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The Fulda Gap Sandbox:

Comparing a Hobby Wargame and Computer Simulation from the Cold War Era

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Introduction:

Hobby wargames that attempt to simulate war in a realistic manner date to the 60's with the Avalon Hill games that were supposed to put the gamer in the position of commander, and possibly change history. It has often been said that these games and their descendents are not really simulations, but merely games, because the validity with which the game represents the reality is clearly questionable. Nevertheless, hobby gaming continued to evolve, depicting not only historical battles, but eventually contemporary situations of the modern world in which combat might occur. In these cases, for which there was not a historical event for comparison, validity is even more suspect.

Yet, contemporary with these games were serious attempts to build a useful representation of modern combat using mathematics, reasoning by military professionals, and later, computer simulation. By the latter part of the Cold War, the 1980s, both hobby wargames and computer simulations used by the U. S. Department of Defense and associated businesses to depict contemporary potential combat were numerous and fairly sophisticated. Could either rightly be called a "simulation"? Well, the computer combat simulations were called that, despite the fact that validity remained an important question just as for the hobby wargames. The purpose here is to compare these two simulation techniques. In the interest of specificity, the focus will be on the "Fulda Sandbox", perhaps one of the most often gamed scenarios within the military analytic community.

By the 1980s, the Cold War was as intense as ever, and in central Europe seemed ever more dangerous despite lack of attention in the press. The Soviet buildup of IRBMs and other tactical nuclear and chemical weapons had reached a point where the NATO threat to go nuclear in response to a successful Warsaw pact conventional attack was no longer seen as a reliable deterrent. Soviet quantitative and qualitative advances, together with exercises apparently practicing for a sudden attack, meant that the challenge of defending West Germany using conventional means needed to be taken seriously. In the United States, studies addressed included logistics, the viability of new weapons such as the M1 tank, guided artillery rounds (Copperhead), multiple rocket launchers (MLRS), various sensors to better inform commanders, and changes to tactics and doctrine. Computer simulations were commonly used in examining these issues. The "Fulda Gap" area of West Germany, defended by the U.S. 5th Corps, protecting Frankfurt and its environs, was a typical focus in these studies. It was a potential battlefield featuring the U.S. forces for which new developments would be intended, and it was a critical defensive task to protect the deeper infrastructure in West Germany.

Scenarios, including information on how the scenario would be expected to evolve, were developed by the U. S. Army Training and Doctrine Command (TRADOC). These were standardized and used widely as a starting point for simulation and modeling efforts. The various versions of "SCORES" (Scenario Oriented Recurring Evaluation

System) scenarios were often used to "calibrate" simulations so that the overall evolution of the battle would be similar. Other associated entities at Ft. Leavenworth such as the Command and General Staff College, other agencies, national laboratories, as well as contractors were involved in the development of simulations, scenarios, options, variations, and studies using them. The topic is too broad for discussion here, but there came to be broad common understanding of how these standard scenarios "ought" to play out. This understanding not only informed the development of analytic combat simulations used as the "base case" for examining possible changes. An example of a typical 5th Corps scenario is shown in Figure 1. [The context for this is seen in Figure 1a and Figure 1b gives a sense of topography in the Fulda Gap region. Can be omitted.]

