The Russians Are Coming: A Computer Simulation

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Aside from defending the homeland, no defense commitment in the post-World War II era has been more important to U.S. decision makers than the defense of Western Europe against a Soviet/Warsaw Pact attack. But from the very beginning of the NATO Alliance in 1949, the Alliance's ability to stop a Pact invasion without resort to nuclear weapons has been in doubt. Concern about NATO's conventional defense has increased as U.S. strategic nuclear superiority has declined and was brought to the forefront during the debate on the Intermediate-Range Nuclear Forces Treaty. But before we can come to grips with NATO's problems, we need the tools to evaluate the deficiencies and strengths of the Alliance in a war against the Pact. This paper presents one such tool, a simple computer model of a blitzkrieg, and uses it to examine scenarios of a war in Europe.

Computer Models of Combat

Although computer models are widely used in defense planning, they remain controversial. One defense analyst expresses his doubts about this approach as follows:

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Many students of the conventional balance attempt to go beyond [using] basic calculation[s] by plugging each side's forces into sophisticated models designed to determine battle outcomes. I am doubtful about the utility of such models and believe that the best we can do at this point is make rough estimates based on force ratios at the point of attack.¹

Standards of scholarship require that in order to support one's conclusions, a complete trace of how they were reached should be available to the community of researchers. Because they are usually large, complicated, and inaccessible to interested onlookers, computer models in defense analysis often violate this standard (being either classified or highly technical). Under these circumstances, it is perfectly appropriate for people to be skeptical of conclusions based on a research method they do not understand and cannot examine.

Another major objection to a computer model or any other explicit model—for example, a mathematical model—is that it simplifies by leaving out many features of the real world. Conclusions about a real world situation are then based on this simplification, mistaking the model for reality and drawing erroneous conclusions. For example, a model of conventional warfare may emphasize things that are simple to count (e.g., amount of equipment and number of units) and ignore aspects of combat that are harder to quantify (e.g., morale, command, and communications). Indeed, some analysts would argue that the factors most difficult to put into a computer model are precisely the most important ones in the evaluation of the European balance.

These criticisms are important but should not blind us to the advantages of computer models and the limitations of other approaches. In point of fact, *all* analysts use models. For example, John Mearsheimer concentrates on the force-to-space ratio and its consequences for the outcome of a war in Europe in his analyses of the conventional balance.² But this is a simplification of reality, ignoring the specifics of terrain, morale, surprise, and other factors often omitted from computer models. The point is not that Mearsheimer's work is bad but rather that he, like any other analyst regardless of research approach, emphasizes some factors at the expense of others and that these choices affect his conclusions.

Once this is recognized, we can appreciate some of the advantages of computer models. If assumptions are made explicit, it is easier to evaluate the model than if the assumptions are only implicit. Further, the assumptions that are put into the form of a computer model (if—and

this is a big if—the model is available to other analysts) can be altered to see the impact on the conclusions drawn from the model. This sort of exercise is impossible with a less formal type of model.

In conclusion, computer models are not the only way to analyze the balance in Europe, but they do have some advantages. And when dealing with an issue that is of such importance to U.S. national security policy, it would be foolish to ignore any approach that can contribute to our knowledge.

The Blitzkrieg Strategy

Before building a blitzkrieg model, we need a more explicit understanding of it. Assume that the defender adopts a linear defense against the blitzkrieg, with forces arranged in a continuous line to prevent any loss of territory. The defender's rear, then, is populated with a variety of command and supply targets, as well as with lines of communication. There are three phases to a blitzkrieg: initial breakthrough, penetration, and exploitation.³

Breakthrough Phase

The breakthrough phase begins with the attacker using frontal assaults to open up several holes in the defender's line. This may be done using whatever type of units are available to the attacker; in World War II, the Germans relied extensively on infantry. The key is to achieve local superiority at several points along the defender's line to force breakthroughs. Not seeking to advance along a broad front, the attacker need not be superior except in the narrow breakthrough areas and may accept a limited degree of inferiority along the rest of the line. The goal of forces in nonbreakthrough sectors is to prevent a counteroffensive by the attacker and to pin down the bulk of these defender forces so that they cannot easily be used to staunch holes in the line.

Penetration Phase

Once the breakthrough phase is successful, the penetration phase begins. Mobile columns advance as fast as possible through the holes, driving deep into the defender's rear areas. Although armored forces are not necessary for the breakthrough phase, they are necessary for the penetration phase. Tactical airpower plays a large role in a blitzkrieg. As a successful blitzkrieg moves very quickly, it is difficult for artillery to keep up with the pace of advance, and there are serious problems of resupply. Tactical airpower can serve as "flying artillery," al-

lowing the attacker to keep up with the pace of advance and solve the resupply problem.

Exploitation Phase

In the exploitation phase, although the defender still holds most of the front line, withdrawals are ordered to meet the confusing array of threats that have developed in the rear. But the forces employed in a frontal defense usually do not have the requisite mobility to race against the armored columns, and when the front is abandoned, additional attacker forces are able to advance into the defender's territory. Highly mobile forces are not necessary for this advance; even infantry on foot can accomplish the task.⁴

The most important question about the military situation in Europe concerns the chances of the Warsaw Pact conducting a successful blitzkrieg against NATO. As this discussion suggests, the overall ratio between opposing forces and equipment—the typical method of evaluating the European balance—is only of secondary importance. The key issues are the Pact's ability to create breakthroughs in selected portions of NATO's line and NATO's ability to react to any such breakthroughs.

