GEOMATIC ENGINEERING IN HUMANITARIAN DEMINING

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ABSTRACT:

One of the most notable problem with the strongest impact on the civilian population during the war and specially after the war is the landmine problem. This paper describes Mine Information System (MIS) for Humanitarian Demining with the all necessary data and the way of bringing it together. Before the MIS implemented a lot of preparatory works has been done: marking of photogrammetric control points, GPS measurements along with the adjustment, aerotriangulation, creation of DTM using stereo instruments and at the end production of high resolution (0.20m) Digital Orthophoto (DOP2). Besides, the Scan centre has bee established to help the operator in the vectorisation of the military objects from the maps used for planing war activities. Croatian Mine Action Geoinformation Project (CROMAC GIP) is the title of the most important part of MIS, data capture procedure standardisation, data modelling on conceptual, logical and the implementation level are the key issues and tasks of it.
The GPS based system for the new mine related data collection has been developed along with the web based application for data maintenance. This unique system is developed with the idea to become a one of the standards on demining and it is going to be presented to the UN Institutions and International centre for humanitarian demining in Geneva GICHD.

1. INTRODUCTION

Performing mine action activities is one of the prerequisites for socio-economic development of every country with the mine problem. It entails more than removing landmines from the ground. Teaching and helping people to protect themselves from danger in the mine affected area is undividable segment of mine action (Pavicic et al. 2006.).

To be effective in the mine action it is impossible to work without actual geodata and the sophisticated technology for data capture, storage and also for data presentation. With that idea in mind we proposed the solution for the Croatian Mine Action Centre (CROMAC).

The whole project involves many aspects of geodesy and geoinformatics such as marking of photogrametric control points, geodetic measurements, aero photogrametric measurements, adjustment of GPS network and the bundle block adjustment of photogrametric data, spatial database modeling, process modeling, implementation of the database and the programming of the system. To input a new data to the system users can decide either to use hand held GPS to collect new data and upload it to the system or to collect data in the analog form and to enter them in the system later.

To be more precise in the determination of the mine suspected area (MSA) CROMAC operators are using old military maps. All of the war activities are marked on these maps and the main issue was to extract these data and to put them into the MIS. For that reason we have proposed CORMAC to establish a Scan centre to do all digitalization. Conversion from the symbols drawn on the analog maps to the database features is developed as semi-automatic process giving opportunity to operators to accept proposed feature or to reject it and to select the right one.

2. HIGH RESOLUTION ORTHOPHOTO FOR THE MINE SUSPECTED AREA

The process of producing digital orthophoto in the scale of 1:2000 is based on the official state specification for DOP2. These specifications gives requirements on the surveying and premarking of the ground control points, defined the scale for the aerial photography (1:8000), defines the way how the aerial triangulation should be done, compilation of the digital terrain model and the production of the Orthophoto.

To make it possible to fulfil all the requirements defined in the specifications it is necessary to use sophisticated equipment. Geofoto is using two types of photogrametic cameras: Leica RC20 film camera and the Vexcel UltraCam digital system (Figure 1).

Figure 1. Vexcel UltraCam digital system

During operation digital camera is used with the Somag gyro-stabilised camera mount and with the Forward Motion Compensation.

Preparing of the flight plan is done using GPS/CCNS Windows Mission Plannig module (Figure 2). This software supports the usage of digital terrain models (DTM). Using DTM user can have better overlap control. Results are highly correlated with the accuracy and the resolution of the DTM. For this project, with the requirement that the pictures should be in the 1:8000 scale, suitable solution was to use SRTM DTM datagrid with the resolution of 2 arc seconds.

Figure 2. GPS/CCNS Window Mission Plannig module

Besides flight planning this software gives you possibility to prepare and to store data on the PC data card so the data can be loaded in the aircraft's computer to be used for navigation.

Ground control points are determined using GPS technology (fast static method of measurement). At least two different base lines are observed from national GPS reference network (ETRF). For the whole block it was necessary to use four trigonometric points that are established in the old geodetic datum, but still widely used. These four points are needed to calculate "best" transformation parameters for some specific area of interest.

The measurement are performed using 6 Trimble dual frequency receivers. GPS vector optimisation and the network adjustment is done using Trimble Geomatics Office (URL 1).