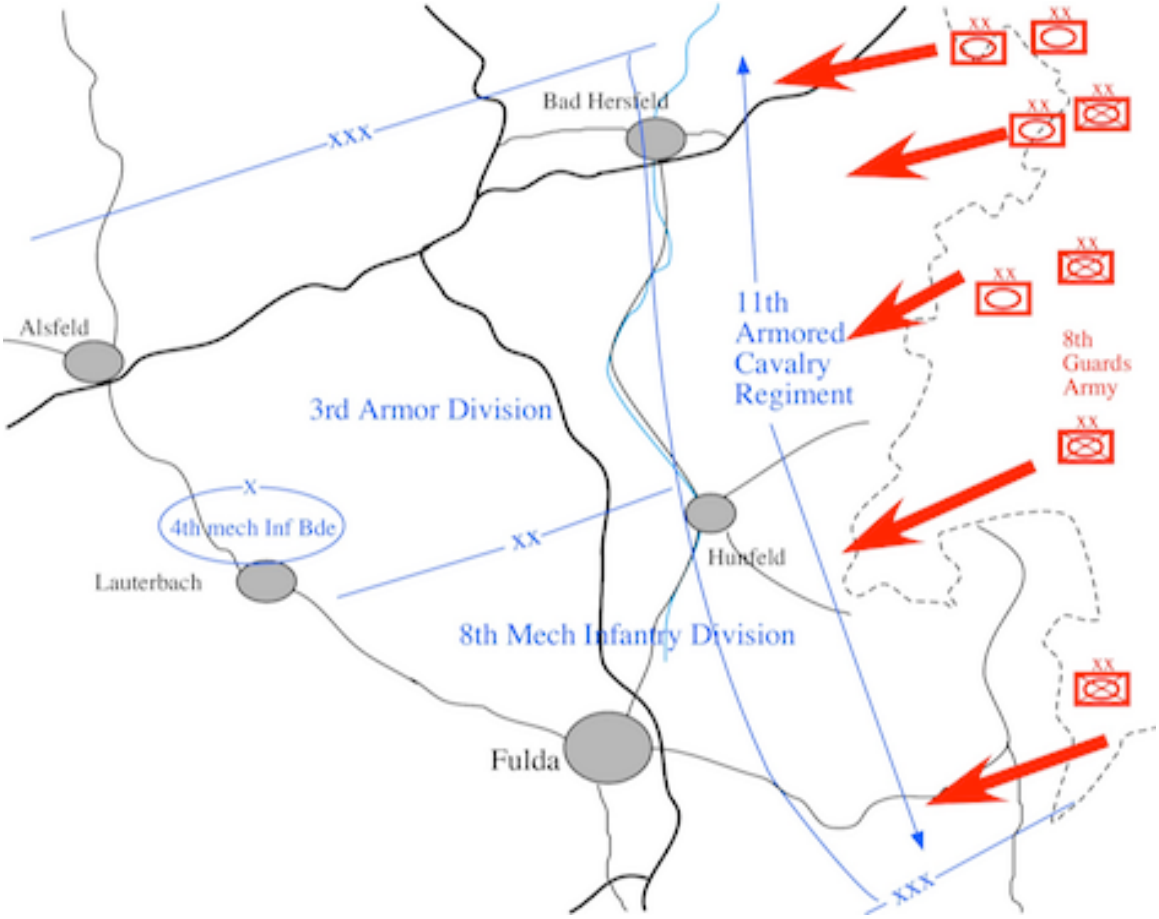

Figure 1 Map of Fulda Gap Advanced Warning Scenario

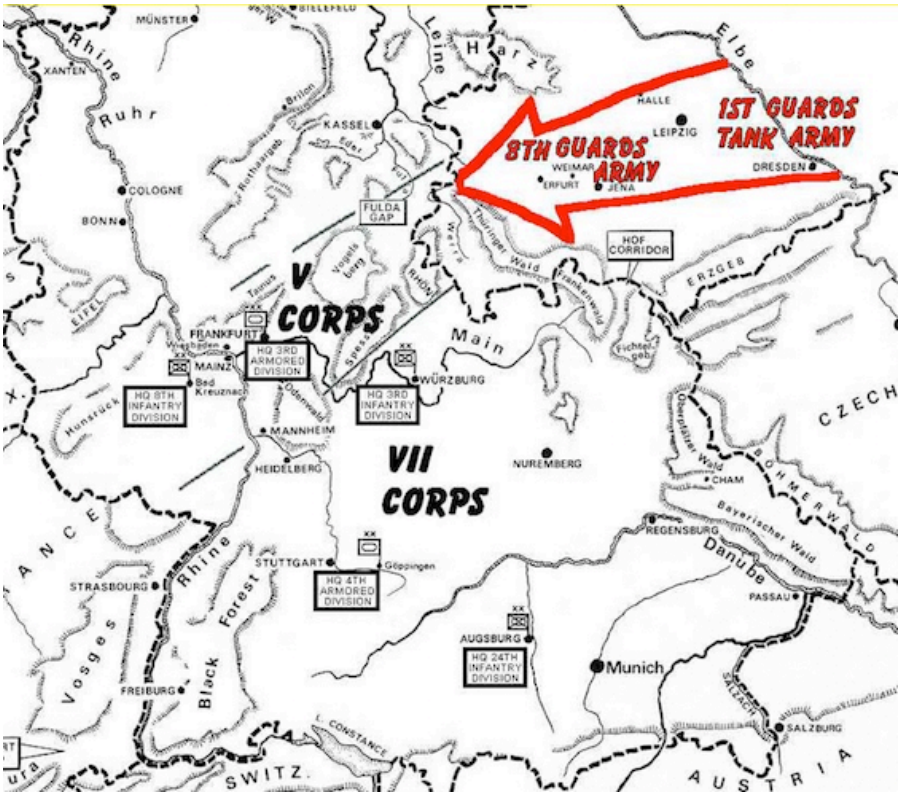

Figure 1a Fifth Corps in the Context of Defending Southern Germany

Figure 1b The Fulda Gap – Topography and Key Points.

A typical scenario for a 5th Corps scenario assumed that the two divisions plus an armored cavalry regiment (ACR) would be defending against several Soviet divisions of the First Guards Tank Army and the Eighth Guards Army. Figure 2 shows one such scenario used in 1978-79 for the "Corps Level Electronic Warfare" study. The Soviet tank divisions are "echeloned" with the two primary attack divisions being followed each by another tank division that would support then take over the attack as the first division was expended. This particular scenario had the primary attack in the north, while the divisions in the South made a secondary attack. Other variations had different Soviet forces and attacks, and some had a U.S. reinforcing brigade available. The ACR was expected to slow down the Soviet attack between the border and the main line of resistance running roughly from Bad Hersfeld to Fulda. On the second and third day the main attack would be made, typically around Hunfeld, forcing the river, and threatening a breakout toward Frankfurt.

An interesting instance of such a game as a command exercised featured German Generals Balck and von Mellinthin as an advisory capacity. They played the commander of the northern sector division, using flanking counterattack tactics that had proved successful during World War 2 against the Soviets, while General Gorman played the southern sector. Figure 2 shows the "final situation" for this exercise. This may be an optimistic outcome, but shows the kinds of forces and maneuvers people were thinking about concerning this critical potential battlefield. (*Generals Balck and Von Mellinthin on Tactics: Implications for NATO Military Doctrine*, BDM Corporation, publication BDM/W-81-077-TR, December 19, 1980). [Original had Red, Blue. Could be added.]

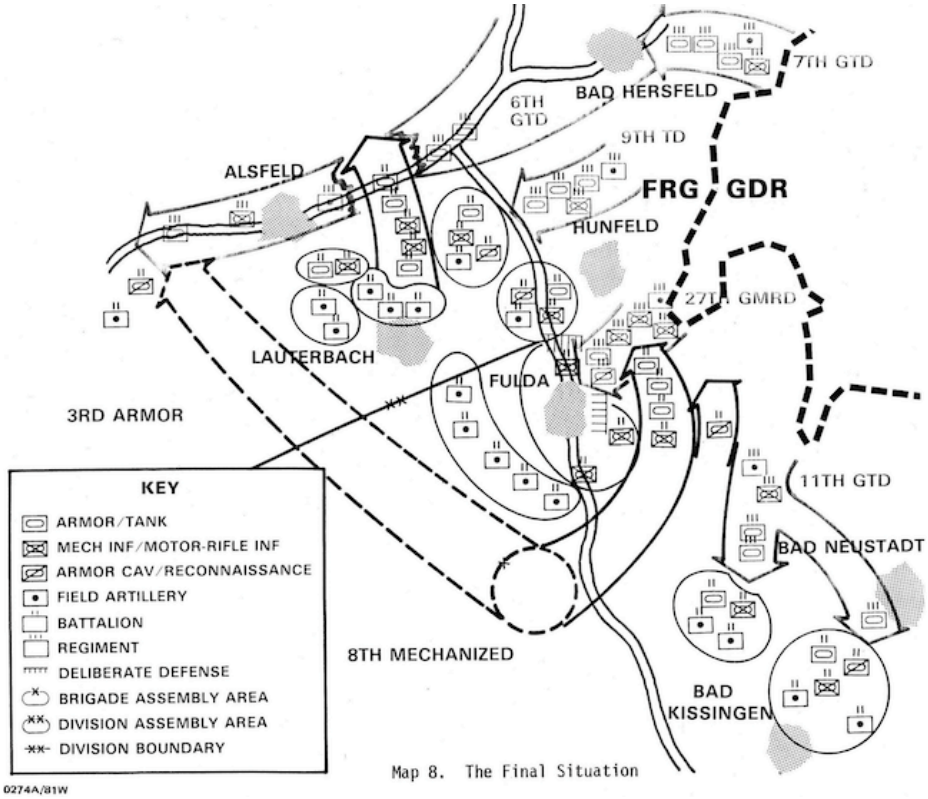

Figure 2 "Final Situation" from Fifth Corps wargame / exercise, 1980

The wargame hobby simulation: "Fifth Corps, SPI, S&T nr.82, Sept/Oct 1980.

