SCIENTIFIC RESEARCH

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APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN COMPUTER ASSISTED EXERCISE (CAX)

Summary

This paper shows a model for applying geographic information systems (GIS) in the Computer Assisted Exercise through the ESRI Company's ArcReader program of the ArcGIS 10 application. The ArcReader program provides access to digital spatial data outside the GIS cabinet with licensed GIS software. The importance of using modern GIS applications within the decision making process is outlined and there is analysis of the plot of land as part of the intelligence preparation of the battlefield.

Key words: geoinformation systems, CAX, military geography, military analysis of the terrain

Introduction

The Computer Assisted Exercise has been held at the Croatian Defence Academy for 11 years now as the final exercise for most levels of military education. Based on the syllabus of Ban Josip Jelačić War College, Blago Zadro Command and Staff School, the Advanced Officer School, and the Higher NCO School, the goal of the exercise is to enable attendees to participate in the preparation and conduct of operations at the strategic, operational and tactical level. As the exercise includes NATO's guidelines for preparation and conduct of the Bi-Sc Exercise Directive 75-3, Allied Joint Doctrine AJP 01 (C) and the guidelines for operational planning of Allied Command Operations (GOP 2006), attendees are trained to conduct tasks at the national and international level. The exercise is related to the conduct of peace support operations, i.e., crisis response operations and, as for the form, it is a staff computer assisted exercise. Computer assisted exercises (CAX) within NATO simulation exercises belong to the group of constructive simulations with the elements of virtual and live simulations. Virtual simulations were conducted on the simulation model JCATS (*Joint Combat and Tactical Simulation*) for the needs of CAX in the Simulation Centre of the Croatian Army. The features of the JCATS model enable multi-service interoperability with the land, air force and naval functions, the conduct of activities up to the level of task forces and wide range war operations simulations (Jakob etc. 2006).

An imaginary exercise scenario is taking place in the territory of the following imaginary states: Sarawaka, Selengor and Mimaropa (Figure 1). The territory of the Mimaropa state consists of five federal provinces: Bidor, Gurun, Jitra, Kangar and Senai. Mimaropa's population is heterogeneous with a majority of Kasurians (about 65% of the population) and a numerous Midan minority (27%). The third ethnic group is composed

Figure 1. Theatre of operations - political chart

of Labuans (5%), whereas the rest of the population (lesser ethnic groups, mixed population, the population who did not declare national affiliation) makes up 3%. Sarawak wishes to unite all members of the Midan population into one state and is showing expansionist intentions toward Mimaropa, which is strengthening the control of its borders with Sarawak. At the same time, the Midan minority in the Bidor province organised their own military units and, with the direct support of aviation and armored units, Sarawak managed to master the entire area of the Bidor province except the Kasurian enclave alongside the wider city, Tilly. Mimaropa entered into an alliance with Selangor and, in July 2011, it attacked its former Bidor and Sarawak province. The frontline was formed at the border dividing Bidor and Gurun provinces as well as on state borders of the states in conflict. Despite several UN resolutions (resolution on the arms embargo, resolution on the establishment of UN observers in the area of conflict), the warring parties violated the agreements and the conflict continued. Under diplomatic pressure from the international community, and because of their own economic and military exhaustion, the conflicting parties accepted and signed the General Framework Agreement for Peace. By the UN resolution on threats to international peace and resolution on the preservation of peace, the North Atlantic Alliance is given the authority to conduct a NATO peacekeeping mission in the assigned area of responsibility. According to this scenario, it is a NATO led operation called *Peace Keeping* under a UN mandate, in accordance with Chapter VII of the United Nations Charter.

This paper presents the application of the military geoinformation system (GIS) during the conduct of the CAX. It is related to the education and training of the attendees of the Advanced Officer School and the Higher NCO School working with GIS systems. It includes the modeling of military databases, the areas on which the exercise is being conducted, and the military-geographic analysis (tank and maneuverability, the protective potential of land areas, areas suitable for heliports, etc.) and their cartographic visualisation. The military database and thematic maps thus obtained form the basis for the students Command and Staff College during their training and for applying the modern management system for spatial analysis within the decision-making process with the emphasis on the terrain. The established GIS system is the basis for operational monitoring of events during the exercise and decision-making at the strategic level of the War College attendees.

