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Olena POMORTSEVA, PhD (Engin.), Assoc. Prof.
ORCID ID: 0000-0002-4746-0464
e-mail: elenapomor7@gmail.com
O. M. Beketov National University of Urban Economy in Kharkiv, Ukraine

Sergiy KOBZAN, PhD (Engin.), Assoc. Prof.
ORCID ID: 0000-0002-5257-8117
e-mail: s.kobzan@gmail.com
O. M. Beketov National University of Urban Economy in Kharkiv, Ukraine

Inna GAMAYUN, Student
ORCID ID: 0000-0002-8730-1580
e-mail: Innavl2002@gmail.com
O. M. Beketov National University of Urban Economy in Kharkiv, Ukraine

DESIGN OF MILITARY GEOINFORMATION SYSTEMS. PROBLEMS AND THEIR SOLUTIONS

The article deals with the actual task of designing military geoinformation systems. Such GIS can significantly simplify the solution of an operational and tactical task for the Armed Forces of Ukraine. The analysis of similar geoinformation systems used by the armed forces of other countries shows that in the modern conditions of conducting military operations, it is impossible to do without digital technologies and geoinformation systems. The practical experience of solving such problems, in which topographical and geodetic data are used, is difficult due to the large volume of data and the complexity of their processing. Most of the calculations performed while preparing for the execution of a combat task are solved with the help of military information systems at the stage of setting and clarifying a task. The purpose of the article is to solve topographic and geodetic problems with the helping of geoinformation systems in a shorter time. The use of specialized military assignment systems makes it possible to significantly reduce the time needed to assess the situation and develop action plans for troops. The authors conducted studies of various types of complex information-processing algorithms. To solve the task of designing a geoinformation system for military use, it was suggested to use the existing geoinformation system. Such a GIS must be improved for use in the Armed Forces. It is possible to perform the task by introducing a programming language for solving specific problems and cutting off unused modules. It is an important that throughout the entire life cycle it will be necessary to maintain the level of secrecy until the last stage of the project. Results. The authors developed an algorithm for designing a geoinformation system for military using.

K e y w o r d s *: geoinformation systems, automated military system, geospatial information, electronic map.*

The development of the modern army, as well as the development of modern society, is based on the introduction and development of information technologies. The most important component of most technologies is the means of processing digital information about the terrain in conjunction with various data about the enemy and troop deployment. For tactical purposes, it is extremely important to use geographic information systems for command and control of troops and weapons, support for decision-making by the command, planning of military operations and combat logistics.

At present, as practice shows, geographic information systems (GIS) in Ukraine are not widely used for military purposes. This is due to both objective and subjective reasons. This is partly due to the ideology of the existing GIS:

- initial orientation of GIS to other, non-military areas of use;
- the need for extremely fast data updates – this is due to a change in the operational situation and should be displayed on electronic maps.

The next group of reasons is related to the existing approach to the conduct of hostilities. The management of military units using topographic maps is based on information about the terrain according to the following scheme: preparing an application for the area of interest, processing this application in the warehouse of topographic maps, creating an appropriate set of tablets, delivery, gluing, applying service inscriptions and tactical conditions and a report decision maker.

Such an algorithm for bringing topographic and geodetic information to headquarters and troops cannot be implemented in any automated control system, although it is these systems that can significantly increase the efficiency and, consequently, the effectiveness of troop control.

Since the 90s of the XX century, quite diverse experience has been accumulated in the creation and use of GIS as part of automated military systems (AS MIL). During this time, various approaches to the construction of military GIS have been developed and tested in practice, primarily as a means of displaying the operational situation on electronic maps.

For 15 years, the US Army Topographic and Engineering Center has been developing a military geographic information system called the Combat Terrain Information System (CTIS). Its core is the Digital Topographic Decision Support System (DTSS), which combines the functions of GIS and remote sensing data processing systems (*Lisenko, Pugachov, 2016; Zakiev, Kozhakhmetov, 2021*).

