An Approach to Management Decision Support: The Coal Mine Pljevlja Management Information System

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ABSTRACT: In this paper we describe the approach that has been used in the development of the Management Information System (MIS) in the Coal Mine Pljevlja in Montenegro. The methodology of this approach was based on new information technologies and management techniques which have already been successfully applied in other related fields. Its main goal was to introduce modern management techniques to mining, adapted to specific features of the mining industry, its operations and environment, thus enabling the tactical management in mining to apply novel management technologies which are already being used with success in other industrial branches.
MIS is an intelligent system for supporting decision making in the mine, developed within the Technological Information System (TIS), using a combination of different IT technologies such as .NET, OLTP, OLAP, WEB, SQL Server Reporting Services and others. It is a system for direct analytical data processing implemented through Microsoft® SQL Server™ 2000 Analysis Services which supports multidimensional views of business data.
The methodology has already been applied in the development of the first phase of the Coal Mine Pljevlja MIS aimed at monitoring and management of transportation costs, in the summer of 2005. It resulted in the establishment of an efficient system of information, thus motivating the mining management, especially on the tactical level, to initiate enhancements of production processes, as well as the development of more complex components of management. The first results showed that considerable reduction of transportation costs are possible and the coal mine top management made a decision to continue developing the other subsystems of the MIS following the same approach.

1 INTRODUCTION

Technology alone is not the panacea for overcoming challenges faced by the mining industry. Leadership and a collaborative strategy are also very important. Technological change is not simply the implementation of new machines, computers and software. Technology should be employed to plan, design and operate differently, to be better informed and intelligent in decision-making, more efficient in operation, safer, and more responsible to society. This paper is focused on the excavation process: ore delineation, development, production and waste management. Design and planning of these processes in the future needs to be closely integrated into more holistic mining systems, considering all controlling factors and impacts (technical, economic, environmental and social). It is crucial for the mining industry to develop a strategy for information technology and human resource development to address all of the issues that will improve its sustainability over the next two decades.

2 THE TECHNOLOGICAL INFORMATION SYSTEM

The Technological Information System (TIS) encompasses the most important segments of mine business operations, namely: personnel record keeping and job classification; mining equipment data management; monitoring of coal production; managing of equipment maintenance information; and MIS - management information and decision support system.
TIS provides real time information generation during the production process organized in shifts for improved management control. As each machine works, its action is recorded in the TIS database. As a

web based reporting tool MIS allows mine personnel to view reports from any location. The defined framework of electronic business (e-business) opens up the possibilities for the Mine to integrate its systems with IT solutions of third parties - business partners and clients, in a single business chain through Internet. Furthermore, e-business contributes to competitiveness, cost reduction and facilitates the accomplishment of production tasks. E-business technology enables the management to efficiently plan, carry out and monitor the realization of tactical and strategic goals.
Figure 1 shows the architecture of TIS as a starting point for the construction of an e-mine. This figure shows two open pits, but if new sites and production complexes are opened, they can also be included in the system.

