GEOGRAPHIC INFORMATION SYSTEMS FOR THE CHERNOBYL DECISION MAKERS IN UKRAINE

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1.0 INTRODUCTION

Following numerous national and international studies conducted on the overall impact of the 1986 Chernobyl nuclear power plant disaster, decision-makers of the affected countries have oriented their efforts on environmental clean-up and population safety. They have focused on activities leading to a better understanding of radionuclide contamination and to the development of effective environmental rehabilitation programs. Initial developments involved the use of domestic USSR technologies consisting of mainframe IBM computers and DEC minicomputers. Later, personal computers with imported software packages were introduced into the decision-making process [Prister et al., 1994]. Following the breakup of the former USSR, the Ministry of Chernobyl (MinChernobyl) was created in Ukraine in 1991. One of the Ministry's mandate was the elimination of the environmental after-effects of the Chernobyl disaster.

1.1 Inform-Chernobyl

The creation of MinChernobyl in Ukraine focused all activities surrounding the elimination of the Chernobyl disaster after-effects into one government structure similar to that of the Ukrainian Cabinet of Ministers. MinChernobyl activities also involves the cooperation among its member departments and with a number of other government Ministries and agencies, such as the Ministry of Atomic Energy, Ministry of Public Health, State Committee of Hydrometeorology, several departments of the Ukrainian Academy of Sciences, Main Administration of Geodesy, Cartography and Cadastre, and others. To facilitate the environmental management functions of MinChernobyl, a comprehensive system entitled Inform-Chernobyl was initiated. The system would be based on information technologies suitable for providing support in decision making and problem solving activities involved in the elimination of the Chernobyl disaster after-effects. Ukrainian managers established global and local objectives or directions for Inform-Chernobyl [Prister et al., 1994].

The global objectives provide decision-makers with the information necessary to develop policies for the effective, long-term management of the environmental effects of the Chernobyl accident. The objectives for Inform-Chernobyl are listed as follows:

1) calculate the radioactive pollution levels of milk and potatoes through related environmental parameters;
2) determine the optimal and economical management of the polluted territories for the cultivation of minimally contaminated agricultural commodities;

3) evaluate GIS and related technology for creating a full-scale Radio-ecological GIS (RGIS) for the Ukrainian territories affected by the Chernobyl disaster;
4) establish principles of integration for RGIS and Radio-ecological Decision Support System (RDSS).

For the shorter term, a number of local objectives were also defined for Inform-Chernobyl. They are listed as follows:

1) design and develop an integrated radio-ecological database (IRDB);
2) classify the contamination of natural resources by contamination type and level;
3) develop a land information system as a sub-system of RGIS and as a principal tool for environmental management;
4) integrate RGIS with spatial statistical analysis tools for the production of single and multi-variable contamination maps;
5) integrate RGIS with complex models of radio nuclide migration, in particular with modelling systems of radio nuclide migration in the hydrosphere and lithosphere;
6) integrate RGIS with multi-criteria evaluation methods in GIS as a mathematical base for achieving global objective 2).

1.2 Chernobyl GIS Pilot Project Objectives

The Chernobyl GIS Pilot Project was designed as a subsystem of RGIS. Therefore, the pilot project objectives were set up within the scope of the Inform-Chernobyl objectives. The objectives included:

1) installation of a suitable GIS in Kyiv;
2) training of local personnel on the operation of the system;
3) design and population of an integrated database;
4) development of GIS applications for the pilot project area relevant to the elimination of the Chernobyl disaster after-effects.

2.0 GIS PILOT PROJECT COMPONENTS

The Chernobyl GIS pilot project has been attached to MinChernobyl and housed in the Main Administration of Geodesy, Cartography and Cadastre (attached to the Cabinet of Ministers) in Kyiv. This chapter presents a summary of the pilot project's essential components. More information is included in a paper presented at the 7th International Conference in Geomatics in Ottawa [Palko et al., 1995].

2.1 Hardware and Software

The hardware and software configuration for the Chernobyl GIS pilot project constituted a major component of the technology transfer. Most of it was purchased in Canada and installed in Kyiv, with the exception of a locally supplied PC. The following is a list of the hardware and software components.