A Simple Computer Model of a Blitzkrieg

The computer model of a blitzkrieg is simple by most standards. The heart of it has been thoroughly documented by Joshua Epstein;⁵ some additional features of the model will be discussed below. The program is written in a language that is widely used (C) and runs on an IBM personal computer. These features mean that the model can be grasped by individuals with a variety of backgrounds, and those with some training in programming can modify it to suit their own preferences.

This model treats only the breakthrough phase of a blitzkrieg; it is designed to answer the first question noted above: given a set of parameters and force inputs, can the attacker make deep penetrations in the linear defense of the defender. It does not directly model the exploitation and the penetration phases. But it is the breakthrough phase that is the key to the blitzkrieg.

Epstein's Model of Ground-Air Combat

Epstein models ground combat, factoring in the effects of close air support. CAS is assumed to occur independently of the air-to-air battle. Ground forces are expressed as lethality scores. Epstein himself uses

armored division equivalents, but other measures are possible.⁶ The attacking force can vary the prosecution rate (expressed as a value between zero and one) with which it presses its assault. A higher prosecution rate produces greater losses for the defender, but also for the attacker. If the attacker's attrition rate exceeds a threshold, the prosecution rate begins to drop. The defending force begins with a withdrawal rate of zero and holds its position until the threshold attrition rate is exceeded. At that point, the defender begins to withdraw. As the withdrawal rate increases, the ability of the attacker to inflict losses on the defender decreases. However, a faster withdrawal rate abandons more territory to the attacker. Thus, each side has a mechanism that will alter the level of casualties it sustains and inflicts.

The model is asymmetric in that the roles of attacker and defender cannot be switched. Even if the prosecution rate of the attacker drops to zero, the model does not allow the defender to counterattack (although this feature could be added). Given space considerations, it is not possible to discuss the model in more depth. The specific equations of the model are given by Epstein, and the major relationships of the model are summarized in table 1.⁷

Compared with the "traditional" models of conventional combat, Epstein's battle model portrays a great variety of behaviors with a modest level of complexity.⁸ In some circumstances, the attacker cannot budge the defender and is gradually worn down until few forces are left. In other circumstances, the defending side holds firm for a number of days and then, once its threshold attrition rate is reached, retreats until finally it is moving backwards at the maximum possible rate. Finally, the attacker may initially move the defender back, but as the attrition rate rises, the defender may be able to stabilize the line and stop withdrawing. The ability of the same model to produce these diverse forms of behavior is impressive.

With all these attractive features, why not simply use the existing model to assess the outcome of a NATO-Warsaw Pact war? Epstein himself does this⁹ and concludes that NATO has the ability to stop a Warsaw Pact attack. But there is a serious problem in this way of modeling warfare at the operational level.¹⁰ Using Epstein's model at this level implies that the Warsaw Pact will attack NATO using a broad front attrition strategy. But as discussed earlier, most analysts believe that the Pact will *not* use a broad front attrition strategy and will instead conduct a blitzkrieg. The Pact will try to overwhelm NATO at a few small areas along the line to produce the psychological collapse that is the object of a blitzkrieg. If one believes that the Pact will try to stage a

Table 1
Major Components of Epstein's Battle Model

Variables to Be Calculated	Factors Affecting Variables	Impact of Factor
Lethality destroyed by CAS ^a aircraft	Number of CAS aircraft Sortie rate of CAS aircraft AFVs ^b destroyed per CAS sortie CAS aircraft attrition rate	Positive Positive Positive Negative
Attacker's ground-to-ground attrition rate	Attacker's prosecution rate Defender's withdrawal rate as proportion of maximum withdrawal rate	Positive Positive
Attacker's surviving ground lethality	Losses due to defender CAS Losses due to ground combat	Negative Negative
Defender's surviving ground lethality	Attrition rate of attacker Casualty exchange ratio Attacker lethality remaining Losses due to attacker CAS	Negative Negative Negative Negative
Current attrition rate	Amount of lethality lost Lethality at start of day	Positive Negative
Defender's withdrawal rate (if > threshold) ^c	Withdrawal $t-1$ ^d –maximum withdrawal Defender attrition rate Withdrawal $t-1$	Negative Positive Positive
Attacker's ground prosecution rate	Prosecution rate $t-1$ Attacker threshold attrition rate Attacker attrition rate	Positive Positive Negative
Defender total withdrawal	Withdrawal t ^e Total withdrawal $t-1$	Positive Positive

^aClose air support.

^bArmored fighting vehicle.

^cDefender withdrawal rate is more than zero only if defender attrition is above defender threshold attrition rate.

^d $t-1$ = value of variable on previous day.

^e t = value of variable on the day.

blitzkrieg, then Epstein's battle model is not appropriate to simulate a NATO-Pact war. The challenge is to create a simple blitzkrieg model that builds upon Epstein's model to simulate the fighting that would occur at various points along the overall front. The next section describes such a model.