This game was the first of SPI's "Central front" series sharing common rules and spanning the West German – Warsaw pact border. It's a big improvement on the earlier (1977) "Fulda Gap" game covering the same topic. Fifth Corps remains readily available on eBay and is not rare or expensive. (As this is written, five copies were listed.) The magazine contains considerable background information including an expected order of battle. The scenario assumes a rather sudden onset to the war. Moves #54 (Dec-Jan 1981) has an interesting article discussing the game and how it portrays the situation.

The terrain resolution is 4 km per hex. Minor rivers like the Fulda River are not shown; it seems assumed that the Soviets had plenty of bridging equipment and that would not be an issue. Figure 3 shows the Fifth Corps terrain. The small diamonds between hexes indicates "access routes", secondary roads and trails allowing movement through difficult terrain. The map is shown with North at the top. (The lettering is most easily read from the East.) The light green represents "broken" terrain, as opposed to the "rough" dark brown. The red dots are minor towns. The heavy red line is autobahn.

Figure 3 Fifth Corps Map Detail around Fulda

Most line units are battalions (NATO) or regiments (Warsaw Pact). Some units such as the U.S. armored cavalry regiments break down into company size. Units are represented as having combat and movement values, as well as five Friction Point "steps" which represent the ability of the unit to continue in combat. Friction Points are recovered, one per turn (two for artillery) if supplied. While the sequencing is alternate phases by the two players during each turn, the limit on movement is 12 operation points (movement plus attack) per phase. Each activation of a unit costs another Friction Point. Each activated unit moves and can make attacks (at the risk of losing more friction points) until the player chooses to activate the next unit. Artillery within range can be called on for support by both the attacking and defending units (unless EW prevents it).

Figure 4 shows a situation at the end of two turns: one day. The Soviets have captured the critical bottleneck town of Bad Hersfeld after a tough fight, and have reached and entered Fulda. The remnants of the 11th ACR can be seen in and north of Fulda (the 1-1 and 1-2 company sized units). The Fifth Corps game assumes a short warning scenario, in which Soviet units do not start on the map but march onto it from approximately the East German border. NATO units are caught unprepared; only the 11th ACR and German 2nd Jaeger (infantry) division are deployed. The U.S. 3rd armored does not move until the 3rd day, and the 8th Mech is off map to the west, and not included in the game. The 5th Panzer Division is the only reinforcement available to counter the Soviets during the first few days. Most of the NATO units seen in the figure are from the 5th Panzer. Units of the 1st Guards Tank Army do not enter until turn 4, Day 2 PM.

Figure 4 Fifth Corps, at the End of Day 1 (two turns)

The multiple phase Friction Point mechanism with attacks as part of movement was a clever and innovative way to represent the fluid and urgent deep attacks expected from Soviet doctrine. The Combat mechanism is conventional but allows a variety of tactics. Figure 5 shows the table. Attacks can be prepared, hasty, or from the march, with varying operation points costs. In addition, an attack can be an "overrun": the

defender's losses are reduced 1, but with success the attacker can then ignore the unit's zone of control and move right through the defender. This also prevents a defender from retreating; all losses must be taken as friction points. Chemicals used by the Soviets can shift the odds three columns (first 3 days). Smoke / ground fog can also give the attacker a favorable shift on an overrun. Towns shift the odds left a column.

[8.6] COMBAT RESULTS TABLE

Defender's Terrain	Combat Ratio (Attacker to Defender)														
City	2–1	3–1	4–1	5–1	6–1	7–1	8–1	9–1	10–1	11–1	12–1	13–1			
Rough/Woods	1–1	2–1	3–1	4–1	5–1	6–1	7–1	8–1	9–1	10–1	11–1	12–1	13–1		
Rough, Marsh Broken/Woods	1–2	1–1	2–1	3–1	4–1	5–1	6–1	7–1	8–1	9–1	10–1	11–1	12–1	13–1	
Broken, Flat/Woods	1–3	1–2	1–1	2–1	3–1	4–1	5–1	6–1	7–1	8–1	9–1	10–1	11–1	12–1	13–1
Flat		1–3	1–2	1–1	2–1	3–1	4–1	5–1	6–1	7–1	8–1	9–1	10–1	11–1	12–1

Attack Type																
DIE RESULTS																
Prepared	Hasty	March														
1	–	–	1/1	1/1	1/1	0/1	1/2	1/2	0/2	1/3	0/3	1/4	0/4	0/5	0/5	0/6	0/6
2	*1*	–	1/0	1/1	1/1	1/1	0/1	0/1	1/2	1/2	0/2	0/3	1/4	0/4	0/5	0/5	1/6
3	*2*	*1*	1/0	1/0	1/1	1/1	1/1	0/1	0/1	0/1	1/2	0/2	0/3	1/4	0/4	1/5	0/5
4	*3*	*2*	1/0	1/0	1/0	1/1	1/1	1/1	0/1	0/1	1/2	0/2	0/3	0/3	0/4	0/4	0/5
5	*4*	*3*	1/0	1/0	1/0	1/0	1/0	1/1	1/1	0/1	0/1	1/2	0/2	0/3	0/3	0/4	0/4
6	*5*	*4*	2/0	2/0	1/0	1/0	1/0	1/0	1/1	1/1	0/1	0/1	1/2	0/2	1/3	0/3	0/4
–	*6*	*5*	2/0	1/0	1/0	1/0	1/0	1/0	1/0	1/1	1/1	1/1	0/1	1/2	0/2	0/3	0/4
–	–	*6*	2/0	2/0	2/0	1/0	1/0	1/0	1/0	1/0	0/1	1/1	1/1	0/1	1/2	0/2	1/3

Figure 5 Fifth Corps Combat Results Table

A couple of representative engagements are used to illustrate how this works. Figure 6 shows an encounter early in the covering force action in Turn 1. The Soviet Motorized rifle regiment has no on-board artillery support yet (the artillery units are farther back in the entry column). An overrun is conducted, so the defender has a strength of 1 (the first number) but the attacker 14 (mark over the 14 on the counter). It's a hasty attack into rough/woods. A slightly worse than median roll of 4 gives "0/3". The defender loses 2 "Friction points" (-1 for overrun) and the attacker can continue moving right through down the autobahn (paying 3 points for the attack and 1 point for the two hexes). It will have 3 points left over to hasty attack Bad Hersfeld. Using such tactics, the Soviets seek to penetrate and disrupt the defense before the main NATO forces can get into position.