Marking of the ground control points (GCP) according to the specification for DOP2 is carried on using marks with the dimensions and shape as it is on Figure 3.
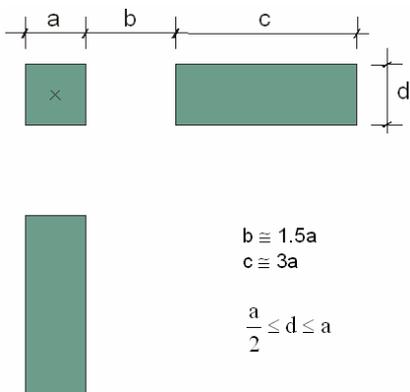

$$b \cong 1.5a$$
$$c \cong 3a$$

$$\frac{a}{2} \le d \le a$$

Figure 3. Dimension and the shape of the GCP

As it is marked on the Figure 3 dimension of the parameter a is scale dependent. For the aerial photography in the scale range from 5000 to 10000 it should be 0.3m.

One of the important prerequisites for high resolution orthophoto production are high accuracy exterior orientation parameters and the high accuracy digital terrain model (DTM). Exterior orientation parameters are determined during the aerotriangulation process. The whole process exterior orientation, GSP identification, measurement and the adjustment is carried out with the use of the ISAT software (ZI/Imaging).

DTM is captured according the specification using digital photogrammetric workstations. Features defined in specification are visualized and presented on the Figure 4.
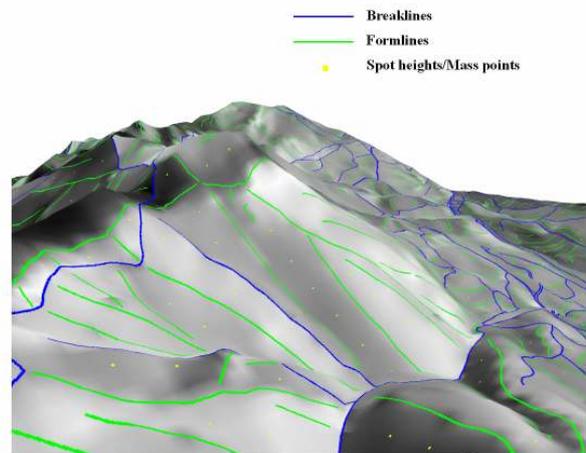

Figure 4. Base structure in the DTM data

All elevation data are checked and then used to produce DTM With the automatic correlation method additional mass points are added to the linear features. Checking is preformed using Terrasolid's Terra Modeller. From the elevation data Triangulated Irregular Network (TIN) has been generated and used for orthophoto production. For the TIN generation the SCOP++ was used. It is software developed at the TU Vienna (Figure 5).
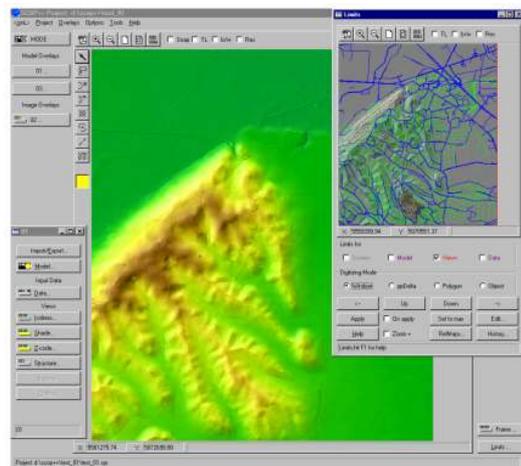

Figure 5. TIN generation

Geometric orthophoto rectification is done at the end of bundle block adjustment and DTM calculation. OrthoMaster and OrthoVista are used for rectification and for mosaicking. On the Figure 6. and Figure 7. mosaicking process is presented befor and after radiometric adjustment. That is necessary because of local variations in contrast.
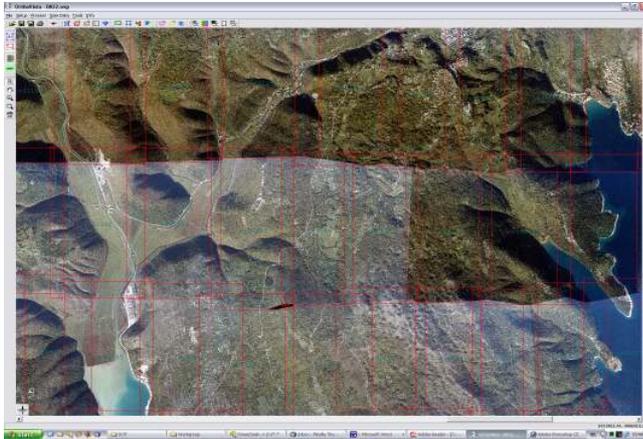