The Blitzkrieg Model

The blitzkrieg model adds four major elements to Epstein's model: the division of the front into breakthrough and quiet sectors, the ability to allocate forces to different sectors, the ability to allocate CAS aircraft across sectors, and the reinforcement and reallocation of ground and air units.¹¹

Division of the Front into Sectors

In the computer model of a blitzkrieg, the total length of the front is 750 kilometers (approximately the length of the front in Central Europe). Breakthrough sectors of the front are assumed to be 50 kilometers wide.¹² Four breakthrough sectors are assumed,¹³ distributed at equal intervals across the front with a larger "quiet" sector on either side. Thus, the front alternates between quiet sectors of 110 kilometers and breakthrough sectors of 50 kilometers. Obviously, the use of identically sized, evenly spaced breakthrough sectors is an abstraction to simplify the model, but the arrangement does capture the essence of the blitzkrieg. In the quiet sectors, the main goal of the attacker is to pin down the forces of the defender so that these cannot easily be used to reinforce the breakthrough sectors. However, if the defender is worn down by the attack in the breakthrough sectors, this may so weaken the defense in the quiet sectors that an advance is possible there as well. In essence, in the blitzkrieg model nine separate smaller battles are fought, rather than the single one in Epstein's model.

Allocation of Ground Forces

Ground forces and close air support are allocated to each sector, one set of force levels for the breakthrough sectors and another set for the quiet sectors. If there are enough forces, all sectors of the same type will contain the same number of units.

The allocation procedure is similar for both attacker and defender. The attacker specifies the force-to-space ratio (in terms of division equivalents per 25 kilometers) in the breakthrough sectors. In the present version of the model, the attacker allocates one division equivalent per 25 kilometers in the quiet sectors (this limitation will be changed in future versions). This is consistent with the standard "rules of thumb" on defending against an armored attack.¹⁴

The defender can specify different force-to-space ratios for the breakthrough and the quiet sectors. If the defender's force-to-space ratio is the same in both types of sector, the defender has arranged its forces

in a strictly linear defense. However, if one assumes that NATO can identify the location of the Pact's breakthrough sectors, this can be modeled by inputting a higher defender force-to-space ratio for the breakthrough sectors.

After a side's forces are allocated using the force-to-space ratios, any remaining ground forces are placed into a ready reserve. These forces may be allocated to any of the sectors on the following day.

No attempt is made to argue that by allowing for two defender force-to-space values, we can see the full implications of terrain and NATO's intelligence capability. But *at a high level of abstraction*, we can glimpse the effects of these factors by manipulating the two parameters.

Allocation of Close Air Support

CAS is allocated to different sectors. The attacker and the defender each specify the proportion of total CAS to be allocated to the breakthrough sectors. For example, the defender can specify that 40 percent of total CAS is allocated to the breakthrough sectors. This means that 10 percent of its CAS is allocated to each breakthrough sector, and 12 percent of its CAS is allocated to each quiet sector.

Contrary to the assumptions of many analysts, even if the Pact's CAS is inferior to NATO's, it may still aid a Pact breakthrough. If an extremely large proportion of Warsaw Pact CAS is allocated to breakthrough sectors, the effect will be to attrite NATO forces, even if NATO's CAS aircraft are far more numerous and capable than those of the Warsaw Pact.

Reinforcement and Reallocation of Forces

The final major element that the blitzkrieg model adds to Epstein's battle model is a procedure for reinforcement and reallocation of forces. Each side may receive reinforcements on a daily basis after combat has been resolved. These new air and ground forces may be allocated to the various sectors of the front, and existing ground and air forces in a sector may also be reallocated.

In each sector, the size of the remaining forces (in division equivalents) is compared daily with a goal for force levels in that type of sector (i.e., breakthrough or quiet) and adjusted accordingly. Two different goals can be specified for forces in a sector. One is to have the forces in the sector reach the initial force-to-space ratio for the sector. The second is to match the level of the opponent's forces at the end of the preceding day.

After the allocation of new and old forces is completed, the next

day’s battle is fought. The cycle of fighting, reinforcement, and reallocation of forces continues until the time limit specified by the user is reached. At the beginning of a run, the initial values for the forces, along with all the other parameters, are displayed (see table 2).

Summary of the Blitzkrieg Model

In evaluating the ability of NATO to stop a Pact blitzkrieg, the most important figures are those showing the retreat of NATO forces. If the Pact can advance no further than a few kilometers into NATO territory, NATO’s defense should be judged a success. A second important set of figures is the total forces available to both sides at the *end* of the simulation. If NATO has been able to stop a Pact attack but is worn down to only a small proportion of the remaining Pact forces, it will collapse a short time after the simulated attack. Conversely, if the Pact has penetrated NATO’s line but has suffered large losses, it is unlikely to be able to win the war in the long run.

With this information, the user can draw conclusions about NATO’s ability to prevent the Warsaw Pact from achieving a breakthrough in narrow sectors on NATO’s Central Front. But a breakthrough, even a series of breakthroughs, is *not* identical to a Warsaw Pact victory. Such breakthroughs would result in a number of armored columns traveling behind NATO’s front line. This would lead to a Pact victory if it disrupted NATO psychologically to such a degree that its troops could no longer function effectively on the battlefield. But if NATO retains its effectiveness, its units could reform the front line and hunt down the

Table 2
Daily Output of Blitzkrieg Simulation

For Each Sector:
Sector number
Whether sector is a breakthrough sector
Attacker, defender ground forces at end of day
Attacker, defender CAS at end of day
Attacker prosecution rate
Attacker, defender attrition rate
Defender withdrawal at end of day
Defender total withdrawal
Summary Information:
Attacker, defender total allocated ground forces
Attacker, defender ready reserve ground forces
Attacker, defender not ready reserve ground forces
Attacker, defender total CAS

Pact columns or wait until the columns ran out of ammunition, food, and fuel.

