders of battle and the like. Thus, when it came time to write down our attrition equations and calibrate the coefficients, we never even thought about attempting to do anything "rigorous," much less doing so within the particular framework of the QJM alone.¹⁹ Instead, our intention was to incorporate all the important factors and processes, and to draw on the diverse sources of information for "roughly right" baseline numbers with the understanding that RSAS analysis would emphasize uncertainty and not take baseline "predictions" seriously at all.

Bruce Bennett generated the first "official" RSAS ground-combat attrition equations in 1985, using a variety of data, statistical methods, and analytical judgments that we had made after a lengthy internal discussion (Bennett, et al, 1988, pg 57).²⁰ It was an example of analytic art, not rigorous calibration. Although the model was fully documented, the number crunching details of calibration were not. Over time, however, RSAS users spent a great deal of time comparing RSAS behavior to that of other models, historical examples, and military judgment about specific situations.

Over the years, the RSAS was modified and fine-tuned many times to represent anecdotal and other information from military officers with recent field experience, as well as some newer information from the Soviets or historical analysis. Along the way, RAND also held workshops to discuss particular issues.²¹ There were also one-on-one meetings in which Bruce Bennett went through model details and rationale with interested parties. Finally, an RSAS Newsletter (later renamed the Military Science Newsletter) described developments and discussions over time. Similar discussions continue on the JICM model, but the attention, of course, is on future warfare.

Some Misimpressions About the RSAS

Let me now comment briefly on some misperceptions in James' Taylor's interesting article in the *TNDM Newsletter* (Taylor, 1997), which describes Trevor Dupuy's work in terms of a "system picture." First, as discussed above, we at RAND

were quite familiar with Dupuy's work and believed that we understood well what we were doing as we moved on, drawing also on many other sources of information. Second, despite Taylor's impressions, we most assuredly did "recalibrate" when using Dupuy's and other historical data—not in the way he might have suggested, especially if using Dupuy's data as a closed system, but in a way that attempted to disentangle the kinds of nonlinear effects that Taylor correctly notes exist in the QJM.²²

Second, despite Taylor's impression to the contrary—due probably to our failure to discuss this in the public-release documentation—we used Dupuy's analysis of personnel loss rates versus armored loss rates from the beginning of our work. At the time of the original RSAS development, Dupuy's work was the only good information on how to translate personnel losses into equipment losses, albeit crudely.²³ The RSAS and JICM focus on equipment losses, as do most models, but when called for, we "go backward" and generate estimates of personnel loss rates, which are typically estimated to be several times smaller (a function of simulated repair rates, the type unit, type battle, and other factors).

Third, Taylor puzzles about why RAND did not use the ratio of fractional loss rates to simplify the attrition equations. He is, of course, quite right on the simplification. However, when constructing the RSAS, we were not convinced that the relevant equations should even be symmetric between attacker and defender, which ruins the simplification. Further, as mentioned above, our equations were developed by fitting algorithmic forms, not merely coefficients, to previous models and data.²⁴ Finally, it was analytically convenient in studies where we varied parameter values to do so for the constants in defender loss rate (a measure of intensity) and ratio of loss rates (a measure of defender advantage). I merely report this, without claiming that our approach in this regard was better or worse than alternatives. My personal preference in special studies of theoretical matters has often been to go for analytical simplicity of precisely the sort Taylor suggests,²⁵ but a computer model doesn't really care about such aesthetics.

One further point on this topic may be of interest here. In the late 1980s I suggested on theoretical grounds using ratio of fractional loss rates (RLR) as a key variable dictating ground movement rate.²⁶ Bruce Bennett and I worked out details and the movement model was changed accordingly (Allen, 1992). Somewhat later, Robert Helmbold of the Army's Concepts Analysis Agency reported historical analysis that showed reasonably good correlation between RLR (what he calls FERV) and battle outcomes, including movement.²⁷

Finally, a word on documentation. Taylor's article grumbles about what he thought was a lack of documentation. As a general proposition, he is correct: DoD's models (and RAND's) are usually poorly documented. This said, there has been an enormity of documentation available to RSAS and JICM users, especially if one considers unpublished materials, on-line documentation within the program (a predecessor of today's ubiquitous software "assistants"),

and opportunities for both workshop- and one-on-one discussions between developers and users. My own lament is that we have usually lacked *consolidated* top-down documentation, particularly as the RSAS and JICM models have continued to evolve. Bennett (1988) and Allen (1992) are among many reports I consider good documentation (as were reports by IDA on TACWAR and IDAHEX), but models in actual use change over time and follow-up documentation is typically delayed, incremental, and unpublished. The moral of the story here is that even in the best of cases there is no substitute for interested parties visiting with developers and discussing matters face-to-face, sometimes looking at the computer screen itself. Impressions from published material are often inadequate and misleading. It does not help that proprietary considerations cause many model builders not to publish critical information. As I write this, I do not know, for example, whether the much simpler TNDM is fully documented in public documents—even though the original QJM (Dupuy, 1979) was laid out in detail. Dupuy (1987) leaves out parameter values.

Current Models and Comparisons

The discussion above has focused on history rather than what exists today. The QJM was improved and clarified over the years. It spawned the TNDM, which incorporates further improvements. The current JICM continues to be an evolving model with data reflecting a myriad of inputs over the last decade. It seems likely that the QJM and JICM ground-combat attrition models are still somewhat similar philosophically, and would often agree fairly well in quantitative predictions for some types of discrete battle. They would disagree sharply in other cases. For example, the RSAS/JICM/START family has a “breakthrough effect” modeled to represent large-scale operations such as those in World War II. If the defender is attempting to hold ground with a poor force-to-space ratio, then when that ratio falls below a threshold, the models predict a breakthrough characterized by a very large non-Lanchesterian attrition to the defender and fast movement rates for the attacker. Movement slows again when the attacker encounters a new defense line, goes too far ahead of its logistics, or reaches its objective for the operation. This was my 1985 attempt (with help of Pat Allen) to represent in the aggregate what would be seen in high resolution as the collapse of a front line due to some penetrations and local encirclements made possible by the inadequate force-to-space ratio worried about by Liddell Hart and others (Liddell-Hart, 1960). Qualitatively, the results of movement and attrition over time in battles looks much like that reported in WW II. In passing, I note that in the RSAS/JICM/START, movement is *anticorrelated* with intensity (casualty rate), precisely as Dupuy suggests in one of his verities (Dupuy, 1987, page 157).

The later RSAS, JICM and START models also penalize a combatant with an imbalanced combined-arms mix, to an extent dictated by the situation—including the combined-arms mix and level of the opponent (Allen, 1992). This ef-

fect is ignored by many models, even relatively detailed ones. It can be large when, for example, one imagines three 82nd Airborne Divisions trying to defend in the desert against one mechanized division. Models like the QJM and TNDM may correct each side’s score for the physical situation, but they do not take into account that one side’s effective score should really depend on the character of the opposing force.²⁸

There are also differences between the JICM scoring methodology and the OLI used in the TNDM, but I am not acquainted enough with either at this point to comment. The current JICM methodology was developed by Bruce Bennett and is largely heuristic.

There would likely be major differences between JICM and TNDM predictions for relatively complex operations involving, e.g., large-scale maneuver and countermovement and other aspects of strategy such as deep and parallel battle. This would depend on how such issues were handled in JICM “war plans” and in offline analysis in the case of TNDM.²⁹ Fundamentally, after all, JICM is a simulation model generating behavior over time and the TNDM is a static model attempting to capture overall results of a battle. Comparison, then, is difficult and depends sensitively on the analysts using the models.

Looking to the Future

What is most important for current RAND work is that the nature of warfare has changed dramatically over the last decades, especially for U.S. forces. As a result, our studies are often driven by the effectiveness of long-range precision fires rather than close combat. C⁴ISR also plays an important role that cannot easily be handled with a single parameter. So also, suppression of air defenses (SEAD) and other special operations matter a great deal to results. We can no longer assume large more or less equally matched combatants. Thus, the relationship at this point between JICM and TNDM ground-combat models is only a small part of the overall story. Unfortunately, historical data is of little use in for “RMAish” effects, i.e., effects associated with the so-called revolution in military affairs. Instead, we must rely on a combination of experimental data, interviews, and high-resolution simulation—tempered by historical and speculative insights about likely action-reaction cycles—to establish the effectiveness numbers and their sensitivity to macroscopic variables. As of this time, the state of the art is poorly developed for doing so.

My own views on the state of military modeling and simulation and the need for a new research can be found in a study that I led for the National Research Council (NRC, 1997) and a new RAND report (Davis and Bigelow, 1998). One theme in both is the need for model *families*—including highly aggregated models such as the TNDM and even simpler models focused on fires, simulation models of varied resolution and character, and special-purpose analytical models. Ideally, we would know how the models in such families relate to each other. In contrast, there are few model families today, they are almost never integrated, and the relationships

among members is only seldom well understood. I suspect that high-resolution models, however imperfect, will be increasingly essential—not just because we lack historical data on future warfare, but also because so many of the issues arising are not well reflected in intuitively estimated “scores.”³⁰ So also, experiments will be increasingly crucial, with distributed interactive simulation providing the basis for creating some *synthetic history* that will be a good deal better than nothing. There is much to be done. It would be very nice if Trevor Dupuy were still with us to push the frontiers.

