ISSN No:-2456-2165

Open-Pit Mining Information Systems Support for Effective Strategic Schemes to the Pakistan Mineral Development Corporation

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Abstract:- Undeniably, ore blending is an essential process of open-pit mining, which to a high magnitude determines the efficiency of processing plant production. Therefore, it is necessary to manage this process efficiently, using contemporary ICT infrastructure. We have comprehended that the current software market in Pakistan is generally occupied or outsourced by foreign ICT companies offering expensive and closed-end software or digital solutions, especially in mining and drilling areas. At the same time, new ICT technology and modelling methods allow the software developers for developing models of mining process as a root for open source national mining software development for Pakistan`s setting. This paper suggests an open source information system for designing efficient technological schemes for open pit mining operations, which could be a positive trigger for ICT development in Pakistan`s software and mining industry and more specifically for Pakistan Mineral Development Cooperation (PMDC).

Keywords:- *open-pit mining, ore blending, ore flow management, simulation modelling, open source software*

I. INTRODUCTION

For mining companies, operational planning and controlling are the primary processes determining production effectiveness. Management mining operations are the organisation and coordination of all units to produce a commodity, with the prerequisites of the amount, quality and time for the maximum efficient consumption of available resources. The efficiency of ore processing depends on the consistency of the characteristics of raw material fended in a plant. When raw ore is highly variable in grade, the only method to ensure compatibility is to reclaim it before processing. Thus, redeeming of raw ore, to reduce the amount of variation in categories, is the indispensable part of mining. The other reasons for recovering in open-cast mining are to allow raw ore of different categories to be mixed to achieve a specified targeted grade and to homogenise the raw material [1]. This should be performed within the entire cycle of ore production and processing. Thus, there are three primary phases of reclaiming in the open-pit mining.

II. THEORETICAL GROUND

A. Blending theory

Many scholars and technologist considered the problem of ore blending in different techniques. In scientific and engineering literature, these reclaiming issues have been addressed in the primary site of mining areas [2], [4]. Authors like [5] and [6] have remarkably published the works on stabilising ore grades. Among several notable authors like [7], [8], [9] have already targeted the significant hurdles in the blending theory of mineral. The primary way to achieve targeted ore grade is related to the scheduling of mining operations, which means minimising the ore grade variations between the phases in addition to within each stage of deposit development. Mining operations scheduling allows reducing grade variation by ore faces. The disadvantages of planning and scheduling are the high complexity of this phase due to uncertainty related to geological issues of ore bodies, as well as the possibility of average ore grade only in large quantities. This method is a necessary phase in the overall scheme of the reclaiming process but not sufficient.

Another way involves the regulation of loading the currently used mining faces. Variations in mining face loading and technological schemes of extraction and loading operations are handled in a way so that the overall ore flow grade variations are minimal [3]. This method allows for smoothing out the mid-range and short-range variations in grade so it can be cast-off as a primary technique of blending in open cast mining. Combining with using special facilities and apparatus is the third way of achieving targeted ore grades. The most commonly practised and effective method is stockpiling, which allows reclaiming, blending and homogenising bulk materials. This method has the benefit of being simply dramatised to various geological and mining conditions and provides uniform loading of production equipment, allows achieving sufficient degree of reclaiming and, improves the reliability of the “pit - processing plant” system. However, it requires additional area and equipment, which increases the cost of production. A combined automobile and rail open-pit transportation system is considered to have the enormous potential of reclaiming. Therefore, reclaiming process could be performed not only within mining sites but also by operating transportation traffic as well as at open-pit stockyards, which could be determined in this case as blending facilities [1]. Current improvements in information and communication technologies allow for model systems with high complexity levels, thus making it possible to design and implement software models, which could reflect physical principles of the reclaiming process in mining planning and management more intensely [12].

ISSN No:-2456-2165

B. Open Source Schema (OSS)

Currently, leading software systems such as PolyMap mine and Ezvol software solutions, which are US-based mining information system software in the market offer an integrated, unified closed architecture and are less risky. Hence, national mining companies can only buy closed source software, which are based on developed patterns of mining process technological schemes determined in Figure 1.