Hardware:
- Sun Sparc Station 10, Model 51 with 32 Mbytes RAM and 1.05 Gigabyte Disk;
- 5 Gigabyte Backup Device;
- CD-ROM;
- PC-486 with a Large Digitizing Table (Data Entry Workstation);
- Laser Printer;
- Large Size Pen Plotter.

PC Workstation Software:
- DOS;
- Tydig Digitizing Software;
- Database Management System (SPANS Tables);
- SPANS Map for Data Presentation.

SUN Workstation Software:
- SUN OS 4.1.3 (UNIX);
- MOTIF ICS Version 1.14;
- SPANS GIS Version 5.23;
- Data Translation Software to Interface data from the Local Map (F1) Database.

2.2 Database

The data used for the pilot project originated from two sources: the F1 database and the contamination measurement files. The F1 format is the digital topographic map format of the former USSR. Software was written to extract the relevant information from the F1 database and to convert it into the SPANS import file format. The data derived from the F1 database were classified into eight themes: hydrography, relief, populated places, boundaries, transportation, radiology, man-made objects and vegetation. Each of the data themes contains a number of spatial entities. The entities related to the data themes have not been re-structured from the original data sources. They are a combination of entities defined in the documents obtained from Ukraine.

For example hydrography is composed of the following entities:

bluffs	rapids
canals and ditches	reservoirs
channels	rivers
dams	rivers and channels
dikes and banks	springs
fords	wharves
isobaths	water bodies
lakes	wells
oceans and seas	
ponds	

while contamination samples is composed of the following entities:

air contamination level
cattle contamination level

farm product contamination level
human contamination level
soil contamination level (medical-caesium, strontium, plutonium, potassium, level of exposure)
water contamination level

Hydrography entities were divided into two thematic layers (linear and polygonal features). In order to process lakes into quadtrees, they had to be transferred to SPANS as polygons. Radiology data were imported as point entities and converted to quadtrees for modelling. Each entity was described by spatial and non-spatial attributes as well as by metadata to identify source documents and field collection methods.

3.0 PILOT PROJECT RESULTS

As part of the Chernobyl GIS pilot project implementation, Ukrainian specialists received both theoretical and hands-on training on the installed system. Details of the training are described in a paper presented at the 7th International Conference in Geomatics in Ottawa [Dombrowski, Palko, 1995]. As part of their hands-on training, Ukrainian specialists have developed the following three principal applications:

1) integration of the Digital Chart of the World (DCW) data with local map data;
2) preparation of countermeasure maps, i.e., delineation of zones by density and type of radionuclides;
2) identification of natural landscape zones.

3.1 Integration of the Digital Chart of the World (DCW) Data with Local Map Data

Ukrainian GIS users tested geographic data exchange and data integration, and acquired a readily available map coverage extending beyond their national boundaries. As expected, DCW data proved to be useful for generating overview maps and integrating with local digital topographic map data at small scales. The successful integration of DCW data with local digital data illustrates the benefits of utilizing this data source as a starting point for building a database which could be easily used for small-scale topographic mapping. Figure 1 shows the location of the Polessie District study area and represents an example of the DCW and local data integration. The DCW data is represented by the country boundaries and hydrography data.

3.2 Delineation of Zones by Density and Type of Radionuclides: Countermeasure Maps

The objective of this application was to produce integrated maps (also referred to as countermeasure maps), based on contamination data and other relevant information, for the pilot project area at the scale of 1:200,000 (the smallest de-classified scale). The preparation of these maps tested the methodology of merging existing digital topographic map information (such as base map features, settlements, vegetation and land cover) in F1 format with georeferenced radio nuclide data in Gauss-Krüger coordinate system. This application required the conversion of all the data into SPANS import format. Analysis included interpretation, classification and contouring. The intended use of these maps was for the: identification of the type and level of contamination for populated places and forests; zoning of settlements; and delineation of the exclusion zone under different scenarios. Figure 2 is a sample map showing the caesium-137 contamination for the pilot project study area.