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¹ I headed overall RSAS development from 1982 until about 1988 when I shifted attention exclusively to defense planning and analysis. Bruce Bennett was my deputy from early in RSAS development. He took over the lead in 1988 and continued it through the transition to the JICM. The best single point of contact for current aspects of the JICM is Daniel Fox in RAND's Washington Office (202-296-5000). Nearly everyone in RAND can be reached by e-mail in the form Firstname_Lastname@rand.org, using formal first names.

² For description of overall RSAS architecture, rather than the combat-model components, see Davis (1986).

³ START was developed by Bruce Bennett and Barry Wilson.

⁴ I established the philosophical approach and did much of the early theoretical work, including links to Dupuy. I was helped a great deal in this by Robert Howe, Patrick Allen, and Bruce Bennett, who then took the lead in developing and calibrating the model actually programmed, and in making many other improvements over subsequent years. Carl Jones did the programming and integration, and contributed much to the model as well. Pat Allen made major contributions in the mid-to-late 80s, particularly to the "situational scoring" used in the later RSAS, JICM, and START (Allen, 1992).

⁵ Such exploratory analysis is a major theme of RAND work. For related philosophy and its implications for higher level defense planning that emphasizes planning under uncertainty and adaptiveness, see the related chapter in Davis (1994) and an issue paper circulated to influence the QDR (Davis et al., 1996).

⁶ Advocates of such models (e.g., CEM, TACWAR, IDAHEX, VECTOR) often criticize simpler approaches as though the matrix models are "correct." These models have mathematical virtues and have long since proved their value in analysis, but "correct" they are not. For example, they depend on highly uncertain bottom-up calibration processes to establish killer-victim matrix data. Further, they have often not incorporated a number of factors we believed in RSAS work to be important.

⁷ This tilt was similar in spirit to Dupuy's use of OLI scores, OSD's use of WEI/WUVs or ADEs, and simulation work at RAND by Milt Weiner and Lou Wegner (Tally-Totem in the 1970s and Master in the early 1980s). However, we maintained information by weapon category and differentiated sharply among them when estimating attrition.

⁸ Letter, Paul K. Davis to T.N. Dupuy, HERO-TNDA-Publishers, 3 January, 1992.

⁹ See the verities published some years later in Dupuy (1987) and *Armed Forces Journal*. As I recall, I concluded from the journal article that Dupuy was not well acquainted with simulation models and how the kinds of phenomena he was describing would or would not be seen in simulations. Good use of the RSAS generated results very consistent with most of his verities (e.g., those of pp 174 ff in *Understanding War*). However, to get such results we needed intelligently developed and adaptive operational strategies. Simulations using unimaginative "scripted methods" often flunk his test of verities.

¹⁰ See Davis (1988a) for an example in which qualitative factors had a major impact on recommendations for conventional arms control. The Central Region has long ago disappeared, but the work was well received by policy makers at the time. It depended on understanding the potential implications of reserve forces having an effectiveness in offensive operations that depended strongly on how much training time they had before commitment. Although I do not recall Trevor Dupuy having included that factor in the QJM, doing so was very much in the spirit of his thinking, as he noted to me in conversation after a presentation. For another example of how Dupuy-inspired factors affected policy-level analysis, see Davis (1988b). This work noted how perceptions of the balance could change markedly if one considered that not all non-Soviet Warsaw Pact forces would fight as effectively as their equipment would permit. In the study behind this paper, we also examined the potential effects of some NATO allies performing less well than others. "Surprise attacks" (which really should be named "attacks before the defense prepares adequately") also played a large role in the study and the subsequent one on arms control.

¹¹ In time, Dupuy appears to have taken a similar view, as evidenced in his book predicting what would happen in Desert Storm (Dupuy, 1990).

¹² I recall discussing this with Trevor when he visited RAND in the mid 1980s. I noted that, unlike others, I had no quarrel with his approach of applying a model to data, observing anomalies, looking more deeply into those cases, finding additional factors to add into the model, and iterating. That was just real science to my eyes (my background was in theoretical chemistry and physics). However, it was a different matter to then claim that because the iterated model eventually fit the data, it could then be considered predictive. He had come to realize this, of course, was always looking for "new" data, and was enlisting the help of others in the community to improve the rigor of his work. His later book *Understanding War* was a big improvement and I still recommend it to students and other newcomers to combat model-

ing. In my view, however, Trevor never emphasized adequately the considerable variance of results. I have been pleased to see that the TNDM Newsletter often does show such things. The TNDM need not be *reliably* precise and predictive to be very useful.

¹³ Later versions of the QJM and TNDM corrected some of these problems. Also, *Understanding War* improved the exposition.

¹⁴ This factor played a crucial role in influential mid-to-late-80s arms-control analysis, although some initial analysis on the so-called operational minimum underestimated the potential ability of small forces—when fighting other small forces—to compensate for a bad force-to-space ratio with good C3I and maneuver capability (Davis, 1990).

¹⁵ Another example was the potential impact of Soviet Operational Maneuver Groups (OMGs), which could not be represented adequately in a straightforward deterministic aggregate-level analysis, but which could be studied if merely one tried hard enough. For a look at our early reasoning on such matters, before actually building the model, see Davis and Williams (1992).

¹⁶ The unpublished Allen, Davis and Bennett (1985) describes some of this effort.

¹⁷ See Kerlin et al, 1967 and Dupuy (1982).

¹⁸ We were also reasonably familiar with models such as CEM, TACWAR, IDAHEX, and VECTOR, but they were not especially useful to us for the purposes discussed here because they represented quite different approaches. The principal exception was IDAHEX, developed by the late Paul Olson, which strongly affected our thinking about maneuver effects.

¹⁹ Yet another consideration was that the DoD was to some extent willing to tolerate and generate ADE scores using WEI/WUV methodology, but was uninterested in Dupuy's OLI alternative.

²⁰ As examples here, we sought algorithms that would be less dramatically dependent on force ratio than Lanchester equations and that would be different for attacker and defender.

²¹ In reading Taylor (1997) I was reminded of one important “shoot-out” workshop in which advocates of the matrix-Lanchester approach argued with those taking the RSAS’ “score” approach. Taylor attended this meeting and made very helpful suggestions based on his knowledge from reviewing many prior models.

²² For a taste of what is involved in this type of work, see Allen (1992), footnotes 4, 5, and 7.

²³ Looking back, I was surprised to see we had not mentioned this in Bennett et al. (1988). Much space had been devoted to it in our unpublished documentation (Allen, Davis, and Bennett, 1985) and I had personally looked for comparable information in sources like Herzog (1984), Soviet, and British sources, without great luck.

²⁴ Some of this is discussed in Allen (1992), which describes fully the situational scoring methodology adopted for the RSAS, JICM, and START. See especially page 41, including discussion of considerations used in fitting and calibrating.

²⁵ Davis, Paul K., *Aggregation Disaggregation, and the 3:1 Rule in Ground Combat*, RAND, 1995. Available online at <http://www.rand.org/personal/pdavis>.

²⁶ The essence of the idea is simple: fast movement occurs when the attacker has won a local battle, not when the combatants are still face-to-face “duking it out” at high intensity. The ratio of fractional loss rates is a measure of who is “winning” the local battle. The loss rates we use here include losses calculated separately from air-to-ground attacks by tactical aircraft and helicopters, and missiles.

²⁷ See Helmbold (1995), which is based on work around 1991, his article on pg 27 of the September, 1997 *Phalanx* newsletter of the Military Operations Research Society, and earlier papers also in *Phalanx*.

²⁸ This fundamental point is generally lost in score-based discussions. It is developed theoretically in work by RAND colleagues using Lanchester systems for analytic convenience (Hillestad and Juncosa, 1993).

²⁹ Although TNDM is a static model, applications can be much broader in scope. I was struck, in 1991, by how closely Trevor Dupuy's published analysis anticipating the Desert Storm campaign corresponded to my own thinking, using RSAS concepts, and British analysis performed at the Defence Operational Analysis Organization (DOAE). The DOAE work, by the way, emphasized nationality-dependent fighting-effectiveness factors based on their own historical research, primarily by David Rowland. I have never seen a side-by-side comparison of his work and Dupuy's. For a good recent discussion of related issues, including what the authors call “attacking flair,” see Speight, Rowland, and Keys (1997).

³⁰ Some related discussion of how high- and low-resolution models can complement each other will be included in the appendix volume of a forthcoming Defense Science Board study on tactics and technology for the 21st century.

³¹ To order RAND publications search abstracts at the web site <http://www.rand.org/PUBS>, using the appropriate name syntax (e.g., Smith, J. rather than John Smith). 

How Advance Rates Are Calculated in the TNDM

by Christopher A. Lawrence

The advance rate formula for the TNDM is more complicated than the QJM. The original QJM advance rate formula, as published in *Numbers, Predictions and Wars*, was:

$$\text{Advance Rate} = \text{Standard Rate} \times \text{General Terrain Factors} \times \text{Road Quality Factors} \times \text{Obstacle Factors} \times \text{Day/Night}$$

In effect there were four lookup tables, one for each factor, which are recreated in the sidebar on the next page. Night advance rates are half of daytime advance rates.

The main point, if one looks at the Advance Rate table, is that advance rate is driven first by force ratio, degraded by posture of defender (whether hasty, prepared or fortified defense), and degraded by attacker force type (armored, mech, infantry, horse cavalry).