Thus, a Pact breakthrough of NATO is a *necessary*, but *not sufficient*, condition for a Pact victory. There is no question that NATO should strive mightily to prevent a breakthrough, but if that does happen, NATO might still be able to bring the Pact advance to a halt. This should be borne in mind when interpreting the simulation results presented in the next section.

Table 3
Basic Parameter Values for Simulation Runs

Attacker Parameters	
Breakthrough force-to-space ratio	2.0
Threshold attrition rate	
Breakthrough sectors	.075
Quiet sectors	.075
Initial ground prosecution rate	
Breakthrough sectors	.05
Quiet sectors	.05
CAS attrition rate per sortie	.05
CAS daily sortie rate	2.0
CAS AFV killed per sortie	.25
Proportion of CAS in breakthrough sectors	.50
Reinforce to initial force-to-space ratio	
Defender Parameters	
Force-to-space ratio	
Breakthrough sectors	1.0
Quiet sectors	1.0
Threshold attrition rate	
Breakthrough sectors	.06
Quiet sectors	.06
Maximum withdrawal rate	20.0
CAS attrition rate per sortie	.05
CAS daily sortie rate	3.0
CAS AFV killed per sortie	.50
Proportion of CAS in breakthrough sector	.50
Reinforce to initial force-to-space ratio	
General Parameters	
AFVs per division equivalent	1,200
Points per division equivalent	47,490
Attacker-defender casualty exchange ratio	1.85
Number of breakthrough sectors	4
Number of days	30

Note: Basic parameter values are taken from Joshua Epstein, *The 1987 Defense Budget* (Washington, D.C.: Brookings Institution), pp. 36-45.

The Blitzkrieg Simulation Runs

What follows is the presentation of several scenarios. The parameters would have to vary to make sure that the results obtained were not unique to a particular set of values but representative of a set of reasonable alternative parameter values. For the time being, the results presented here should be considered illustrative, not definitive.

To highlight the difference between Epstein’s conception of the war in Europe and the conception used here, I contrast results using Epstein’s model,¹⁵ with two variants of a blitzkrieg. To facilitate the comparison between Epstein’s battle model and the blitzkrieg model, the parameters for the runs (with one exception discussed below) and the force inputs will be taken from Epstein’s work (see table 3).

The force inputs will be the same armored division equivalent scores Epstein used (see table 4). The scores are generated on the assumptions that NATO will begin to mobilize three days after the Warsaw Pact and that the mobilization of both sides will proceed smoothly—obviously idealized situations. Since NATO’s divisions are larger than those of the Pact, when forces are expressed in terms of ADEs, NATO actually has a slight advantage in the first days of mobilization. This advantage disappears as the mobilization race continues.

The Simulation Runs

The analysis of this paper varies one key parameter across three

Table 4
NATO and Warsaw Pact (WTO) Force Levels

Days of NATO Mobilization Before Attack	Armored Division Equivalents		
	WTO	NATO	(WTO/NATO)
0-3	24.0	25.8	0.93
4-10	40.0	32.6	1.23
11-14	40.0	33.0	1.21
15-30	61.0	34.3	1.78
31-45	61.0	36.8	1.66
46-60	81.0	40.2	2.01
61-90	81.0	43.0	1.88
91-120	81.0	45.8	1.77

Note: Figures are from Andrew Hamilton, “Redressing the Conventional Balance: NATO’s Reserve Military Manpower,” *International Security* 10, 5 (Summer 1985): pp. 111-136, table 3. All figures assume that NATO begins mobilization three days after the Warsaw Pact (M + 3).

scenarios. The three scenarios are a broad front attrition strategy by the Pact (represented by Epstein's battle model), a fully mobilized blitzkrieg, and a "bolt from the blue" blitzkrieg. The parameter that is varied across the three scenarios is the attacker-to-defender casualty exchange rate.

The attacker-to-defender casualty exchange rate is a very important parameter. It is, literally, the number of points of ground combat effectiveness lost by the attacker for every point lost by the defender. This parameter is an indicator of the relative combat ability of the two sides. While the ADE is a yardstick to measure the combat effectiveness of the two sides (i.e., inputs to combat), the exchange rate measures the relative fighting ability of the two sides (i.e., ability to destroy the combat power of the other side).

In his analysis, Epstein uses a ratio of 1.85. To test the sensitivity of the results to this ratio, a range of values will be used for all three scenarios. The values to be used, in addition to Epstein's value of 1.85, are 1.0, 1.5, 2.0, 2.5, and 3.0, and their inverses (reflecting an advantage in fighting ability for the attacker over the defender), .67, .5, .4, and .34.

Broad front attrition. The first scenario is the one offered by Epstein, which assumes that NATO will have 90 days of mobilization before the war begins. The Pact will then attack all across NATO's front, using an attrition strategy to push NATO back and destroy NATO's forces.