The applying of GIS at the Croatian Defence Academy

The development of GIS systems at the Croatian Defence Academy (CDA) is related to the acquisition of the first GIS ArcView software packages from the ESRI Company in the late nineties. These software packages enable installation of the Spatial Information System of the Croatian Armed Forces (SIS CAF) developed by the General Staff of the Croatian Armed Forces. In the first phase of its implementation, the basic and advanced GIS courses were organised for the needs of the Croatian Defence Academy teachers and the General Staff of Croatian Armed Forces employees who were using the digital spatial data of the Republic of Croatia. A further incentive in the application of GIS

in the system of military education was obtained with the donation of the GIS Data Company from Zagreb. It included six new ArcView licensed software packages with 3D Analyst modules, Spatial Analyst and Arc Press, enabling the formation of the GIS cabinet with twelve job posts. Modern GIS study was the basis for the launch of the first specialised educational curriculums within the new military schools. In the academic year, 2003-2004, the basics of GIS were introduced within advanced officer training and, after that, it was a subject at the Command and Staff School named GIS analysis. Today, the subject matter of GIS has been lectured in the Basic Officer Course within the subject Military Topography and GIS, at the Advanced Officer Course as GIS practicum, but also at the Advanced NCO Course as the basis of GIS and at the Senior NCO Course as part of the Military Geography.

The central training place for the field of GIS application in military analyses is the GIS lab, with fifteen workstations having the new ArcGIS 10 program package installed. The biggest problem regarding the wider application of the GIS, in the conduct of tactics and operatics curriculum and in conducting a wide spectrum of exercises, has been solved by applying the module of the ArcGIS program package – ArcReader. ArcReader is a free of charge ArcGIS Desktop browser that enables browsing, searching and chart printing. It facilitates the browsing of charts created by the ArcPublisher module. Digital charts need to be prepared and edited in the ArcGIS program and converted in PMF (*published map files*) databases by the ArcGIS Publisher module with which they are ready for distribution through the network or by any CD-ROM. The digital geographic data that is made in PMF form is downloaded in the ArcReader application so that a large number of users can have access, search and print the prepared spatial data at any location where this application has been installed. As its name says, the downloaded data can be read only i.e., can be browsed, searched or printed but any deletion, change or addition of new data is not possible. This fact does not diminish the functionality of the application itself because the prepared layers of the database contain all the data needed for a good quality military geographic analysis of the land whose presentation, i.e., visual overlapping and linking, is done by the user himself in order to reach the optimal spatial information. By simple compiling of the layers needed, the user alone matches the desired cartographic depiction within the application. The complex thematic layer of the number and the nationality of the Mimarope population according to villages is shown on Figure 2. Simple use of the ArcReader program enables a large number of users to accept the work in this program disregarding their previous information and geo-information knowledge.

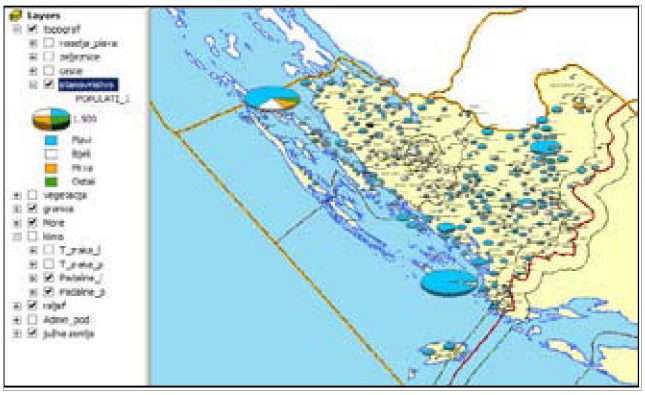

Figure 2. Geochart displays the number and nationalities of the Mimarope population across the villages (ArcReader program)

Applying GIS during the Exercise

To explain the application of the geoinformation system during the conduct of the CAX Exercise, spatial data layout has been presented; from basic data to output products in the form of analogue charts and spatial data bases downloaded into the ArcReader program. (Figure 3)

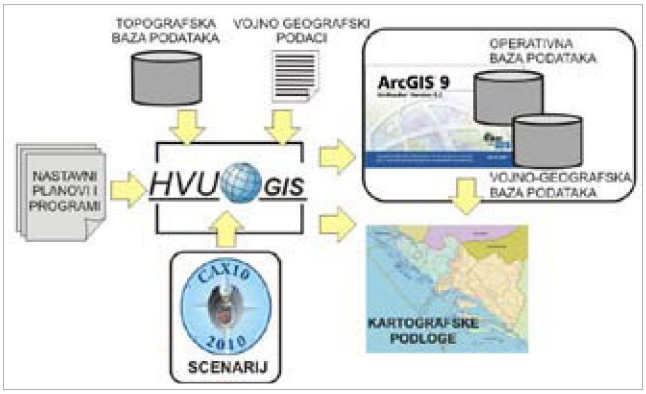

Figure 3. GIS application within CAX

The central place for data collecting and data processing is the GIS lab. As GIS is made of the triad composed of computer support, program support and professionals, the GIS lab is replaced by the term: CDA GIS (Figure 3). Based on the curriculum, the attendees of the Advanced Officer Course within the subject - GIS Practicum, and the attendees of the Senior NCO Course for Military Geography in the GIS

