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THE COMPLEX USE OF THE SATELLITE AND GIS-TECHNOLOGIES IN SUBMARINE NAVIGATION

ABSTRACT Some specific method and software of using the satellite and GIS technologies is presented in the paper.

INTRODUCTION

For solving the problems of accumulation, keeping, analysis and representation of heterogeneous information users have paid more attention lately to the opportunities of geoinformatics. It represent the scientific study of the principles, the technique and the technology of obtaining, accumulation, transmission, processing and presentation of data, as well as the means of obtaining on their basis new information and knowledge about spatio-temporal phenomena.

The main technology means of geoinformatics represent geographical information system, which imply the aggregate of computer equipment, software, geographical data and the user's arbitrary planning of the course of work for accumulation, keeping, modification, processing, analysis and visualization of all Bort of information referring to geographical information.

The digital map is the basis of each GIS and it allows creating maps on various scales and in projections with diverse coloration. The opportunity of the system (which is an analytical instrument) to determine the spatial connection between the objects of the map is its principal advantage. GIS keeps the data with, which help its possible to create any necessary map that will meet the demands of the consumer.

Thus, the main purpose of GIS is efficient presentation to the user of the reliable and processed spatially distributed information, which is required while solving administrative and analytical problems.

SOME OPTION OF USING GIS TECHNOLOGY IN NAVIGATION

One of the main problems in using the GIS-technology is accumulation and keeping of the raw data. Data survey is a labour intensive process. Traditional nautical navigational maps (NNM) represent the most available source of information for creating digital maps. However, it occurs expedient to use remote means for lack of MNM or in case of the necessity to get efficient information of the larger spatial scope. A special part here is assigned for satellite information.

In the GIS, where the results of the remote space sensing of the surface of the Earth (of the ocean) represent the regularly renewed source of the data necessary for forming information strata of electronic maps on a wide spectrum of scales (from 1:10 000 to 1:10 000 000). Moreover, the remote sensing means information allows not only to estimate efficiently but principally to make renovation and proof-reading of the used graphical strata. Furthermore, this satellite information may be used as a bitmapped "wafer" in a number of GIS- supplements, without which it is impossible to imagine administrative activities nowadays (and especially in the future). In addition it's necessary to mention while using GIS not only the information strata are important but also the precise reference of the objects disposed in the GIS to geographical coordinate system.

The complex information from the following satellite systems may be useful in forming graphical strata:

- navigational (GLONASS, GPS, GLONASS+GPS) satellite system;
- satellite system of intelligence and target designation;
- oceanographic satellite system;
- meteorological satellite system;
- topogeodesic satellite system.

The use of average orbital navigational system is provided for coordination and synchronization of time of all kind of surveys.

System of intelligence and target designation serves for accumulation of information about the enemy (his forces, location and so on).

For accumulation, preliminary processing and transmission of the oceanographic and meteorological data it's supposed to use oceanographic and meteorological ICS.

For conducting of a cartographic survey of the surface of the Earth (of the ocean) in creating digital maps it's supposed to use topogeodesic satellite system.

The main systems providing data accumulation for GIS are satellites with remote sensing means working in optical span. Qualitatively new methods are offered for efficiency of the satellite information transmission. They stipulate the use of vector picture-quantization or immediate conversion into digital form on board the space device for their further transmission to the user. Vector picture-quantization represent one of the promising methods of block digital encoding, which can be used both in combination with other methods of digital encoding and as an independent efficient method. It consists in joint quantization of the elements (or parameters) of the initial signal as the united vector, in contrast to scalar quantization when each element (or parameter) of the initial signal is quantized separately. Conformably to the image vector quantization consists of the following. The initial picture is divided into blocks of elements. The blocks are identified with the vectors the dimensions of which are determined by the quantity of the elements that form the block. Then these initial vectors are compared with the code vectors that make the codebook. And the one of the code vectors set with which the adopted measure of distortion that characterize the distance between the initial and code

vectors is minimized. The index of the code-vector determine the quantized vector as there is an identical codebook on the receiving sideand while receiving the number of the index the appropriate code vector is chosen from the code book on the receiving side and the code vector fills up the place of the image with correspond to the place of the initial vector.

