Application of Digital Geoinformation System to the Environmental Control of Mine Waters Within a Coal Mining Area

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ABSTRACT

This contribution deals with the proposal of the information system for the environmental control of mine waters. It gives an informative description of geoinformation system followed by the system development according to the System development methodology. All phases are briefly described and diagrammatically displayed. The system is being realised in the frame of geological information system.

Its content covers the following chapters: Introduction; Integrated digital geoinformation system; Planing of the information system for the environmental control of mine waters; Proposal of the information system for the environmental control of mine waters; Creation of the data base; Production lines for the data base update; Retrieval and display; Conclusions and recommendations; Literature

INTRODUCTION

The concept and the operationality of the information systems have entered various fields of sociological, managerial, technical, educational and other nature. Geosciences are not an exception since the geoinformation plays ever increasing role for human environment planning and land resources management. Properly structured geoinformations stored in the data base files which are linked to the computer graphic systems and analyzed by the used oriented queries represent powerful tool for support of the decision making process.

This paper aims to show the approach of generating a specialised information system related to the environmental control of mine waters in the frame of the Integrated digital geoinformation system. System development methodology in used to design all three components of the system, namely technology, database and infrastructure. The proposal is based on the information and knowledge about coal mines in Velenje and Zasavje in Slovenia.

INTEGRATED DIGITAL GEOINFORMATION SYSTEM

Since the computer handling of geo data began, various terms have been used to identify this activity. This term does not have an agreed definition nor criteria to determine if a particular system collects, verifies, process, archives and retrieves "geo" data then it is a geoinformation system. (GIS)

Integrated digital geoinformation system (IGDS) is the collection of selected geodata in digital form with the following tasks:

- display of geodata
- query of geodata base for specific tasks
- map analysis with reference to a specific problem
- spatial modelling including spatial statistics for analysis of geodata
- provision of the capability to support an ongoing decision process
- provision of the relevant data for research and development

Figure 1 shows the concept of the IGDS. System contains selected geoinformation related to soil, forestry, geology, hydrography, topography, etc. Topographic subsystem provides among other components also the metric base for the georeferencing.