Since ESRI is a leader and leading manufacturer of GIS, the development of ESRI's software products clearly shows the evolution in the approach to creating GIS. If earlier it was a small set of logically complete software products, now more and more attention is paid to the development of tools that can be thought of as a large set of small bricks from which you can build a complex system, but at the same time, relying on a solid foundation (for example, ArcInfo) in the form of standards, exchange formats, classifiers. To implement these tasks, a GIS is needed, which allows you to create and maintain digital models of the operational environment (DSM) for each specific combat operation (*Jardim, dosSantos, Neto, Muradas, Santiago&Moreira, 2021*).

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Military GIS should have the following capabilities: expanding the functionality of the basic software product, an intuitive interface, the availability of a complete set of documentation, the ability to develop and issue aeronautical documentation. Based on these characteristics, the center of air navigation support for aviation of the Armed Forces of Ukraine (AFU) selected the following GIS – "Map 2005" and a tool for developing GIS modules based on Delphi – GISToolkitFree (*"KB Panorama", 2022*).

GIS data provide simultaneous work with several types of maps, images, matrixes of heights for many users using a computer local distributed grid. The volume of cartographic data can represent tens of terabytes and provide coverage of any part of the earth's surface. he GIS "Map-2005" and its newer version "Map-2008" allow displaying the operational situation, keeping duty maps, generating standard electronic and graphic documents (command decisions, flight missions), conducting command and staff training and exercises, analysing the location and predict the enemy's next move (*Lytvynenko, Fedchenko, 2020; Tolok, Pampukha, Savkov, Zatserkovnyi, Lykianchuk, &Shatkovska, 2019; Bokhanov, 2015*).

In other countries, the military quite successfully use such GIS as "Operator", developed by the design bureau "Panorama". It is a specialized addition that, as part of the global management system, provides processing of data from various sources. "Operator" was adopted by the Armed Forces of Belarus.

The Swedish Armed Forces use GeoPres GIS. It is intended for creating tactical situational maps, planning combat operations, analysing targets, monitoring the situation, and solving various operational and tactical tasks (*Studiawan, Grispos. &Choo, 2023*).

Since 2014, the APU has been actively using the innovative GIS control system "Arta", which was developed due to the cooperation of Ukrainian programmers with British companies in the field of digital cartography. As a result of this cooperation, special software was developed for the Armed Forces of Ukraine, which not only reduces the time for firing a shot, but also increases the accuracy of the hit.

The essence of the innovation is that the commander has access to an encrypted GIS map. This map displays operational data from the battlefield. With the help of all available reconnaissance means, the coordinates of enemy objects are plotted on the map. Headquarters officers choose which means of destruction to strike (mortar, artillery, UAV). That is short, medium, or long range. This means that strikes can be launched from any direction and by any possible means of destruction. The target is fired upon in a second (with the help of other control systems it takes about 20 minutes)

If earlier, when identifying an object, artillerymen spent an average of 20 minutes to destroy it, now it takes no more than 30 seconds.

Like Uber's taxi technology, which locates a passenger and picks up the nearest available driver, this system, after identifying a target, picks up the optimal artillery, mortar, missile crews or combat drones that are within range. At the same time, GIS "Arta" has shown itself well as a basic system of situational centers and command and control centers, a tool for planning, monitoring, processing, and disseminating the results of reconnaissance operations. In the first versions of this GIS, it was only possible to determine the coordinates and enter data. All work on the project took place by working out the errors, which were immediately reported by the fighters from the front line. During the time when the GIS "Arta" was given for testing to the first military, the program went through eight versions. Now it is almost a multi-profile command and control system, which is still more focused on the work of artillery. It can process data from drones, smartphones, rangefinders, and the like. The system is being developed and modernized based on close work and constant consultation with direct users on the front lines.

The purpose of the article is to solve topographic and geodetic problems using geographic information systems in a shorter time.

Most of the calculations performed during the preparation of hostilities with the help of military information systems must be performed even at the stage of setting and understanding the task. The use of specialized military systems makes it possible to significantly reduce the time for a commander to decide, which is necessary for assessing the situation and developing action plans for military units.