Figure 6 Fifth Corps Covering Force Encounter

Figure 7 shows a coordinated, prepared attack. The ACR has moved out and a battalion of 2 Jaeger Division has moved in with its defense strength of 7. All of the units activate together (but only one stack will be able to continue operations). Artillery in direct fire mode is doubled, so the odds are 37-7: 5 to 1. EW is used to prevent the defender from receiving artillery or helicopter support. Chemicals (an extra 3 column shifts) and attack from 3 hexes 92 more shifts) makes it 10-1. A slightly better than

median roll of 3 gives: "1/2". The defending unit absorbs two Friction Point but remains in place. The attacking units all lose an F.P. in addition to an extra F.P. for each artillery unit, and the artillery F.P. for smoke. In addition, the direct attackers lose the F.P. for activating. Cities are a problem. The exchange favors NATO, but can they keep it up?

Figure 7 Fifth Corps Coordinated Prepared Attack Example

The computer simulation: CLEW2, TCOR/I, ICOR, CORBAN simulations

Military computer simulation in the 1980's was widespread. A 1989 catalog compiled by the Joint Chiefs of Staff lists 347 different simulations, war games, exercises, and models (http://www.dtic.mil/dtic/tr/fulltext/u2/a213970.pdf). Most are computer simulations or use the computer for part of the simulation. By the early 1980's, computer based simulation allowing units to maneuver had become possible, but might be better called "computer assisted" gaming since human interaction was needed to provide command. The technique, sometimes called "Man in the Loop" (MITL) used the computer to represent combat, movement, logistics, and often other processed such as EW and sensor operation. (Fully automated computer combat simulation at that time organized the battlefield into sectors rather than freely maneuvering units, so the command process did not have to control maneuver, just allocation of forces and other resources among the fixed sectors.)

The simulation chosen for this comparison to SPI's Fifth Corps, CLEW2 (there were later derivatives) was chosen due to a similarity of scale and scenario, information availability, approximately contemporary with Fifth Corps (about 1989), as well as familiarity. A family of combat simulations sharing a software basis were developed by BDM Corporation in the late 1970's into the 1980's which were hexagon based (rather than sector based) allowing the kind of free movement by discrete units that hobby wargamers take for granted. The hexagons were arranged in groups of seven, each of which was a single hexagon at a higher level, so conceptually simulations could operate with multiple resolutions, although this seldom occurred in practice. The TCOR/I (the "I" standing for an emphasis on interdiction missions using the MLRS system), ICOR and CORBAN simulations were later derivatives of the same family, the last including more command automation to brigade and division levels. CLEW2 was used to study the

impact of proposed electronics warfare systems. That study, as most using these simulations, was conducted at the SECRET level, although the simulation itself was unclassified.

The terrain resolution was 3.57 km. That odd number comes from the hexagon hierarchy. When the simulation family originated, someone thought hexes of 25 km were appropriate for division resolution simulations. Each of those broke down into seven 9.4 km hexes for brigade level simulation, and breakout of those hexes gives 3.57 km for battalions. (The Corps Level Electronics Warfare (CLEW) earlier simulation in 1977-78 used the brigade level hexes; subsequent simulations used the battalion sized hexes.) Within each hexagon, terrain was defined as having one of three levels of forestation, ruggedness, and urbanization. Each hex side had one of three levels of roads and rivers. So, you can think of having light, medium or heavy woods; villages, towns and cities; and some hills, rolling and hilly terrain. Likewise streams, minor and major rivers, and primary, secondary, and minor roads. This is fairly close to what Fifth Corps does. A sample of the terrain for CLEW2 is shown in Figure 8. Of course, this is just a visual representation; the computer saw binary coded descriptors. The human players generally looked at military terrain maps with a hex overlay. The numbers on the map coded the built up extent, approximately 15%, 40%, or 70% or more. Forestation used similar percentages. The roughness values of 1 to 3 represented degree of rugged terrain in like percentages, or terrain having slopes of up to about .03, .06, or .10 or more. Rivers present here were of only the smallest of three varieties. Note that the terrain shown is from an initial database used for the CLEW2 study. It not be exactly what was used in later studies. I know that the 5th Corps area terrain was redone for the CORBAN simulation (since I did it, at least for the initial version).

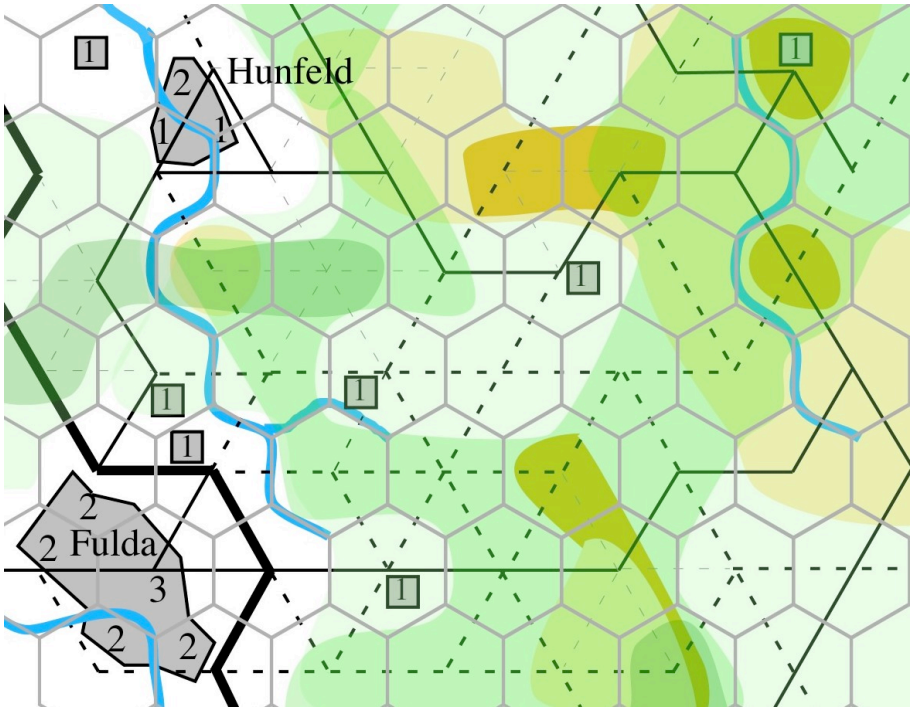

Figure 8 Terrain for CLEW2 (TCOR/I, ICOR, and CORBAN similar)