Since the quantity of the binary units necessary for the transmission of the code vector indexes is considerably less than the quantity of the binary units necessary for the immediate transmission of the initial images so the ratio of these numbers may be very large.

The success of the functioning is determined mainly by keeping the following basic (general) demands made:

1. GIS must be total, i.e. envelop all aspects of the information and technology provisions and the software that are met in the process of the system exploitation.
2. GIS must be complex. The main advantage of the GIS technology compared to the traditional methods consists of the opportunity of the joint analysis of large groups of parameters in their interconnection. And this is exceptionally important for the studying of the complicated phenomena and processes.
3. GIS must imitate the technology of the reflected process. The natural block linkage is necessary.
4. GIS must be open providing modification easiness and ability of being readjusted for the purpose of its up-to-date level maintenance. Transformations are necessary both for development providing and for solving diverse problems.
5. GIS must be provided with the boundary protection. At different management levels the access to the information should be m~asured: the FB officer shouldn't have access to the information that is designed for the submarine commander.

The additional demands to GIS are given below. The GIS must assist in the solution of the following problems:

- creating and conducting of the spatially distributed data bases;
- creating and editing of the digital maps in diverse projections and on various scales;
- representation of the various data in a map, graph or diagram aspect;
- analysis of the mapped data;
- geometric dimensions measuring of the natural objects, of the distances from geographic points to the districts with some certam conditions and so on;
- change of the scales of the reflection, of the form and aspect of the representation of the graphic and mapped data;
- correlation of the data bases information and the geographic objects on the digital maps;
- interpolation and construction of the vector and scalar fields on the data bases information;
- implementation of the requests on multiform data bases retrievals;
- implementation of the requests on the representation and spatial analysis of the mapped data (according to the parameters, time periods, districts and so on);

- compiling the documents of the information production;
- application of the supplements for implementation of the special aspects of information processing, keeping and so on.

Thus, the new technology possesses the following advantages that promote it to the leading roles:

1. intergrated approach to the information
2. efficiency of its representation in compact form
3. the possibility to use visual methods of its representation
4. analysis of heterogeneous information and the possibility to work out well-grounded management decisions
5. mobility of the system

In the sphere of naval science GIS-techologies can be applied in the following spheres:

1. cartography;
2. navigation, hydrographic;
3. analysis of the theatre of naval operations, including separate water areas;
4. strategical, operational and tactical planning of battle and everyday actions;
5. organization of realization of nawal operations and battle operations;
6. reconnaissance, including hydrometeorologic one;
7. information support of the nawal base functioning (including suitability estimation of firing grounds of battle training, analysis of natural conditions and so on).

Combination of the complex satellite information and GIStechnologies opens essentially new perspectives in creation automated information-managing systems.

Let's consider the opportunity of using the new technology in automated information-managing system for submarines (AIMS-S). The system is designed for automated preparation of well-grounded management decisions of the battle and everyday submarine activities under conditions of the enemy counteractions in the course of solving problems peculiar to them.

The structure of the created AIMS-S must correspond to the nominal frame of a submarine. And AIMS-S is constructed on the base of the local area network (LAN), that provide the information support of making management decisions within the competence bounds of the diverse submarine officers links, including officer of the watch (OW). Algorithms of input-output should be provided in the system, as well as the algorithms of filtration, analysis and proof-reading of the data, and the opportunity to upgrade the number of headings, to remove useless and to rename the available ones.

The access to the information is realized according to the technology "user-server". The first computers used for mapping the information flows were muld-purposed mainframes computers.