Fully mobilized blitzkrieg. In the fully mobilized blitzkrieg, NATO is given the same 90-day mobilization period as in Epstein's model, but the Pact uses a blitzkrieg to attack NATO. The Pact allocates forces to achieve a force-to-space ratio of 2 ADEs per 25 kilometers in the breakthrough sectors. This means that in every 50-kilometer breakthrough sector, 4 Pact ADEs are attacking 2 NATO ADEs. But since Pact divisions are only worth about two-thirds of an ADE, this means that the Pact is attacking with a force of 6 divisions in each breakthrough sector (i.e., the front for an attacking Pact division is about 8.3 kilometers wide). The Pact allocates 1 ADE per 25 kilometers in the quiet sectors, confronting an equally sized (in ADEs) NATO force. NATO allocates its forces to achieve 1 ADE per 25 kilometers across the entire front. After initial ground force allocations are made, the Pact has 43 of its 81 ADEs in reserve and NATO has 15.8 ADEs in reserve. Each side allocates 50 percent of its CAS aircraft to the breakthrough sectors.

Bolt from the blue blitzkrieg. In the third scenario, the Pact is assumed to begin its blitzkrieg after three days of mobilization. Such an approach denies the Pact the use of its large reserves in the initial as-

sault; in fact (as table 5 shows), NATO actually has a slight advantage in ADEs (the Pact has 24 ADEs to NATO's 25.8). However, since the Pact has the better capability to reinforce its troops quickly, a bolt from the blue blitzkrieg may work to the advantage of the Warsaw Pact. Note that in this scenario, each side receives ground and air reinforcements for the 30 days of the run.¹⁶

All three scenarios are run for 30 days for each value of the casualty exchange rate. In Epstein's battle model, if either side loses all its ground forces, the run is terminated. In the blitzkrieg model, if the forces in a sector drop to zero and no reinforcements are available, they are "reconstituted" to a value of .01 ADEs. This reflects the assumption that a side can always cobble together a minimal force even after a massive defeat. Thus, all blitzkrieg scenarios run for the full 30 days.

Simulation Results

The results of the runs are displayed in table 5. The starting ADE scores for each side and the Pact-to-NATO ratio are shown. The comparable figures for the end of a run are displayed as well. In the bolt from the blue scenarios, each side receives reinforcements that are not directly reflected in these ratios. The average distance advanced in the breakthrough sectors is reported, as well as the maximum distance advanced in the quiet sectors. The average distance in breakthrough sectors is used since each sector is fairly narrow and a single penetration might not be serious for NATO. On the other hand, given the large size of the quiet sectors (110 kilometers wide), a large advance in even one of these would be a significant blow for NATO, so the maximum advance in these five sectors is reported. For the broad front attrition scenario runs, the same figure is reported for both types of sectors since the Epstein model has only a single advance. In the cases in which the Epstein model stops before a full 30 days, the maximum NATO withdrawal (20 kilometers per day) is assumed for the remainder of the 30 days.

The results for the 1.85 exchange ratio are discussed first, followed by the results for low attacker-to-defender casualty exchange rates (less than or equal to 1.0, with no advantage for the defender) and the results using a high casualty exchange rate.

Casualty exchange rate of 1.85. The results for the broad front attrition strategy make clear why Epstein is so optimistic about NATO's chances. After 30 days, NATO loses almost no territory, and by the end of the time period, the surviving NATO forces are larger (in ADE scores) than those of the Pact. Notice the extremely large attrition rates for both

Table 5
Summary of Model Runs

Model	ADEs at Start			ADEs at End			Withdrawal	
	WTO	NATO	Ratio	WTO	NATO	Ratio	Brk ^a	Quiet ^b
CasEx ^c = 1.85								
Epstein ^d	81	45.8	1.77	7.6	9.6	.79	7.1 ^e	7.1
Full Blz ^f	81	45.8	1.77	16.4	10.9	1.50	148.1	0.0
Blue Blz ^g	24	25.8	.93	12.8	10.6	1.21	26.4	132.4
CasEx = .34 (Note: Epstein ends after 10 days)								
Epstein	81	45.8	1.77	57.8	0.9	** ^h	530.3	530.3
Full Blz	81	45.8	1.77	56.9	0.6	**	525.3	468.4
Blue Blz	24	25.8	.93	40.1	1.23	32.64	485.8	498.1
CasEx = .40 (Note: Epstein ends after 12 days)								
Epstein	81	45.8	1.77	54.7	0.1	**	518.3	518.3
Full Blz	81	45.8	1.77	54.5	0.1	**	509.9	449.7
Blue Blz	24	25.8	.93	38.2	1.0	39.47	469.1	486.6
CasEx = .50 (Note: Epstein ends after 15 days)								
Epstein	81	45.8	1.77	49.9	0.1	**	496.8	496.8
Full Blz	81	45.8	1.77	50.5	0.1	**	484.0	405.7
Blue Blz	24	25.8	.93	35.4	1.2	29.25	440.8	426.3
CasEx = .67 (Note: Epstein ends after 15 days)								
Epstein	81	45.8	1.77	42.7	0.1	**	457.1	457.1
Full Blz	81	45.8	1.77	43.7	0.1	**	444.9	338.2
Blue Blz	24	25.8	.93	30.6	1.8	16.82	395.2	333.5
CasEx = 1.00								
Epstein	81	45.8	1.77	29.5	0.1	**	359.0	359.0
Full Blz	81	45.8	1.77	31.1	0.6	49.46	369.7	194.7
Blue Blz	24	25.8	.93	22.4	3.1	7.35	263.1	254.8
CasEx = 1.50								
Epstein	81	45.8	1.77	14.6	3.4	4.33	156.1	156.1
Full Blz	81	45.8	1.77	19.7	6.2	3.17	249.7	19.1
Blue Blz	24	25.8	.93	14.8	7.4	2.01	83.3	208.2
CasEx = 2.00								
Epstein	81	45.8	1.77	9.6	9.9	.96	0.0	0.0
Full Blz	81	45.8	1.77	15.3	12.5	1.22	104.5	0.0
Blue Blz	24	25.8	.93	11.9	11.9	1.00	12.1	40.6
CasEx = 2.50								
Epstein	81	45.8	1.77	9.6	15.9	.60	0.0	0.0
Full Blz	81	45.8	1.77	13.6	17.4	.78	3.3	0.0
Blue Blz	24	25.8	.93	11.5	15.7	.73	0.9	0.7
CasEx = 3.00								
Epstein	81	45.8	1.77	9.6	19.8	0.5	0.0	0.0
Full Blz	81	45.8	1.77	13.6	21.2	0.6	0.2	0.0
Blue Blz	24	25.8	.93	11.5	18.3	0.6	0.0	0.0