As with Fifth Corps, the fundamental NATO units were battalions, though as with Fifth Corps covering force units (of the Armored Cavalry Regiment) were companies. Soviet units were also resolved to the battalion level, so a "game" typically had many more "Red" units than Fifth Corps does. Each unit consisted of some numbers of various assets such as tanks, APC's, trucks, artillery pieces, and so forth, rather than rolled up into an abstract "strength" as for Fifth Corps. (The assets could be broken down by type, so that Soviet BMP's were distinguished from BRDM's.) This kind of unit book-keeping is a strength of computer simulation. Artillery units were typically down to the battalion level as well, and sometimes to battery level for certain studies.

Each unit also has its "orders" that, within the computer simulation, it tried to carry out. The orders were assigned by the "Man in the Loop," representing the command echelons for each side. Usually the Blue (U.S. / NATO) command team was separated and isolated from "ground truth", seeing only what "intelligence" was presented to them. Red was usually played by experts in Soviet doctrine and tactics. Blue was often played by U. S. Army personnel or experts with similar background. Typically the simulation was stopped every 4 hours of game time to assess whether any unit orders needed to be changed. The whole exercise ran at close to real time speed although the computer simulation ran faster. However, it took a lot of time to get the results, plot them manually, and then derive the information to be presented to Blue.

Each unit's orders consisted of an objective, an orientation ("facing"), a mission code (attack, defend, delay, etc.) and possibly contingency orders for what to do if, for example, the unit arrived at the objective. Orders could thus be chained to give a unit a series of objectives. The unit chose its own path, and assumed an operational posture appropriate to its circumstances. For example, a unit might have an attack mission, but would be in a march posture while moving along the road, then go into an attack posture when it encountered an enemy unit. A unit could also be given a "follow" order, where some other unit rather than a geographic point was the objective. (This relative was developed because in a column of moving units, if the first got held up, the others would scatter in any way forward across country individually instead of queued up in column. A BDM manager referred to this as the "Keeping the bastards on the roads" problem.)

Movement took place along paths connecting the centers of adjacent hexes. Thus, each one hex move was along no road or one of the three types of roads, and possibly across one of the types of rivers. Speed was calculated based on the terrain and the operational posture of the unit. (In the presence of an enemy unit, the moving unit would go into an attack posture, thus moving more slowly than in a road march or march to contact posture.)

The units also made individual (automatic) decisions based on a small number of "circumstance" descriptors: whether the unit had reached its objective, whether it was in combat or not, whether unit strength had reaches a marginal or ineffective level, and whether the unit was flanked. Tables 1 and 2 show the prescribed the reaction for each of these circumstances, including changes of operational posture, mission, and "actions". (These particular tables are from a test simulation run; more fully vetted data would have

been developed for analytic runs.) In some cases such as being in combat and ineffective, the actions included generation of a new "objective" to the rear (G in the code) and a retreat toward that objective. Wargamers will recognize this as a "defender (or attacker) retreat" combat result. A current order could be temporarily set aside "pushed (u) or returned to "popped" (p). Additional actions such as reconsidering movement, sending messages, requesting fire support etc. are not shown. This primitive "artificial intelligence" for the units only needed to result in behavior that was sufficient until the next stop point when the man-in-the-loop could intervene by issuing new orders. (In later simulations, more complex "rule" methods were used.)

Table 1 Situation Table

			Combat Situation					
At Objective	Effectiveness		No Flank Danger			Flank Danger		
		not	adj	hex	mtg	adj	hex	mtg
no	full	1	2	3	4	5	6	7
no	marginal	1	8	9	10	11	9	10
no	ineffective	12	13	14	14	14	14	14
yes	full	15	16	3	4	17	6	7
yes	marginal	15	18	9	10	19	9	10
yes	ineffective	20	13	14	14	14	14	14

Table 2 Response Table (operation/mission/action)

	Situation code(rows for 0-9, 10-19)									
	0	1	2	3	4	5	6	7	8	9
1.Prep def.	-/-/-	m/m/ug	-/-/-	-/-/-	h/-/-	-/-/-	-/-/-	h/-/-	-/-/-	d/d/ug
"p"	h/d/ug	-/-/-	m/m/u	d/d/ug	w/w/g	-/-/p	-/-/p	-/-/-	-/-/p	
2.Hsty def.	-/-/-	m/m/ug	-/-/-	-/-/ug	h/d/-	-/-/ug	d/d/ug	h/d/ug	-/-/-	d/d/ug
"q"	h/d/-	-/-/ug	m/m/u	d/d/ug	w/w/g	-/-/p	-/-/p	-/d/ug	d/-/p	
3.Delay	-/-/-	m/m/ug	-/-/-	-/-/g	h/-/pg	-/-/g	-/-/g	h/-/ug	-/-/-	-/-/ug
"d"	h/-/ug	-/-/-	m/-/u	-/-/ug	w/-/ug	q/-/p	q/-/p	-/-/ug	q/-/ug	
4.Withdraw	-/-/-	m/-/ug	-/-/-	-/-/-	h/-/g	q/-/g	q/-/g	h/-/g	-/-/-	-/-/g
"w"	h/-/ug	-/-/-	m/m/u	-/-/g	-/w/ug	q/q/p	-/q/ug	-/-/ug	q/q/g	
5.Hsty att.	-/-/-	-/-/ug	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-	-/-/g	-/-/g
"h"	-/-/g	-/-/g	-/-/u	-/-/-	w/w/ug	-/-/p	-/-/p	-/-/p	-/-/p	
8.Recon	-/-/-	-/-/ug	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-	-/-/g	-/-/g
"r"	-/-/g	-/-/g	-/-/u	-/-/-	w/w/ug	-/-/p	-/-/p	-/-/p	-/-/p	
9.March	-/-/-	-/-/-	q/q/p	h/q/p	h/q/p	q/d/p	h/d/p	h/d/p	q/q/p	h/w/p
"m"	h/w/p	q/d/p	-/-/-	q/w/p	w/w/p	q/q/p	q/q/p	d/d/p	q/q/p	

actions: u=push, p=pop, g=generate and objective
Operations 6 Coordinated attack and 7 Breakthrough attack not shown.