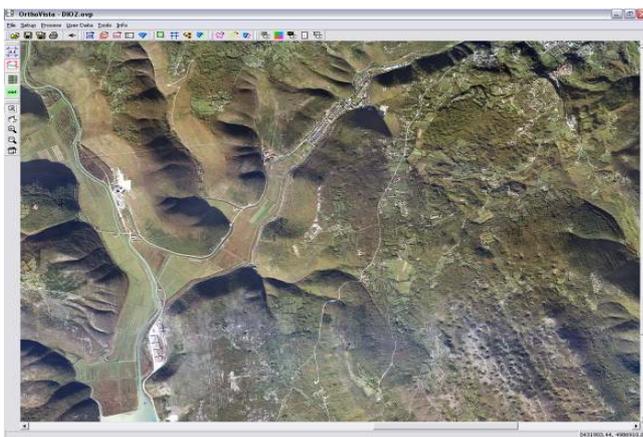Figure 6. Mosaicking before radiometric adjustment

Figure 6. Mosaicking after radiometric adjustment

The size of the MSA in the Croatia is about 1174 sqkm. The required orthophoto should cover the MSA with the buffer of approximately 100m so the total orthophoto area estimated by CROMAC is 1500 sqkm. Two Geofoto's aircraft are used for the surveying mission: Turbo Piper Aztec (Figure 7) and Cheyenne I (Figure 8).

Figure 7. Turbo Piper Aztec

Figure 8. Cheyenne I

Both aircrafts meet technical requirements for the photogrammetric work such as: twin engine operation, high climbing rate stable in flight and the payload sufficient to carry crew members and a camera system.

3. DEVELOPMENT AND IMPLEMENTATION OF THE MINE INFORMATION SYSTEM

Demining standards and Croatian laws defines the basis for all of the demining activities. The International Mine Action Standard IMAS (URL 2) defines framework for the more specific standards intended for the state level usage. These more specific standards are called Standing Operating Procedures (SOP) (URL 3) and they define particular mine action activities. Every country with the mine problem prepares its own SOP documentation.

CROMAC is permanently improving procedures described in the SOP documents.

The main project difficulty was the lack of the international experience and the standards in the demining field. All of the issues were solved by experts on geodesy and geoinformatics. To avoid compatibility problems with the data sharing and data dissemination on the web, besides standard on demining the standards and the specifications in geoinformation field were used (URL 4).

3.1 The Old MIS

In order to achieve higher efficiency in demining processes it was necessary to record all relevant data. Until present day, data was acquired in various ways; part of data was inherited from UN, part was inherited from army and police, and part of data was collected by employees of Croatian Demining Centre.

Since the establishment of the CROMAC, a general survey of the whole Croatian territory has been made in order to define and classify MSA. This action began in the end of 2004. and lasted for 18 months (URL 5). Collection of data is a very complex procedure that almost always requires field work. This paper is mostly concentrated on the new MIS development and implementation by changing the old way of working but still using all of the collected data.

Existing Mine Information System is based on tools MapInfo (URL 6) and MS Access (Jelinić, 2001). The main shortage of

this system is expressed duality when registering geometric data and attribute data, and biggest shortage is inability to acquire data with GPS equipment. All coordinates acquired with GPS had to be retyped from GPS equipment to the system. Beside that, to adjust data from MapInfo and MS Access it was necessary to form a special application which would map coordinates from one system to another. That approach let to data inconsistency.

Entering data into the MapInfo wasn't done in the controlled way which resulted with the more data inconsistency.

Beside removal of functional shortages of the existing system, the new system had as assignment to implement all new SOP documents and the implementation of newly produced geodata (DOP2). Old system was implemented in every CROMAC office as a simple copy without some central database. During the night time synchronization of the data was preformed.