The TNDM methodology is:

$$\text{Advance Rate (km/day)} = 1.6 \times \text{Sr} \times \text{me} \times \text{rm} \times \text{hm} \times \text{RQ} \times \text{RD} \times \text{St} \times \text{uar} \times \text{dn} \times \text{Su} \times \text{ff}$$

Sr = Standard (unmodified) unmodified advance rate (Table 13)

me = Mission Effects Factor. For an attacker making an “all-out” effort, the factor is 1.3. A commensurate increase in the casualties will be incurred.

rm = Terrain Factor as it affects mobility (Table 2)

hm = Weather Factor as it affects mobility (Table 3)

RQ & RD = Road Quality and Road Density (Table 14)

St = River or Stream Factor (widths greater than 20 meters (Table 15)

uar = Posture Factors as it affects advance rate (Table 6)

dn = Day/Night Factor. When the time of engagement is less than 24 hours, and all or most in darkness, the standard rate is one-half the normal rate, a factor of 0.5; if the period is entirely daylight, the factor is 1.2; for a 24-hour period, the factor is 1.0.

Su = Surprise Factor (Table 11). For a period of more than one day, the factor is reduced by one-third the second day, by two-thirds the third day, and is not operable thereafter.

Fatigue Factors (ff): For every day of normal sustained combat the advance capability of a unit declines by 0.016, from a maximum value of 1.0 (See Table 10). It is assumed that this factor cannot be reduced below 0.6. The formula is:

$$\text{ff} = 1 - (0.016 \times \text{Days})$$

It is recalculated every day during sustained combat.¹

Effectively, the differences in the two methodologies can be considered as shown in the table below:

	<i>QJM as listed in NPW*</i> Range of Values	<i>TNDM</i> Range of Values
Constant	None	1.6
Force Ratio	3 – 60 km	1.5 – 60 km
Main/Max Effort	1.2	1.3
Terrain Factors		
Inf & Combined Arms	.3 – 1.05	.3 – 1.05 **
Armor & Cavalry	.2 – 1.00	.2 – 1.00 **
Weather Factors	Not included	.5 – 1.00
Road Quality	.6 – 1.0	.6 – 1.0
Road Density	.6 – 1.0	.6 – 1.0
River/Stream Factor	.5 – .9	.5 – .9
Posture Factor	.125 – 1.0	.25 – .9 ***
Day/Night Factor	.5 – 1.0	.5 – 1.2
Surprise	Not included	1.0 – 1.6 ****
Fatigue	Not included	.6 – 1.0

* The QJM as used in the 1980s was not the same version as in *Numbers, Predictions, and War*. The formula given for the QJM in *Understanding War* (1987) was:

$$A = \text{sr} \times \text{rm} \times \text{hm} \times \text{RQ} \times \text{RD} \times \text{ST} \times \text{uar} \times \text{dn} \times \text{Su} \times \text{ff} \times \text{me}$$

These are the exact same variables (less the constant) that are in the TNDM.

** Table clearly has some values adjusted.

*** There is also a 0.0 multiplier for both sides holding (a common situation).

**** 1.0 assumes “no surprise.”

Lookup Tables from *Numbers, Predictions, and War*

Standard (Unmodified) Advance Rates

	Rates in km/day			
	Armored Division	Mechzd. Division	Infantry Division or Force	Horse Cav Division or Force
Against Intense Resistance (P/P: 1.0–1.10)				
Hasty Defense/Delay	4.0	4.0	4.0	3.0
Prepared Defense	2.0	2.0	2.0	1.6
Fortified Defense	1.0	1.0	1.0	0.6
Against Strong/Intense Resistance (P/P: 1.11–1.25)				
Hasty Defense/Delay	5.0	4.5	4.5	3.5
Prepared Defense	2.25	2.25	2.25	1.5
Fortified Defense	1.85	1.85	1.85	0.7
Against Strong Resistance (P/P: 1.26–1.45)				
Hasty Defense/Delay	6.0	5.0	5.0	4.0
Prepared Defense	2.5	2.5	2.5	2.0
Fortified Defense	1.5	1.5	1.5	0.8
Against Moderate/Strong Resistance (P/P: 1.46–1.75)				
Hasty Defense/Delay	9.0	7.5	6.5	6.0
Prepared Defense	4.0	3.5	3.0	2.5
Fortified Defense	2.0	2.0	1.75	0.9
Against Moderate Resistance (P/P: 1.76–2.25)				
Hasty Defense/Delay	12.0	10.0	8.0	8.0
Prepared Defense	6.0	5.0	4.0	3.0
Fortified Defense	3.0	2.5	2.0	1.0
Against Slight/Moderate Resistance (P/P: 2.26–3.0)				
Hasty Defense/Delay	16.0	13.0	10.0	12.0
Prepared Defense	8.0	7.0	5.0	6.0
Fortified Defense	4.0	3.0	2.5	2.0
Against Slight Resistance (P/P: 3.01–4.25)				
Hasty Defense/Delay	20.0	16.0	12.0	15.0
Prepared Defense	10.0	8.0	6.0	7.0
Fortified Defense	5.0	4.0	3.0	4.0
Against Negligible/Slight Resistance (P/P: 4.26–6.00)				
Hasty Defense/Delay	40.0	30.0	18.0	28.0
Prepared Defense	20.0	16.0	10.0	14.0
Fortified Defense	10.0	8.0	6.0	7.0
Against Negligible Resistance (P/P: 6.0 plus)				
Hasty Defense/Delay	60.0	48.0	24.0	40.0
Prepared/Fortified Defense	30.0	24.0	12.0	12.0

Road Quality Factors

Road Quality:	Good Roads	1.0
	Mediocre Roads	0.8
	Poor Roads	0.6
Road Density:	European Standard	1.0
	Moderate Density	0.8
	Sparse	0.6

General Terrain Factors

	Infantry (Combined Arms) Force	Cavalry or Armored Force
Rugged, Heavily Wooded	0.4	0.2
Rugged, Mixed	0.5	0.4
Rugged, Bare	0.6	0.5
Rolling, Heavily Wooded	0.6	0.6
Rolling, Mixed	0.8	0.8
Rolling, Bare	1.0	1.0
Flat, Heavily Wooded	0.7	0.7
Flat, Mixed	0.9	0.9
Flat, Bare, Hard	1.05	1.0
Flat, Desert	0.95	1.0
Desert, Sandy, Dunes	0.3	0.6
Swamp, Jungled	0.3	0.2
Swamp, Mixed or Open	0.4	0.3
Urban	0.7	0.7

Obstacle Factors

	Width (m)	20	50	100	500
River or Stream:	Fordable	0.9	0.85	0.8	0.7
	Unfordable	0.85	0.8	0.7	0.5
Minefields:	Density/km of Front, to 10 km of depth	10	20	50	100
		0.9	0.8	0.7	0.6

Note that there is also a Main Effort Factor, which is applicable to no more than one-third of a force of division size (approximately 10,000 men or more) or larger.

- a. Main effort sector: 1.2
- b. Other sectors: 1.0

So in conclusion, we can state that the new TNM procedure is very similar to the old QJM procedure. The main differences are that the posture factor has been disaggregated from the original table and put in a separate table, and weather, surprise and fatigue has been added. Beyond that, the overall methodology remains the same and is keyed off of force ratio, heavily modified by terrain and condition factors. Over-

all, advance rates between the two models remain the same; while the QJM had an upper limit of 60 kilometer per day, the TNM in ideal circumstances can produce advance rates up to 86.4 kilometers a day, but by the fourth day, this will degrade to 51.4 kilometers a day. Effectively, advance rates under the TNM use the same methodology, but the effects of weather, surprise and fatigue are now incorporated. 🌐

¹The following exceptions must be considered:

- (i) For a defending unit in delay posture there is no change in ff.
- (ii) For a withdrawing unit not seriously engaged the ff factor is increase by 0.016 per day.
- (iii) For an advancing unit in pursuit and not seriously delayed there is no change in the ff factor.
- (iv) The ff factor of a unit in reserve, or inactive, increases by 0.05 per day, up to a maximum value of 1.0.
- (v) When a unit in combat, or recently in combat, is reinforced by a unit at least half its size (in numbers of men), with a higher ff factor, it adopts that factor. If the ff factor of the reinforcement is the same as, or lower than, the ff of the reinforced unit, both adopt the ff factor of the reinforced unit.
- (vi) When a unit in combat, or recently in combat, is reinforced by a unit less than one-half the size of the original unit, but at least one-quarter its size, both units adopt a factor that is a mean of the two factors. When such a unit has a factor less than the reinforced unit, it adopts the factors of the reinforced unit.
- (vii) When a unit in combat, or recently in combat, is reinforced by a unit less than one-quarter its size, the reinforcing unit adopts the ff factors of the reinforced unit.

THE EFFECT OF THE MOBILITY EQUATION AND EVERYTHING ELSE ON ADVANCE RATES

While many other factors are not directly included in the advance rate equation, everything is indirectly included. For example, the mobility equation gives highly mobile forces a combat power advantage. This increased combat power will result in a force having a higher advance rate. The same is true for virtually every factor in the TNDM that influences combat power, from air superiority to terrain to weather to CEV. As they first influence combat power, they influence the P/P ratio that is used to establish the basic advance rate. In many cases, the factors used in calculating the advance rate have been previously applied to calculating the combat power. In effect, some factors applied two (or more) times to influence advance rates.

Therein lies the complication of this “simple” model. It is not a series of lookup tables connected by formulas. As

such, one cannot simply just pull a table from the model and use it as is. The model is indeed an entire system. Some factors affect merely one aspect of the model, other factors affect multiple aspects of the model (i.e. combat power, mobility equation, attrition and loss rates). Therefore, one cannot understand the model by just looking at the tables. Furthermore, one cannot take the factors from the model and use them in isolation with another model, unless one validates that new model with the factors included.

