COMPARING SIMULATED RESULTS AND ACTUAL BATTLE EVENTS FROM 1944 – A CASE STUDY USING SANDIS SOFTWARE

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ABSTRACT

We used Sandis simulation tool to study a historical battle of Loimola in summer 1944. The first goal was to study war history and address a novel method in Finnish environment. The second goal is to publish the methods used in military analysis. Instead of the classified questions and scenarios in modern Finnish defense, the battle of Loimola 27th July 1944 was used to get a public example of the analysis method. As a third goal, this simulation is an example of the tens of historical simulation studies needed to validate simulation software.

Sandis simulation tool has been used for cost-effect and tactical analysis in Finnish defense forces. With Sandis the human operator is responsible for tactical decisions during the scenario building phase. During the calculation phase the computer calculates the combat losses, platoon/squad states (operational, defeated or destroyed), ammunition consumption and also other values not used in this study. During the analysis phase, charts, tables and killer-victim scoreboards are created.

Our case study focuses on the day of 27th July 1944, when the Soviets assaulted the Finnish defense lines near Lake Suovajärvi. The unit hierarchies, weapons, weapon parameters, positions and movements of the units were set as input. The results match the historical events: the Finnish losses were 30 according to the literature; simulated loss distribution (95%) was between 25 and 44, mean 35. In the simulations the attacking units are defeated and stopped as in literature. The ratio of losses caused by artillery and light infantry weapons did not conflict the values from larger area available from the literature. Thus in this case study, Sandis performed well.

In future work, different historical battles could be simulated in order to get better insight of our history and key issues of war, helping to improve our future defense.

1. INTRODUCTION

Simulation has been used as a tool in war history; see e.g. (Sabin 2012). However, tactical simulations have rarely been applied to Finnish war history. Some examples were found though: Mika Laitinen's study of Kollaa front (Laitinen & Lappi 2008) and also some computer war games which have included Finnish forces such as Panzer General II (SSI, 1997).

In the historical case study we use Sandis simulation tool (Lappi 2012) to gain better understanding of war history and the nature of war, also helping to solve problems in our future defense. This is probably the first time NATO simulation procedure (Horne & Seihter, 2013) is used in Finnish war historic environment.

Second goal of the study is to create a public example of the simulation process used in classified military studies. Instead of the classified scenarios, a well-documented historical battle near village of Loimola on 27th July 1944 (Keinonen 1971: 184-200) is used.

Instead of present defense planning questions, we study the Finnish battalion commander's analysis after the war. According to the battalion commander (Keinonen 1971), the Soviet attack was halted on 27th July, thanks to the hard work fortifying the second defense before the attack, massive use of accurate defensive artillery and the open swamp terrain in front of the Finnish positions. After the simulation, we discuss whether it can answer the question and whether the simulated results agree with battalion commander's analysis.

As a third goal, our case study serves as an example of the dozens of case studies needed to validate simulation tools through comparing the results of the simulation with the historical outcome. There is plenty of literature on the topic of validation of military models, e.g. (Hartley, 1997) mentions using field tests and historical data as empirical evaluation methods. The sub models of Sandis have been validated using field tests (Lappi, 2012; Åkesson et al, 2013), but this is the first time a historical case study is simulated.

In this paper we first describe the scenario and provide a short introduction to Sandis. The scenario creation process is presented in sufficient detail to a military officer or a 3rd year cadet to reproduce a similar case study after Sandis user training. After the scenario creation process and the first simulations we compare the simulated results and the real events and perform speculative simulations by changing the factors of the simulated base case in order to answer the research questions.

The scenario

In summer 1944 the Continuation War between Finland and Soviet Union had been in standstill for over two years as both sides waged trench warfare. The Finns had no intention of advancing any further and were content just waiting for the eventual peace, while the Soviets were busy elsewhere fighting Nazi Germany. Because the war had not progressed for