The heart of any military simulation is the representation of combat itself, weapons firing at targets. In Fifth Corps this is the "Combat results Table", and its use occurs when a unit or units "attack" another, a discrete event initiated by the player. This is where the computer simulation differs most radically from the hobby simulations. Combat is automatic and continuous. Every unit is automatically and always engaged in

combat with all adjacent enemy units. You can think of this as a "zone of control" effect; any unit that moves adjacent to an enemy unit will be fired on. As simulated, "attrition" (the losses due to combat) was calculated for each 5 minute interval, based on the weapons and target assets of the units involved and their respective operational postures. (Notice how differently the term "attrition" is used from hobby wargames.) The operational postures gave units defending an advantage, but defending units couldn't move. The effect similar to "defender back two" that you see in wargames was not an outcome of the combat / attrition process directly. Rather, a unit suffering attrition would reach an effectiveness threshold and its decision table would cause it to generate an objective to the rear and delay or withdraw toward that objective.

Attrition equation (direct fire):
Losses = Nweapons*terrain*alloc*disposition*killrate*suppression
"terrain" is a factor for the combination of terrain in target hex
"alloc" is the proportion of the weapons fire against that unit, asset
"disposition" is a factor that depends on the proportion of weapons "up"
"killrate" is the characteristic of the weapon. Depends on firing rate, pkill
"suppression" is a factor to account for incoming fire effects.

In the early 80's, what the operators of the simulation actually saw was a printed "listing" from the computer simulation program, at a particular stop time, of where the various units were and what their status was. This information was then plotted, typically with grease pencil on acetate covered maps, for presentation in filtered form to the MITL decision makers, along with any additional "intelligence" appropriate to the study being conducted. (Often the control and Red command were combined, with Red pretty much following a scripted plan.) Sometimes Tektronics high resolution graphics terminals were used to generate monochrome plots, but these were expensive and slow. Later computer images could be superimposed on videodisk maps, but these had poor resolution. Late in the 1980's, color computer graphics became more common.

The manner in which the simulation operated is illustrated in Figure 9, showing the action at discrete times in an unclassified test simulation run. Against a Blue unit in hasty defense at Hunfeld, two Red battalions with an objective at that place nevertheless chose routes to flank the objective, despite heavy terrain. However, once the Blue unit senses itself flanked, it goes into a delay toward a generated objective one hext to the rear. The Red units will later move to Hunfeld. There is a similar action in the south, just east of Fulda. In the middle, an initial hasty attack on the Blue unit fails as the attacker becomes ineffective, generates an objective to the rear, and withdraws. A second first echelon battalion to the south threatens to flank the Blue unit, which has lost effectiveness. The Blue unit withdraws, and the second echelon battalion and the flanking unit both reach their objective. Note the times given. In CLEW2 units "jumped" from hex center to hex center. In later simulations they moved along a path connecting the hexes, with speed adjusted every 5 minutes. (In a more typical analytic run the unit density would be much greater.)

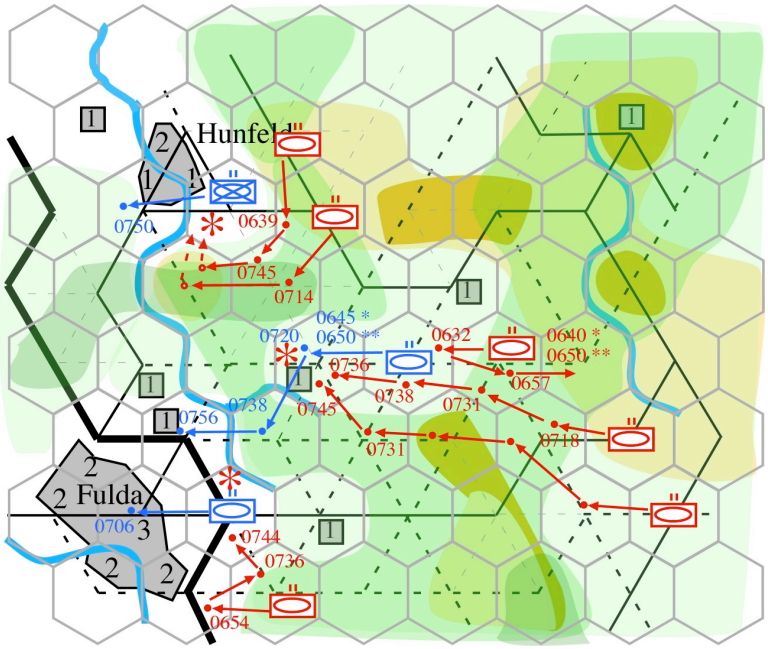

Figure 9 Examples of movement, combat and decision making in CLEW2

Comparison:

There are some interesting differences between the two simulations aside from attributes depending on how they were built. The scenario itself is quite different: a very short warning for Fifth Corps such that no U.S. Division could maneuver for three days. This is the sudden, "bolt from the blue" attack. Or, perhaps an attack in which the political will to respond to impending attack was lacking, even if military professionals understood what was happening. One is reminded of the onset of Barbarossa, the German invasion of the Soviet Union in World War 2. It would indeed not be surprising for Western governments of the era to avoid mobilizing to avoid "provoking" the Soviet Union. On the other hand, all of the many studies I participated in assumed a buildup period. The calculus was that the Soviet Union needed some time to get troops and logistics forward, and would benefit more than NATO from a quick mobilization rather than attack from a standing start in the barracks. That was what I was told at the time by people more knowledgeable than I. Perhaps this reflects that the military professionals could not justify planning on the basis of the national political leadership being idiots. Hobby wargame designers were free to do so. (It also would not seem that Fifth Corps depends at all on the scenario and wargaming activity at Leavenworth. Rather, game developers twiddled the rules and factors to make it come out a viable game. The MOVES article on Fifth Corps discusses this process.)

A second aspect of the scenario that differs is that in no analyses of Fifth Corps that I participated in, or even heard of, were the German forces modeled. Fifth Corps was always two divisions, an ACR, and often an independent brigade. It was assumed that the Germans were defending to the north, but that wasn't represented. On the other hand, Fifth Corps by SPI includes only one full U.S. division, and it is 5th Panzer that assumes the defensive burden in the Fifth Corps sector early in the war. If you consider the purpose of the analytic studies, whether to buy a system, or use a different tactic, it

makes sense to use only U.S. forces. They are the ones which would benefit. Furthermore, gathering data on the Germans for purpose of analysis would complicate the study, lead to additional expense, and possibly annoy an ally.