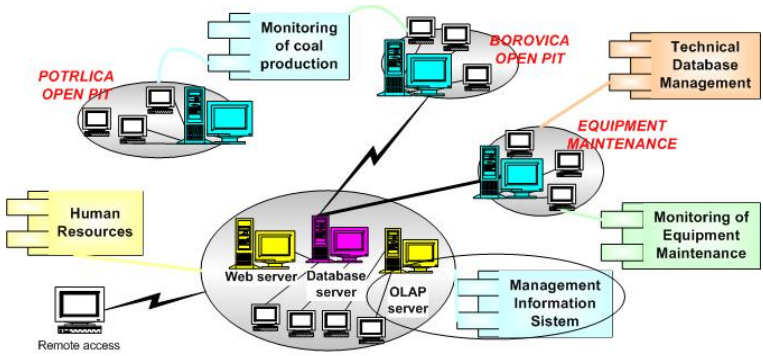

Figure 1. Architecture of TIS for Coal Mine Pljevlja

2.1 Human resources

The human resources system enables monitoring of data of an employee, starting from the moment when he/she joins the company. Personnel files contain general information about an employee, such as: date of birth, address, personal documents, education, qualifications, family status and state of health, labour relations, data on previous employment(s), special skills, as well as other general information.
The most important modules are: maintenance of the employee files (identification, classification and general information about the employee, professional training, occupation, state of health, etc.); monitoring of labour relations (organizational entities, job classification, all kinds of decisions pertaining to labour relations, change of workplace, etc.); reporting on labour relations (enquiries about an employee, statistical reviews on various basis, internal and external reports, etc.)

2.2 Technical database management

The system for technical database management realizes information support for equipment maintenance and includes all maintenance subjects, i.e. all types of equipment, facilities and transport means and connects them to corresponding graphical technical documentation. Therefore, this program system should regularly define and keep updated the basic technical characteristics of all maintenance subjects. Considering technical complexity of this program system, it is located in the places where maintenance is being carried out, i.e. technical preparation services of the pits' mechanical and electrical maintenance units, and the central maintenance unit.
For the purpose of easier management of data on equipment, a catalogue of equipment components has been made, containing prototypes of the hierarchical structure of equipment. Namely, component trees according to the types of equipment represent prototypes of the equipment with all their integral parts. All the parts, starting from the smallest ones (belt, steel rope,...), assemblies (hand-brake pushing system, cab assembly), to the very machines (dump truck, grader) are entered in the lists of equipment types. Detailed information has to be entered for every part mentioned above. Figure 2 shows a hierarchical tree with equipment components, and respective part characteristics on the right side of the form. The technical database, connected with technical documentation and drawings (assembly drawings, production drawings, workshop drawings, etc.) represents the technical basis for all other business processes related to maintenance, production, development, etc. The documents are classified according to types, and they can also relate to technical drawings.

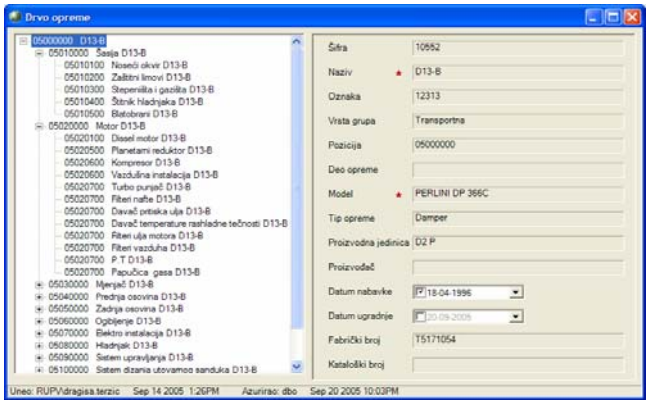

Figure 2. Component tree for mining equipment

2.3 Monitoring of coal production

The system for monitoring of production and preparation of coal is designed in such a way as to collect, register and present for perusal, mostly to those who manage coal production, all of the most significant production parameters, production events and circumstances, which considerably influence the monitoring process and the capability to manage coal production. Recording of the most important information from the production process, in all the technological phases, is being carried out by regular data input, in order to make data electronically registered in real time and presented for inspection, to help production process management and periodical reporting.

All production capacities in the technological chain of production are defined on basis of data on equipment and locations. The technological chain of production is being elaborated through production operations. The solution encompasses the data on all production capacities in the technological chain of production, the data on all production events and subjects, as well as places of vital importance for production monitoring (excavating-loading equipment, transport equipment, equipment for drilling-blasting works, coal preparation equipment, auxiliary machinery and equipment, electric energy installations, dumps, locations where data have been taken from, shifts, etc.). Respective jobs and operations are defined for each production unit, followed by locations where they are carried out.