lab are taught practical knowledge on the use of GIS. Through these curricula, the attendees make spatial data from the CAF Spatial Information System and Military GIS and military geographic data. This includes the defining of spatial borders based on the Exercise Scenario (CAX), vectorisation of the layers needed from topographic and thematic charts (geological, pedological, climatological, etc.), downloading certain descriptive data i.e., attributes with current spatial data, compiling some layers in thematic unities and other actions dealing with collecting and storing spatial data (Pahernik 2006b).

Teachers check out all collected, processed and stored spatial layers extending and correcting them as required and make additional adaptations to a scenario. Thus, the basis for creating database output regarding the land on which the exercise is taking place has been created. This is a military geographic database that contains data needed for military geographic spatial analysis (Collins, 1998). (Table 1) Through the ArcPublisher module, the database mimaropa.pmf was created and it contains the mentioned data that cam be opened with the ArcReader program.

Table 1. Simplified conceptual model of Mimarope military geographical databases

Layer	Name	Attributes	Domain	Note
	VILLAGES	Name	Text	
		Municipality	Text	
		Number of inhabitants	Number	
	RAILWAY	Type	Single track, double track	
	ROADS	Type	Highway, state, regional, local	
	POPULATION	Village	Text	
		Municipality	Text	
		Region	Text	
		Number of population	Number	
		Kasurians	Number	
		Midans	Number	
		Labuans	Number	
		Other	Number	
	VEGETATION	Code	Number	
		Type	Deciduous trees, coniferous trees, mixed forests, bushy vegetation, chaparral	
	BORDERS	Type	State, district, regional, security zone border, safety zone border, demarcation line	
		Kind	Land, sea border	
	RIVERS AND STREAMS	Name	Text	
		Code	Number	
		Type	Occasional stream, brook, river, canal	Small rivers are shown
	WATER AREAS	Name	Text	
		Code	Number	
		Kind	Sea, lake, river	Bigger rivers are shown
	AIR TEMPERATURE (L)	Temperature	Number	Isotherm value
	AIR TEMPERATURE (P)	Temperature	Text	Isotherm value range
	PRECIPITATION (L)	Temperature	Number	Isohyetal value
	PRECIPITATION (P)	Temperature	Text	Isohyetal value range
	RELIEF	Class	Number	Hypsometric classes of 200 m
	SLOPE	Class	Number	0-10°, 10-20°, 20-30°, 30-50°

Layer	Name	Attributes	Domain	Note
	SHADOWS	Value	Number	
	ADMINISTRATIVE DATA	State	Text	
		District	Text	
		Region	Text	
		Municipality	Text	
		Enclave	Text	

By agreement between the scenario team and MEL/ MIL (*Main Events List/ Main Incidents List*), the second database for the needs of the exercise was made, the operational database (o_baza.pmf). This database contains administrative borders and villages with attribution-value of the population number and nationality structure, the layers containing data on village facilities and organisational layers located in a village (Table 2). As can be seen from this table, all village facilities have the attribute – "condition" containing the domain: "whole", "damaged", "demolished" and the "unknown". As a response to a certain event, the condition of the facility itself should be taken into consideration, as well as potential accommodation facilities (hotels and hospitals have the number of beds as an attribute) etc.

Tablica 2. Simplified conceptual model of operational Mimarope database

Layer	Name	Attributes	Domain	Note
	GENERAL HOSPITAL	Name of the village	Text	
		Region	Text	
		Condition	Text	
		Number of beds	Number	
	HEALTH CENTER	Name of the village	Text	
		Region	Text	
		Condition	Text	
	INFIRMARY	Name of the village	Text	
		Region	Text	
		Condition	Text	
	PHARMACY	Name of the village	Text	
		Region	Text	
		Condition	Text	
	VETERINARY CLINIC	Name of the village	Text	
		Region	Text	
		Condition	Text	
	ELEMENTARY SCHOOL	Name of the village	Text	
		Region	Text	
		Condition	Text	
	SECONDARY SCHOOL	Name of the village	Text	
		Region	Text	
		Condition	Text	
	NURSERY SCHOOL	Name of the village	Text	
		Region	Text	
		Condition	Text	
	HOTEL	Name of the village	Text	
		Region	Text	
		Condition	Text	
		Number of beds	Number	
	POLICE DEPARTMENT	Name of the village	Text	
		Region	Text	
		Condition	Text	