The thing that makes the TNDM work is not that it is “top-down,” “aggregate-scored,” “made-by-a-genius,” or other such theoretical considerations. The thing that makes the TNDM work is that the entire system has been continuously tested to “real-world” (historical) data.

ADVANCE VERITIES FROM *UNDERSTANDING WAR* (pages 158–163)

1. Advance against opposition requires local combat power preponderance.
2. There is no direct relationship between advance rates and force strength ratios.
3. Under comparable conditions, small forces advance faster than larger forces.
4. Advance rates vary inversely with the strength of defender’ fortifications.
5. Advance rates are greater for a force that achieves surprise.
6. Advance rates decline daily in sustained operations.
7. Superior relative combat effectiveness increases an attacker’s advance rate.
8. An “all out” effort increases advance rates at a cost in higher casualties.
9. Advance rates are reduced by difficult terrain.
10. Advance rates are reduced by rivers and canals.
11. Advance rates vary positively with the quality and density of roads.
12. Advance rates are reduced by bad weather.
13. Advance rates are lower at night than in daytime.
14. Advance rates are reduced by inadequate supply.
15. Advance rates reflect interactions with friendly and enemy missions.

It is interesting to note that verity 3 (small forces advance faster than large forces) and verity 14 (advance rates are reduced by inadequate supply) are not included in the TNDM advance rate equation. As the TNDM nominally treats logistics limitations as part of the CEV, then it would sort of included under there with a reduced CEV (which would reduce the P/P ratio, reducing advance rates), but this is a weak construct. Verity 3 is simply not addressed. Since the final and still incomplete step of our original battalion-level validation is to look at advance rates, this issue will be examined at that time. As such, it may be the source of generating a lookup table that modifies advance rate by unit size.

Lookup Tables from *Numbers, Predictions, and War*

Table 2
TERRAIN FACTORS (r)¹

TERRAIN CHARACTERISTICS	Mobility Velocity km	Tanks			
		10	20	30	40
1 Rugged	0.30	1.00	1.00	1.00	1.00
2 --Heavy wooded	0.30	1.00	1.00	1.00	1.00
3 Rugged--Mixed	0.45	1.00	1.00	1.00	1.00
4 (or extra)	0.50	1.00	1.00	1.00	1.00
5 Rugged--bare	0.55	1.00	1.00	1.00	1.00
6 Rolling Foothills	0.75	1.00	1.00	1.00	1.00
7 --Heavy wooded	0.90	1.00	1.00	1.00	1.00
8 Rolling Foothills	0.90	1.00	1.00	1.00	1.00
9 --Mixed	1.00	1.00	1.00	1.00	1.00
10 Rolling Foothills	0.60	1.00	1.00	1.00	1.00
11 --Bare	0.95	1.00	1.00	1.00	1.00
12 Flat--Mixed	1.05	1.00	1.00	1.00	1.00
13 Flat--Bare, Hard	0.90	1.00	1.00	1.00	1.00
14 Flat Desert	0.30	1.00	1.00	1.00	1.00
15 Rolling Dunes	0.30	1.00	1.00	1.00	1.00
16 Swamp--Jungle	0.40	1.00	1.00	1.00	1.00
17 Urban	0.60	1.00	1.00	1.00	1.00

¹Also for velocity of an infantry or combined arms force; for velocity of cavalry or armor force, use r1.

Table 13
STANDARD (UNMODIFIED) ADVANCE RATES (S) IN KM/DAY

Resistance Description	E/P	Arm Div	Mzd Div	Inf Div	Horse Cav Force
Very Intense	1.03-1.05	2.0	2.0	2.0	1.5
Intense	1.06-1.09	2.3	2.3	2.3	1.7
Near Intense	1.10-1.14	2.7	2.6	2.6	1.9
Very Strong/Intense	1.15-1.19	3.1	3.0	2.9	2.2
Strong/Intense	1.20-1.24	3.6	3.4	3.2	2.5
Near Strong/Intense	1.25-1.29	4.2	3.9	3.6	2.9
Less Strong/Intense	1.30-1.34	4.8	4.4	4.0	3.3
Low Intense	1.35-1.39	5.5	5.0	4.4	3.7
Very Strong	1.40-1.44	6.2	5.6	4.8	4.1
Near Very Strong	1.45-1.49	6.9	6.3	5.2	4.5
Strong	1.50-1.54	7.6	7.0	5.6	4.9
Near Strong	1.55-1.59	8.4	7.7	6.0	5.3
Moderate/Strong	1.60-1.65	9.2	8.5	6.5	5.7
Near Moderate/Strong	1.66-1.72	10.1	9.3	7.0	6.1
Less Moderate/Strong	1.73-1.80	11.0	10.1	7.5	6.5
Low Strong	1.81-1.89	12.0	11.0	8.0	7.0
High Moderate	1.90-1.99	13.0	11.9	8.6	7.6
Near High Moderate	2.00-2.10	14.0	12.8	9.2	8.3
Moderate	2.11-2.24	15.0	13.7	9.8	9.1
Near Moderate	2.25-2.39	16.0	14.6	10.4	10.0
High Slight/Moderate	2.40-2.55	17.0	15.5	11.0	11.0
Slight/Moderate	2.56-2.72	18.0	16.4	11.6	12.0
Near Slight/Moderate	2.73-2.90	19.0	17.3	12.2	13.0
Low Slight/Moderate	2.91-3.09	20.0	18.3	12.9	14.0
More-than-Slight	3.10-3.31	21.5	19.3	13.7	15.5
Slight	3.32-3.59	23.5	21.0	14.7	17.5
Near Slight	3.60-3.99	26.0	23.0	15.9	20.0
Less than Slight	4.00-4.44	29.0	26.0	17.2	23.0
Negligible/Slight*	4.45-4.99	35.0	32.0	18.6	26.0
More-than-Negligible*	5.00-5.69	42.0	38.0	20.2	30.0
Near Negligible*	5.70-6.50	50.0	46.0	22.0	35.0
Negligible*	6.50-plus	60.0	55.0	24.0	40.0

* For armored and mechanized infantry divisions, these rates can be sustained for 10 days only; for next 20 days standard rates for armored and mechanized infantry forces cannot exceed half these rates.

Lookup Tables from *Numbers, Predictions, and War (cont.)*

										TNDM
Table 3										
WEATHER FACTORS (h)										
Weather Characteristics	Mobility	h	h	h	h	h	h	h	h	h
1 Dry, Sunshine--	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme heat	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 Dry, Sunshine--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temperate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3 Dry, Sunshine--	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme cold	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4 Dry, Overcast--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme heat	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5 Dry, Overcast--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temperate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6 Dry, Overcast--	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme cold	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7 Wet, Light--	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme heat	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8 Wet, Light--	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temperate	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9 Wet, Light--	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme cold	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10 Wet, Heavy--	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme heat	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
11 Wet, Heavy--	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temperate	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
12 Wet, Heavy--	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Extreme cold	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

The following table shows the values for the weather factors.

App B-4

										TNDM
Table 14										
ROAD QUALITY AND DENSITY FACTOR (RQ and RD)										
Road Quality (RQ)										
Good Roads	1.0									
Mediocre Roads	0.8									
Poor Roads	0.6									
Road Density (RD)										
European Standard	1.0									
Moderate Density	0.8									
Sparse	0.6									

Table 15

RIVER OR STREAM FACTOR (St)

Width (meters)	20	50	100	500
Fordable	0.90	0.85	0.8	0.7
Unfordable	0.85	0.80	0.7	0.5

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TNDM											
Table 6											
POSTURE FACTOR (u) WITH ATTRITION VARIABLES											
	Posture Factor				Attrition Variables (uc) ¹						
	Inf. armor u1/u2	air uy	arty ug	S us	vul uv	adv ⁴ uar	Attack pers att.	Def pers att.	Attack tank att.	Def tank att.	
Attack: Normal Effort, Standard Defense											
Fortified						.4					
Prepared						.5					
Hasty						.6					
Delay						.7					
Withdrawal						.8					
All-Out Defense											
Fortified						.3					
Prepared						.4					
Hasty						.5					
Attack: All-Out Effort ² Standard Defense											
Fortified						.5					
Prepared						.6					
Hasty						.7					
Delay						.8					
Withdrawal						.9					
All-Out Defense											
Fortified						.4					
Prepared						.5					
Hasty						.6					
Attack: Secondary Standard Defense											
Fortified						.3					
Prepared						.4					
Hasty						.4					
Delay						.5					
Withdrawal						.5					
All-Out Defense											
Fortified						.25					
Prepared						.3					
Hasty						.3					
Holding (Both Sides)						0.0					
Footnotes for this table appear on the following page.											

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TNDM

Footnotes to Table 6

¹Attacker Personnel Attrition; Defender Personnel Attrition; Attacker Tank Attrition; Defender Tank Attrition.

²The posture factors determined by the defender's posture are applied to the attacker's weapons (inf, armor, arty, air), posture factor applied to Force Strength, S, is applied to defender's S.

³A mission effects factor of 1.3 is applied to the attacker's advance rate. Some special rules apply to the "all-out effort." No more than 35% of the total operation of a force of division size or larger can be assigned to an "all-out effort." That force may attack no longer than 48 hours, after which it must rest for 48 hours or continue at lower intensity for 72 hours before regaining the capability to undertake a main effort.

