New achievements in WWII military historical reconstruction with GIS

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Recently geoinformatics has become a well–known and widely applied discipline in different human sciences. There are several interesting examples of applying geographical information systems to manage the information of various time periods in military history and archaeology. Our research topic covers modern age military history, and so it is a very sensitive topic because of the recent dates. Therefore we always used objective data acquisition techniques and an applied engineering approach. The military historical GIS database, which was created in this way, can be handled as an objective and reliable basis for further research by scientists in object or even in event reconstructions. Firstly, we had to define a strategy, a methodology, which is suitable to achieve our aims — a uniform GIS database — considering the existing and currently accessible data sources. This methodology consists of three main parts: the reconstruction of the period's environment, the military objects and finally the military historical events. According to this methodology we reconstructed particular sectors of the two major World War II defense lines (Attila– and Margit–line) in Hungary. Beside the GIS based reconstructions of the environment, the military objects and the events, we investigated further analytical and representational functions, which can also support these kinds of applications. The methods enable various spatial and attribute queries and animation possibilities that are also useful and sometimes necessary. The typical examples of these functions are also discussed in the paper.
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Introduction

Recently, there are many nice examples of GIS and remote sensing applications in human scientific areas, e.g. in archaeology and cultural heritage. In our prior research we investigated the possibilities of applying these technical and engineering methods in the reconstruction of various periods' military historical events and the connected objects. As the result of the research we defined a methodology which integrates the different remote sensing technologies and the GIS solutions in one procedure. Hence the archaeological and other human data can be handled in a uniform system. This engineering type approach of the archaeological problems provides objective results, which can be considered authentic and enables us to confirm or deny previous archaeological or military historical examinations, theories. [1] In our previous research we have demonstrated, that the various remote sensing methods are

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perfectly feasible for data acquisition of military historical reconstructions and other archae-ological research. We have investigated the possibility of integrating cutting edge remotely sensed data into these databases, such as high resolution satellite images or LIDAR (Light Detection And Ranging) data. In addition we have also shown that an entire reconstruction process can be achieved in the unified system, provided by GIS. Hereinafter we present the short summary of this reconstruction process that has three major parts: the environmental, the object and the event reconstruction. [2]

GIS in military historical reconstruction

The environmental reconstruction

Representing the environment is reasonable and necessary in most cases. Environmental objects, as external factors, have a great influence on the location, size and other parameters of the military defense objects. In strategy, the topographic environment especially has a key role, thus the reconstruction has to be carried out for an appropriate result. In practice the digital base map of the selected area has to be created. This base map consists of the environmental objects of the researched period. The environmental reconstruction may support the basic orientation and helps when we have only relative information according to the environmental objects. (Figure 1)
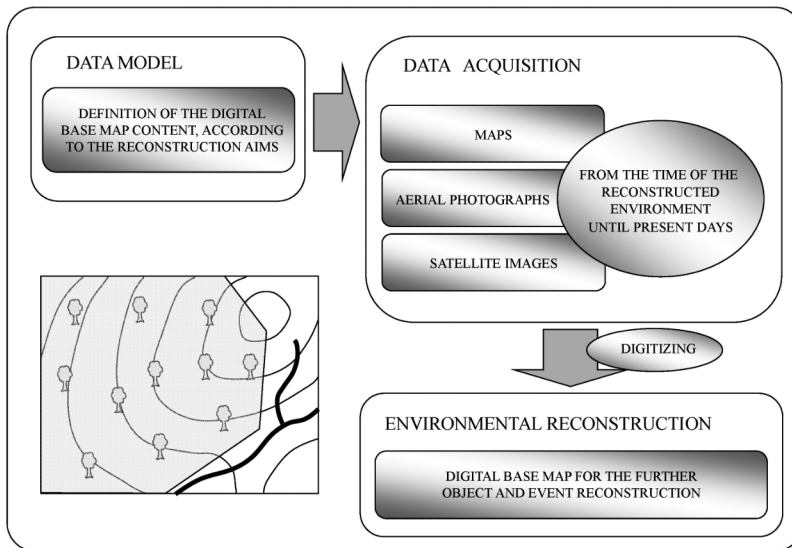