Layer	Name	Attributes	Domain	Note
	FIRE FIGHTERS	Name of the village	Text	
		Region	Text	
		Condition	Text	
		Fire truck	Number	
		Cistern	Number	
		Technical vehicles	Number	
	UTILITIES	Name of the village	Text	
		Region	Text	
		Condition	Text	
		Water supply	Yes/No	
		Garbage disposal	Yes/No	
		Funeral services	Yes/No	
		Road maintenance	Yes/No	
	PETROL STATION	Name of the village	Text	
		Region	Text	
		Condition	Text	
	RELIGIOUS FACILITY PATEISM	Name of the village	Text	
		Region	Text	
		Condition	Text	
	RELIGIOUS FACILITY KATEISM	Name of the village	Text	
		Region	Text	
		Condition	Text	
	RELIGIOUS FACILITY ITEISM	Name of the village	Text	
		Region	Text	
		Condition	Text	
	RED CROSS	Name of the village	Text	
		Type of service	Central office, regional office, central storage, regional storage, field office	
	NATIONAL PROTECTION AND *RESCUE*	Name of the village	Text	
		Type of service	Central office, regional office	
	ICRC	Name of the village	Text	
		Type of service	Central office, regional office	
	REFUGEE CAMPS	Name of the village	Text	
	OESS	Name of the village	Text	
		Type of service	Central office	
	UNHCR	Name of the village	Text	
		Type of service	Central office, regional office, central storage, regional storage, field office	
	UNMISEE	Name of the village	Text	
		Type of service	Regional command	
	CIMIC	Name of the village	Text	
	VILLAGES	Name	Text	In the VILLAGES layer all supporting facilities and organizations are shown
		Region	Text	
		Number of population	Number	
	ROADS	Type	Highway, state, regional, local	
	BORDERS	Type	State, district, regional, security zone border, safety zone border, demarcation line	
	WATER AREAS	Name	Text	
		Code	Number	
		Kind	Sea, lake, river	Bigger rivers are shown

Basic functionality of the ArcReader application enables various layers to be displayed and overlapped for making certain spatial decisions. There are other advantages of using the ArcReader program; first of all it enables the spatial identification of the object out of the databases. Identification includes the selection of the tools needed. By a mouse click on the searched object a dialogue frame will be opened and information from the database for that object will be shown.

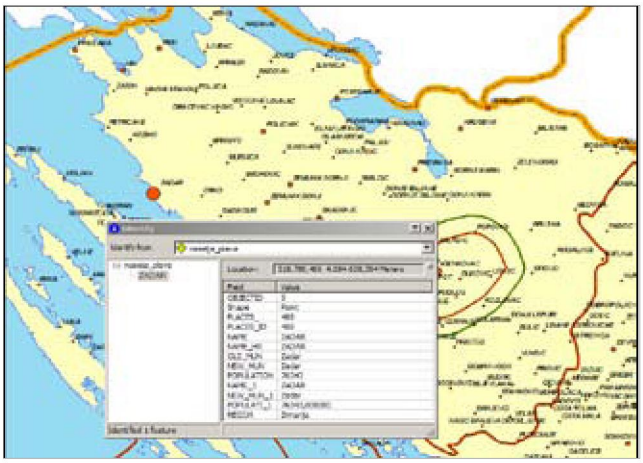

Figure 4. Identification of attributes of Zadar objects in the Village layers

On the other hand, it is possible to easily find a certain location of the searched spatial object. When we write down the searched object and select the spatial layer in which it is located, the dialogue framework of the cartographic display will show us the answer (Figure 5).