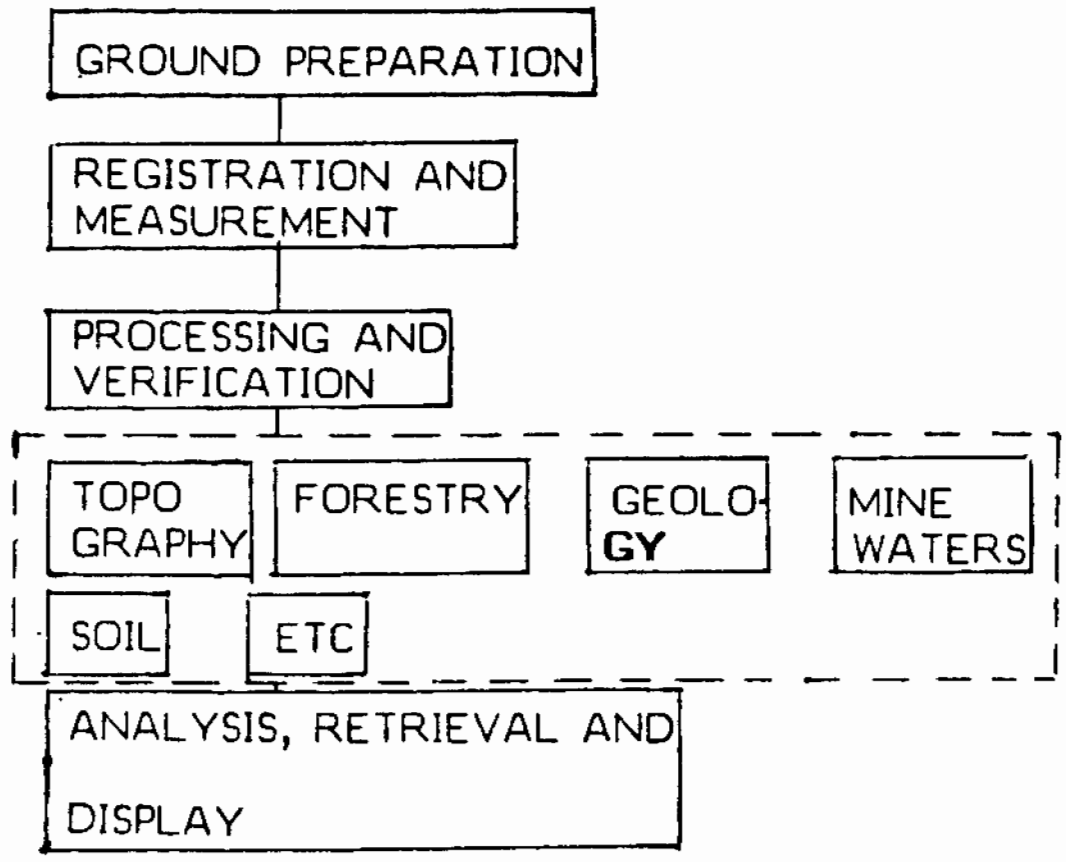


Figure 1. Concept of IGDS

Data input to each of the subsystems consists of ground preparation, registration and/or measurements and preprocessing wit verification. Archived data are analyzed, retrieved and displayed/presented ion the form according to the user requirements.

In the complex environmental and land resource management analysis data are aggregated and combined from various subsystems. In this context the geological data play an important role specially in the management of non renewable resources and human environment planning. One of the components of this subsystem are also the mining areas with the specific problem of the environmental control of mine waters being also important from the aspects of mining areas in the regional geionformation system.

PLANNING OF THE INFORMATION SYSTEM FOR THE ENVIRONMENTAL CONTROL OF MINE WATERS

In the coal mining methodology the underground water is pumped out during the excavation of the coal. This water, if not properly regulated, physically and chemically purified and conveyed into the natural water stream has the negative direct and indirect impact on to the environment. This disastrous effects can be summarised as follows:

- subsisting and/or land sliding of the particular terrain segments
- deflection of the location (relocation) of the existing river streams
- installation of the sometimes extensive drainage objects (wells, drainage, pipes, conveyance pipes and other technical infrastructure)
- variation in the level of ground water
- variation of the water quality of surface and ground water
- variation of the water quantity of surface and ground water

Due to the fact that each of the above mentioned impacts on the environment requires different data base structure and specific hardware/software configuration for data base update the entire system should be broken down to relevant subprojects. Figure 2 shows general diagram of System Development Methodology (SDM) which could be used to design an implement each of the subprojects.

METHODS	TECHNIQUES	MINE WATERS SYSTEM
INFORMATION SYSTEM PLANNING	ENQUETTE	INFORMATION IS NEEDED BY RESEARCH AND CONSULTANT OFFICES AND REGIONAL ENVIRONMENT PLANNING
DEFINITION STUDY	COST BENEFIT	INVESTMENT IS DUE TO THE EUMINATION OF COSTLY TERRAIN WORK RETURNED IN THE FRAME OF ON MIDJERM PERICO
SYSTEM DESIGN DETAILED SYSTEM DESIGN	FUNCTION AND DATA ANALYSIS	TECHNICAL DESIGN, LEGAL STATUS DESIGN, INFORMATION/DOCUMENTA-TION DESIGN FOR MINE WATERS DESIGN
IMPLEMENTATION	PROGRAMMING	COMERCIAL SOFTWARE PACKAGES WITH ADITTIONAL PROGRAMMING
INSTALLATION	HARDWARE AND SOFTWARE INSTALLATION	DATA BASE UPDATE PRODUCTION LINES, HARDWARE/SOFTWARE
OPERATION AND CONTROLL	MANAGEMENT	CREATION OF DATA BASE DATA BASE UPDATE QUALITY CONTROLL RETRIEVAL AND DISPLAY MAINTANANCE