Figure 1. The environmental reconstruction process. [3]

Military object reconstruction

Environmental reconstruction is the basis of further reconstruction tasks; first of all, military object reconstruction. It is the most interesting and complex component of the whole process. The prior investigation and later the identification and integration into GIS of the various objects are achieved by diversified work. Contrary to the environmental objects, not only the geometry but the attributes of the objects are also important. The geometrical data are captured mostly from archive aerial photographs and field measurements. Before the field work it is recommended to investigate the other available data sources. It is easier to locate and identify the defense objects if it is known where and what are we looking for. There can be several data sources in this prior research; e.g. investigation of the available literature: history, military history, archaeology, warcraft, arms, geography, engineering and mapping. For example special fortification regulations (German, Hungarian and Soviet) were used in our World War II research. These regulations contain the precise and authentic geometrical and attribute data about the period's defense objects (e.g. anti–tank and infantry ditches). After this prior research the defense object identification and interpretation were carried out. The interpretation of the archive aerial photographs and the satellite images need professional expertise, especially when the ditches are already buried. In these cases we have to identify the ditches by various environmental signs, called indicator signs (in vegetation). Mostly the same data sources can be used for the attribute data acquisition as mentioned above. (Figure 2)
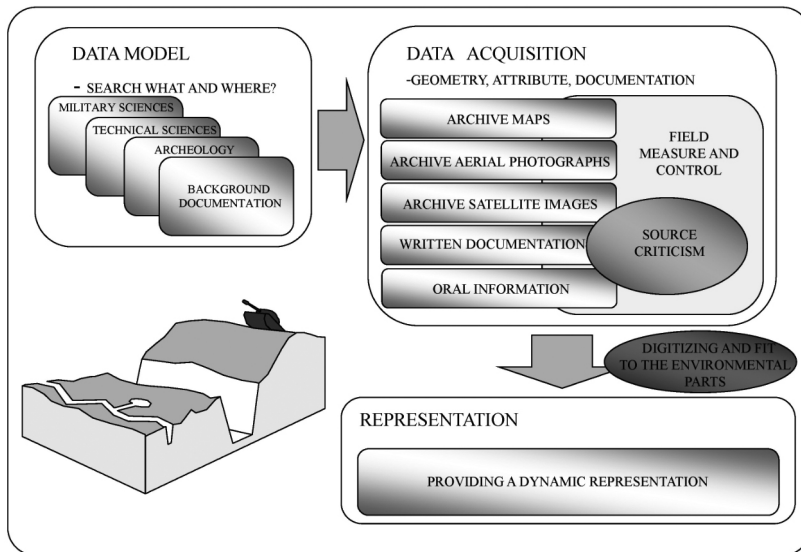

Figure 2. Military object reconstruction process. [3]

Military event reconstruction

After successful environmental and object mapping we can make an attempt to reconstruct the selected military (historical) event. There are two major factors that have a great influence on the quality of the event representation. Firstly, the time period when the particular military event happened; then the amount and the quality of the accessible data about the event. Obviously, these two factors are related to each other. As a general rule we can declare that the more we step back in time, the less we can find, considering the precise and reliable data. The three main data sources are the various maps, the written documentation, and if possible, the reminiscences. This component of the reconstruction process is the most critical one because the researcher likely has to face contradictions. The lack of accurate and reliable information makes source criticism mandatory. (Figure 3)
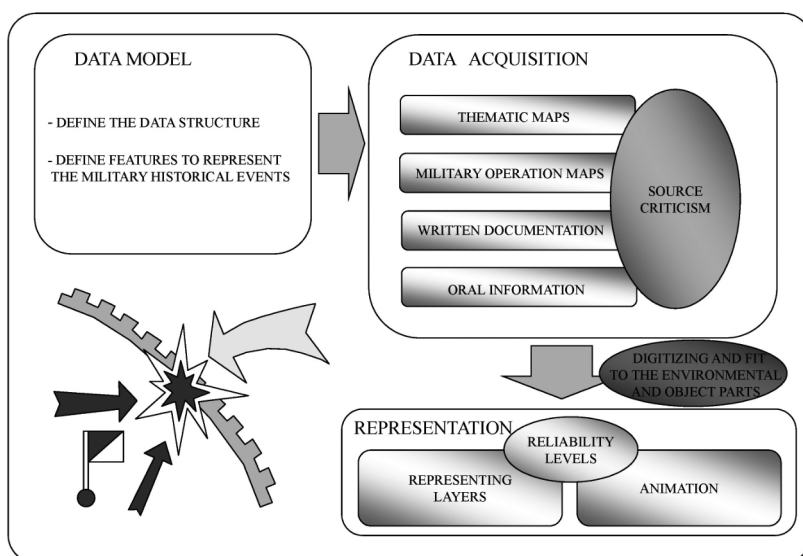