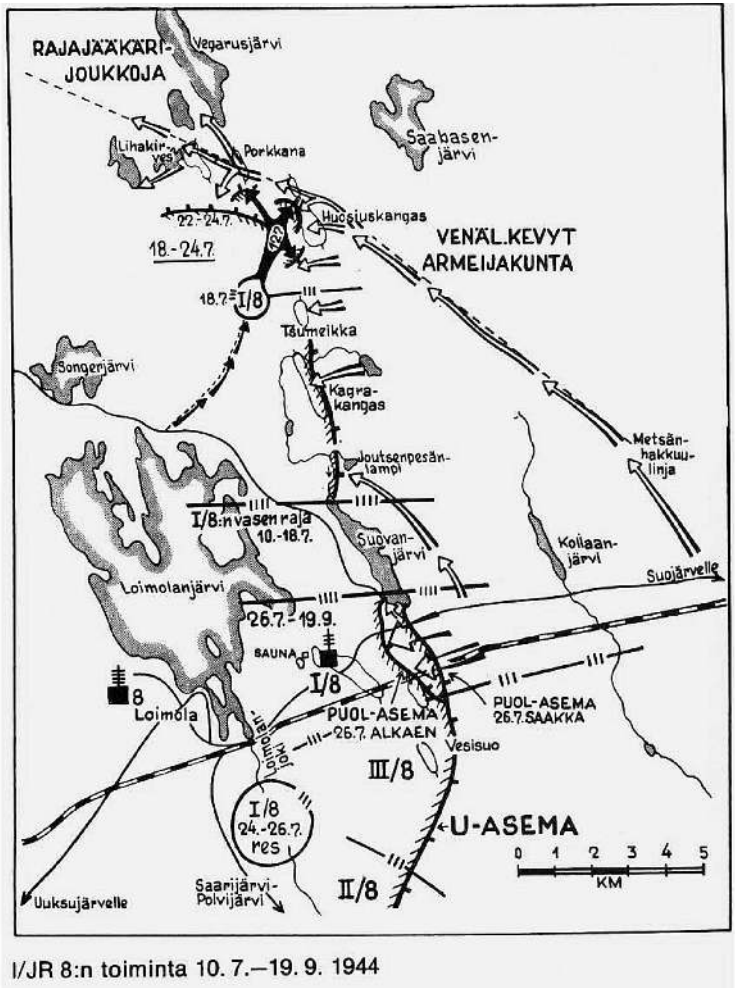

Figure 1: Map of the battle area (from Keinonen 1971)

a long time and the whole world was expecting the Soviets to focus most of their military might against Germany to beat the Western Allies in the race to Berlin, Finland was caught somewhat unprepared when the Soviets started their major offensive in Karelian Isthmus and north of Lake Ladoga. (Keinonen 1971: 84-86)

2.

The best known battles of 1944 were fought in Karelian Isthmus where both sides had placed most of their forces. However, there were critical battles on other fronts too. If the Soviets had managed to break through on the northern side of Lake Ladoga, it would have soon become impossible to defend the Isthmus as the Soviet forces would have been able to assault the Finnish defense lines from behind. One of the decisive battles on the northern side of Ladoga was fought near the village of Loimola, on a strategically important location due to the road and the railroad there. If the Soviets had been able to gain control of Loimola they would have had an open route south. The fighting took place from 15th July to the end of war 4th September with the main battles happening during two weeks in the end of July. (Kronlund et al 1992: 316-328).

On the day before the events of the simulated scenario, the Soviet forces had managed to break through the Finnish defense lines on the southern shore of the Lake Suovajärvi and the 2nd Battalion of 56th Infantry Regiment (II/JR56) was withdrawing. Soviets had been slow with their advance, most likely because they were rotating fresh troops to the frontline. The Finnish 1st battalion of the 8th Infantry Regiment (I/JR8) retook the second line of defense after a fast counter attack. After I/JR8 recaptured the second defense line they strengthened the defensive positions.

The scenario itself focuses on what happened the next day, 27th July 1944, when the Soviets assaulted the new Finnish defense lines attempting to take over the village of Loimola by any means necessary. The scope of the modeled scenario covered the two Soviet regiments (over 1400 infantrymen each) attacking the Finnish battalion (525 infantrymen), located south of Lake Suovajärvi. Both sides also had artillery and air support. The offensive lasted for 5 hours, during which the Soviet forces made seven assaults against the Finnish lines and suffered heavy casualties while Finland suffered 30, eventually repelling the attack (Keinonen 1971: 192).