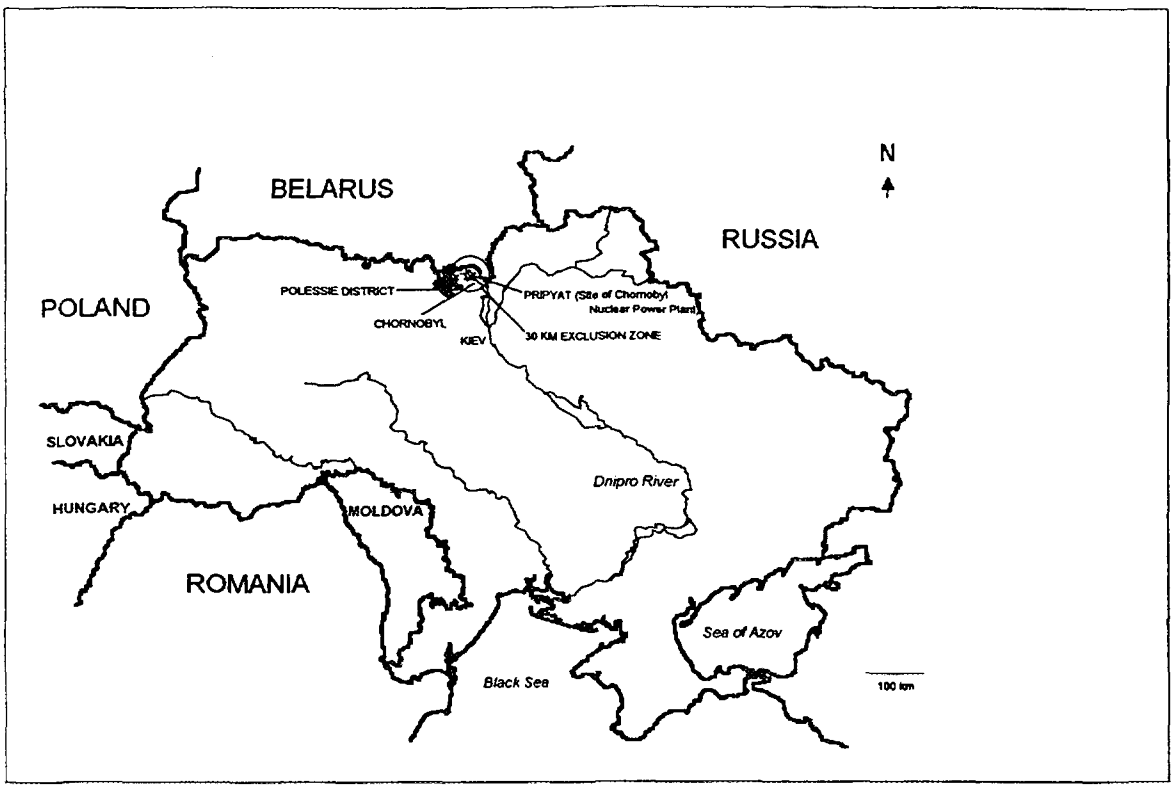

Figure 1: Location of the GIS Pilot Project Study Area

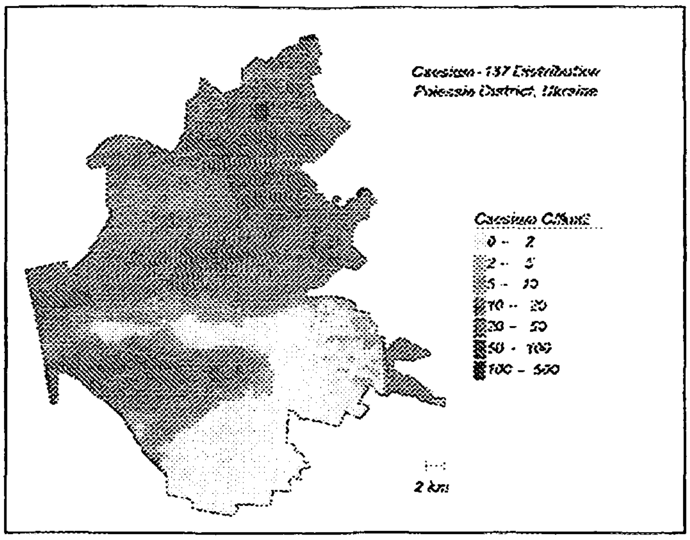

Figure 2: Map of Caesium-137 Contamination in the Polessie District

3.3 Identification of Natural Landscape Zones

The manual delineation of natural landscape zones based on a classification system designed by Ukrainian scientists [Davidchuck, 1994] was replaced and facilitated by the GIS. The process involved the integration of data from various scales and sources; calculation of slopes; spatial analysis and overlay of multiple data sets; classification; and presentation of integrated results (e.g. contamination levels of soil types). Ukrainian scientists considered the natural landscape zones an essential component of countermeasure maps.