Figure 2: System development methodology (SDM)

PROPOSAL OF THE INFORMATION SYSTEM FOR THE ENVIRONMENTAL CONTROL OF MINE WATERS

The design and the implementation of the information system for the environmental control of mine waters is composed of the following parts:

- data base creation with data base management system
- generation of the production lines for data base update
- data retrieval, display and presentation

Data base creation

The diagram for the data base creation is shown on the Fig. 3. Input documents are in the form of the existing maps and physical measurements which are converted into the digital form. Data are structured such that the efficient data base management is possible. For this specific information system the relational date base is preferred enabling links to other (regional) files for GIS applications.

Data base update

Diagram for the data base update is presented in the Fig. 4. it should be emphasized that the technology for various subsystems differs significantly due to the integrated nature of the entire system.

Ground monumentation in the mine area is necessary to provide the geometric frame for the georeferencing of the data in any subsystem. The coordinate can be generated by Global Positioning System (GPS), Aerial Triangulation (AT), Geodetic survey and by digitising the existing maps. Ground points have to be properly signalised and maintained to allow the metric remeasurements for subsequent data base update.

Digital Terrain Model represents the terrain in digital form. Its availability in combination with digital monoplotter simplifies the updating of the river stream and drainage objects file. Digital Terrain modelling software can be used also for presentation of the ground water bodies and volume computations.

Ground subsidence and land slide file is updated by using the combination of aerial and terrestrial photogrammetry. It is proposed that terrestrial photography is used for registration and measurements of the land sliding in predetermined time intervals whereas the aerial photography is used for the determination of the ground subsistence vectors.
Both systems use similar software packages and equal measuring registration devices.

River stream and drainage objects can be updated by using digital monoplotter. Aerial photography taken by the non-metric camera mounted on the microlight aircraft can be digitised and directly entered into the river stream and water objects file together with corresponding attributes. Link to the detailed installation data for drainage objects is also provided.

Ground water file is updated by using the data from newly drilled holes. Usually lower and upper ground water level are stored in this file together with the proper location.