There were two main reasons for choosing the Soviet attack in Loimola as the scenario for this case study. The first one was that the scale of the scenario was similar to some of the classified studies and such that it was ideal to use Sandis rather than some other simulator. Nearly 2000 attacking men is too many for any platform level simulation software like PAXSEM, see e.g. (Kallfass, D.& Schlaak, 2012), or FLAMES (Ternion corp, 2014), yet too few for high-level score-based methods like Quantified Judgment Model QJM, see e.g. (Dupoy 1990).

The other reason for choosing Loimola as our scenario for this study was the access to a good description of the events that took place, the forces that took part in this battle and the losses they sustained. Unfortunately (Raunio & Kilin), an excellent source for many other battles, did not give detailed data of the Suovajärvi battle, so Soviet losses were not accurate. Although Raunio and Kilin give superior data about losses in other battles, we need information from other sources, as they do not break down to platoon/company level, which is needed for accurate simulation.

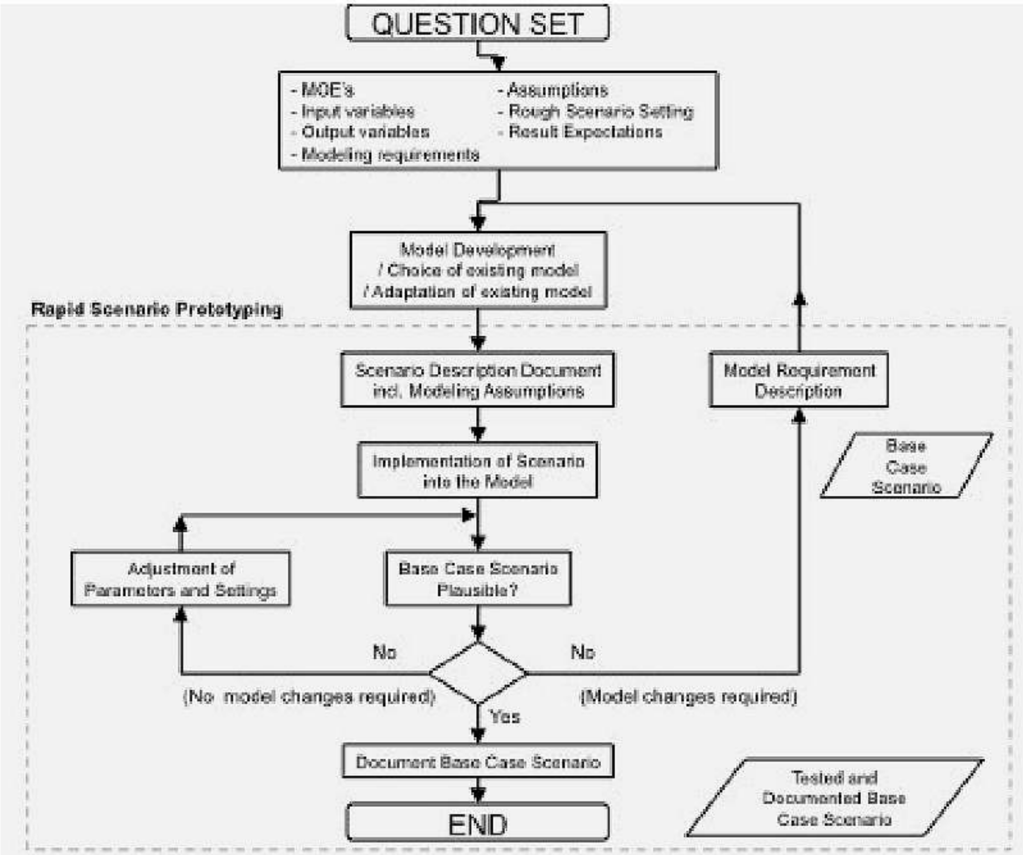

Figure 2: The tested simulation method Fast Scenario Prototyping according to NATO MSG-088 Final Report. The procedure is also available in Horne & Seihter, 2013.

3. MODELING PROCESS

3.1 Rapid scenario prototyping with Sandis software

We used Sandis – a simulation tool, which has been used for cost-effect and tactical analysis from platoon to brigade level in Finnish defense forces. There is a good description of Sandis in (Lappi 2012). With Sandis the human operator is responsible for tactical decisions during the scenario building phase. In calculation phase the computer calculates the combat losses, platoon strength distributions, platoon/squad states (operational, defeated or destroyed), average ammunition consumption (not distribution) and average medical evacuation, radio connections and operation failure fault tree analysis. In analysis phase we can create charts, tables and killer-victim scoreboards to see output variables and which unit and weapon caused losses to target units.

