Modeling Accident Data for Decision Support in Underground Coal Mines

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***Abstract*— Mine managerial officials have to take a variety of decisions on a routine basis for the smooth running of the mine. For arriving at any form of decision which is responsible for production, productivity or ensuring the safety of mine and miners, availability and easy access of information along with decision support will certainly not only to expedite but also to arrive at the right decision at the proper time. Making decisions concerning complex systems like underground mine safety often strains our cognitive capabilities. In many situations related to safety or disaster management or emergencies, the quality of decisions is very important which should be rationally supported by the available data and information. More recently the decisions are supported or enhanced by a variety of techniques originating from information science, cognitive psychology, and artificial intelligence, have been implemented in the form of computer programs, either as stand-alone tools or as integrated computing environments for complex decision making. Such environments are often given the common name of decision support systems (DSSs). A safety information and decision support system (SIDSS) for an underground coal mine is proposed here to realize coalmine safety under the uniform data management platform based on the technology of integration of coalmine information and decision support models as a modern safety information management system. A prototype SIDSS is discussed in detail here.**

Keywords*— *Decision Support System, Safety Information System, Coal Mine, Safety Management, Statistical Model

I. INTRODUCTION

In the past recent years, severe and fatal coal mine accidents have occurred in our country. The coal mine accidents have not only caused serious economic losses to the country and people, but also have had a negative impact on society and affairs of state. Therefore, coal mining safety and especially underground coal mine safety requires immediate consideration.

Currently, the management scheme adopted in these accidents, which is the experience management method. . Coalmine information is a kind of information which changes dynamically and relates closely to the spatial position of the advancing and/or retreating position of the mine. The rationalization management of information will clearly influence the prophecy and prevention of coalmine safety problems. How to realize the mining information and make it available when required immediately is very important since the information quantity involved is huge which includes Production Data, Ventilation Data, and Machinery Data etc. Decision-making Support systems (DMSS) are Information Systems designed to interactively support all phases of a user's decision-making process. There is little awareness of Decision Support Systems used in mining and frankly the underground mines in India have no such system to facilitate decision making of Safety managers or officers. A safety information and decision support system (SIDSS) for an underground coal mine is proposed here to realize entire underground coal mining data and use models to help the decisions of underground coal mining safety engineer for better safety and accident prevention.

II. NEED OF DECISION SUPPORT WITH INFORMATION MANAGEMENT

Analysis of safety in coal mines represents a very complex process. Published studies on mine safety analysis are usually based on research related to accidents statistics and hazard identification with risk assessment within the mining industry. Complexity of the subject matter requires a high level of expert knowledge and great experience. Often the decision taken during emergency situations are not supported by logical data. In day to day working of an underground coal mine, lot of information needs at one place which has multiple sources. The safety management personnel may or may not have direct control of the source and management of information. This could create problems or cause accidents.

Making decisions with reference to complex systems like underground mine safety often strains our process of perception, reasoning and judgment. In many situations related to safety or disaster management or emergencies, the quality of decisions is very important which should be rationally supported by the available data and information. More recently the decisions are supported or enhanced by a variety of techniques originating from information science, cognitive psychology, and artificial intelligence, have been implemented in the form of computer programs, either as stand-alone tools or as integrated computing environments for complex decision making. Such environments are often given

the common name of decision support systems (DSS). Thus, the solution is in the creation of a system with fusion of Information Management and Decision Support, whose knowledge base represents a formalization of the expert knowledge in the mine safety field. Using computer database, all safety and rescue related data could be uploaded in the system for future use. Analysis of data can identify possible areas of weakness in the mine safety system, and data can be used as a guideline for the decision making process to improve mine safety performance.

Decision-making in coal mine safety management deals with broad issues, which include:

(1) decision-making of safety management on a bropad perspective concerning the important problem about policy, guideline, governance structure, inspecting system of coal mine management, application of rules, laws, regulation and inspection mechanism etc;

(2) decision making with respect to the fields of coal mine enterprise that covers safety management in any phases of Planning, Organizing, Leading, balancing and Controlling;

(3) decision- making for the safety management of engineering project in coal mine, such as planning, or restructuring a mine;

(4) the decision-making of preventing, response and dealing with a coal mine accident. These decisions are serious-minded and significantly meaningful since they cover many fields of coal mine system and refer to most members in the coal mine organization.