The following types of information are considered: produced quantities of coal per assortments, realized efficiency of equipment, realized wages, production standstills, breakdowns, operative events, condition of equipment and facilities, condition of dumps, quality of coal and waste water, shift reports, consumption of spare parts, fuels, lubricants, consumables, etc. If changes of mining conditions and/or availability of production units occur during a shift, the previous schedule will be updated.

During a shift the production process is monitored, stoppages are registered and orders for repair of defects are prepared, as shown in Figure 3. Every event assessed as interesting in the first place for production process is registered (defect, stoppages, but also foul weather, fogs, conflagrations, averages, etc.). Breakdowns are classified as: mechanical, electrical, organizational and meteorological, and the place of occurrence is also recorded.

2.4 Monitoring of equipment maintenance

The system for equipment maintenance represents information support for the tasks of technological-technical preparation of maintenance and keeps records of the performed maintenance tasks. The main task of this program system is to register practically all maintenance jobs of some significance on the machines or the equipment, i.e. the issuing of work orders for all maintenance tasks, if possible.

The system for maintenance of equipment cannot function without previously realized system for technical database management, which defines all maintenance subjects, their structure and requests for preventive maintenance according to the equipment manufacturer's recommendations or on basis of personal experience. Also, it is necessary to connect this program system with the program system for technical graphics, because practically all maintenance works are carried out using technical documentation and corresponding drawings. Maintenance works are defined per every type of equipment.

The basic module of this system is for issuing maintenance work orders, which includes technical elaboration of: equipment maintenance operations, troubleshooting, required workforce per norm, all spare parts, materials and drawings necessary to carry out the works, as shown in Figure 4.

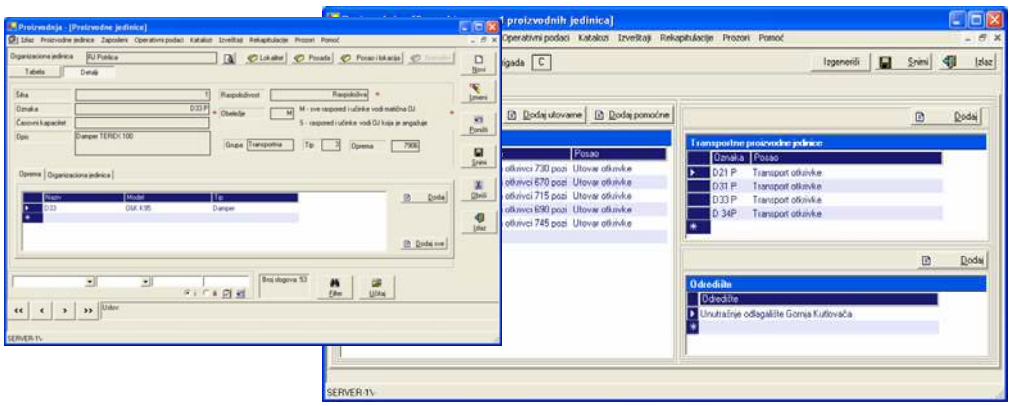

Figure 3. Recording of production data

This program system is used for issuing and monitoring of realization of internal orders for procurement of necessary equipment or spare parts, requisitions of materials and spare parts from the warehouse, orders to the Commercial Department concerning services of third parties, orders for obtaining drawings of technical documentation, orders for prospective drawing up of projects required, orders for modification of technical documentation, and so on.

3 MIS SYSTEM

The possibility to apply the most advanced IT in these areas contributes to the value of business in many ways: improvement of the system, availability and possibility to develop relationships with clients, users interface that offer better strategic as well as operative decision making possibilities, cooperation with business partners based on the Web, insight into great possibilities allowed by scenarios of strategic decision making, etc. Speaking of the time needed to make an efficient decision, optimization of the process must be carried out at all levels of planning and implementation: strategic, tactical and monitoring level.

3.1 Reporting module

The aim of this program is to make available online all the most important summary data from the daily operative events in the mine to the managers.

The managers' reporting needs are modeled through by a global model of data related to the most important business segments (production, maintenance, operative costs, etc.). MIS presents updated and precise data to the managers of the company in a clear and synoptic way. It is necessary that all the operative business segments of interest for the managerial structure of the company be electronically supported, so that summary information can be automatically provided.