⁴When advance rate is 10 km/day or more, the defender is automatically in delay or withdrawal posture (0.75 unless otherwise determined).

App B-8

TNNDM

Table 11
SURPRISE (Su)

1st Day 2nd Day 3rd Day

A. Operational-Tactical Surprise Factors*

Mobility (SuM)

Complete Surprise
Substantial Surprise
Minor Surprise

Surpriser's Vulnerability (SuVa)

Complete Surprise
Substantial Surprise
Minor Surprise

Surprised's Vulnerability (SuVd)

Complete Surprise
Substantial Surprise
Minor Surprise

B. Casualty Rates (SuC)

(Affects side surprised only)

Complete Surprise
Substantial Surprise
Minor Surprise

C. Armored Attrition (SuI)

(Affects side surprised only)

Complete Surprise
Substantial Surprise
Minor Surprise

D. Advance Rates (SuA)

(Use reciprocals if defender achieves surprise)

Complete Surprise
Substantial Surprise
Minor Surprise

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App B-13

TNDM

Table 10

FATIGUE FACTORS (ff)

(Affects advance rates and casualty-inflicting capability)

Day	Factor	Day	Factor
0	1.000	13	0.792
1	0.984	14	0.776
2	0.968	15	0.760
3	0.952	16	0.744
4	0.936	17	0.728
5	0.920	18	0.712
6	0.904	19	0.696
7	0.888	20	0.680
8	0.872	21	0.664
9	0.856	22	0.648
10	0.840	23	0.632
11	0.824	24	0.616
12	0.808	25	0.600

App B-12

App B-12

Iranian Casualties in the Iran–Iraq War (1980–1988): A Reappraisal



Pt. 2: Casualty Causes

by H.W. Beuttel

Casualty Causes

The definitive or representative breakdown of Iranian casualty cause to specific Iraqi weapon categories is not known. However, this author will speculate a possible distribution. There is no significant quantified data to support this speculation. It is rather qualitatively derived from extensive study of the nature of the fighting, the conditions of combat, the force structures of the opposing forces, and few quantifiable clues.

Chemical Weapons

The only more or less firm figure we have is that Iraqi chemical weapons accounted for about 4% of Iranian battle casualties. It seems that mustard agents—particularly the infamous and effective Iraqi “dusty” mustard—caused the majority of chemical casualties in the war judging by post war Iranian medical literature where populations of gassed soldiers studied are as high as 1,500.¹ In WWI mustard gas caused 39% of all US gas casualties and 90% of all UK gas casualties (and 14% of all battle casualties) suffered after its introduction in fall 1917.² One source gives the interesting statistic that 10–20% of Iranian chemical *deaths* were due to mustard gas.³ In WWI mustard usually only had a lethality of about 2%.⁴

Other agents were of course used. The Iraqis devised at least two major “cocktails.” In 1983–84 they employed a mix of mycotoxin, Yperite and Tabun (GA) in munitions which had 20% lethality. By 1985 they used a blend of cyanide, mustard, Sarin (GB) and Tabun. The latter was claimed three times more lethal.⁵ Combining these statistics we may suggest that 20% of Iranian chemical *deaths* were induced by mustard alone, 20% by “Cocktail 1” and 60% by “Cocktail 2.” Cyanide based blood agents such as Hydrogen Cyanide (AC) and Cyanogen Chloride (CK) were also used, but lethality was probably low. Of the 63 toxic chemical agents employed in WWI, cyanide was used only once and dropped as too inefficient.⁶ Cyanogen chloride was used against Iranian forces at Mehran in July 1987 with little result.

As noted above Iranian casualty experience with toxic agents is in agreement with overall WWI data. It is tempting to apply the other WWI casualty cause distribution (artillery 57%, small arms 38%) to the Iran–Iraq War but other non-WWI elements were present on this battlefield (improved airpower, large numbers of armored fighting vehicles, anti-tank guided missiles, mines, attack helicopters etc) .

Artillery

Artillery seems to have been the major casualty causative agent for Iranian forces during the war. Chronically short of artillery themselves, they faced an adversary who deployed over three times the number of tubes and whose motto was “We Attack with Artillery.”⁷ A veteran of the war recounted that “every time we sent the Iraqis one rocket, they sent us a hundred in reply.”⁸ Iraqi artillery inflicted casualties on the high and the low. On 21 June 1981 at Dehlavieh, Dr Mostafa Chamran, the Iranian Minister of Defense, was killed in an Iraqi mortar attack.⁹

In the Gzuyl sector northeast of Basra during 1984 one source reports the Iraqis firing hundreds of thousands of dollars worth of ammunition an hour. Rounds were delivered at a rate of one every two seconds.¹⁰

In the *Wal al Fajir*–8 fighting, Iraqi artillery crews were known to have fired up to 600 rounds a day in desperate attempts to stem Iranian advance. Iraq used up so much of its entire inventory of artillery ammunition in this fight that it had to scour the world for emergency purchases of new ammunition stocks. A French artillery advisor who was present described how the Iraqis fired air bursts with their French GCT howitzers. “With a single GCT round they could wipe out every Iranian within a kilometer [sic]. This is how they stopped the human waves. They were firing like at Verdun. It was a real massacre.”¹¹ Likewise, 200 Iraqi tanks had to be refitted with new main gun barrels which had been burned out by high rates of fire.¹²

Artillery has accounted for anywhere from 40% to 70% of all casualties in 20th Century Wars.¹³ As so many other aspects of the Iran–Iraq War resemble WWII, this author will *speculate* on the basis of no evidence to the contrary that artillery probably accounted for 55% of Iranian casualties. Given WWII lethality (about 19% per casualty incident), then artillery would have accounted for something like 118,400 dead (63% all dead) and 504,751 wounded (53% of all wounded).

Land Mines

Mines played a large role in the Iran–Iraq War and were a significant casualty agent. During the *Fatah al Mobin* offensive of March 1982 an Iraqi officer described the assault of Iranian forces:

“They came at us like a crowd coming out of a mosque

on a Friday. Soon we were firing into dead men, some draped over the barbed wire fences, and others in piles on the ground, having stepped on mines.”¹⁴

Iranian ground forces are conducting massive mine clearing operations over a 17,170 square kilometer region to remove both Iraqi and Iranian minefields planted in the War of Sacred Defense. An estimated 16,000,000 Iraqi mines were laid in 40,000 square kilometers of Iranian territory. In addition there are tens of millions of pieces of unexploded ordnance of calibers from small arms to heavy artillery scattered all over the area. This has also included at least 100 rounds of Iraqi chemical ordnance which has yielded agent types of Tabun, Sarin, Soman, mycotoxins, mustard, cyanide and an unknown toxic agent dubbed “empirite.” In addition some sections of Khuzistan were still contaminated as of 1991.¹⁵

As of April 1994, 5,470 square kilometers had been cleared of 1,710,000 anti-personnel, 470,000 anti-vehicle and 2,347,000 anti-tank mines.¹⁶ By October 1996 12,500 square kilometers had been swept of another 2.5 million mines, but not without a price. Eighty-five Iranian combat engineers have been killed and 361 disabled in these operations.¹⁷ From 1991–1995 mines claimed 6,000 total civilian victims, 2,144 of which were fatalities. In the last six months of 1996 Iran cleared another 7,600 square kilometers of 2,141,000 anti-personnel and 548,000 anti-tank mines. Another 18,350 square kilometers would be cleared in 1997 according to Brigadier General Rahim Ebrahimi.¹⁸ Brigadier General Darjazi, commander of Iranian ground forces in the southern and western operational regions, stated in July 1997 that his forces had retrieved and detonated 480,000 anti-personnel, 175,000 anti-vehicle and 291,000 anti-tank mines as well as 377,000 pieces of unexploded ordnance. The bodies of 434 Iraqi MIAs

were also recovered during the operations and returned to Iraq.¹⁹ In all some twelve million mines and pieces of unexploded ordnance have been cleared in these efforts. Since the end of the war no less than fifty million mines and pieces of unexploded ordnance have been disposed of according to Major General Naser Arasteh, acting Chief of the Armed

Forces Joint Staff. Another grisly result of these operations has been the collateral recovery of the remains of 4,000 Iranian MIAs.²⁰

This final fact may provide an indicator of mine warfare casualty effectiveness. 4,000 MIAs have been found in minefields and 23,000 elsewhere. A simple inference is that the 4,000 found in minefields were killed by mines, those found outside minefields were not killed by mines. 4,000 represents 15% of the total MIA bodies recovered so far. This suggests that perhaps as many as 15% of the total MIA may have been killed by mines. This further implies that as many as 15% of total dead were due to mines or $188,000 \times .15 = 28,200$. If the killed to wounded ratio for post-war civilian incidents—1:1.8—held true in the war, then 50,760 were wounded by mines. This would represent 5% of all wounded ($50,760/945,000$). It is likely that these represent a much higher proportion of the 200,000 permanently disabled, perhaps as much as 25%. Total killed and wounded percentage would be $78,000/1,133,000 = 7\%$. This is somewhat higher than US experience in WWII and

Korea (4–5%), but not surprising given the number of mines employed. The killed and died of wounds percentage theorized—15%—matches US experience in Vietnam.²¹

Airpower

Iraq claimed its pilots had flown 400,000 sorties of all

Iran News

14 March 1998

Iran Counts 213,000 "Martyrs"

TEHRAN (AFP) - An Iranian religious foundation has released comprehensive statistics on the number of "martyrs," people who died for the cause of Islam and the country's 1979 Revolution.