With the appearance of the mini-computer's network the model of the processor with shareable resources emerged. In this model almost all the calculations were

made on the personal computers. The advantage of this model was that it allowed all the network users to share expensive resources. Such components of the equipment like the printer, the drive storage device, the modem have become more available, because their use could be distributed among a large number of users. The personal computer network development has led to the distribution of the computer power throughout the whole system. The computing problems were perfectly solved both on the host-computer and on the personal computer. And user-server calculations represent the distribution of the calculating process to the whole information system. The software is made on the desktop personal computer ("the user part"), and the other on the more powerful computer ("the server part"). The user-server calculations are based on the electronic message exchange and depend on events. The term "message based model" means that the user sends a request to the server and gets the answer. The notion of the event-driven model implies that with the coming of a certam event the special trigger reacts to it and the trigger generates and send a concrete message (for example, informing about the data change).

The main element of the AIMS-S is the specialists' workstation (WS). A model WS consists in the personal computer of naval implementation with the uninterruptible power supply source and the software with data bases. And it uses the information about the objects from the radar station and the hydroacoustic complex as well as from the outward means of intelligence and target designation. AIMS-S is designed for work with electronic maps according to the International Hydrographic Organization standard S-57.

AIMS-S can be realized on the computers of the PC type with random access memory not less than 16 megabytes under the control of the operating system Windows 95 and further. Computers can be part of the local area network or work autonomously. The system is realized in adopted in the Navy programming language Visual Basic 4.0. It's supposed to use GTS Arc/View 3.0 and the text editor Word 7.0 as the basic program means. The format HTML is chosen as the hypertext data bases format and the formats DBF and may be is chosen for the relational databases.

For the officer of the watch the possibility to on line a notebook type PC at the alarm signal (at the submarine dive) is transferred to the pressure hull.

One of the problems at the creating WS for a specific user (for the present instance - for the nawigator) is the working out of the interface (the navigator's console). In the first place it is the problem how to provide the nawigator efficiently with the total information and the reduction of the labour-intensive routine operations of data processing while working out administrative decisions.

Among the existing types of interfaces the most convenient one for more professional users is the interface of the pop-up and pulldown menu type. This kind of interface represent the certain scheme of information processing according to the principle "look and choose" and this makes the interaction between the user and the computer significantly easier, as it's not required to learn the language of communication with the system while using the menu.

It's expedient to realize the principle of interface building up according to the navigator's functional duties. In our opiniom the system must operate with eight data groups that are united (divided) structurally finto the main and auxiliary blocks.

The main units are:

1. cartographic
2. navigation
3. oceanographic
4. tactical
5. simulation block

Auxiliary units are designed for the information and software support. Let's consider the blocks in a more detailed way.

1. The cartographic block. It is designed for working out electronic maps on various scales and in different projections. These maps represent the GIS core. It includes the following sections:

A. The electronic maps: sailing, general, coastal and harbour;
B. Special maps: with graticules of radio navigation, hydro-acoustic and other kinds of isolines;
C. Reference maps: for example review maps, recommended water – ways etc;
D. Auxiliary maps: cartographic graticule, maps - graticules of radionavigation systems, isolines; - for sailing on an arch of the large circle etc;

The block allows:

- to realize the choice of necessary map, it's automatic loading and the map move on the display;
- to operate the map scale and the map loading (basic, standard, total);
- to realize the examination of any geographic region with magnification (diminution) of the whole picture or of the separate district;
- to choose an object on the map and to give the required information;
- to depict the submarine in a symbol or in a contour (outline)

2. Navigation block. It's designed for management the navigational proces and as the navigation log - book (documenting the circumstances of the sailing). It includes the following parts:

A The means of the navigation equipment (MNE), for example configuration of the coast features, frontiers and borders of different zones etc.;
B Navigational calculations, for ezample grounds for the requirements to the Navigation Equipment (NE) of the battle and everyday operations of the submarine, the defining of the submarine location in different ways; - divergence with the targets etc.;
C Preliminary task, for example selection and loading, duplication, remaining of the route from the data base, forming, review and editing of the route in a table form and on the electronic map, addition, removal putting in, transfer of the

reference-point, the reverse of a route, the calculation of a great circle sailing representation of the additional (spare) transitions route etc.;