The direct fire model parameters are from the literature, and also new field tests with more than 10 000 bullets used have been conducted to validate them (Lappi 2012). The artillery model has been validated with field tests. Some of the validation data has been published in (Åkesson & al. 2013), which can be used as reference when studying details of the artillery model.

In Sandis, incoming fire and casualties force the unit to take cover and treat the wounded, weakening its ability to advance accordingly. The evacuation data is based on field tests, but some of the parameters are rough estimates. (Lappi 2012)

The simulation study has a good guide with NATO Science and Technology Organization (STO) Modeling and Simulation Task Group MSG-088 "Data Farming in Support of NATO" final report. In our case study we mostly concentrated to the part "fast scenario prototyping", which gives a clear procedure for simulation studies.

In the procedure the question set has already been introduced. Input variables and rough scenario description are weapon data and the actions of the troops on 27th June 1944, output variables losses and what caused them, the end positions of attacking platoons and ammunition consumption, which can also be used as measures of effectiveness. The result expectation is the simulations confirming the analysis by Keinonen.

No other simulation model available by Finnish Defense Forces can handle a scenario this large, so using Sandis was an easy choice. The implementation of the scenario in the model took place in Computational War History workshop in Päivölän Kansanopisto during 26th to 30th June 2013. The first two days were spent training personnel in the use of the software and preparing the necessary parameters and data. The gaming phase took the following two days, and on the last day we analyzed the results to estimate whether the scenario is plausible or not. After creating the base scenario, we also ran some additional simulations after the event in order to answer the questions.

3.2. Preparing data

Before creating the scenario itself, we prepared a map image, an equipment file containing the parameters for the weapons used and a troops description file describing the forces involved in the battle. We managed to find digital pre-war maps from the area from Maanmittauslaitos (Maanmittauslaitos 2009). Thus we were able to use maps similar to those used by the Finnish army at the time and had precise information about infrastructure in the area then.

Normally we would not need to edit the standard equipment parameters unless adding new types of equipment, but in this case the battle was fought with 70 years old technology, which obviously differs from modern equipment. We had extensive data on the capabilities of the rifle caliber weapons used by the Finnish, thanks to studies conducted in the 50s

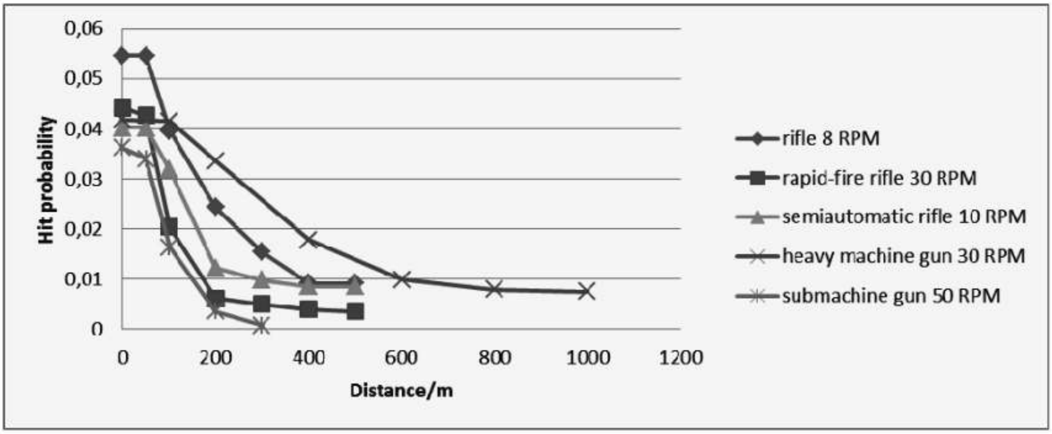

Figure 3: Hit probabilities of different rifle caliber weapons used in the scenario. It should be noted that the effectiveness of a weapon is combination of hit probability and fire rate.