4.0 CONCLUSIONS

The Chernobyl GIS Pilot Project was successfully completed in December 1994. The project has demonstrated that GIS technology provides sophisticated analysis capabilities that are directly applicable to environmental impact studies of the Chernobyl accident. In this context, the project has allowed specialists from Ukraine to gain hands-on experience using GIS as it relates to data integration, data exchange, data modelling and map production. The pilot project has provided a better understanding of: the existing data types (e.g., paper maps, radionuclide databases); the administrative support available for GIS applications in Ukraine; the collection, input, analysis and output related to the initial applications; and, the production capacity of GIS installed in Kyiv. Following the pilot project completion, specialists trained on the system continued to develop innovative GIS applications beyond the objectives and scope established at the onset of the project.

The pilot project has identified serious weaknesses in the reliability of existing data (e.g., lack of geographic coordinates for point data), clarified which data analyses were realistic, and helped to define follow-up requirements for improved data collection methodologies. In addition to GIS technologies, the significance of remote sensing has become apparent during the course of the pilot project implementation. Remote sensing imagery would provide important and current map information on vegetation and land cover, monitoring of spring floods and forest fires for modelling applications. The credibility of countermeasure maps for the contaminated territories would be enhanced, if prepared using remote sensing images as base maps. The pilot project has been successful in meeting most of the objectives identified, as well as in highlighting the requirements to be addressed in follow-up projects.

The authors hope that this pilot project will contribute to a better understanding of the impact of nuclear accidents and, in particular, how the GIS technologies can facilitate the formulation of policies for the rehabilitation of contaminated territories. Given the possibility of similar accidents at nuclear facilities elsewhere around the globe, the development of recovery mapping methodologies and policy strategies based on the Chernobyl experience could be invaluable in the future. The pilot project is also considered as part of the Canadian contributin to the G-7 initiatives to close the Chernobyl nuclear power plant, and to eliminate environmental consequences of the disaster.

REFERENCES

Chabanyuk, V.S. 1994. Semantic Modelling in the Chernobyl GIS Project. Proceedings, Canadian GIS Conference, June 6-10, 1994. Ottawa. pp. 1036-1047.

Holtham, C.; ed. 1992. Executive Information Systems and Decision Support. UNICOM Applied Information Technology 15. London, England: Chapman & Hall.

Dombrowski, A.; Palko, S. 1995. GIS Training in the Former USSR: A Case Study. CD-ROM Proceedings, The 7th International Conference on Geomatics, June 11-15, 1995. Ottawa.

Guariso, G.; Page, B.; ed. 1994. Computer Support for Environmental Impact Assessment. Proceedings of the International Federation for Information Processing, Technical Committee 5, Working Group 5: Working Conference, Como, Italy, October 6-8, 1993. Amsterdam: North-Holland.

Nagel, S. S.; ed. 1993. Computer-Aided Decision Analysis: Theory and Applications. Westport, Connecticut: Quorum Books.

Palko, S.; Glieca, M.; Dombrowski, A.; Kéna-Cohen, S. 1995. Belarus-Canada-Ukraine Project on Chernobyl. CD-ROM Proceedings, The 7th International Conference on Geomatics, June 11-15, 1995. Ottawa.

Phillips, F.Y.; ed. 1992. Thinkwork: Working, Learning, and Managing in a Computer-Interactive Society. Westport, Connecticut: Praeger.

Prister, B.S.; Tabatchnyi, L.J.; Chabanyuk, V.S. 1994. Liquidation of the Chernobyl After-Effects and GIS. Proceedings, Canadian GIS Conference, June 6-10, 1994. Ottawa. pp. 1025-1035.