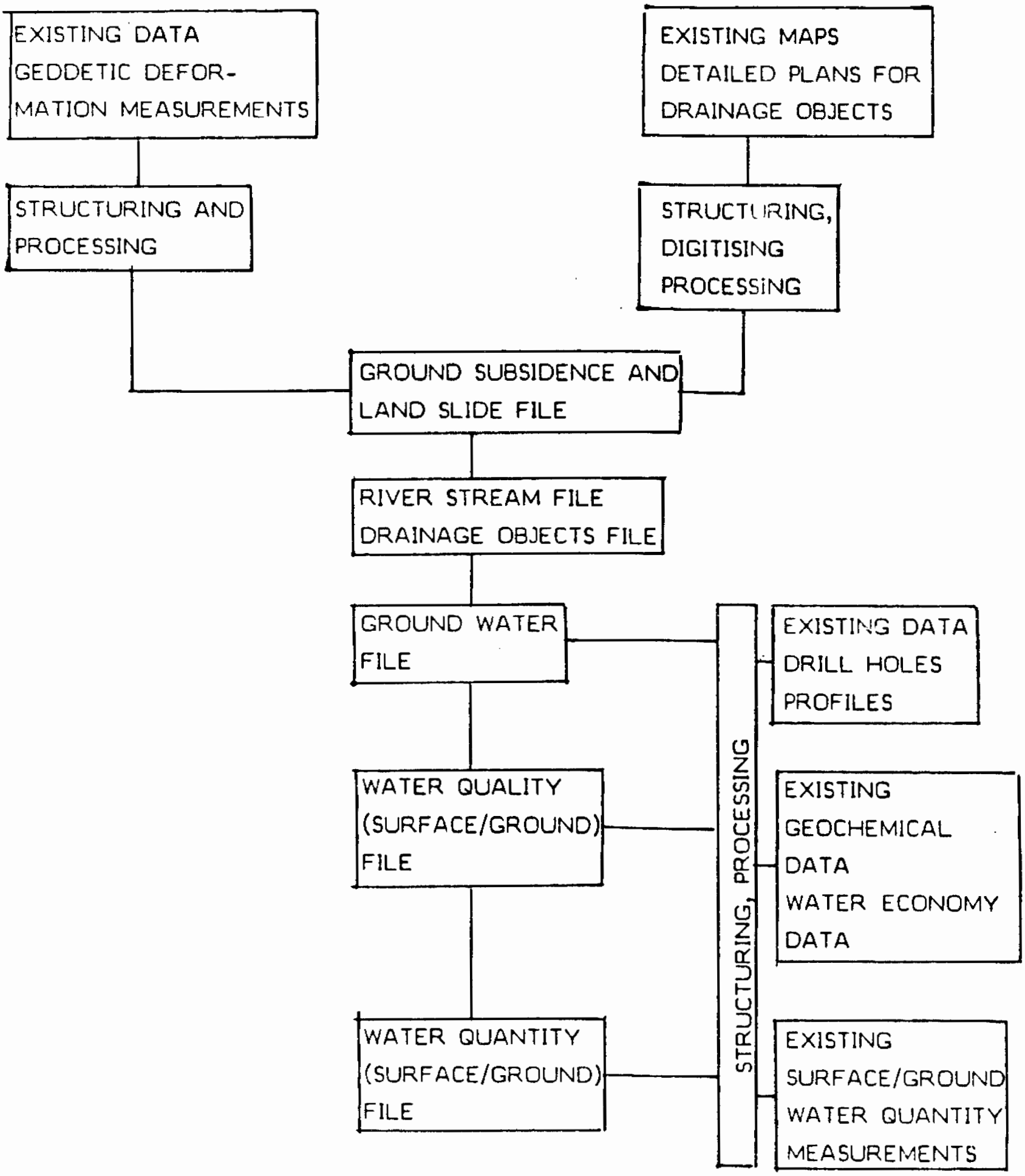


Figure 3. Creation of Data Base

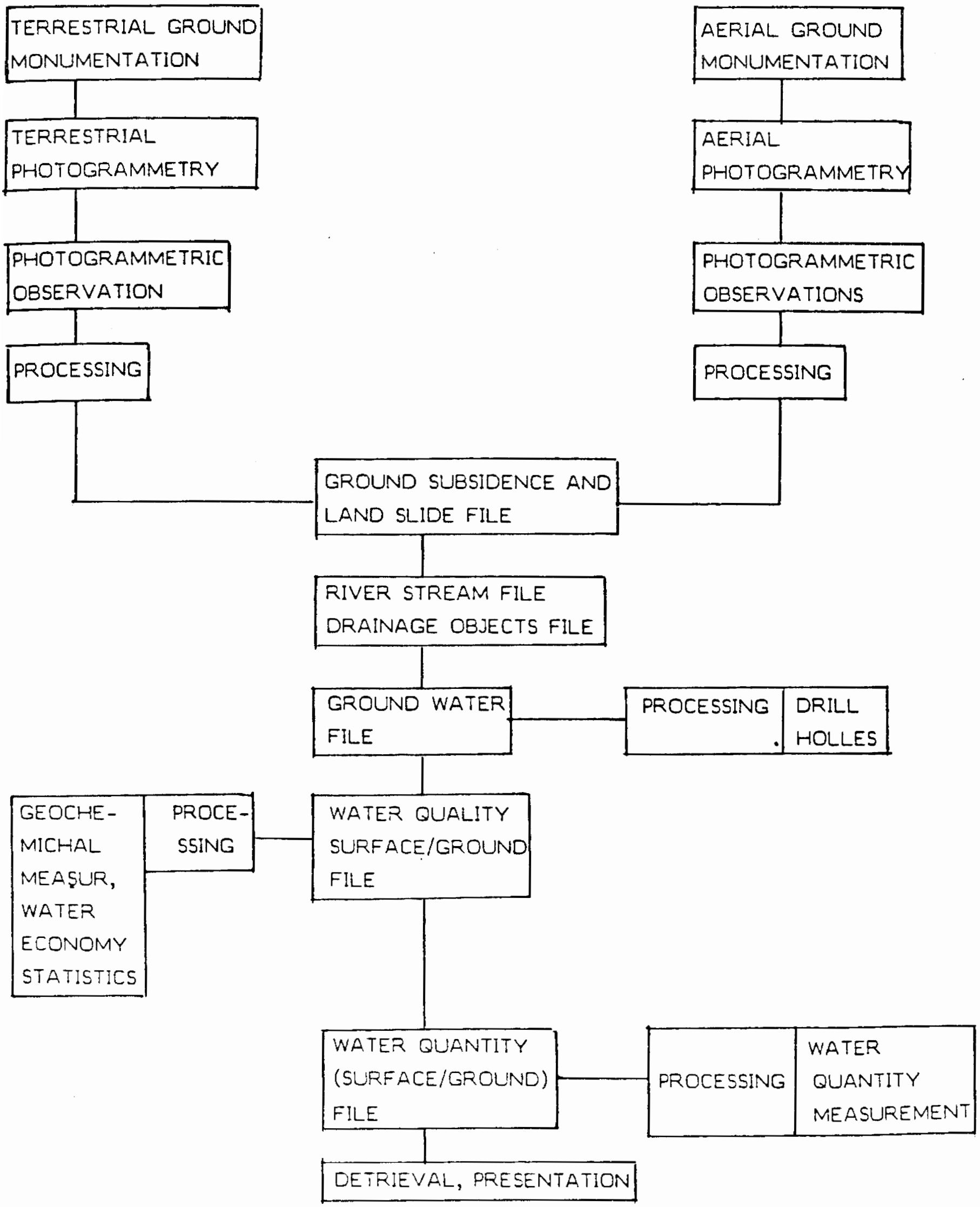


Figure 4. Data Base Up Date

Water (surface/ground) quality file is updated by making use of the data obtained from the geochemical analysis and data derived by the water economy statistics. Data are properly structured and entered with geocode into the data base.

Water (surface/ground) quantity data are updated using measurements an derived data. Data are stored with proper attributes and georeferenced.

Retrieval and display

After the results for the specific query have been generated the data from various files are displayed and presented in graphic and/or tabular form.