(Keinonen 1954). The values used for rifle caliber weapons are shown in Figure 4.

Most notably the artillery shells had less explosive power. The artillery shells were estimated to have lower speed of fragments than modern ammunition (700m/s) (Gurney 1943)(Heaton 1962: 26)(Keinonen 1954).

The troops file contains each side's forces, equipment, and command hierarchy. Technically you would only need a list of units and their manpower and equipment, but having sensible names, symbols and hierarchy makes the scenario easier to understand and work with. Sandis can handle units of any size, but the model is designed for platoon-sized units and its accuracy suffers if using units of significantly different scale (Lappi 2012: 37). In this case we decided to use squads for the Finnish forces and platoons for the Soviet, given the total sizes of the forces. We did not have precise information available, so we approximated the composition of units based on what we knew about the total sizes of the forces and the military organizations in general. For Soviet unit structure there were many options available. We used the values presented by Steadman as they were reasonably average and thus a conservative choice (Steadman 1997)(Ilomantsi sodasssa 2012).

3.2 Playing out the battle

We placed the units on the map as close to the descriptions available as possible. We also had information of the compositions of artillery units taking part in the battle on the Finnish side (Ahonen et al 1994: 369-375).

The initial positions can be seen in Figure 7, where the software was set to display all units at platoon level. Note that only the positions of the units participating

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            <DecelerationModelParameter Name="C2"
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Figure 4: Example of XML data describing a 122mm artillery shell. The difference to modern ammunition is fragment velocity. The fragmentation model of Sandis is presented in (Åkesson et al 2013).

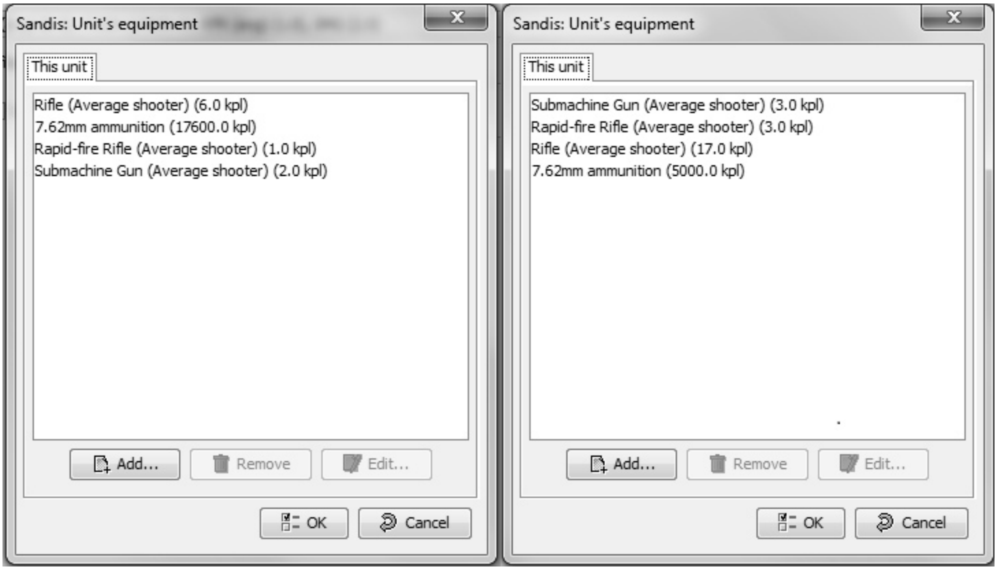

Figure 5: Screen captures from Sandis showing the weapons used by infantry units. Finnish units were played on squad level and Soviet units on platoon level. Both were given enough ammunition to not run out of it during battle.

in the battle are relevant to the simulation; the Soviet battalions scheduled to attack later, for example, were simply distributed in the general area and moved more accurately when they started their attack. There was also some additional artillery left outside the picture.

While performing the actions in the battle we aimed to match the timing and magnitude of artillery strikes and infantry attacks to the historical data as closely as possible while also having the simulated scenario to play out naturally after this scenario building procedure. This turned out to not require additional effort, so neither model development loop nor parameter adjustment loop were needed in process in figure 3. Only some adjustments in settings were needed.