A production balance is made at the end of each shift, i.e. the data on the produced quantities of coal per assortments are registered, as well as realized efficiency of the equipment, realized wages, workers involvement, data on production standstills, equipment and machinery failures, information about all types of operative events that influence production, drilling-blasting works, condition of equipment and facilities, condition of dumps, quality of coal and waste water, shift reports, etc. Figure 4 presents the form with parameters for report generation and the preview of the report.

Reporting and reviews on maintenance enable insight into operative readiness and circumstances and condition of production and other equipment, performed maintenance works, maintenance costs and other reviews based on available data. These processes require close cooperation of maintenance workers, operative staff, as well as the team for spare parts and intermediate goods management which provides necessary spare parts. This enables timely and reliable decisions to be made on: plan of preventive

maintenance and parameters for defining the schedule of the planned maintenance; processes based on the course of work and in such a way that the problem is handled immediately after the planned stoppage of works; monitoring the costs of the equipment work life in real time and measuring deviations from expected values; priorities for including equipment from the maintenance process.

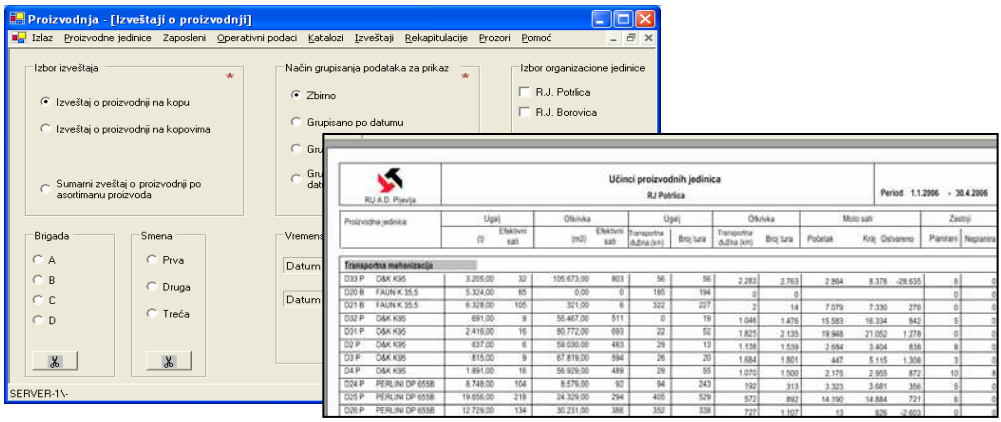

Figure 4. Form with parameters selection and generated report

3.2 Online Analytical Processing

MIS, as an intelligent system for support of decision making in the mine uses the combination of various IT technologies, such as OLTP (On Line Transactional Processing), OLAP (On Line Analytical Processing), WEB, SQL Server Reporting Services, etc. Hence, it is a system for direct analytical data processing implemented through Microsoft® SQL Server™ 2000 Analysis Services, which supports multidimensional views on business data, using the technology of multidimensional or relational databases. Managers and analysts who often require higher levels of aggregated views on business data use this technology.

Online analytical processing is a capability of management, decision support and executive information systems that enables managers and analysts to interactively examine and manipulate large amounts of detailed and consolidated data from many perspectives. OLAP involves analyzing complex relationships among thousands or even millions of data items stored in multidimensional databases to discover patterns, trends, and exception conditions. An OLAP session takes place online in real time, with rapid responses to manager's or analyst's queries, so that their analytical or decision-making process is undisturbed. Online analytical processing involves several basic analytical operations, including consolidation, "drill-down" and "slicing and dicing".

Consolidation involves the aggregation of data. This can involve simple roll-ups or complex grouping involving interrelated data. For example, production by each production unit can be rolled up to production by type of equipment and further can be rolled up to open pit, or the whole mine, aggregated for specified period, by products (figure 5).