Figure 3. Military event reconstruction process. [3]

The reconstruction of the Attila– and Margit–lines

Introduction of the investigated period

The last months of World War II in Hungary were the specific selected period of our research. Our major objective was to create a GIS database representing the period's national defense system and the main military historical events. The defense system was located approximately diagonally across Hungary, starting from the eastern–north part, then going along the foreground of the Northern Mid–Mountains, Budapest, Lake Velence, and Lake Balaton and finished at the river Dráva. (Figure 4) Obviously this complex system was composed of different parts. The three major defense lines were the Karola–, Attila– and the Margit–lines. Also there were several auxiliary defense lines in the system, but the importance and impact

of these lines were irrelevant compared to the three major ones. The aim of this system was to stop the soviet attack started from the eastern–southern direction in the end of 1944; and it was partly successful.

The defense of Budapest was a major consideration in the system. Therefore in September 1944, the German commander Hans Freissner ordered the building of the Attila–line around Budapest. This horseshoe–shaped line contained three zones (Attila I, Attila II, Attila III lines) on the Pest side. The line was completed in November.

The Margaret–line was on the western part of the country (Transdanubia), it started from Budapest and ran along Lake Velence and Balaton and ended at the river Dráva. The soviet troops broke through the eastern part of the defense line when they encircled Budapest. We also investigated this part between the river Danube and Lake Velence. It is important to mention that the German and Hungarian forces tried to free Budapest several times ("Conrad" and "Spring awakening" operations) [4] and these battles also occurred in this area, thus the reconstruction and the identification of the military objects connected to the various operations, periods was very interesting. It was difficult to decide whether the German or the Soviet troops built some of the identified defense lines.
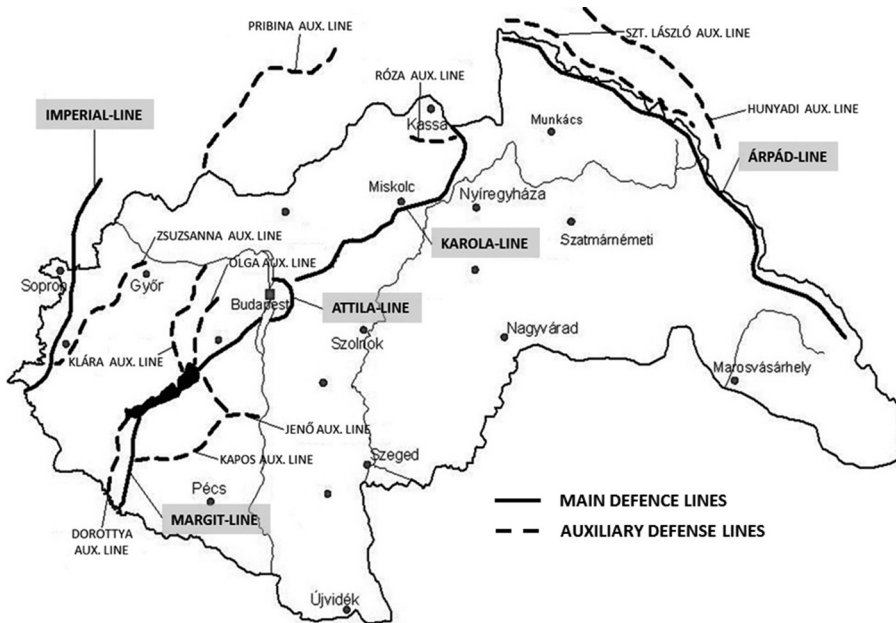