A third difference is the expected role of air cavalry. In the SPI game, the 11th ACR has an air cavalry battalion that operates like artillery, supporting a unit in combat (if EW does not prevent that). In most analysis efforts I recall, it was assumed that the air cavalry would instead operate independently. In particular, they were expected to engage and slow down the onrushing hordes in order to give the ACR units the opportunity to withdraw. (I recall one instance during development when the helos refused to move forward. They stopped at Shlitz, on the west bank of the Fulda River. It turned out that the helos wouldn't cross the river without a bridge. It took a while to figure that out. A bit in the unit definition was set wrong. A human wargamer would never have made that error!)

Rivers are another place where the simulations differed. Fifth Corps left them out, except for the very largest ones. In the computer simulations, even small rivers like the Werra and Fulda were included, and did have a significant effect on movement. This was particularly the case when a unit was held up at a river by scatterable mines (one of the systems studied) or by contact. The trailing units then also got held up, and the attack could lose synchronization. In SPI's game, with time is treated much more abstractly, such delays and their effects cannot be accounted for explicitly. The Werra is mentioned because of an interesting incident when developing CORBAN. One of the first echelon Soviet tank divisions deployed 2 regiments up, and two in support as is normal. However, the decision making logic assigned the left follow-on regiment to support the right first echelon regiment, and vice versa. The division's sector happened to straddle the Werra River. As the first echelon attacked, the second echelon regiments were busy trying to cross the river in opposite directions over a limited number of bridges. I believe they were something like six hours late supporting the attack. I briefed this incident as an example of how difficult and important the development of C2 data is. To my surprise, a guy in a green suit stood up in the back of the room and said he's seen that (a similar incident) happen.

It is clear that Fifth Corps includes many more nuances explicitly than the computer simulation. Examples of things Fifth Corps explicitly includes, and CLEW2 (or later similar simulations) didn't, include:

1) Ground fog, smoke. In the SPI game, it gives a favorable shift to overruns.
2) EW (in general). Many computer simulations included explicitly modeled sensors, but playing the interference with message traffic was only modeled by later simulations, but certainly not in CLEW.
3) Requirements for division integrity in attacks, and prohibition on such for different nationalities for NATO. Equivalent restrictions could be implemented by the human controllers, but were ignored by the software.
4) Soviet initial preemptive strike on ground forces. In some analyses it was assumed that the air war would absorb the attention of most aircraft for both sides and none would be spared. In others, the U.S. Air Force was

able to perform some interdiction missions (that was what was being studied).

The computer is able to play logistics, account for individual tanks and even rounds of ammunition if necessary. Weapons could be represented as choosing munitions appropriate to different types of targets, and the process of maintenance and repair could be modeled. Sensors could be modeled in great detail, including shadow effects, the effect of Doppler on moving targets, and the possibility of mistaking what is detected. Bookkeeping of this sort is entirely beyond what a hobby wargamer would want to do.

Despite the differences, many attributes of both simulation approaches are similar. Both used hexagons as a way to regularize movement. (Trying to plan routes and perform combat in a continuous Cartesian space is very difficult and computationally expensive. In 1980 only the largest computers had floating point hardware, so everything that could was done with integers.) The terrain was quite similar in its representation. Both simulations used battalions with some company sized units, with Fifth Corps needing to use Soviet regiments as a matter of practicality. Finally, there was some similarity in operation representation: Fifth Corps used different values for attack and defense, etc. and the computer simulation used operation dependent factors that accomplished much the same. Ultimately, both methods of simulation depended on human beings being in the loop for decision making.

Observations and Discussion:

Hobby wargames and analytic computer combat simulations come to the problem from completely different perspectives. Designing a wargame is an art. One reads history, considers effects, and then attempts to devise a practical system that plays out realistically, yet is manageable by a few human beings with a dislike of record keeping. The test of whether such a wargame is a sufficiently valid simulation of the reality is in the hands of the gamer, and is a matter of interpretation and application of judgment. When a game covers a hypothetical battle as Fifth Corps does, the question comes up whether the wargame is useful as a predictor of what might happen. That's a matter of guesswork, and few people would have confidence that the important factors of the reality have been captured accurately enough. If the simulation is judged a failure, then the gamer has spent money and time on a game that wasn't satisfactory. Even then, it still might be useful as a tool to think about the problem. Often, the reality depicted in the scenario never comes to pass, very fortunately in the case of Fifth Corps.

Analytic simulations of combat originated as far back as 1916 with a British mathematician, Lanchester, who used a simple simultaneous differential equation model to represent the aggregate flow of air combat [**reference from Wiki:** Lanchester F.W., *Mathematics in Warfare* in *The World of Mathematics,* Vol. 4 (1956) Ed. Newman, J.R., Simon and Schuster, 2138-2157. I once had a copy of the original 1916 paper, but can't find it now.]. The most basic form is that Blue losses are proportional to the number of Red weapons systems, and Red losses are proportional to the number of Blue systems. More complex situations with multiple units and weapons systems become more difficult

mathematically, but with the computer it became possible and practical to calculate losses and other outcomes of mathematically expressed combat models. Analytic combat models and computer simulations have been relying on this approach ever since.

The central problem in these analytic combat models, as for the hobby wargames, is one of validity. Originating in the analytic domain of Operations Research (OR), addressing serious problems for which real world decision makers needed answers, and having rather large sums spent on them, more was expected than for hobby wargames. The approach generally taken, then, was to try and derive from first principles the mathematical model and the coefficients for combat and other related processes. For example, a certain type of tank has a given possible rate of fire, has a certain probability of hitting a target, and that if it hits, there is a certain probability that the target is "killed" in the sense of no longer being viable. These probabilities and related parameters can be established with exercises and tests. In a tank on tank engagement then, one can use the combat model to calculate the rates at which each side suffers losses. One can also derive reasonable assumptions about fire rate inefficiencies due to terrain line of sight blockage, target acquisition delays, and other such factors. You might think that this would give a valid model. It wouldn't.