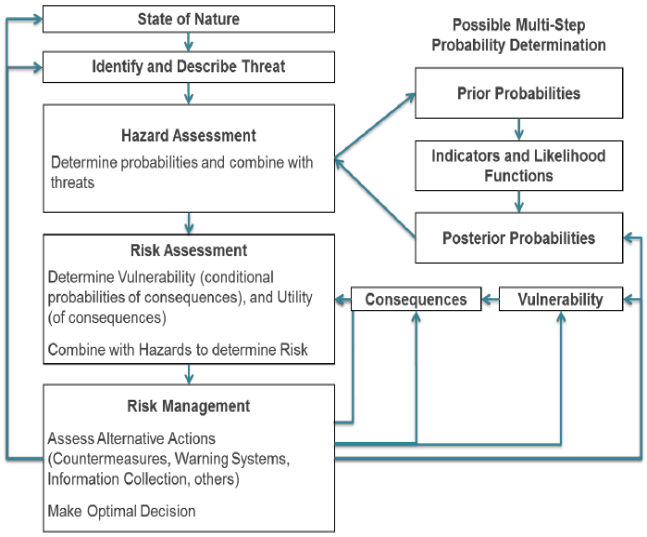

Fig 1:- The pattern of mining process in Poly Map system [4]

Those are as a rule sufficiently different from national ones and, therefore, do not fully meet requirements of domestic mining consumers. Therefore, mining companies become dependent on software vendors and are unable to extend the functionality through a 3rd party or internal upgrade, thus, hampering system modernisation and evolution [11]. Therefore, for the national mining industry, the development of open source domestic mining software is a subject of interest. An OSS approach applied to mining software will not only extend the functionality by unifying development and reducing duplication but also recover the exactness and reliability of the used calculations and create a "natural selection" among developed algorithms, which result in the ability to extend national mining software inexpensively [11].

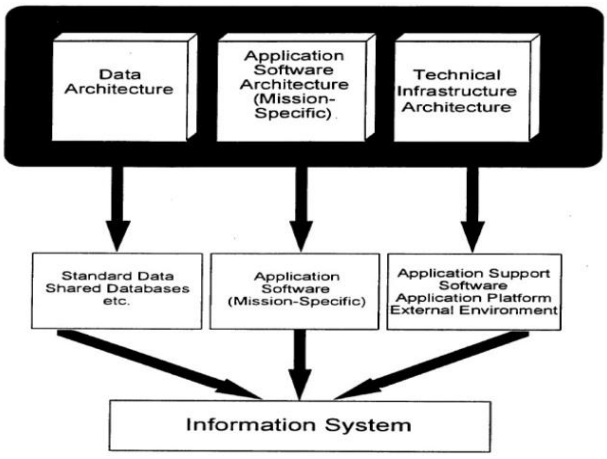

Fig 2:- TAFIM model for mining information system support [11]

From this perspective, the open system environment referential model (OSERM) defined by the POSIX working group of the Institute of Electrical and Electronics Engineers, is the most applicable for the development of a proposed geographic information system [11]. As shown in Figure 2, an extensible framework which has further codified the standards by relating them within a technical architecture for information management (TAFIM) form that allows (e.g services, interfaces, protocols, and supporting information formats etc.) to be distinct regarding nonproprietary specifications that evolve through open (unrestricted), consensus-based forums. A designated suite of requirements that defines these interfaces, services, protocols for a specific class or domain application is called a "profile" [8]. Furthermore in [12], [7] have identified numerous policy-based motives for implementation of open source platform specifically, the intensified value proposition from open source (when associated with peak proprietary) in the categories like the security, affordability, interoperability, and localisation.

III. SYSTEMATIC APPROACH FOR STABILIZATION

The objective of this research work is to develop an open-source information decision support system (IDSS) for designing efficient technological schemes of open-pit mining operations to stabilise ore grade fed to the processing plant. The primary objective of the proposed TAFIM is to organise operational planning and control mode, which allows reducing ore grade variations during the whole cycle of mining operations at the pit. This could be accomplished through the optimisation of excavating and operating processes as well as bed-blending on the stockyards [4]. This should lead to economic benefits for mining production as the homogenization of raw ore fed for processing reduces enrichment costs. At the first stage, it is essential to describe a controlled system which in this case is presented by ore flow within the open pit mining process. According to cybernetics approach, it is required to determine which external factors and systems of higher order effect and impose constraints and limitations on the controlled object and the management process itself. A framework which covers the whole cycle of ore reclaiming process within the open pit is determined in Figure 3.