Figure 4. The defence lines of Hungary 1944–45. [3]

Data acquisition

Despite the relatively recent date of the investigated military events and objects, the precise maps and documents are missing. The original defense plans and maps were mostly destroyed during the war or taken away by the soviet troops and are hard to access. There are only short descriptions about the researched lines in the Hungarian military historical literature. These are the following:

"The *Attila–line* built from 22nd of September 1944. Its wings lean on the river Danube and connect to the Karola– and Margit–line. The Attila–line had three defense zones (Attila I. II. III.). The outer one followed the Dunaharaszti — Vecsés — Ecser — Maglód — Valkó — Gödöllő — Szada — Veresegyház — Csomád — Alsógöd line, the middle one followed the Soroksár — Soroksárpéteri — Pestszentimre — Pécel — Isaszeg — Kerepes — Mogyoród — Fót — Dunakeszi line, and the inner one was on the margin of the suburbs of Csepel — Pestszenterzsébet — Pestszentlőrinc — Rákoskeresztúr — Rákoscsaba — Cinkota — Rákosszentmihály — Rákospalota — Újpest. It did not run on the Buda side. The line was not completed because of lack of manpower, soldiers, time, tools and weapons."

"The eastern part of the *Margit–line*:

Major defense zone, 1st line: Danube — railway station Nagytétény — St. László barren — Baracska–south — Kápolnásnyék–south — Kisvelence–south — northern coast of Lake Velence.

Major defense zone, 2nd line: Kismarton–north — Martonvásár–south — railway station Baracska — Pázmánd–south." [5]

The written sources also declare that the Soviets were able to go along relatively easily without facing serious opposition in this part of the line. The serious fights occurred between the two lakes and the western part of the Margaret–line.

These short descriptions are suitable to identify the approximate position of the defense lines, but provide insufficient information to map the particular line system. Thus we used them as basic information for further data acquisition. There were various data sources applied during the investigation of the two selected areas. According to the area's extent, we chose M=1:50.000 and M=1:25.000 scale topographic maps as the basis of the environmental reconstruction. In addition we used archive aerial photographs (1950–53 from the first nationwide aerial photographic campaign in Hungary) [6] to locate and identify the defense objects. Most of these objects were anti–tank and infantry ditches and in some places artillery and flak placements. The mentioned objects were relatively well identifiable despite the low quality of the archive photographs. Indeed this photo interpretation was the most important part of the whole reconstruction task. Furthermore, if there was a chance to find and identify any significant part of the system, we looked up these spots. These field measurements have two major aims: firstly, to locate the position of new objects then secondly, to verify the previously interpreted objects. The next figure below consists of a montage of the typical data sources. (Figure 5)
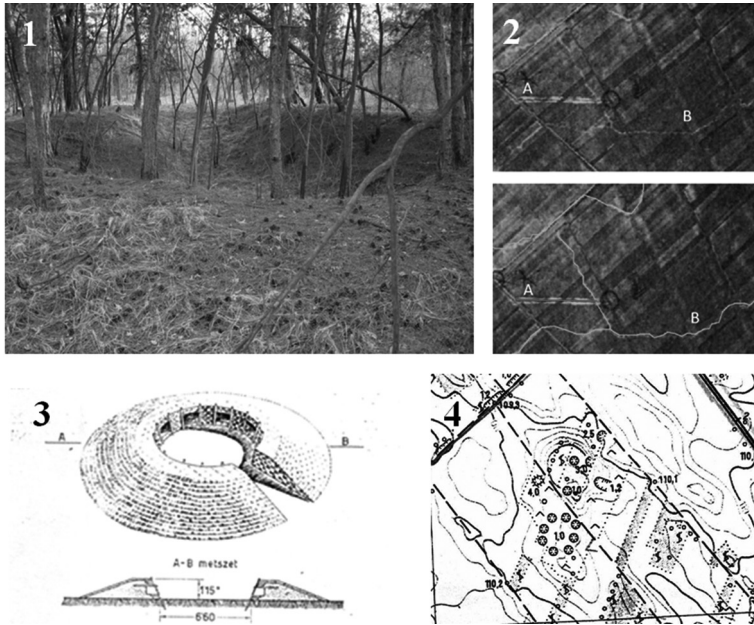
Figure 5. Data sources of the object reconstruction.