D The current task for example receiving, processing and representing of the information from the navigation sensing elements, representation of the submarine location and auxiliary information on the electronic map, control over the preliminarily laid route passing and working out of the recommended parameters of the submarine movements etc.;

E Automated documenting of the current navigation parameters and the circumstances of the sailing, for example the review of the records in the electronic log – book, reproduction of the sailing circumstances on the electronic map, input of the efficient notes and text records;

F Working out the signals and warnings, for example the allocation of the dangerous isobathic line, representation of dangerous relative angles, detection and integral lightning of hazards, the signal "Area of dangerous depths" etc.;

The block allows:

- to base the choice and represent the main and spare routes of the submarine deployment (transition) to the regions of warfare; to put over them the geographic, oceanographic, reference and other information strata;
- to mark the current task, to make navigation and tactical calculations;
- to form a "mosaic" from different information strata or from their fragments;
- to mark the situation on general maps with representation of our forces location, of the MNE (means of navigation equipment), geomagnetic and navigation fields, and other necessary information;

3. <u>The block of the oceanographic data</u>. It's designed for accumulation, keeping, and analysis of the data about the environment with the purpose to guarantee the use of the weapon and technical means, the secure submarine sailing. It includes:

A. Hydrographic information about: the depths, the flows characteristics, the characteristics and peculiarities of the ground, the hydroacoustic characteristics (of the underwater sound channel, the vertical extension of the sound speed, the remote, zones of the acoustic illumination, the horizontal refraction of the sound beams and so on).

B. Geophysical information about: the characteristics of the magnetic and gravitation fields of the Earth, their anomalies, the plumb-line deviation, the structure of the sea bottom.

C. Oceanographic information about: the currents (the direction and the speed, their mutability, the characteristics of the jet, the presence and the characteristics of the oceanic fronts and whirlwinds, the speed and the direction of the displacement of internal waves, of the meanders, appropriateness of their mutability in time and space, the temperature, the salinity level, the density of the marine water, the bioluminiscence;

D. Meteorological information about: the direction and the speed of the wind, the tornadoes, the air temperature and the cloud cover and so on.

The block allows:

- to prepare the initial data about the estimation of the environment influence on the effectiveness of the mission implementation and the enemy's antisubmarine forces;
- to make prognostication of the environment condition and to take finto consideration it's influence on the security and stealthiness of the submarine sailing;
- to use the information for preliminary estimation of the opportunities of using the radionavigation means and different fields of the Earth in the sphere of submarine navigation and independent creating gravitation reference-points;
- to give out the oceanographic information to the users of other fighting units.

4.<u>The tactical block</u>. It fis designed for:

A taking into account the enemy's counteractions while making the battle gasket, planning the NHE (navigation hydrographic equipment of the submarine actions and conducting play war of the commanding staff;

B making the operational-tactical calculations;

C taking into account the demands of the dominating documents on the tactics of the submarine actions.

It includes:

- the technical capabilities of the fighting ship of the probable enemy and the own navy;
- the capabilities of the armament and war equipment;
- the borders of the operational navy zones, the firing grounds of fighting training;
- the borders of the minefields and the types of the represented mines;
- the regular armament and the fighting equipment of the combatant ship of the probabie enemy and our own for different projects;
- the information about the nawal bases and ports, the main world good traffics;
- the intelligence information got from the systems of intelligence and target designation;
- the information about the location of our forces and the enemy's forces;
- the submarine load;
- the points and regions of anchorage;
- the submarine bedding-out finto liquid ground;
- the points and regions of dispersal according to different levels of fighting trim.

The block allows:

- to create operational-tactical background where the submarine warfare will take place;
- to give out the tactical information (including that of efficient character), necessary for making up the situation map;
- to prepare the initial data for making tactical calculations in the simulation block on the use of the armament and deviation from the enemy's actions.

5.The simulation block. It's designed for efficient making of well-grounded management decisions with the help of the automatization of the process and applying mathematical models, based on the method of operations research, mathematical statistics, the game theory, imitational modelling and so on.