Thus, the issues in coal mine safe management are complex and most of them are non-structured or semi-structured. The making of these decisions will be a gradual procedure, which requires a lot of information and knowledge referring to the domains production methods, level of technology and automation, manpower, resources available etc.

III. OBJECTIVE OF THE DEVELOPING A SAFETY INFORMATION AND DECISION SUPPORT SYSTEM (SIDSS)

The overall objective of the development of safety information and decision support system for an underground coal mine is to realize coalmine safety under the uniform data management platform based on the technology of integration of coalmine information and decision support models as a modern safety information management system. In detail, this can achieve the aim of multisource coalmine information collection, input, storage, index, query and professional analysis. It can further make the output of multisource information, real-time online analysis, process and decision, expert consultation in coalmine accident controlling. A comprehensive mining safety information management and decision support system for underground coal mine safety will have an emphasis on the development of the analytical / mathematical model for the decision support. The objectives are as listed below:

1. To develop a safety information management system, which will allow gathering of safety, accident and disaster related information to be collected and stored for use of analysis and decision support.
2. To develop analytical / mathematical models for analyzing decision-making situations, including a knowledge component.
3. To use data from the integrated information systems present, in and out of the underground coal mine as a basis of a decision support model.
4. To bring together human judgment and computerized information for semi-structured decision situations. Such problems cannot be conveniently solved by standard quantitative techniques or computerized systems.
5. To design a decision support model which draws information on the condition of the entire mine and adds an interpretative and preventative analytical layer together with data analysis capability to reduce the uncertainty and variability in the interpretation of mine data.
6. To provide support for various managerial levels from safety managers to mine manager.
7. To be easy to use, user friendly, with graphical capabilities, and an interactive human-machine interface for greater effectiveness of a Decision Support. ..

The aim is to develop a comprehensive online or web based safety information and decision support system for an underground coal mine with following components

- The Database
- Model Base
- Knowledge Base
- GUI

Some of the intended major capabilities are the following:

- To bring together human judgment and computerized information for semi-structured decision situations. Such problems cannot be conveniently solved by standard quantitative techniques or computerized systems.
- To be easy to use, user friendly, with graphical capabilities, and an interactive human-machine interface for greater effectiveness of a Decision Support.
- To use models for analyzing decision-making situations, including a knowledge component.
- To improve the effectiveness of decision making rather than its efficiency.
- To provide support for various managerial levels from safety managers to mine manager

IV. CONCEPT OF SAFETY INFORMATION AND DECISION SUPPORT SYSTEM (SIDSS)

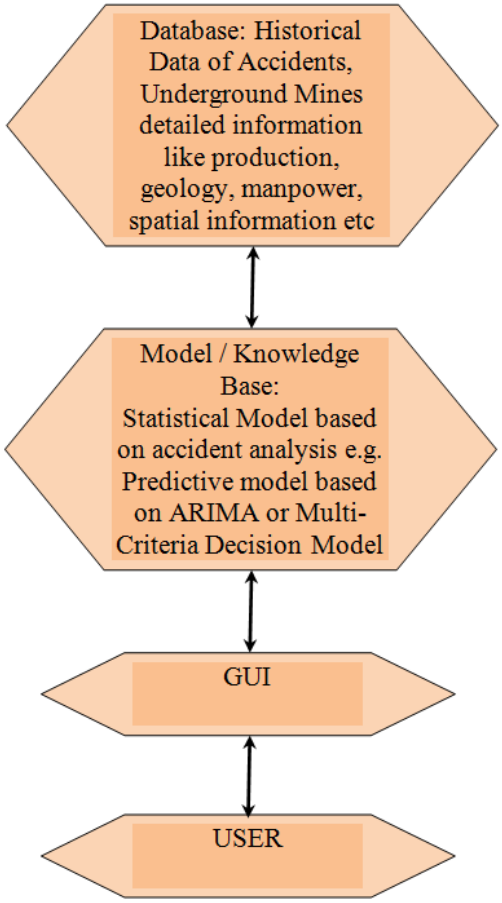
Safety Information and Decision Support System for an Underground Coal Mine is a model-based or knowledge-based system intended to support decision making in semi-structured or unstructured situations of safety management. It is not meant to replace a decision maker, but to extend safety managers decision making capabilities. It uses data, provides a clear user interface, and can incorporate the decision maker's own insights.