(1: Flak today, 2: Anti–tank (A) and infantry (B) ditches on archive photo,
3: Flak fortification regulation, 4: Flaks on topographic map) [7]

The results of the reconstruction

The reconstruction of the Attila–line and the eastern part of the Margit–line in the unified GIS database resulted in novel and confirmative information, too. Firstly, in connection with the Attila–line the reconstruction resulted in finding a similar structure in zone I and III (anti–tank ditches, complex, proportioned defense system), that can be found in the description in the previously mentioned documents. But there were only infantry ditches, infantry and artillery placements identified in zone II In addition, in contrast to old theories, this middle zone or line did not have a horseshoe shape. It was connected to zone I near Maglód settlement. (Figure 6)
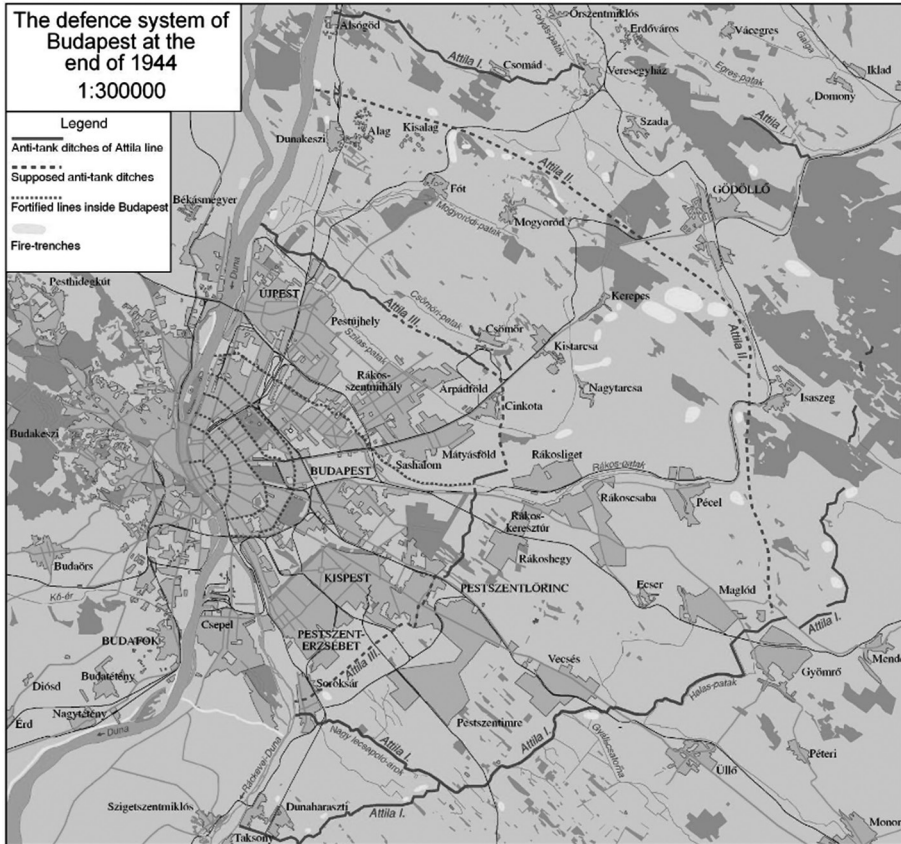
Figure 6. The reconstruction of the Attila–line. [8]