I happened to be involved in developing the combat code and parameters for "CLEW," the predecessor of CLEW2, a brigade level simulation, in 1977-1978. The parameters derived resulted in combat way to intense, as judged by company employees with considerable analytic military experience. We ultimately settled on a factor of eight – attrition between units would occur at 1/8 the rate the raw data suggested. In the study, various retired senior generals were used as the Blue corps commander, giving orders to Blue forces based on what intelligence was provided by certain new sensors being studied, or in the control cases without the extra sensors. I was the low level flunky running the computer terminal to enter data and get results. One of our consultants, General William E. DuPuy, was waiting for computer results. He was discussing computer simulation with some of the company's senior management who were present. I recall him saying that combat simulations like this one typically ran a factor of three too fast. That's an additional factor of three on top of the factor of eight that we already did not analytically understand!

In trying to bridge the gap between proving grounds numbers and what intelligent, experienced military men expected to be the reality, one must deal with the fact that war is a human enterprise. Humans, especially organizations of humans, are not well understood. At least, they are not well understood in the sense that a mathematician or operations research professional can easily characterize and quantify the effects on combat. The hobby wargamer doesn't try to build an analytic justification for his model, but the analytic simulation designer is obligated to try. Combat models did improve, but at the expense of adding parameters to represent the effects of such things as suppression that are very difficult to define, much less measure. Ultimately the combat model depends on many such parameters, like the relative fire effectiveness of a unit in hasty attack versus defense. Some of these parameters could be tied to data derived from

studies, others could not. Ultimately, the analytic basis of such analytic computer combat simulations remains suspect, just as it does for hobby wargames.

Getting a model considered analytically acceptable became much more difficult with explicit decision making added to the simulation's representation. It is difficult to get experts on Soviet forces to agree on things like "break points", at which units would become ineffective and would seek to withdraw. What would actually happen wouldn't be in fact a decision by the unit, but by individuals within the unit. War gamers don't have any trouble with the concept of "rout" and "morale checks". Would a Soviet unit actually rout, or fight to the last tank? This becomes an even bigger problem for Blue. What U.S. Army officer is willing to go on record saying that a typical U.S. unit will rout at some particular remaining force percentage? Trying to come up with even these parameters was difficult. Many others need to be defined to complete the data and rules governing unit behavior. Even so, these models with their suspect data had to be more realistic than those which prohibited maneuver, effectively putting units on rails which were part of the underlying spatial abstraction.

Validation is the process of demonstrating that a simulation, or wargame, is sufficiently representative of the reality. For wargames representing a particular battle, history provides one (and only one) instance with which performance of the wargame can be compared. Gamers debate the validity of even those games. For analytic computer combat simulations, validation is an even tougher challenge. One might be able to apply the simulation to historical actions, and see how well it does. This was done in a number of cases. For example, VECTOR was used to represent the Arab-Israeli combat in the Golan Heights, and CEM was used to simulate the Battle of the Bulge, both able to show reasonable correspondence. Were the simulations "tuned" to come out right? There are a lot of arbitrary settings that might differ for an important then-future battle with the Soviets. Ultimately, the conclusion was reached that validation, as understood for things like engineering simulations, was just not possible.

One of the problems derives from the analytic origin of these computer simulations. If every process and parameter needs to be analytically justified, then it becomes easier to entirely leave out a process or consideration than to try and represent it without an analytic grade justification. This isn't just laziness; anything going into the model often had to be approved by a review board. The argument was made that suppression should be left out because nobody had data. Detection of enemy units should be deterministic rather than stochastic (random) because of lack of data. Furthermore, if the simulation included random processes, even for just detection, one would have to run the simulation multiple times to get a statistical sample, a matter of administrative inconvenience.

Ultimately it was recognized that combat simulations by themselves had very little assured predictive power, at least those which tried to address big messy problems like Fifth Corps. Still, they were useful in doing comparative studies. One might not know how the real battle would go, but if the simulated battle was consistently better with new sensor systems X and Y, or artillery system Z, there was a good chance these

systems would be helpful in the reality, should it ever occur. So it was that combat simulations continued to be used, despite validity concerns, because they added knowledge, even if not predictive knowledge. Often the very experience of running an exercise using simulations led to new insights, in addition to the formal goals of the study.

But, do not these same considerations apply to wargames? We correctly argue that they cannot be considered accurate simulations, especially when applied to the future. The same is true of computer combat simulations. We may be able, however, to use them with some value to compare different cases, "what if" exercises, where the scenario is the same except for the one issue to be studied. That seems to be potentially useful.

Conclusion:

Hobby wargames and computer combat simulations approach the problem differently, but there has been something of a convergence as the computer simulations try to be more flexible, represent maneuver warfare, and the functions of command. So which was the better simulation of the Fifth Corps scenario? They both suffer from the fact that "validation" is impossible, and that they both were ultimately adjusted to meet expectations with a common basis in military experience, perhaps even both informed directly or indirectly by the Army's analytic studies by TRADOC at Fort Leavenworth.

I do recall just one instance of good prediction. At a presentation at West Point, Col. T. N. DuPuy was describing his "Quantitative Judgement Model", a combat model based on historical engagements, using a relatively unsophisticated mathematical formulation. Some in the analytic community looked down on this work as not sufficiently based in quantitative methodology. They saw it in effect as "tuned" to fit the data, and would not necessarily have predictive value. Col. DuPuy remarked that his methodology had allowed him to quantitatively rank various nations or cultures for military effectiveness independent of other considerations. He rated the Iraqis as "the bottom of the barrel." Nobody's combat simulations accounted for such cultural factors, because there was no analytic methodology and data considered good enough to support them. Hence, nobody using simulations except perhaps Col. DuPuy would have predicted the quick, early, and almost lossless victory by the coalition in the war of 1991 over Kuwait.

There is really no way of knowing which simulation approach might better predict the possible battle. But if there are two different, preferably independent, ways to represent the same thing, and they both agree, that would be useful. (If they disagree, one should have less confidence in what one "knows.") In the late seventies, the Army believed that serious doctrinal and equipment improvements were needed in central Europe. Simulation was useful in examining the options. Fortunately, we never had the validation exercise to see which model was best.

(Reference:<ismor.cds.cranfield.ac.uk/25th.../scenarios...for.../KrondackScenarios.pdf> Mr. William J. Krondack, "Scenarios – Foundation for Combat Developments", TRADOC Analysis Command, Scenario and Wargaming Center, Fort Leavenworth, Kansas). Many suitable maps (Fig 1a, 1b, others) http://www.1-33rdar.org/centralfront.htm. Other references are in the text for now.