The database stores the data, model and knowledge bases store the collections of models and knowledge, respectively,

and the GUI allows the user to interact with the database, model base, and knowledge base. The database and knowledge base can be found in a basic information system.

Database

The database provides the data with which decisions are made. Database may include various safety data related to Production, Machinery, Environment, Safety Compliance, Training and past accident data.



Model Base

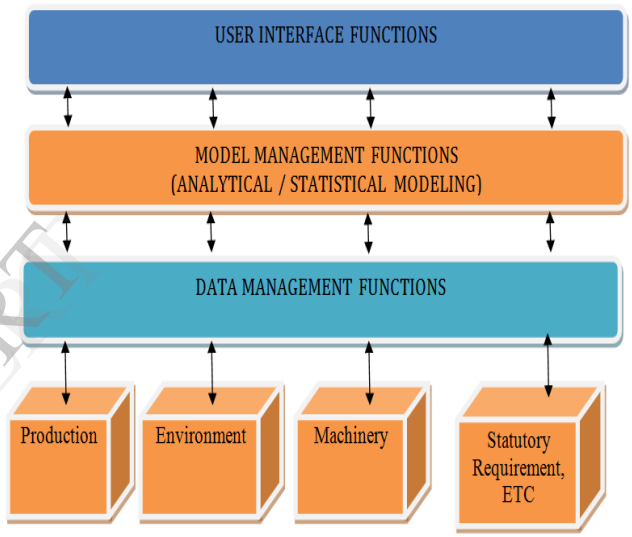
A model base will contain statistical, optimization, or simulation models that provide the analysis capabilities. Some popular optimization models include linear programming, integer programming, and nonlinear programming. The DSS allows the ability to invoke, run, and change any model or combine multiple models.

GUI

The graphical user interface (GUI) covers all aspects of communication between a user and a DSS application. The user interface interacts with the database, model base, and knowledge base.

A Safety Information and Decision Support System (SIDSS) for an Underground Coal Mine should be distinguished from more common management information systems (MIS). An MIS can be viewed as an information system that can generate standard and exception reports and summaries for safety managers, provide answers to queries, and help in monitoring the performance of a system using data processing. Traditionally, MIS has been used for relatively simple data processing and data presentation. However, as these systems have become more popular and organizations have become larger and more complex, an enormous amount of data is generated routinely. That is when a need for well-developed SIDSS is felt that can assimilate this data and derive meaningful decisions of managerial and economic significance. Today, the era of the Internet has taken information sharing to new heights, allowing billions of users to share information on the World Wide Web (WWW) simultaneously. SIDSS, which are now critical to the efficient functioning of any organization, need to be upgraded and must be Web-enabled.

DEVELOPMENT OF MODELS OF DECISION SUPPORT SYSTEM



The Entire Safety management of an underground coal mine consists of many sub-systems like production, environment, machinery, roof support and ground control, explosives and blasting. Accidents can take place in any sphere of working of an underground coal mines and hence covering all aspects under the models will make the research work very exhaustive and time consuming. Hence it is proposed to develop Decision Support models for three functions of safety which will be selected based on their occurrence, risk involved and previous historical data.

V. CONCLUSION

Safety Information and Decision support system can aid human cognitive deficiencies by integrating various sources of information, providing intelligent access to relevant knowledge, and aiding the process of structuring decisions. It can also support choice among well-defined alternatives and build on formal approaches Proper application of decision-making tools will increase overall safety, productivity, efficiency, and effectiveness and, allowing safety managers to

make optimal choices for technological processes involving underground coal mine safety and its various parameters. SIDSS will not replace humans but rather augment their limited capacity to deal with complex problems of underground safety or emergency.

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