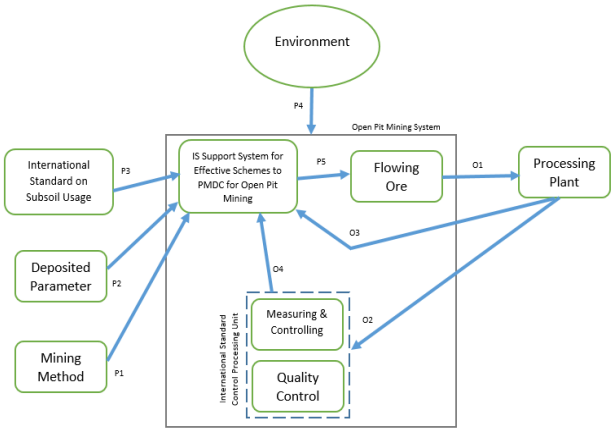

Fig 3:- Proposed framework labelling key factors affecting ore stabilisation process

ISSN No:-2456-2165

The following external and internal factors are reflected to be crucial for the process of stabilising ore grades. First is P1 – mining engineering methods, aspects and process parameters: loading and excavation, haulage and hoisting system, surface infrastructure. Second is P2 – geological parameters of the deposited ore: the attitude of the ore body, mode of ore body occurrence, ore type and mineralisation, limiting grade of ore. The third is P3 – international standard on subsoil usage. Fourth is P4 – processing plant requirements: the required grade and quantity of ore fed from the pit. Fifth is P5 – climate and geological conditions. For the output process O4 – describes management decisions on technological parameters of blasting, loading and excavation, truck dispatching, reclaiming at the stockyard. Meanwhile, O3 – is the variations in grades of ore fed from the pit. Lastly, O2 – is feedback provided by ore parameters control devices and quality control data.

IV. MODULATION OF INFORMATION SYSTEM SUPPORT

The modular structure of the proposed IS (information system) will reduce the project implementation time and will gradually extend system functionality and foster the assembling process described in Figure 4.

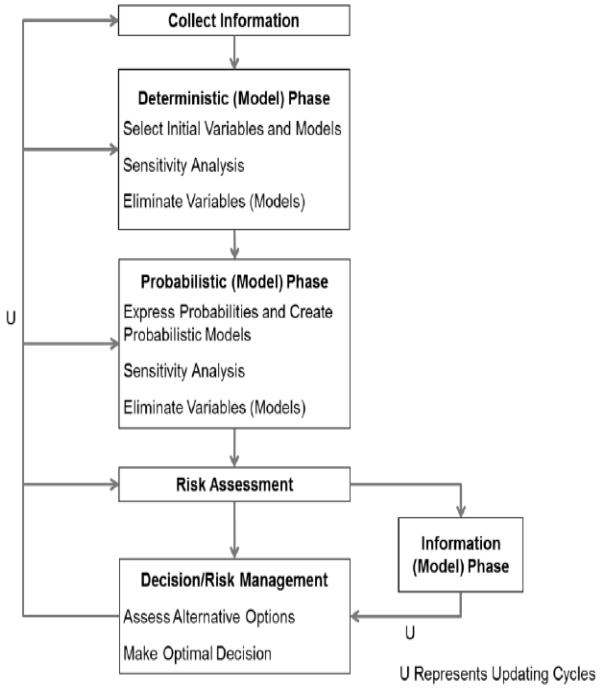

Fig 4:- Proposed modular IS for operational planning [12]

The analysis of reclaiming methods and operational planning and management objectives as well as the functional application of the software currently used in Pakistan mining allows the authors to propose an information system design, which includes four interconnected but independent modules. These modules aligned with four primary processes of the entire cycle of mining operations before ore shipment to the processing plant are 1) blasting 2) excavation and loading 3) haulage 4) storing and reclaiming at open pit stockyards. Functionality and interaction of the modules of the information system are shown in Figure 5.