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Results

For the widespread introduction of modern GIS in the Armed Forces, it is necessary to solve a whole range of scientific, technical, and organizational tasks. it first, the transformation of existing funds of cartographic, topographic-geodesic and aerospace information into a digital form, the formation of electronic maps and the creation of effective means for their use.

A certain difficulty in the development of information technologies is the problem of formalizing output data for the creation and application of space-time models of combat operations, including considering physical and geographical conditions.

The main task of the military GIS (AS MIL) is to provide authorities at all levels with reliable access to spatial data with a visual form of their presentation. That is, a certain level of secrecy is implied, even under the condition of multi-user and remote use. A geographic information system, which is created and operates in the interests of the military, must include software and information components. The software component includes service and calculation programs for entering spatial data and data that describe the properties of these objects, their processing and output of results (*Pomortseva, Kobzan, Voronkov & Yevdokimov, 2021*). The information component should contain digital, electronic maps, three-dimensional terrain models and the corresponding database. Also, the AS MIL must be efficient, because it is for the solution of military tasks that time is an extremely important condition, because the data changes every hour. This information should include reconnaissance data obtained through means of space, air, ground and undercover intelligence, meteorological information received by means of geophysical support, specialized information about the background-target situation for high-precision weapons. At the same time, to solve specialized tasks of command and control, information must be under

control, a certain level of secrecy must be observed. Accordingly, this should be provided for in the AS MIL.

The speed of obtaining information is extremely important during the conduct of hostilities. It can only be guaranteed by a modern automated system with the ability to document the information provided and the ability to create vector, raster and matrix maps and quickly update information (*Pomortseva, Kobzan, Nesterenko & Sorokin, 2022*).

One likely technology to be adopted would be a set of rules for determining coordinates based on what3words. The essence of this technology lies in the fact that the area is divided into squares and each of them is marked with three nor related words. The advantage of this technology lies in the fact that in this way it is possible to break down any terrain in such detail that each house, street, landmark will have a simple coordinate, without additional information, which minimizes the possibility of error. It also contributes to maintaining a certain level of secrecy in encryption due to the random selection of words.

In our opinion, a military geoinformation system should provide solutions to the main tasks that involve the accumulation, storage, processing of data, calculation results and forecasts that have a geospatial reference. Also, AS MIL should be simultaneously a decision support system using geospatial data and allow them to be visualized. An important aspect is the process of creating GIS add-ons for solving information and calculation tasks, starting from analysis and assessment of the terrain, and ending with modelling the actions of troops at different levels. During its operation, the AS MIL should provide the following standard functions:

- assessment of the terrain and conditions of warfare using geospatial data;
- maintaining the operational-tactical situation;
- planning the movement of equipment and personnel, taking into account the specific situation, the state of the terrain, stealth, time of day, season, characteristics of specific military equipment;
- flight planning for aviation and unmanned aerial vehicles with a variety of tasks;
- determining the most probable enemy movement routes and planning the deployment of countermeasures;
- solution of information and calculation problems (visibility zones, possibility conditions, flooding and camouflage zones);
- formation of graphic documents and their printing.

In addition to the presence of the above functions, the AS MIL must have a sufficiently powerful built-in programming language that would allow solving non-standard user requests. In our opinion, C++ can become an ideal option as a programming language that can provide the following features: work with data arrays; links with other programs; management of various functions; creating dialog boxes; operations with character strings and tables; working with directories and files; introduction / withdrawal geographic operations (creation of buffer zones, crossing, merging areas); creation of vector objects (polyline, polygon).

Also, AS MIL should be a complex specialized automated system, which consists of four main structural components: a technical (hardware) complex; software complex; information block; operating personnel.

Software package is a set of integrated software modules that provide the basic functions of a GIS in compliance with a certain user interface standard. The principles of the structure of the software package, the list of operations in groups and the groups themselves, just like the interface standard, can change significantly, depending on the list of tasks that are solved by the system, on the requirements for its functionality, as well as on financial capabilities.