3.2 The Concept of the New MIS

The new Mine Information System (MIS) is established using separate platform for each application layer. It is slightly modified standard three-layer (three-tier) software architecture with the user interface, functional process logic and the database. Oracle database is installed on the database server running on the RedHat Linux OS (data tier), application server (AS) is running Intergraph (URL 7) based software on Windows platform (logic tier) and the client software for CROMAC employees responsible for maintaining database is Windows based (presentation tier). On the other hand, there is no request for the operating system for the users with the limited access. Limited access users can view data using Internet browser (presentation tier). Simplified system schema is presented on the Figure 9.
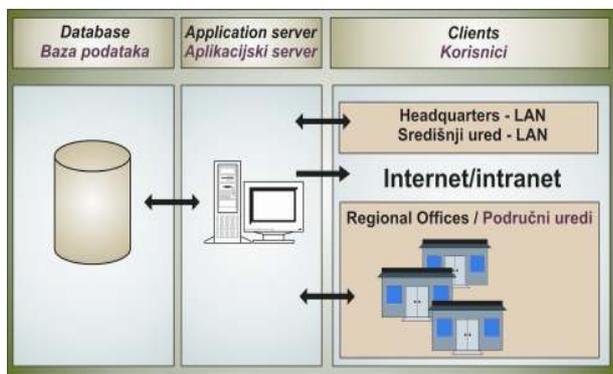

Figure 9. Simplified Mine Information System Schema

Modification of the three-layer software architecture is presented on the Figure 10.

As it is possible to see on the Figure 10 there are two connections to the database. One connection is realized from the AS (GeoMedia WebMap and IIS) and the other connection is direct from the client application. AS is used to produce interactive visualisation from the database. Client sends request to the IIS using HTTP protocol. Using APS and the custom developed application (HCRSrv) installed on the AS the request is transformed and sent to the Intergraph software for web mapping - GeoMedia WebMap (GWM) (URL 8). GWM is connected to the spatial database and by the instruction from

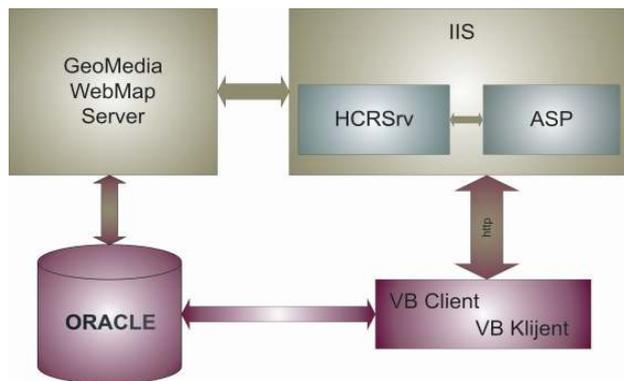HCRSrv generates SVG (URL 9) file which is sent back to the VB client.

Figure 10. System Architecture Shema

To work with objects without geometry, client application communicates directly with Oracle database.

All of the spatial queries (Oracle 2003a) are programmed in PL/SQL (Oracle 2003b) and implemented in the Oracle database.

On the client side, interaction between SVG and the user is programmed using javascript. It is possible by working in the web environment to enter the new graphic data to the system and to modify existing data. In that sense GWM acts as a transactional web feature server (URL 10). Figure 11 shows application GUI. Data presented in the front window (Figure 11) are generated by AS and the back window data are directly connected to the Oracle.
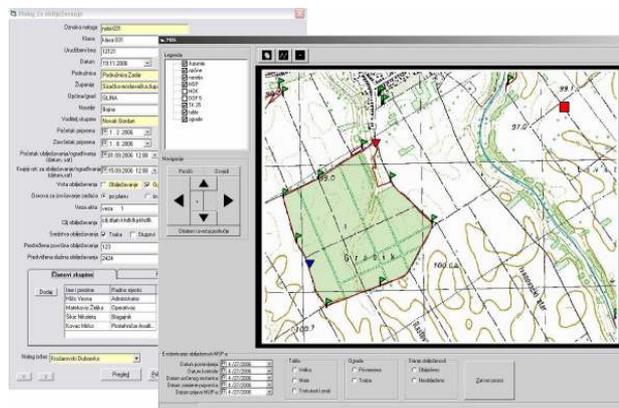