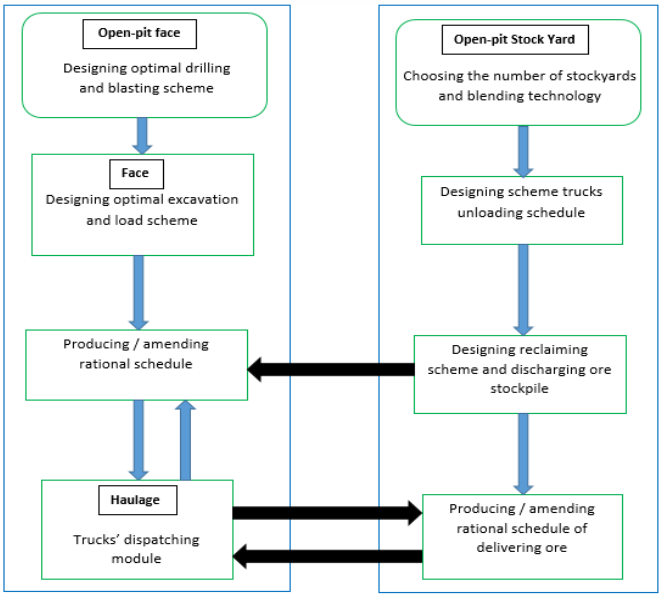

Fig 5:- The modular structure of decision support information system

Modules communicate through input and output. Previous module output data are input data for the next module. Each module resembles one of the four stages of reclaiming - if the result is not achieved at the final stage and ore grades at the output of the open pit do not meet processing complex requirements the system goes back to previous phase simulation, and the process repeats until it extends the preferred outcome. Input and output modules of an information system are presented in Table 1.

Modules Input Vectors

Bench	Face	Haulage	Open-pit stockyard
1. Schedule of open-pit mining operations	1. Geological data	1. Number of faces	1. Ore grade fed to dressing treatment
2. Digital model of ore deposit	2. Number of faces	2. Number of open pit stockyards	2. Stockpile geometry
	3. Bench parameters	3. The actual capacity of excavation and loading equipment	3. Current ore grades within stockpile and stockyard
	4. Schedule of open-pit mining operations	4. The capacity of haulage unit	4. Ore quantity and grade by zones of the stockpile
	5. Maximum capacity of excavation and loading equipment	5. Quantity and ore grade in each haulage unit	
		6. Distance between face and ore stockyard	

Table 1. The input and output parameters of information system modules

ISSN No:-2456-2165

Modules Output Vectors

Bench	Face	Haulage	Open-pit stockyard
1. Bench parameters	1. Corrected mining operations schedule	1. Current ore grades within stockpile and stockyard	1. Schedule for unloading trucks by stockyard zones
2. Excavation process parameters	2. Planned capacity of excavation and loading equipment	2. Schedule for dispatching trucks by stockyards	2. Stacking/ Reclaiming technology
3. Optimal faces allocation	3. The planned quantity of ores from each face		3. Average ore grades in shipment transportation units
4. Drilling and blasting process parameters	4. Quantity and ore grade in each haulage unit		4. Variation of ore grades within set periods

V. CONCLUSION

Currently, ore grade stabilisation remains a topical issue for the Pakistan Mineral Development Cooperation (PMDC) mining industry operating on mineral deposits characterised by significant variations of ore grades. The information decision support system for designing efficient technological schemes for stabilisation of ore grade at the open-pit output proposed by the authors is aimed at improving the quality of national mining operational planning and management through the development of national open-source software, which would be an alternative to expensive western closed architecture commercial offers. As mining remains one of the leading economic sectors in Pakistan and many other Commonwealth of Independent States (CIS) developed countries, the authors expect national software developers to be interested in contributing to the development of alternative open-source mining software.

ACKNOWLEDGEMENT

We would like to express our gratitude to the management and staff of Pakistan Mineral Development Cooperation (PMDC) for their support, assistance and allowing us to visit their information systems and data for the referential purpose.

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