In drilldown reports, OLAP can go in the reverse direction and automatically display detailed data that comprises consolidated data. For example, equipment breakdowns can be accessed by mining production system, equipment or its component part, as well as by the breakdown type or more detailed causes.

Slicing and dicing refers to the ability to look at the database from different viewpoints. One slice of the human resources cube can represent all employees of the same age, another of the same sex, etc. as displayed on figure 6 with the browsed data and structure of the OLAP cube in MIS.

The developed system provides the possibility to: access very large amount of data, for example several years of coal production; analyze relationships between many types of business elements, such as equipment, production, breakdowns, operational costs, organizational units; compare aggregated data over hierarchical time periods: monthly, quarterly, yearly and the like; and present data in different perspectives, such as breakdowns by equipment versus breakdowns by type and by working hour per organizational unit.

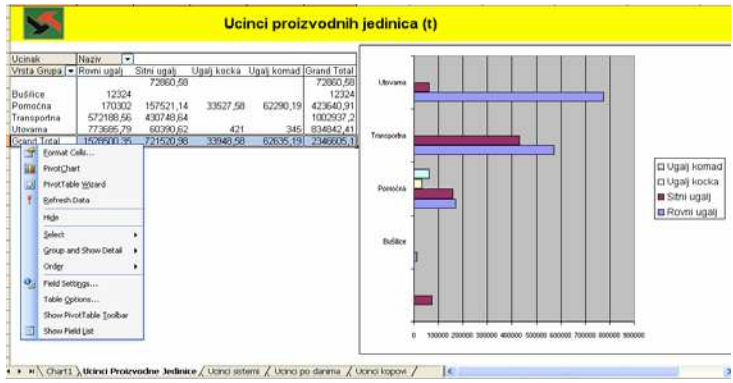

Figure 5. Pivot table based on OLAP cube with rolled-up production

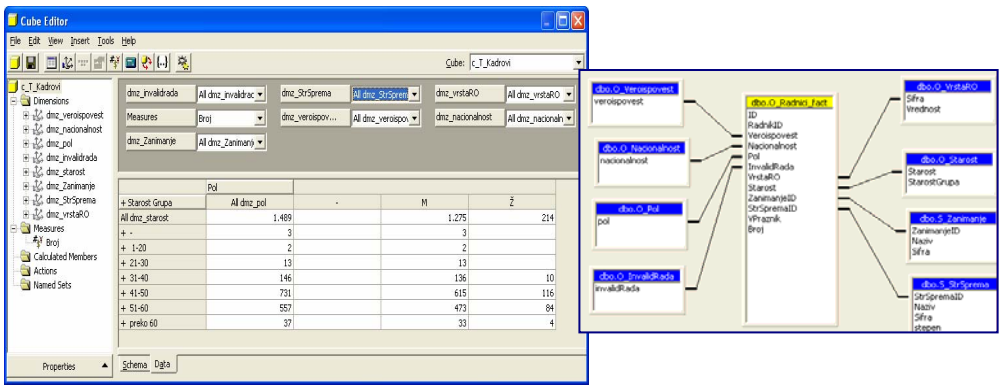

Figure 6. OLAP cube

4 CONCLUSION

TIS encompasses the most important segments of Coal Mine Pljevlja business operations, and they refer to: personnel records keeping and job classification, data on equipment included in the production process, production monitoring and coal preparation, maintenance information that influences the production costs, and finally MIS (Management Information and decision support System), which consists of a part of sublimated reports intended for the management structure of the company referring to production monitoring and coal preparation.

The presented methodology has already been applied in Coal Mine Pljevlja aimed at monitoring and management of coal production costs, in the summer of 2005. It resulted in the establishment of an efficient system of information, thus motivating the mining management, especially on the tactical level, to initiate enhancements of production processes, as well as the development of more complex components of management. The first results showed that considerable reduction of transportation costs are possible and the coal mine top management made a decision to continue developing the other subsystems of the TIS following the same approach.

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