Figure 11. Graphical User Interface

3.3 Field Data Collection

Most of the data are produced by field survey. While working on the filed CROMAC operators are equipped by hand held GPS device (Trimble GeoXT). All data necessary for field operation can be uploaded into the GeoXT and edited on the field. One of the data layer uploaded into the device is DOP2. DOP2 gives possibility to the filed operators to make more precise representation of the MSA and other spatially related features like tables and fences used to mark danger areas. Figure 12 shows in the simplified way work of the field operators.
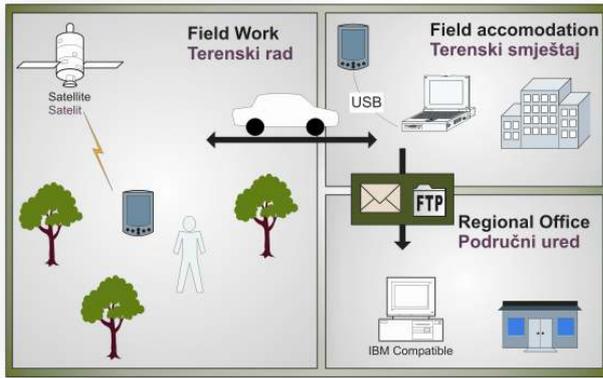
Figure 12. Scheme of data collection using GeoXT

In regional CROMAC offices data is prepared for field operations and transferred to GPS device. Usually, field teams on the locations further away from the subsidiaries need to organize accommodation so they could fulfil daily plans.

Depending upon the situation on the field, data in digital form is not necessary to be entirely recorded. Control and input of remaining data can be done after workday on a safer and more peaceful place.

After the data is recorded and controlled, it is sent to regional offices for additional control and to be loaded into database.

Before DOP2 production field operators have to use old black and white orthophoto in the scale 1:5000 (DOP5). Comparison of the black and white DOP5 and the colour DOP2 is presented on the Figure 13.

Figure 13. Comparation of the DOP5 and the DOP2

Besides DOP2 MIS there are some other geodata implemented in the system: topographic data (Biljecki, 2000), topographis maps in scale 25000, base state map in the scale 5000. These data are not so useful for the field work but they are useful for planning and representation.

3.4 CROMAC Scan Centre

Large amount of data significant for demining process are in analogue form. These are mainly maps used to plan military actions with marked positions of various military objects. Import of such data into MIS is of huge importance on the demining process. In that sense the Scan Centre has been established.

Scan Centre responsible for the map digitalization and automatic (semi-automatic) vectorization of objects drawn on the maps. Figure 13 shows the workflow of the scanning and the vectorization process.
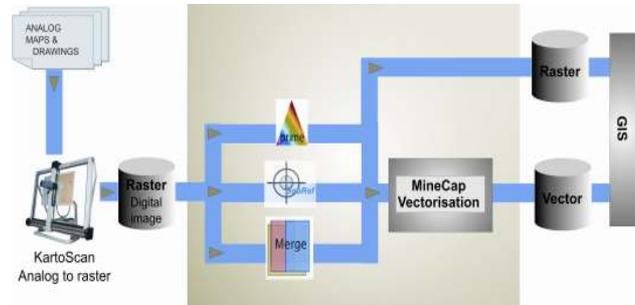

Figure13. Scan Centre Workflow

Analogue maps are set on specially adjusted scanner (KartoScan FB V). With CCD sensor, which has resolution of 2048 pixels for each RGB component, is digital version of the map created, which is then adjusted for further work on specially designed software. Software consists of thee modules: Prime, GeoRef and Merge. Prime is used for colour separation and enhancement of raster quality, GeoRef for geo reference and Merge for mosaic production.

After primary analysis, with specially developed application MineCap and according to data model of mine objects, an automatic vectorization of map objects is preformed.

Content in raster and vector format is further loaded into GIS, respectively MIS.

Before establishment of Scan centre the mentioned objects were not subject of analysis in MIS.

4. CONCLUSION

The creation of the new Mine Information System in function of improvement of current system for recording mine related data considerably helps and shortens demining process of the mine-contaminated area. It provides updated and accurate data to the all-level system users from the government to the citizens who are interested in locations that are mine contaminated.

Integration of the new produced DOP2 made the work of CROMAC field operators much easier and also less dangerous. High resolution (20cm) and the actuality solved most of the unavoidable filed work issues.

Scan Centre and the system for data collection using hand held GPS device shorten the time needed to collect data and enter it into the system. Developed procedures lowered the probability of making some accidental errors during the data input.

Presented solution makes a mine problem more transparent, open and accessible with principal idea to reduce the accidents, shorten the demining time and cost, improve the economy and simplify life with mines.

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