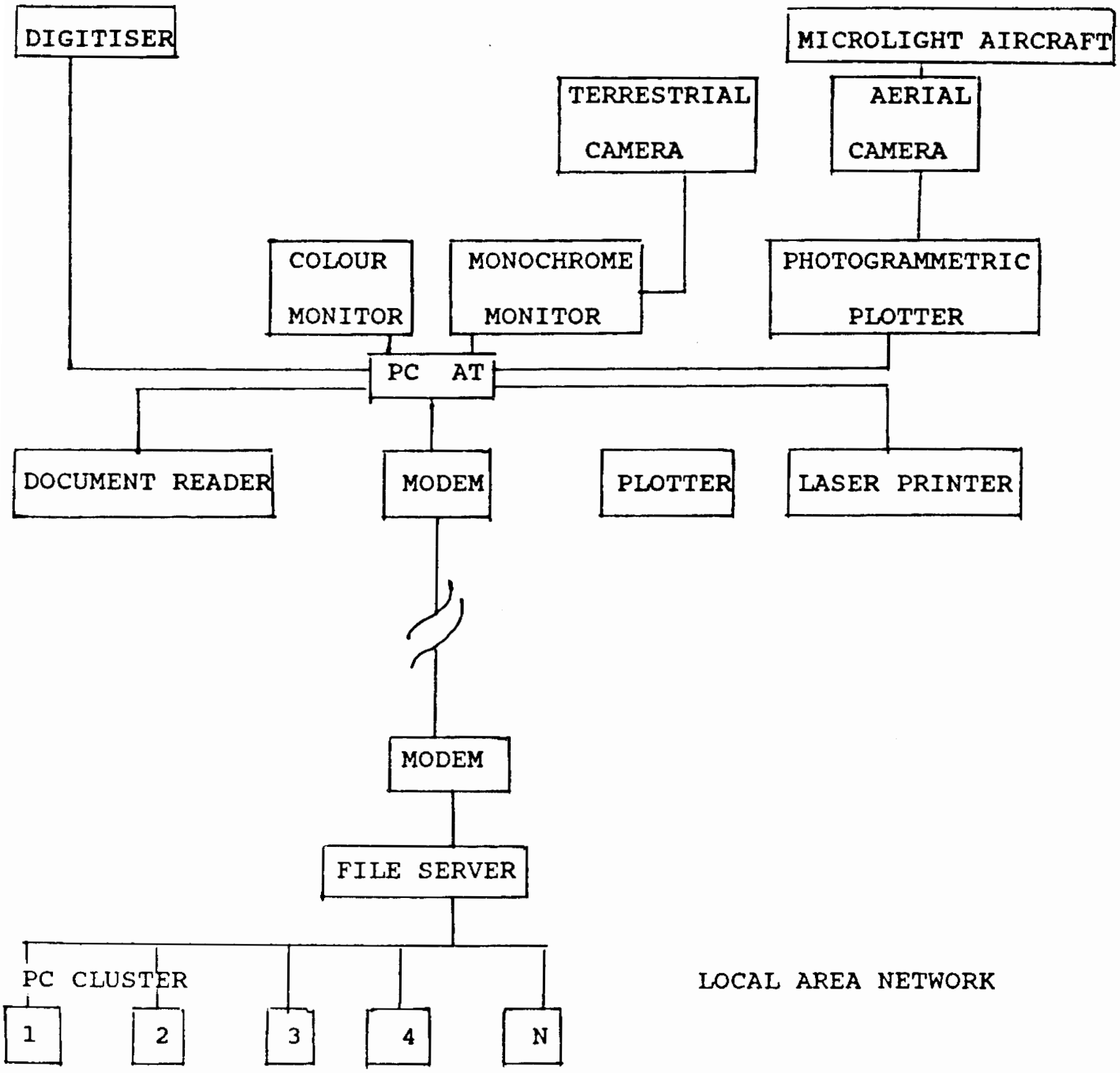
Ground subsistence and land slide presentation is realised graphically by the vectors showing the quantity and direction of the point deformation .This vector display can be overlaid by topographic file to give the georeferencing information. Numerical values of the deformations are also stored in the tabular form for further computations and statistical processing.

River stream and drainage objects are presented as the topographic map in user defined scale. The deflection of the river stream is plotted against the existing files and accompanied wit tabular data of calculated areas. The location of the drainage objects is presented in corresponding graphical standards. This file is linked to the graphical plan of the installation by attribute.

Ground water file presentation by the profile plot of drilled holes with upper and lower water levels. The location of the other data of the holes are given in the tabular form.

Water quality and quantity file is presented in tabular form with respective set of measurements and diagrams.

Hardware configuration



Software configuration

Data base operations

- graphic data base and object generation
- attribute data base generation
- data base management

Data collection

- vector/raster/ vector transformation
- photogrammetric mono and stereo digitising
- document reading software

Data processing

- digital terrain model processing
- statistical and interpretation computation

Data presentation

- plotting software

CONCLUSIONS AND RECOMMENDATIONS

The proposed system will be generated in one of the mines of Slovenia for the testing and necessary modifications. When the operation and control of the system will be at the acceptance level the data will be at disposal also for other users and regional resource management institutions.

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