A total of 213,000 people died during the Revolution and the 1980-1988 war against Iraq or fell victim to political assassinations, the figures showed. The war accounted for 85 percent of the "martyrs," with the clergy paying most dearly. Fifty-five of every 1,000 clerics gave their lives, 14 times more than lay people, said the Foundation of Martyrs, which looks after the interests of the families of the fallen.

In addition, 24 out of every 1,000 clerics lost a child for the cause, 6.5 times the toll for an average family in Iran, the foundation's director Mohammed Hassan Rahimian told Kayhan newspaper. He said 72 percent of those killed were ages of 14 to 24, and 7,000 were under 14, "a fact which drew much attention from the enemies." International rights groups widely criticized the Islamic Republic for recruiting underage boys to fight in the war.

Rahimian defended the special privileges provided to the survivors of martyrs, and said his foundation was taking care of similar families in other countries including Lebanon and the Palestinian territories.

types during the war.²² However, it was clearly recognized their sortie effectiveness was not high when it came to inflicting casualties on Iranian troops. Iranian ground forces resorted to night operations and employing camouflage, dispersion and field fortification to neutralize the effects of Iraqi air power. So good were these techniques that Iraqi air averaged less than one Iranian casualty per sortie, even when employing Tu-16 “Blinders” in saturation bombing.²³ Although nothing like full sortie by type breakdown exists, this author’s study of the war has counted a representative sample of 26,000 Iraqi sorties against Iranian ground forces. Likewise another representative sample has counted 21,500 against maritime and strategic targets. This gives a proportion of 55% “tactical” vs 45% “strategic” sorties. Given this the Iraqi air force flew something like 220,000 strikes against Iranian ground forces during the war. If we assume from the above that each sortie caused less than one casualty (0.5) then total Iranian casualties from Iraqi airpower were on the order of 110,000. This would result in Iraqi airpower causing some 10% of total Iranian casualties. Applying a standard killed to wounded for casualties from aerial ordnance (.22 KIA, .78 WIA) then Iraqi air accounted for 24,000 dead and 86,000 wounded.²⁴ These are respectively 13% of all KIA and 9% of all wounded.

These figures, if anything, are probably inflated.

Small Arms and Infantry Weapons

If the above calculations and speculations are roughly right, then small arms and other infantry weapons accounted for approximately 280,000 or 25% of all casualties. This would represent just 15,000 killed (only 8% of all KIA) and 265,000 wounded (28% of all WIA). The only other source I know of where ubiquitous small arms were claimed to cause so few killed in a general sustained conflict is in the case of the British Army in WWII where official UK forces overall statistics credit only 10% of “casualties” (probably meaning KIA) to bullets.²⁵ Brigadier Ali Samimi, chief of ground forces training support, stated in September 1997 that the average engagement range in the war was 200–300 meters due to the dearth of long range weapons.²⁶ This is classic small arms range and one would expect more killed from small arms fire.

While the numbers themselves were ultimately derived as a residual from other causes cited above, they present an abnormally low killed to wounded ratio of 1:18 within the category itself. WWII data tended to indicate that generally 25%–42% of those hit by small arms fire were killed.²⁷ It is likely that Iranian experience more closely resembled these figures than it departed from them. However, we are lumping all infantry weapons (small arms, infantry guns and AT weapons, grenades and mortars) into this category. Grenades and mortars have very low lethality (5% and 10% respectively) yet may account for very large numbers of overall casualties (e.g. 50% in the WWII South Pacific).²⁸

Another reason is probably an inflation of the mine and airpower categories. Minefields are always covered by small

arms fire and it is likely that some of the 4,000 MIA “mine deaths” I have used above were actually caused by small arms. If I have inflated the mine killed category by, say, 50% then small arms KIA would rise to 20,000 or 11% of all KIA (and reduce mines to 10% of all KIA).

However, this distribution of KIA matches closely US experience in Vietnam where of DoWs (approximating KIAs) 16% were small arms, 65% were shell fragments and 15% were mines. My figures for Iranian KIA are 8%, 63% and 15%. The lower showing of infantry weapons in terms of lethality in Iran’s case may be biased by Iraqi airpower (arguably possibly inflated in this study) and chemical weapons employment (neither of which was used against US forces in Vietnam).²⁹ If Iraqi airpower casualties have been inflated by 100% (based on a 5% casualty effectiveness for WWII airpower), then 27,000 were killed by infantry weapons (14% of all KIA) and 308,000 wounded (33% of all WIA) representing 30% of all combat casualties. Mine and airpower inflation taken into account together would result in infantry weapons inflicting 20% of all KIA (37,000) and 34% of all wounded (325,000). Infantry weapons then inflicted 32% of all battle casualties. This last distribution closely resembles the US in WWII. However, the killed to wounded ratio is still on the order of 1:10. But then a number of other weapons are included in this category which probably accounts for the bias.

Miscellaneous

Unique and unusual casualty agents are also represented in the fighting. The Iranian amphibious assault into the Hawizeh marshes in Operation Kheiber in February 1984 using rubber boats and small craft was stopped only by the Iraqis use of high power lines diverted into the marshes to electrify them. During this fighting large numbers of *Pasdaran* infantry were crushed in their foxholes by Iraqi tanks.³⁰ After the Battle of Beida in Operation Kheiber in which these incidents occurred, General Hisham Sabam al-Fakhri callously ordered the bodies of 3,000 Iranians so killed bulldozed into a mass linear grave as fill for a causeway.³¹ These seemingly one time and peculiar casualty causes account for only 0.3% of all casualties.

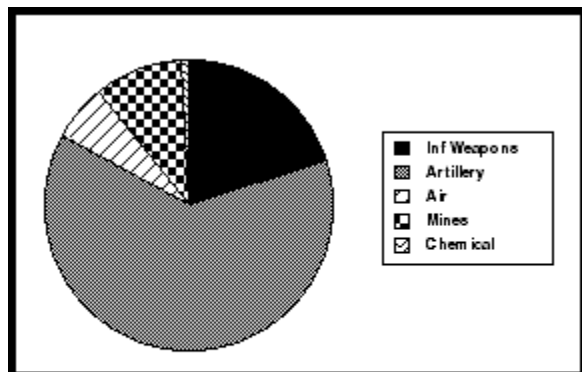
The war also saw the first deliberate use of directed energy weapons against Iranian forces. There are over 4,000 documented cases of Iranian soldiers suffering eye injuries from Iraqi laser systems. The number of incidents is indicative of deliberate use of non-eyesafe laser rangefinders to sweep attacking Iranian infantry formations specifically for casualty producing effect.³²

Cold Steel

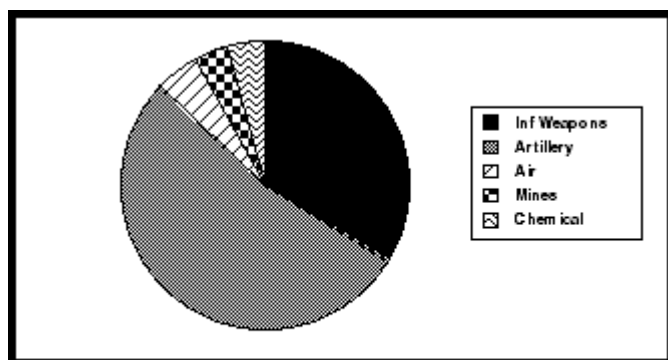
Cold steel weapons were used in the War of Sacred Defense. In the *Wal Fajir*–8 offensive of February 1986 fighting in the wetlands of the Fao Peninsula often devolved into struggles at extreme close quarters with bayonets, trench knives and entrenching tools much like WWI.³³ In the fighting

in Gilan e Qarb in the early part of the war, a local female *Pasdaran* fighter was known to have killed a number of Iraqi soldiers in hand to hand combat with an axe.³⁴ However, it is unlikely they accounted for any significant percentage of casualties. It was probably on the order of the 0.1% experienced by US forces in WWI.³⁵ If so, cold steel may have resulted in as many as 1,100 casualties.

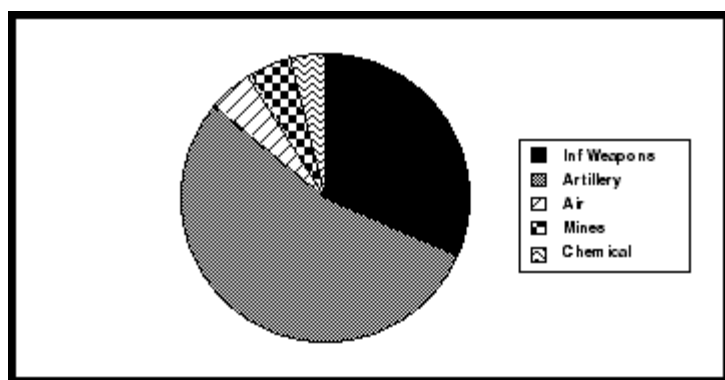
The theorized distribution of casualty agents against Iranian forces is presented in the following graphs.



Causes ~ Killed in Action



Causes ~ Wounded in Action



Causes ~ Total Casualties

The author acknowledges the highly speculative nature of much of the data and argument presented above. It is offered as a preliminary starting point to further study. As such, the author would appreciate hearing from anyone with additional data on this subject. In particular he would invite the Government of the Islamic Republic of Iran to provide any information that would corroborate, correct, or expand on the information presented in this article.