The information block of AS MIL contains spatial information in the form of appropriately encoded layers of homogeneous cartographic data (their quantity and content are determined by the specifics of the task being solved), as well as spatially linked attributive information for a certain territory. The volumes of digital cartographic data, as well as the volumes of attributive information, are limited only by the capacity of the permanent storage device of the computer and can be very significant.

The organizational structure of the AS MIL of Ukraine is created by a system of banks and databases of digital cartographic data about the area; databases of digital aerial and space images; specialized databases of digital data of the current situation; databases of thematic information; databases of statistical information; bases of archival combat graphic documents and repositories of combat graphic documents (in the form of paper copies and on flexible magnetic media) (*Kobzan, S., Pomortseva, O., 2023*). The functional structure of the AS MIL is determined by the list of the main functions that this system implements. The common main functions that are implemented by a geographic information system are the introduction and updating of data; data storage and retrieval; data analysis; derivation and presentation of data and results

Proceeding from this, the GIS of the Armed Forces of Ukraine functionally consists of four subsystems: collection, introduction and updating of data; data storage and retrieval; data analysis; derivation and presentation of data and results.

Military professionals who study logistics can also greatly benefit from this GIS. Logistics tasks associated with very complex problems of placing personnel, equipment, various services, material objects in the right place and at the right time. To meet these challenges, GIS is a key technology. Using the logic module, you can manage the fleet of military equipment, optimize the schedule and routes. Having up-to-date information about the location of the enemy on the selected route, it is possible to plot the route of movement of your military equipment. Then the program will automatically select the route of movement, considering the criterion of the minimum cost and calculate the time of movement.

In this way, a military GIS should have the following characteristics – efficiency, efficiency, secrecy, efficiency, and a simple interface where it is possible to use all existing and necessary tools, existing technologies, tool software, combine the best analogues. The authors propose to use a set of software modules from ESRI and ERDAS to solve the problem posed in the article. However, there is a problem that lies in the efficiency of their use, in other words, the tool must meet the task that is being solved.

The authors have developed the composition of the necessary military GIS modules, which is presented in the form of an algorithm in figure 1.

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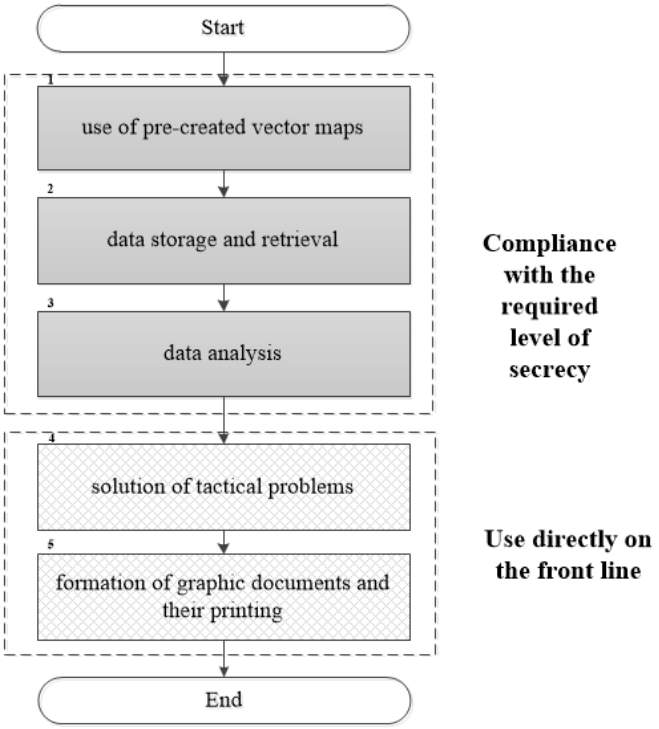

Fig. 1. Algorithm for designing military GIS

Thus, the authors have developed an algorithm for designing a military geoinformation system. The proposed algorithm can be used in the design of various military information systems, which will greatly facilitate and simplify the process of information processing.