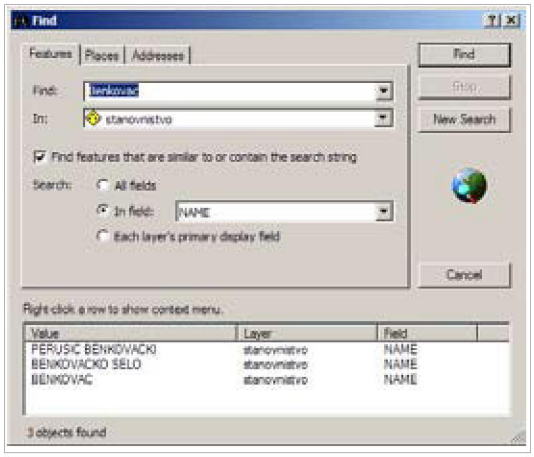

Figure 5. Dialogue framework Find with the search results for spatial objects that contain Benkovac toponym in the Population layer

The tools for the searching of locations are of considerable help for fast and good decision making at the cartographic display, as well as for distance measuring. With the command: Go To XY, it is possible quickly define the location of a specific event on the cartographic display (Figure 6).

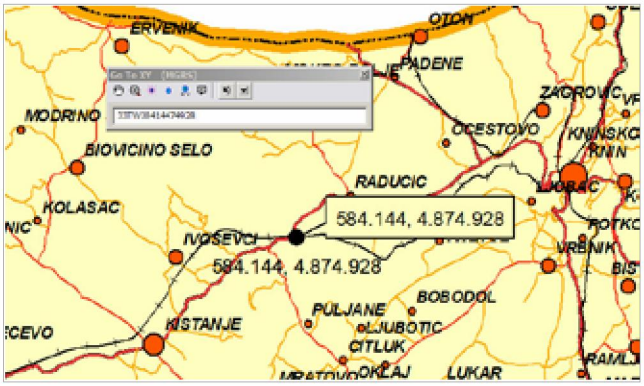

Figure 6. Prikaz tražene pozicije na kartografskom prikazu Operativne baze podataka

All spatial data used in the Military Geographic and Operational Database is geocoded onto a geographic coordinate system of the 33 zones of the UTM projection. When necessary, the user can show the spatial data coordinates by means of geographic coordinates, the coordinates of the 33 zone of the UTM projection or within MGRS (*Military Grid Referencing system*) (Figure 7).

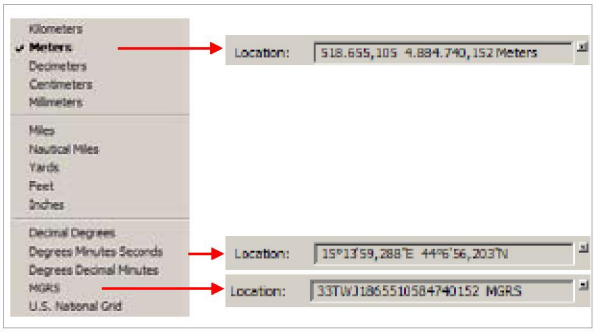

Figure 7. The selection of the display for coordinates of spatial objects

Conclusion

GIS enables simple integration of spatial and other data that is important for the conduct of military operations. The GIS analyst and the commander are able to make a decision based on a large amount of data that is spatially analysed among them. It is

also important that all spatial data has been timely delivered and updated, which enables everybody to have useful, correct and precise, timely delivered information.

The planning, development and implementation of GIS that will provide support to all kinds of military personnel dealing with planning and conducting a complex exercise requires a longer time and more resources. Since the GIS technology is modular and available, it is possible to start with fewer resources and, in due time, build a bigger and more comprehensive system. Such planning for the use of GIS in CAX 10 includes the following: (Pahernik 2006a):

- the development of a GIS detailed plan that clearly defines goals, tasks and responsibilities regarding GIS;
- guidelines for database planning and comprehensive database planning, its creation, procedure and updating policy and criteria for system acceptance testing;
- the making of the configuration management plan in the early phases of the development process, so that GIS will be logically and consistently developed;
- the planning of resources for the required training and maintenance tasks.

The ArcReader program and ArcGIS program package of the ESRI Company enable a wide range of CAX users to apply modern military geospatial terrain analysis. The application is achieved by creating a military geographic database that is used, for example, when reaching a decision i.e., during intelligence preparation of the battlefield and during the exercise itself, while using the operational Database. The use of this database with the ArcReader application enables the attendee to have a wide range of commands with which he can overlap, search, select and mark spatial objects that are important for the conduct of the task, according to his assessment. The final cartographic product of the attendee may be stored in digital form and it can be used in the final analysis of the exercise. It is important to emphasise that the GIS system shown is not a part of the simulation packages, but it is a powerful tool for military geographic spatial analysis and for monitoring certain events on the terrain, that is, in this example, in the simulation model for making a quick and correct decision.

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STANAG 2251 Scope and Presentation of Military Geographic Information and Documentation