Mr. Beuttel is employed as a military analyst by Boeing Information, Space & Defense Systems. The views and opinions expressed in this article are not necessarily those of the Boeing Company.

¹ "Abstracts Obtained from Iran on Medical Research Conducted After the 1980-1988 Iran-Iraq War," www.chronicillnet.org/PGWS/tuite/IRMED/IRANTOC.html.

² Charles E. Heller, *Chemical Warfare in WWI: The American Experience, 1917-1918*, Leavenworth Papers No. 10, Ft Leavenworth, KS: Combat Studies Institute USAC&GSC, 1984, p. 67; Denis Winter, *Death's Men: Soldiers of the Great War*, New York: Penguin Viking, 1978, p.124.

³ "Bis(2-chloroethyl)thioether, C₄H₈SCI₂," www.ch.ic.ac.uk/vchemlib/mol/horrible/war/mustard

⁴ Anthony Cordesman, *The Lessons of Modern War, Volume II: The Iran-Iraq War*. Boulder CO: Westview Press, 1990, p. 525, n. 56.

⁵ Kenneth R. Timmerman, *Death Lobby: How the West Armed Iraq*, New York: Houghton Mifflin Company, 1991, pp. 145-146..

⁶ Kenneth R. Timmerman, *Death Lobby: How the West Armed Iraq*, New York:Houghton Mifflin Company, 1991, p. 406-407, n. 3.

⁷ Edgar O'Ballance, *The Gulf War*, London: Brassey's Defense Publishers Ltd, 1988, p. 81.

⁸ Cherry Mosteshar, *Unveiled*, New York: St Martin's Press, 1997, p.162.

⁹ "Martyr Chamran, Former Iranian Defense Minister Commemorated," *IRNA*, 16 June 1998.

¹⁰ Anthony Cordesman, *The Lessons of Modern War, Volume II: The Iran-Iraq War*. Boulder CO: Westview Press, 1990, pp.445.

¹¹ Kenneth R. Timmerman, *Death Lobby: How the West Armed Iraq*, New York: Houghton Mifflin Company, 1991, p. 95.

¹² Anthony Cordesman, *The Lessons of Modern War, Volume II: The Iran-Iraq War*. Boulder CO: Westview Press, 1990, pp.219-224.

¹³ T.N. Dupuy, *Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War*, Fairfax, VA: HERO Books, 1990, p.59.

¹⁴ Edgar O'Ballance, *The Gulf War*, London: Brassay's Defense Publishers Ltd, 1988, p. 81.

¹⁵ "IIR 2 762 0059 92 Iranian Anaysis of Iraqi Chemical Ordnance Used During Iran/Iraq War."

¹⁶ "Iran - Military to Launch Mine-Sweeping Operations," *USNI Daily Defense News Capsules*, 14 April 1994; "Chief of Iran's Ground Forces Outlines Plans for Second Five Year Plan," *IRNA*, 19 September 1994.

¹⁷ "Iran—Ground Forces Commander on Readiness of the Army," *USNI Daily Defense News Capsules*, 4 October 1996.

¹⁸ "Iran, Islamic Republic of: Update," *United Nation Mine Project Summary Sheet*.

¹⁹ "Strict Control of Movements in Southern, Western Borders," *IRNA*, 16 July 1997.

²⁰ “Iran—Armed Forces Commander Interviewed on Security,” USNI Daily Defense News Capsules, 11 October 1996.

²¹ T.N. Dupuy, Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War, Fairfax, VA: HERO Books, 1990, p. 58.

²² Anthony Cordesman, The Iran-Iraq War and Western Security 1984-87, London: Jane’s Publishing Ltd, 1987, p. 478, n. 23.

²³ Anthony Cordesman, The Iran-Iraq War and Western Security 1984-87, London: Jane’s Publishing Ltd, 1987, p. 97.

²⁴ Average values derived from WWII Pacific and Mediterranean Theaters in Table 67, Gilbert W. Beebe and Michael E. De Bakey, Battle Casualties: Incidence, Mortality and Logistics Considerations, Springfield, IL: Charles C. Thomas Publisher, 1952, p. 157.

²⁵ John Ellis, World War II: A Statistical Survey, New York: Facts on File, 1993, p. 257. But see his caveats to this data here and in John Ellis, The Sharp End: The Fighting Man in WWII, New York: Charles Scribner’s Sons, 1980, p. 174.

²⁶ “Army Was Unprepared When Iraq Invaded, Samimi,” Iran News, 28 September 1997.

²⁷ Average values derived from WWII Pacific and Mediterranean Theaters in Table 67, Gilbert W. Beebe and Michael E. De Bakey,

Battle Casualties: Incidence, Mortality and Logistics Considerations, Springfield, IL: Charles C. Thomas Publisher, 1952, p. 157.

²⁸ Eric Bergerud, Touched By Fire: The Land War in the South Pacific, New York: Viking Penguin, 1996, pp. 319-320.

²⁹ T.N. Dupuy, Attrition: Forecasting Battle Casualties and Equipment Losses in Modern War, Fairfax, VA: HERO Books, 1990, p. 58.

³⁰ Anthony Cordesman, The Lessons of Modern War, Volume II: The Iran-Iraq War. Boulder CO: Westview Press, 1990, pp.179-181.

³¹ Edgar O’Ballance, The Gulf War, London: Brassey’s, 1988, pp. 144-145.

³² “Iraqi Anti-Personnel Lasers,” www.fas.org/irp/gulf/CIA/970129/970110_092596_UI_001.

³³ “Persian Gulf War,” FYEO, No. 134, 17 March 1986, p. 134-1.

³⁴ “Tourism and Noticeable Relics of the Imposed War,” Tehran Times, 24 September 1998.

³⁵ Charles E. Heller, Chemical Warfare in WWI: The American Experience, 1917-1918, Leavenworth Papers No. 10, Ft Leavenworth, KS: Combat Studies Institute USAC&GSC, 1984, pp. 91-92.

More on the QJM/TNDM

Italian Battles



by Richard C. Anderson, Jr.

In regard to Niklas Zetterling's Article and Christopher Lawrence's reponse (*Newsletter* Volume 1, Number 6) I would like to add a few observations of my own. Recently I have had occasion to revisit the Allied and German records for Italy in general and for the Battle of Salerno in particular. What I found is relevant in both an analytical and an historical sense.

The Salerno Order of Battle

The first and most evident observation that I was able to make of the Allied and German Order of Battle for the Salerno engagements was that it was incorrect. The following observations all relate to the table found on page 25 of Volume 1, Number 6.

The divisional totals are misleading. The US had one infantry division (the 36th) and two-thirds of a second (the 45th, minus the 180th RCT and one battalion of the 157th Infantry) available during the major stages of the battle (9–15 September 1943). The 82nd Airborne Division was represented solely by elements of two parachute infantry regiments that were dropped as emergency reinforcements on 13–14 September. The British 7th Armored Division did not begin to arrive until 15–16 September and was not fully closed in the beachhead until 18–19 September.

The German situation was more complicated. Only a single panzer division, the 16th, under the command of the LXXVI Panzer Corps was present on 9 September. On 10 September elements of the Hermann Göring Parachute Panzer Division, with elements of the 15th Panzergrenadier Division under tactical command, began arriving from the vicinity of Naples. Major elements of the Herman Göring Division (with its subordinated elements of the 15th Panzergrenadier Division) were in place and had relieved elements of the 16th Panzer Division opposing the British beaches by 11 September. At the same time the 29th Panzergrenadier Division began arriving from Calabria and took up positions opposite the US 36th Divisions in and south of Altavilla, again relieving elements of the 16th Panzer Division. By 11–12 September the German forces in the northern sector of the beachhead were under the command of the XIV Panzer Corps (Herman Göring Division (-), elements of the 15th Panzergrenadier Division and elements of the 3rd Panzergrenadier Division), while the LXXVI Panzer Corps commanded the 16th Panzer Division, 29th Panzergrenadier Division, and elements of the 26th Panzer Division. Unfortunately for the Germans the 16th Panzer Division's zone was split by the boundary between the XIV and LXXVI Corps, both of whom appear to have had operational control

over different elements of the division. Needless to say, the German command and control problems in this action were tremendous.¹

The artillery totals given in the table are almost inexplicable. The numbers of SP 75mm howitzers is a bit fuzzy, inasmuch as this was a non-standardized weapon on a half-track chassis. It was allocated to the infantry regimental cannon company (6 tubes) and was also issued to tank and tank destroyer battalions as a stopgap until purpose designed systems could be brought into production. The 105mm SP was also present on a half-track chassis in the regimental cannon company (2 tubes) and on a full-track chassis in the armored field artillery battalion (18 tubes). The towed 105mm artillery was present in the five field artillery battalions present of the 36th and 45th divisions and in a single non-divisional battalion assigned to the VI Corps. The 155mm howitzers were only present in the two divisional field artillery battalions, the general support artillery assigned to the VI Corps, the 36th Field Artillery Regiment, did not arrive until 16 September. No 155mm gun battalions landed in Italy until October 1943. The US artillery figures should approximately be as follows:

75mm Howitzer (SP)	
2 per infantry battalion	= 28
6 per tank battalion	= 12
	Total = 40
105mm Howitzer (SP)	
2 per infantry regiment	= 10
1 armored FA battalion ²	= 18
5 divisional FA battalions	= 60
1 non-divisional FA battalion	= 12
	Total = 100
155mm Howitzer	
2 divisional FA battalions	= 24
3" Tank Destroyer	
3 battalions	= 108

Thus, the US artillery strength is approximately 272 versus 525 as given in the chart.