Discussion and conclusions

At present, the role of geoinformation technologies during warfare is important. The use of geoinformation systems and technologies in military affairs provides a set of qualitatively new methods, especially in terms of spatial planning and processing of battle results. This is due to work with spatially distributed statistical data, a wide range of methods for analysing and modelling information, as well as convenient tools for visualizing the results obtained.

In addition, it should be noted that GIS cannot be perceived only as a tool – it is a cooperation of elements that must be considered together. It is both hardware and software, human, resource, and organizational tasks. For the successful implementation of the system, all these components must be considered at all stages without exception: development, implementation, staff training, operation, and further development. It is this clear and serious approach to the development of military GIS that can be the key to success. It is the active use of military GIS that will significantly reduce costs and move to the stage of highly effective command and control.

The result of the research is the algorithm for designing military GIS proposed by the authors and a visual display on a single basis of all types of information used.

The use of such a geographic information system for military purposes will allow the commander to better assess the situation and quickly make the right decision.

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Олена ПОМОРЦЕВА, канд. техн. наук, доц.
ORCID ID: 0000-0002-4746-0464
e-mail: elenapomor7@gmail.com
Харківський національний університет міського господарства імені О. М. Бекетова, Україна

Сергій КОБЗАН, канд. техн. наук, доц.
ORCID ID: 0000-0002-5257-8117
e-mail: s.kobzan@gmail.com
Харківський національний університет міського господарства імені О. М. Бекетова, Україна

Інна ГАМАЮН, студ.
ORCID ID: 0000-0002-8730-1580
e-mail: Innavl2002@gmail.com
Харківський національний університет міського господарства імені О. М. Бекетова, Україна

ПРОЄКТУВАННЯ ГЕОІНФОРМАЦІЙНИХ СИСТЕМ ВІЙСЬКОВОГО ПРИЗНАЧЕННЯ. ПРОБЛЕМИ ТА ШЛЯХИ ЇХНЬОГО РОЗВ'ЯЗАННЯ

Розглянуто актуальну проблему проєктування геоінформаційних систем військового призначення. Такі геоінформаційні системи змогли б значно полегшити стратегічні й тактичні завдання Збройним силам України. Аналіз подібних геоінформаційних систем, що використовуються збройними силами інших країн, показує, що в сучасних реаліях ведення бойових дій неможливо обійтися без цифрових технологій і геоінформаційних зокрема. Завдання, пов'язані з використанням топографо-геодезичних даних, доволі трудомісткі, а застосовування геоінформаційних систем дозволяє їх вирішити в сотні разів швидше, ніж при використанні традиційних методів. Тому більшість розрахунків, що виконуються під час підготовки бойових дій за допомогою інформаційних систем військового призначення, цілком реально виконувати ще на етапі постановки та з'ясування завдання. Також спеціалізовані системи військового призначення дозволяють значно скоротити час, необхідний для оцінювання обстановки й розробки планів дій військ за рахунок комплексної обробки інформації та наочного відображення на єдиній підоснові всіх видів інформації, що використовується. Для вирішення задачі проєктування геоінформаційної системи військового призначення було запропоновано застосовувати вже існуючу систему, що зарекомендувала себе, але з можливістю її розширення за рахунок упровадження мови програмування для вирішення специфічних завдань і відсікання не модулів, що не використовуються. Протягом усього життєвого циклу проєкту необхідно буде дотримуватись відповідного рівня секретності, аж до останньої стадії – випуску графічної документації. Було розроблено алгоритм проєктування такої спеціалізованої геоінформаційної системи. Запропонований алгоритм можна використовувати при проєктуванні систем військового призначення, що значно полегшить і спростить їхню розробку. А застосування геоінформаційних систем військового призначення дозволить більш якісно оцінювати обстановку, розробляти відповідну тактику та приймати всебічно обґрунтовані рішення.

Ключові слова*: геоінформаційні системи, автоматизована система військового призначення, геопросторова інформація, електронна карта.*

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