Table 5—Continued

^a*Brk* = average withdrawal across all four breakthrough sectors.

^b*Quiet* = maximum withdrawal across all five quiet sectors.

^c*CasEx* = attacker-to-defender casualty exchange ratio.

^d*Epstein* = Epstein's model (broad front attrition).

^eEpstein scenario models entire front as a single battle with fully mobilized forces, so both numbers are the same. All figures are rounded.

^f*Full Blz* = Fully mobilized blitzkrieg.

^g*Blue Blz* = Bolt from the blue blitzkrieg.

^hAsterisks indicate the ratio was greater than 99.99.

sides. The Pact loses about 90 percent of its initial ADEs while NATO loses about 80 percent. It is very hard to believe that the war would last long enough to inflict these attrition rates on the two sides. But the crucial result is that, whenever the war might end, NATO would be the victor.

The fully mobilized blitzkrieg offers a direct comparison with Epstein's results since the initial forces and all parameters are the same. In the simple sense, the results are very different from Epstein's. At the end of 30 days, the Pact has advanced an average of 148 kilometers in the breakthrough sectors. This is the classic blitzkrieg; the attacker achieves a series of narrow but deep penetrations. As noted earlier, this would not necessarily mean a defeat for NATO, but the results do not appear encouraging for the defender.

A closer examination suggests a bit more optimism for NATO. As with the broad front attrition scenario, the attrition rates for both sides are extremely high—about 80 percent for the Pact and 78 percent for NATO. It is hard to believe that a war would continue up to these losses. It is difficult to say at what point it would stop, but let us arbitrarily assume that the war would stop when either side reaches a 50 percent loss in combat effectiveness. This would be at the end of day 16, when the Pact has 39 ADEs remaining and NATO has 23.5 ADEs. At this point, the average NATO retreat in the breakthrough sectors is only 36 kilometers. If the war stopped then, it would be hard to judge it a success for the Pact. But the results of the blitzkrieg model suggest that if the Pact were willing to accept truly staggering losses, it could achieve large-scale advances against NATO.

The results of the bolt from the blue scenario are more intriguing. It is hard to identify an arbitrary stopping point for the scenario, with a less extreme attrition rate for the two sides, since both sides receive reinforcements throughout the scenario. Consequently, I will consider only the final results of the run. The interesting result is that while the

Pact is unable to achieve much of a penetration in more than one of the breakthrough sectors (the actual advances are 2.8, 2.9, 10.6, and 89.2 kilometers), it is able to advance in the quiet sectors (advances here are 0, 0, 132.4, 54.6, and 0 kilometers). The reason for this result stems from the inadequacy of NATO's reinforcements versus those of the Pact; the Pact begins with 24 ADEs and gains 37 ADEs in reinforcement, while NATO begins with 25.8 ADEs and gains only 11 ADEs in reinforcement. As time goes on, NATO is unable to fully reinforce all nine sectors. In the blitzkrieg model, the breakthrough sectors are reinforced first since it is assumed that they are the most dangerous (for NATO) or most advantageous (for the Pact).

But since NATO's reinforcements are inadequate, while it is able to contain the Pact in the breakthrough sectors, NATO is gradually worn down in the quiet sectors, allowing the Pact to achieve large-scale advances. Thus, the threat from the breakthrough sectors diverts NATO's attention (and troops) and allows for an unanticipated collapse elsewhere. This effect is analogous with the earlier description of the exploitation phase of a blitzkrieg (even though the model itself does not explicitly cover this phase); troops are withdrawn from areas of the front still held to contain the breakthroughs of the blitzkrieg.

Casualty exchange rates less than or equal to 1.0. If NATO's combat abilities are less than or equal to those of the Pact (as reflected in a casualty exchange ratio less than or equal to 1.0), the results of all three scenarios converge. Quite simply, there is a total and complete collapse of NATO, as reflected both in the depth of the NATO withdrawal and in the staggering losses of ADEs it suffers.