Secondly, it seems unambiguous that the Margaret–line has not got the same structure in the researched area as the other lines. Furthermore the position of the defense lines is in contradiction to earlier theories. (Figure 7 "A" and "B" line) We identified a complex system at the southern part of the investigated area. (Figure 7 "C" line) Probably, these objects are independent from the Margaret–line and built later during the "Conrad" operations' period; our concept is also confirmed by an expert military historian. It seems that the western part of the identified system is parallel with another smaller ditch–system located south from Lake Velence (Figure 7 "D" line) and the distance between them is appropriate for the deep pro-portioned defense. In conclusion, we can declare that this defense system was created by the Soviets either at the same time or first the western part then later the rest. Since the Soviets expected the German counter–attack they tried to get ready to deter it and close the direction to the capital.
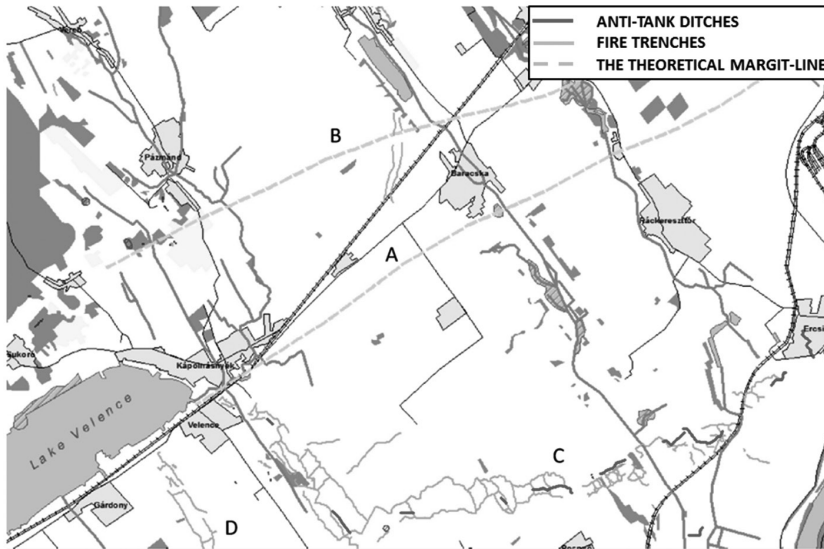
Figure 7. The reconstruction of the eastern part of the Margit–line. [9]

(A, B: the theoretical lines, C, D: the reconstructed lines)

Managing temporal data in military historical GIS databases

The possibilities of temporal data integration in GIS

As a step forward in processing archaeological data in geoinformation system, the next interesting challenge is temporal data management, considering that time has a very important role in these types of research. There are different ways to manage temporal data; first of all, the classical GIS solution, in which the temporal data is considered an attribute. However, there are special temporal databases, in which the geospatial changes in time defined as an entity or a feature (space–time composite, object oriented solutions). [10] In the latest versions of GIS software the temporal data handling is available (tracking analyst, animation); therefore we also investigated how we can use these possibilities in military historical reconstructions.

Representing the military events in GIS

On the one hand, the new possibilities of temporal data handling in GIS are useful and a significant leap forward, but on the other hand these advantages mostly improve only the data representation. In our opinion it is not necessary to apply completely new methods for symbolizing the various events and military objects. Moreover, it is recommended to use traditional military symbols. It means that we represent the front lines (line), the movements (usually arrow shaped polygons) and the fighting troops (the appropriate corps point symbol) the same way as it is represented on operational maps. The various animation possibilities have an important role in military historical reconstructions to represent dynamically the events and the connected objects after all. Hence in this chapter we discuss the three typical animated representation processes of GIS. The most important thing in connection with these

applications, that we have to work with, are time enabled data; namely the spatial objects must have an appropriate date or time attribute.