4. ANALYSIS OF EVENTS

The lopsided results of the battle could be understood the moment we had finished placing the units on map: the position was extremely favorable to the defender, and according to the simulation team member with war experience, an offensive should never have been launched this way. The reasons Soviet did so anyway could be explained by overconfidence and orders from above to quickly wrap things up on the Finnish front. The Soviet did not have the means to effectively destroy the heavily fortified Finnish defense positions, and the attacking infantry was massacred in the open terrain in front of them. A close-up on the field of battle can be seen in Figure 7, though a screenshot

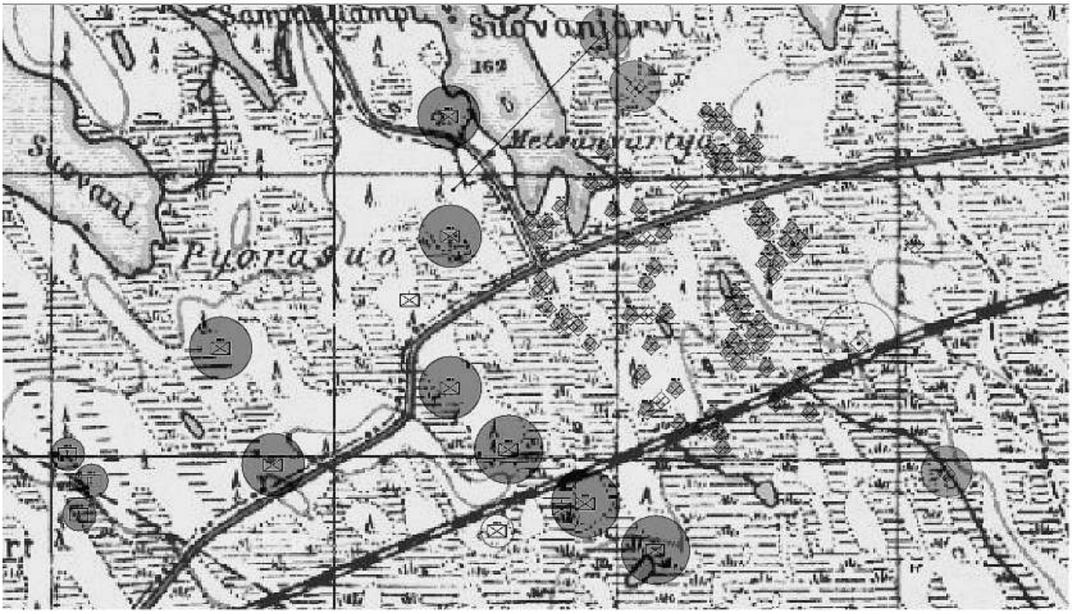

Figure 6: The scenario's initial state. Note that the circle sizes represent the units' areal spread, not their strength. The background map is a color-adjusted image from Maanmittauslaitos (Maanmittauslaitos 2009).

from the software does not do justice to the Finnish forces' overwhelmingly advantageous position, which in the software is presented mostly through parameter values.

5. ANALYSIS OF THE COMBAT SIMULATIONS

Before going further, it should be noted that war is chaotic and even perfect models would not be able to give a definite result for the battle as a whole. That said, Sandis is a stochastic combat simulator, as it uses stochastic models like Markov chains and gives its results as probability distributions. As a simulation system Sandis is deterministic, as no random numbers are used and identical inputs will yield identical outputs (both distributions and average values).

The results of the battle are difficult to boil down to numbers, but we are able to look at each side's casualties and ammunition consumption. In Figure 9 we can see the probability distribution Sandis gives for the remaining strengths of the Finnish forces on the battlefield at the end of the scenario. Sandis predicts an expected value of 35 casualties and the result being between 25 and 44 with 95% probability as seen in Figure 8. The historical source reports 30 casualties, which falls within the simulated probability distribution and