In the broad front attrition model of Epstein, casualty exchange ratios of less than one result in the total destruction of NATO before the end of the 30-day time period. Assuming that the Pact could advance at the maximum withdrawal rate for the remainder of the 30-day period, the total Pact advance is greater with this scenario than with either of the blitzkrieg scenarios. The reason for the difference lies in the force-to-space ratio of the models.¹⁷ In the blitzkrieg model, forces are allocated to the front by both the attacker and defender in terms of concentration of ADEs per 25 kilometers of front. These limits represent force-to-space constraints for the attacker and defender and result in the Pact deploying no more than 30 ADEs on the front line. But in Epstein's broad front attrition model, there are *no* force-to-space constraints. Therefore, both sides are assumed to use all their forces on the front line. In effect, the force-to-space ratio for NATO in the scenario is 16.4 kilometers per ADE (750/45.8), and the force-to-space ratio for the Warsaw

pact is 9.3 kilometers per ADE (750/81). If these figures are reexpressed in terms of real divisions rather than ADEs, the figures are 12.3 kilometers per division for NATO and 6.25 kilometers per division for the Pact. The lack of a force-to-space constraint in Epstein's model allows the Pact to use its full measure of ADE superiority over NATO.

Casualty exchange rates greater than 1.0. As the casualty exchange rate becomes more favorable to NATO, the Pact's attack is less and less successful. With a ratio of 1.5, the distances retreated by NATO are much larger than they are with Epstein's value of 1.85. However, if we again use the arbitrary attrition level of 50 percent, the results are similar. For the broad front attrition scenario, 50 percent attrition is reached on day 11; at that time, the Pact has only pushed NATO back 16.7 kilometers. For the fully mobilized blitzkrieg, the 50 percent attrition rate occurs on day 16. At that time, NATO has retreated 62.3 kilometers in all breakthrough sectors and essentially no distance in the quiet sectors of the front. While this cannot be considered a smashing victory for the Pact, it does show that, given the forces of both sides, a blitzkrieg will produce better results than a broad front attrition strategy.

At an exchange ratio of 2.0, the results are better for NATO. The only scenario in which the Pact achieves a good advance after 30 days is the fully mobilized blitzkrieg. However, when 50 percent attrition is achieved on day 16, the Pact has advanced less than 30 kilometers in the breakthrough sectors. Once again, we can conclude that only if the Pact is willing to suffer extraordinary casualties will it be able to achieve a major advance against NATO.

When the casualty exchange ratio is over 2.0, the Pact cannot achieve any success against NATO, even with extremely high attrition rates.

Discussion of the Results

Before discussing some of the conclusions that might be drawn from these simulation runs, a few cautions should be noted. First, any discussion presumes that the simulations are reasonably correct representations of possible Pact attacks on Europe. This may not be true; either the models themselves or the parameter values may be flawed. In the final analysis, the reader must make a judgment as to the validity of the models. But certainly, additional runs need to be done to determine how sensitive the results are to particular parameters (as was done with the casualty exchange rate), to explore other aspects of a possible Pact assault on Europe, and to match runs of the models to historical blitzkriegs and other armored assaults.

Second, even if the models and the parameters (e.g., the attrition

thresholds) are reasonably accurate, the few experiments that were done may be flawed. For example, the mobilization schedules for both sides assume that the plans on paper are executed without problem. This may be much too optimistic—perhaps for both sides. If this is the case, the results of the runs could be very misleading.

Finally, I wish to reiterate a general caution about inferring too much from a model, whether computer based or not. Any model leaves out some factors in order to concentrate on others. Factors left out of the model may be more important in determining the outcome of a war in Europe than those elements central to it. To cite but one example, both models ignore the problems of resupply by both sides; it is assumed that both can continue to fight for the duration of the simulation run without worrying about the food, fuel, and ammunition requirements of modern warfare.

With all of these cautions in mind, we can draw a number of conclusions from the foregoing simulation runs. First, the results change radically with the value for the casualty exchange rate. If NATO's troops cannot fight as well as those of the Pact, there will be a total collapse of the conventional defense of Europe. On the other hand, if NATO's combat skills are superior to those of the Pact, NATO may indeed fight outnumbered and win. While many might argue that this is obvious, it does suggest a crucial point: troop quality and the proper training are very important. In a time of declining defense budgets, perhaps NATO should focus more effort on these matters, even at the expense of some weapons procurement.

Second, in situations of less than extreme parameter values, the Pact does significantly better using a blitzkrieg than a broad front attrition strategy. The Pact may not have the brute strength to force NATO back all along the front, but it might still be able to achieve victory using a blitzkrieg strategy. Consequently, NATO should devote effort to devising counters to a blitzkrieg—something that must be done quickly and relies on good intelligence and quality performance by lower-level units—rather than to fighting a war of attrition against Pact forces. The new U.S. and NATO doctrines (AirLand Battle, follow-on forces attack) might represent appropriate counters to a Pact blitzkrieg.

Third, if these results are at all indicative of the course of a future war in Europe, the losses from such a war will be incredibly high. These losses (along with the unmodeled effects of logistics and supply) might result in the serious fighting coming to a halt in a matter of weeks. On the other hand, if the Pact chooses to accept high losses, it can achieve significant advances in a variety of circumstances.

Summary: Can Europe Be Defended?