First of all, the simplest solution may be the 2D animation. In this case we use the general top–view with a topographic or a digital base map in the background for example, and only the event reconstruction's objects are animated. Naturally this type of representation is the most similar to traditional maps. However, it has a clear disadvantage: the possibility of the third dimension's visualization is not utilized. (Figure 8)
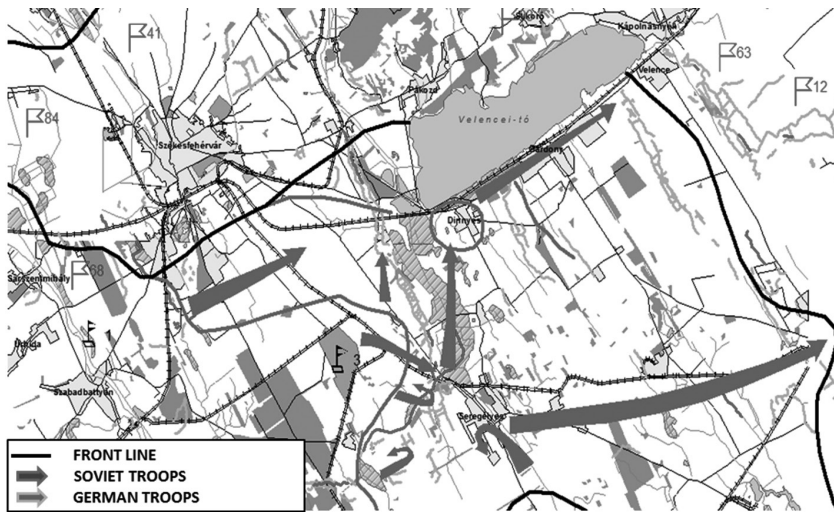

Figure 8. 2D military event reconstruction. [9]

As it is well known, the topographic surface has a very important role in strategy, so it seems obvious to create a digital terrain or a surface model and represent the military events in a 3D environment. This kind of visualization supports the research and the analysis or even the correction of the investigated events. The use of the traditional symbols can be adequate also in this case. (Figure 9)

Figure 9. 3D military event reconstruction. [9]

Fortunately, there is also a possibility of 3D object integration in the latest versions of the applied GIS software. However, it is not suitable for high quality battle simulations of computer games, but we can create very useful representations of a smaller action or battle with the application of 3D tanks, cannons, trees or buildings. (Figure 10)
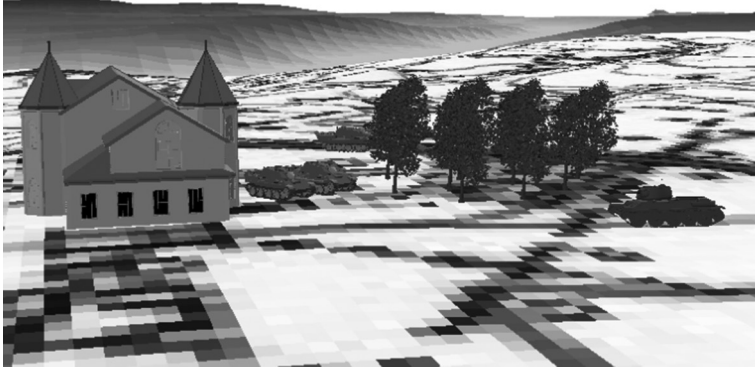

Figure 10. 3D military event reconstruction with 3D objects. [9]

Conclusions

Summarizing the experiences of the represented examples, we can declare the following:
- The geoinformatical methods can be effectively used in military historical process analysis and representation.
- These methods can support and complement the available operational maps and can be applied to confirm or deny previous archaeological or military historical examinations, theories.
- The results of the GIS reconstructions are authentic and convincing because of the objective data sources and the engineering type approach.
- The GIS have the potential to support archaeological and historical research.

Fortunately there is a rising claim in engineering type investigation in several human sciences that will have a beneficial effect on enhanced geospatial analysis.

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