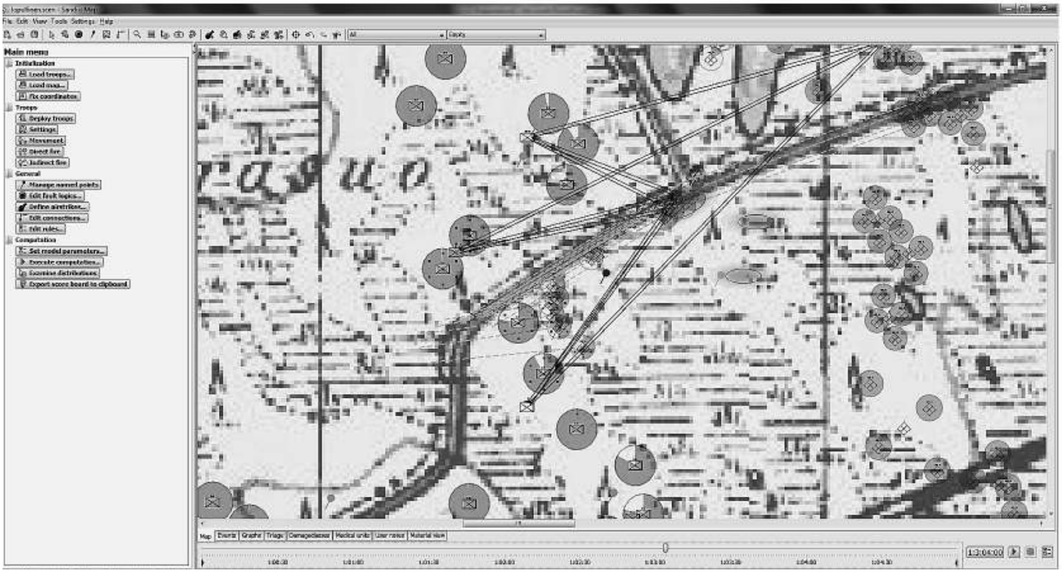

Figure 7: Soviet advance across an open swamp towards Finnish fortified positions is stopped. The background map is a color-adjusted image from Maanmittauslaitos (Maanmittauslaitos 2009).

implies that the winning Finnish side was moderately lucky that day.

Since accurate information about casualties on the Soviet side was not found, we cannot do same comparison for them, but the estimation of 611 casualties given by Sandis seems realistic considering how large a Soviet force was taking part in the attack and the fact that they were forced to retreat. Also the testimonies of captured Soviet soldiers confirm that the Soviets lost thousands of men in Loimola area during the two weeks of fighting (Keinonen 1971: 206).

In comparing our results to the historical data, we could argue that we are comparing the simulated probability distribution of a dice to a single roll of dice. Let us open the results with an example. If we have as a simulated result a sum of 100 rolls of unweighted dice, simulated distribution has mean 350 and with 95% interval between 316 and 384. If the "field test data" is for example 300 or 343 or 2000, we can do some analysis. With 300 it is possible but unlikely that the model parameters are accurate; the dice may be rigged or there may be other sources of error. With 343, simulated distribution does not conflict with the observed result, and the model could be valid. A result of 2000 would be completely incompatible with our model and prove it invalid in this case. In the case of the battle of Loimola, the historical data matches the simulated results as

Figure 8: Finnish battalion's remaining strength at the end of the scenario

the result 343 in our dice example. It is an encouraging result, but in order to validate the model with experiments of this type, we would need dozens of such cases, or perhaps even more.

The ammunition consumption serves as a metric to verify that the scenario was played out as it was supposed to. For that Sandis only tracks the expected values, which are 14600 infantry light weapon bullets, 420 mortar shells and 540 artillery shells fired for the Finnish, and 1375 infantry light weapon bullets, 974 mortar shells and 12240 artillery shells fired for the Soviet. The low consumption of light infantry ammunition on the Soviet side is explained by the fact that they were assaulting through an open swamp against fortified positions, which did not present good targets for accurate firing and Finnish fire forced them to take cover. This might be an error in simulation: Soviets were not given an order to shoot area fire to support their attack.

Finally and most importantly, we need to look at the progression of the simulated battle and make a judgment on whether it was realistic in order to be used as a base case for answering the questions. After all, in constructive simulators like FLAMES (Ternion corporation, 2014), PAXSEM (Kallfass, & Schlaak 2012) and Sandis, much of the scenario data depends on decisions made by human operators. Thus the numbers could often be fabricated by rigging the events to produce the desired ones. While in general this kind of analysis is subjective and heavily based on the operator's actions during the scenario building process, in this analysis, the historical data gave outline for operator action.