This article introduces a computer simulation of a blitzkrieg to explore NATO's ability to defend itself without resort to nuclear weapons. Although the model is an abstraction, it does convey crucial elements of a blitzkrieg and can be used to aid in the assessment of the chances of a Warsaw Pact breakthrough of NATO. The discussion of the computer simulations shows the advantages and disadvantages of this research technique.

The blitzkrieg model was compared with one by Epstein, which models a broad front attrition strategy by the Pact. Although only a few simulation experiments were conducted, they demonstrate the variety of outcomes that are possible with a blitzkrieg. These outcomes range from a broad front advance of more than 400 kilometers by the Pact, to the total defeat of the Pact with only a trivial loss of territory. Can NATO stop the Pact? The conclusions of this article are more pessimistic than those of Epstein, but nevertheless, a Pact defeat is possible. This can be accomplished if NATO can maintain a qualitative edge over the Pact and if it can contend with a Pact blitzkrieg. This is a complex but not a hopeless task. In this sense, analysts such as Epstein have performed a valuable service. While their efforts can be criticized, they have turned the focus of the debate over NATO's conventional capabilities away from the raw numbers and upon the manner in which a European war would be fought.

Notes

1. John J. Mearsheimer, "Numbers, Strategy, and the European Balance," *International Security* 12, 4 (Spring 1988): p. 177.
2. See John J. Mearsheimer, "Why the Soviets Can't Win Quickly in Central Europe," *International Security* 7, 1 (Summer 1982): pp. 3-39; John J. Mearsheimer, *Conventional Deterrence* (Ithaca, N.Y.: Cornell University Press, 1983); and Mearsheimer, "Numbers, Strategy, and the European Balance," pp. 174-185.
3. See Edward N. Luttwak, "The Operational Level of War," *International Security* 5, 3 (Winter 1980): pp. 61-79, and Edward N. Luttwak, *Strategy: The Logic of War and Peace* (Cambridge, Mass.: Belknap, 1987), pp. 91-125.
4. In the German blitzkrieg of France in May 1940, only 17 of their 136 divisions were armored or motorized, less than 13 percent of the total; see Barry Posen,

The Russians Are Coming

The Sources of Military Doctrine: France, Britain, and Germany Between the World Wars (Ithaca, N.Y.: Cornell University Press, 1984), table 2, p. 83.

5. See Joshua Epstein, *The Calculus of Conventional War: Dynamic Analysis Without Lanchester Theory* (Washington, D.C.: Brookings Institution, 1985), and Joshua Epstein, *Strategy and Force Planning: The Case of the Persian Gulf* (Washington, D.C.: Brookings Institution, 1987).
6. In the open (i.e., unclassified) literature, the most widely known measure of combat effectiveness is the armored division equivalent (ADE), which was developed by William Mako; see William Mako, *U.S. Ground Forces and the Defense of Central Europe* (Washington, D.C.: Brookings Institution, 1983).
7. A number of other parameters must be entered to run the model; see Epstein, *The Calculus of Conventional War*.
8. For examples of more complicated force models, see Reiner K. Huber, *Modeling and Analysis of Conventional Defense in Europe: Assessment of Improvement Options* (New York: Plenum Press, 1986).
9. Joshua Epstein, *The 1987 Defense Budget* (Washington, D.C.: Brookings Institution, 1986); Joshua Epstein, *The 1988 Defense Budget* (Washington, D.C.: Brookings Institution, 1987); and Joshua Epstein, "Dynamic Analysis and the Conventional Balance in Europe," *International Security* 12, 4 (Spring 1988): pp. 154-165.
10. See Luttwak, "The Operational Level of War" and *Strategy: The Logic of War and Peace*.
11. The blitzkrieg model was inspired by the attrition-forward edge of the battle area expansion model (otherwise known as the attrition-FEBA expansion model) developed by Richard Kugler and popularized in Barry Posen, "Measuring the European Conventional Balance: Coping with Complexity in Threat Assessment," *International Security* 9, 3 (Winter 1984): pp. 47-88.
12. The figure is taken from Posen, "Measuring the European Conventional Balance," p. 58. This figure is also consistent with the findings in John Erickson, Lynn Hansen, and William Schneider, *Soviet Ground Forces: An Operational Assessment* (Boulder, Colo.: Westview Press, 1986), p. 96, and David Isby, *Weapons and Tactics of the Soviet Army*, rev. ed. (London: Jane's, 1988), p. 25.
13. Most observers believe that there are only three or four areas in Western Europe that can support extensive armored assaults: the North German Plain, the Göttingen Corridor, the Fulda Gap, and the Hof Corridor.
14. See Mearsheimer, "Why the Soviets Can't Win Quickly"; Mearsheimer, *Conventional Deterrence*; and Posen, "Measuring the European Conventional Balance."
15. See Epstein, *The 1988 Defense Budget*.
16. The data for ground reinforcements are taken from Andrew Hamilton, "Redressing the Conventional Balance: NATO's Reserve Military Manpower," *International Security* 10, 1 (Summer 1985): p. 115 (see table 4). The close air support (CAS) reinforcements are based on information in Posen, "Measuring the European Conventional Balance," pp. 71-73.
17. The limits on the ability of the Pact to use its superiority in numbers imposed by

the force-to-space ratio figure prominently in the work of Mearsheimer; see Mearsheimer, "Why the Soviets Can't Win Quickly" and *Conventional Deterrence*.

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