¹ Exacerbating the German command and control problems was the fact that the Tenth Army, which was in overall command of the XIV Panzer Corps and LXXVI Panzer Corps, had only been in existence for about six weeks. The army's signal regiment was only partly organized and its quartermaster services were almost nonexistent.

² Arrived 13 September, 1 battery in action 13-15 September.

The British artillery figures are also suspect. Each of the British divisions present, the 46th and 56th, had three regiments (battalions in US parlance) of 25-pounder gun-howitzers for a total of 72 per division. There is no evidence of the presence of the British 3-inch howitzer, except possibly on a tank chassis in the support tank role attached to the tank troop headquarters of the armor regiment (battalion) attached to the X Corps (possibly 8 tubes). The X Corps had a single medium regiment (battalion) attached with either 4.5 inch guns or 5.5 inch gun-howitzers or a mixture of the two (16 tubes). The British did not have any 7.2 inch howitzers or 155mm guns at Salerno. I do not know where the figure for British 75mm howitzers is from, although it is possible that some may have been present with the corps armored car regiment.

Thus the British artillery strength is approximately 168 versus 321 as given in the chart.

The German artillery types are highly suspect. As Niklas Zetterling deduced, there was no German corps or army artillery present at Salerno. Neither the XIV or LXXVI Corps had Heeres (army) artillery attached. The two battalions of the 71st Nebelwerfer regiment and one battery of 170mm guns (previously attached to the 15th Panzergrenadier Division) were all out of action, refurbishing and replenishing equipment in the vicinity of Naples. However, US intelligence sources located 42 Italian coastal gun positions, including three 149mm (not 132mm) railway guns defending the beaches. These positions were taken over by German personnel on the night before the invasion. That they fired at all in the circumstances is a comment on the professionalism of the German Army. The remaining German artillery available was with the divisional elements that arrived to defend against the invasion forces. The following artillery strengths are known for the German forces at Salerno:

16th Panzer Division (as of 3 September):

- 14 75mm infantry support howitzers
- 11 150mm SP infantry support howitzers
- 10 105mm howitzers
- 8 105mm SP howitzers
- 4 105mm guns
- 8 150mm howitzers
- 5 150mm SP howitzers
- 5 88mm AA guns

26th Panzer Division (as of 12 September):

- 15 75mm infantry support howitzers
- 12 150mm infantry support howitzers
- 6 105mm SP howitzers
- 12 105mm howitzers
- 10 150mm SP howitzers
- 4 150mm howitzers

Herman Göring Parachute Panzer Division (as of 13 September):

- 6-8 75mm infantry support howitzers
- 8 150mm infantry support howitzers
- 24 105mm howitzers
- 12 105mm SP howitzers

- 4 105mm guns
- 8 150mm howitzers
- 6 150mm SP howitzers
- 6 150mm multiple rocket launchers
- 12 88mm AA guns

29th Panzer Grenadier Division

- 106 artillery pieces (types unknown)

15th Panzer Grenadier Division (elements):

- 10-12 105mm howitzers

3d Panzer Grenadier Division

- 6 150mm infantry support howitzers

Non-divisional:

501st Army Flak Battalion (probably 20mm and 37mm AA only)

I/49th Flak Battalion (probably 8 88mm AA guns)

Thus, German artillery strength is about 342 tubes versus 394 as given in the chart.³

Armor strengths are equally suspect for both the Allied and German forces. It should be noted however, that the original QJM database considered wheeled armored cars to be the equivalent of a light tank.

Only two US armor battalions were assigned to the initial invasion force, with a total of 108 medium and 34 light tanks. The British X Corps had a single armor regiment (battalion) assigned with approximately 67 medium and 10 light tanks. Thus, the Allies had some 175 medium tanks versus 488 as given in the chart and 44 light tanks versus 236 (including an unknown number of armored cars) as given in the chart.

German armor strength was as follows (operational/in repair as of the date given):

16th Panzer Division (8 September):

- 7/0 Panzer III flamethrower tanks
- 12/0 Panzer IV short
- 86/6 Panzer IV long
- 37/3 assault guns

29th Panzer Grenadier Division (1 September):

- 32/5 assault guns
- 17/4 SP antitank
- 3/0 Panzer III

26th Panzer Division (5 September):

- 11/? assault guns
- 10/? Panzer III

Herman Goering Parachute Panzer Division (7 September):

- 5/? Panzer IV short
- 11/? Panzer IV long
- 5/? Panzer III long
- 1/? Panzer III 75mm
- 21/? assault guns
- 3/? SP antitank

(cont. on next page)

³ However, the number given for the 29th Panzergrenadier Division appears to be suspiciously high and is not well defined. Hopefully further research may clarify the status of this division.

15th Panzergrenadier Division (8 September):

6/? Panzer IV long

18/? assault guns

Total 285/18 medium tanks, SP antitank, and assault guns. This number actually agrees very well with the 290 medium tanks given in the chart. I have not looked closely at the number of German armored cars but suspect that it is fairly close to that given in the charts.

In general it appears that the original QJM Database got the numbers of major items of equipment right for the Germans, even if it flubbed on the details. On the other hand, the numbers and details are highly suspect for the Allied major items of equipment. Just as a first order "guestimate" I would say that this probably reduces the German CEV to some extent; however, missing from the formula is the Allied naval gunfire support which, although negligible in impact in the initial stages of the battle, had a strong influence on the later stages of the battle.

Hopefully, with a little more research and time, we will be able to go back and revalidate these engagements. In the meantime I hope that this has clarified some of the questions raised about the Italian QJM Database. 🌐



British soldiers advance through an Italian town.

Nicholas Krawciw

by Susan Rich

Major General Nicholas S. H. Krawciw, U.S. Army, Ret., has been the President of the Dupuy Institute since January, 1995. He is also the Secretary's of Defense Senior Military Representative to Ukraine.

General Krawciw was born on November 28, 1935 in Lviv, Galicia, Ukraine, and graduated from the United States Military Academy at West Point in 1959. He received an MS in International Affairs from George Washington University, which he completed while attending the School of Naval Command and Staff at the Naval War College in 1970. He received a fellowship at the Hoover Institution on War, Revolution and Peace at Stanford University in 1976 during his Army War College year. In 1982 he also completed America's highest level diplomatic school, the Senior Seminar, Department of State.

General Krawciw served two combat tours with armored cavalry in Vietnam (1962–63 and 1968–69). During his first combat tour he was seriously wounded in action. His combat awards include three Silver Stars, a Distinguished Flying Cross, four Bronze Stars (two for valor), and a Purple Heart. Between his two Vietnam tours he was a tactical officer and leadership instructor at the US Military Academy at West Point, New York. During this time he also was a co-inventor of spaced armor produced by Aero Jet General Corporation for most of the pilot seats of the Cobra and HU-1 (Huey) series of helicopters.

From 1972 to 1974 General Krawciw participated in peace keeping operations as the Senior U.S. Army Observer and Chief Operations Officer with the United Nations Truce Supervision Organization (UNTSO) in and around Israel. This duty included the period of the Yom Kippur War and its aftermath. He was a member of the UN team that witnessed the Israeli attack on the port city of Suez. It was at this time that he met Trevor Dupuy.

General Krawciw spent a total of 31 years in command and staff positions in the U.S. Army before he retired on 1 July, 1990. He commanded the First Squadron, Second Armored Cavalry (1974–75) along what was at that time the boundary with the Warsaw Pact. As a colonel, he commanded the largest combat brigade in the US Army, Europe, the First Brigade of the Third Armored Division (1979–81). He served as Assistant Division Commander (1984–85) and later Commander (1987–89) of the Third Infantry Division, Mechanized, a forward deployed "heavy" division in Germany.

Other senior staff positions held by General Krawciw included an assignment as Director for Concepts and Doctrine at the US Army Training and Doctrine Command (1977–79), service as the Military Assistant to the Deputy Secretary of Defense (1982–84), and the Executive Officer to the Supreme Allied Commander at SHAPE in NATO (in 1985–86).

In 1990, just prior to his retirement from the U.S. Army, he became the Director for NATO Policy in the International Security Policy Office of the Secretary of Defense in Washington, D.C. In 1992 and 1993 General Krawciw worked for the Council of Advisors to the Parliament of Ukraine in Kyiv, where he was an advisor on defense matters for the Ministry of Defense.

Nick Krawciw is the Co-Founder and President of the Supervisory Board of the International Institute on Global and Regional Security, one of the first independent "think tanks" in Kiev. He is also a member of the Advisory Council of the Harvard Ukrainian National Security Program. He acts as a consultant on matters pertaining to Ukraine in the office of the Secretary of Defense. His work has included attending exercises both here and in Ukraine and extensive interface with all levels of the Ukrainian defense establishment.

Involvement with NATO requires General Krawciw to spend much of his time flying to destinations around the world. He recently traveled to Odessa on the Black Sea for Exercise "Sea Breeze 98" hosted by the Ukrainian Navy and the US Sixth Fleet. Ships and marines from Bulgaria, Romania, and Turkey participated in this exercise, which involved a disaster relief scenario.

Nick Krawciw lives in Annandale, Virginia. He is married to Christina Kwasowska and has three children: Alexandra (a writer-biologist, working in Alexandria, VA), Andy (a captain and A-10 pilot in the U.S. Air Force), and Paul (a student at Dickinson College in Carlisle, PA).



Gen. Krawciw as a Brigadier General in Germany in 1984.