In Figure 8, the snapshot has been taken at the point where the Soviets could no longer make progress. According to (Keinonen 1971), the Soviet forces got near the defensive positions, but were halted by infantry fire. In Sandis, the most probable end position was similar to the reports.

The simulation showed that the Soviet assaults were stopped before they could reach Finnish defense lines. Heavy casualties most likely forced enemy to retreat. The results did not conflict with the data from other reports about termination of the battle (Helmbold 1971: 91), where 50% losses stop the attacker in all cases. In addition the numerical results given by the simulation were close to the actual numbers found in historical sources. This applies to both the casualties sustained by the Finnish side and the ammunition consumption of both sides. It can be said that in this case Sandis's results are as accurate as can be reasonably expected. Thus we have a solid base case, which could be used to answer the two main "questions" of the study.

According to Keinonen, the key factors in successful defense were fortification and artillery support. The losses were mainly caused by indirect fire, so concerning artillery the statement is clear. (Keinonen 1971: 192-193). For artillery effectiveness the same conclusion has already been drawn by for example (Hirva 1952), where experiment-based tables were used instead of simulation.

The fortification was studied with a separate simulation run. In the original simulation with the defenders' fortification level set to "fortified defense", the losses were 30 soldiers and all attacks halted. As we changed the simulated fortification level to "hasty defense", meaning foxholes without cover, the Soviets managed to penetrate the defense lines with their first assault. This corresponds to the estimation of the Finnish battalion commander that the well-prepared fortifications played a crucial role in winning the battle.

The terrain question is obvious for all military personnel, but how did this simulated case study succeed in this topic? There was some correspondence: simulated losses had only few casualties from infantry weapons indicating the difficult terrain for attacker. However, the terrain question shows the limit of the case study: if we chance the terrain, the basic fundament of the battle is chanced. Then the movements and positions from literature become invalid. If we would like to study the effect of terrain, we would have to create a larger set of similar scenarios to different terrain and adjust in each attack a set of different tactics into the simulation system. After this type of data farming we might be able to conclude the terrain to have been one of the key issues based on the simulations.

6. CONCLUSIONS

Studying war history and learning from history can go deeper, if simulation process is added into the historical studies. The NATO MSG-088 rapid scenario prototyping process (Horne & Seihcter, 2013) also works for historical studies and in the end we have an unclassified scenario and research questions. This case study showed Sandis to be capable of handling scenarios of this scale and research questions can be answered by using simulation.

According to Hurtley 1997, validation is defined as "*the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.*" Let us consider only the end of definition, intended use of model. The Sandis is used to do comparative analysis between decision options. Thus our conclusion is that Sandis performed remarkably well in estimating the losses and course of the Suovajärvi battle. As a qualitative overlook, all the attacks were repelled in reality and simulation. Most notably, the casualties suffered from indirect fire were as expected, and both the light infantry weapon direct fire as well as indirect artillery fire forced the Soviet offensive to halt similarly to the reports from the real battlefield. In this case study, the base case is more than accurate enough for research questions concerning fortification and defensive artillery. The terrain question could not be handled with the simulated base case alone.

The process of creating the scenario also showed us how important it is to have skilled users for the software as well as people who understand the military side of the situation at hand. In the ideal situation the user would have solid understanding of both Sandis and military tactics and combat, but unfortunately users like that cannot be found very easily. This means that in practice creating good scenarios requires a team with varied skill sets that complement each other. This is a useful thing to remember when considering who should be using combat simulation software in future studies.

7. FUTURE WORK

We learned that Sandis can quite easily be applied to studying historical battles as long as the types of weapons used are relatively modern and the historical events well documented.

In the future work, different historical battles could be simulated in order to gain a better understanding of our history and key issues of war, helping to solve future defense problems. For example, we might study the effectiveness of precision weapons by adding them into the scenario. We could test, for example, what number of red precision ammunition is needed to penetrate blue defense.

If we start using simulation software in our war historic studies, bit by bit these simulations create data for further validation of the simulation software or initiate improvements to the models.

The time needed for this type of historical simulation case study without testing the research questions and reporting already took 6 man weeks, although a part of the time was used studying the system by the international simulation team and learning the historical case. If we want to use more simulations in our military studies, faster and more effective working methods and more trained simulation operators are needed in order to decrease the time and costs.

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