Machine methods can be taken from the methods library of the Navy and can be worked out the navigator independently. The simulation block must include complex and particular machine methods. For example:

1. Complex methods:
- the model of the warfare at the theatre of naval operations;
- the estimation of the effectiveness of the solving the submarine mission;

2.Particular methods that concern the submarine itself:
- the methods of determining the fighting submarine capacity;
- the methods of determining the submarine fighting readiness;
- the methods of determining the submarine fighting steadiness;
- the methods of determining the secrecy of the submarine actions;

3.Particular methods that concern the submarine actions navigation equipment (NE):
- the efficiency estimation the submarine actions NE taking into account the radioelectronic battle;
- the efficiency estimation of the submarine actions NE in high latitudes
- the efficiency estimation of the NE submarine forcing of the minefield
- the estimation of the submarine actions secrecy while using the means of correction and so on.

The important advantage of the block is that it allows estimating the warfare in the dynamics, as well as in the real time or with the use of the temporal scale. Besides, the block allows to simulate different fighting and everyday situations for nuclear and usual wars, regional and local conflicts.

Auxiliary units consist from the following units:

6.The unit of reference information. It is designed to support the main units functioning with the information of long-term preservation. The information has an auxiliary significance. It contains the following units:

1. Notifications for navigators and navigation warnings;
2. Manuals to sailing: tactical, general (sailing directions and their supplements, lights and sights etc);
3. Directions:
- on the NAVY fighting service;
- on the NAVY fighting provision;
- on the NAVY submarine fighting activities and so on.

4.Rules:
- the rules of the navigator and hydrographic service;
- the rules of the fighting use of the technical navigation means -the rules of using the firing grounds and the means of guaranteeing the fighting training
- the rules of determining the manoevring elements of the ship

- the rules of organization the navigator's service
- the rules of joint sailing
- the rules fighting units training
- the rules of the rocket service
- the rules of the torpedo fire
- the rules of organization hydro-meteorological observations and so on.

5.Handbooks.
- methodical manuals
- hydro-meteorological atlases
- descriptions of the equipment
- training aids
- conventional signs and abbreviations
- tables of the distances between the ports and the Navy bases
- catalogues of maps and books.

6.Calculating aids:
- nautical tables
- The Marine Astronomic Annual
- the tables of altitudes and azimuths of the heavenly bodies
- the flood tables
- the tables for calculation of the submarine location coordinates
- the deviation tables
- other calculating tables
- astrographs.

7.Legal matters:
- the international marine law
- the criminal code of RF
- administrative law
- military legislation and so on.

8.Orders and directives of the Defense Secretary, the Navy Commander-in-Chief, the commander of the Navy (flotilla, squadron) etc.

The block allows to find efficiently and to use for different aims the necessary heterogeneous information that concern the fighting and everyday submarine activities in general and the FE-1 (fighting element) in particular.

7.The archives block. It is designed for archiving of the informational resources and their descriptions, that have lost their urgency. The block allows to keep the archive and to give access to the preserved information for its restoration or realization of the data selection. The block may contain the data that are not included into the navigator's information resources.

8.The block "The Software Functions". It's designed for rendering the navigator different services, including electronic mail and automated secretary. It supports the system administration and realizes the access to all the data that are included into the information resources of the AIMS-S. The block provides the connection and access to the information resources of the common using or to the open resources of other fighting bodies. The block allows implementing retrieval of your own information resources and to send it on E-maik as well as to receive and to include it into your own resources received on the E-mail.

CONCLUSION

Taking into account all above mentioned, to supply a submarine with the similar systems we have an opportunity to get heterogeneous information from satellite navigation and other systems in real time, as well as from the underwater aids of navigation. It is possible with simultaneous use of mathematical models for estimation of battle and everyday operations of the launcher will allow realizing the submarine management in a most effective way. According to preliminary estimation, the productivity of the navigator's work may increase by 10 times or even more. And the level of validity of his decisions fis raised and there fis no need to fulfill the routine work that concern the manual design of maps, making explanatory slips, keeping the documents and correspondence.

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