Asset management and condition monitoring on maintenance of mining equipment lignite mines

Predrag Jovančić

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Prof. Dr Dragan Ignjatovic
Prof. Dr Carsten Drebenstedt
Prof. Dr Vladimir Pavlovic

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Petar Maksimovic
Natalija Pavlovic

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ASSET MANAGEMENT AND CONDITION MONITORING ON MAINTENANCE OF MINING EQUIPMENT LIGNITE MINES

Jovančić P.[1]

Abstract

Maintenance strategy, once set, is not permanent. This strategy should be adapted and altered according to the findings, achieved results, variation of mine product prices, changes in the region etc. On the other hand, maintenance strategy should be: safe operation, higher productivity, reduced costs and functionality of complete system. Asset management represents activities through which mine achieves the optimal and sustainable management of its property, in order to meet the plan - realization of production with optimized costs. Therefore, there is a need for efficient management with mining equipment, including efficient management, while both of these segments could have positive impact on curtail factors of success.

Keywords: asset management, maintenance, mining, monitoring.

1 Introduction

Mining is defined trough large capital investments, where proper asset management protects initial investment and ensures optimal path to the final goal - profit within specified timeframe, i.e. operational life of the mine. Mining industry must exercise global asset management - from geological exploration, i.e. definition of mineral resource potential, impact of global and regional markets, legislation, financial expectations, estimated life of the mine and optimal process and equipment

[1] Jovančić Predrag, University of Belgrade - Faculty of Mining and Geology, Belgrade, Serbia

maintenance in mining. Therefore, more importance is given to the secure operation, health and safety of the employees, environment, reliability of every unit among the assets, standardization of the systems, but also production and maintenance costs. With these emerging changes and challenges, mining industry seeks additional and new solutions from information technologies for the purpose of maximizing utilization of assets/equipment, such as practical improvement of mine's asset management, control of escalation of capital and operational costs and increase of operational profit. In order to provide completely functional operation of mine and equipment management with optimized information, it is necessary to have comprehensive knowledge on organization and control over all critical points and equipment within the mine, whole service and maintenance history (including measurements, calibrations and diagnostics), as well as providing real-time information about operation of mining equipment.

2 Asset management and maintenance strategy

Main task of the mine's technical system is to provide planned production of mineral resource. To achieve this goal it is necessary to perform quality maintenance of mining equipment. Mine management is obliged to ensure quality and efficient management, and therefore they making decisions about who and which type of works will be performed on specific types of mining equipment, with taking into consideration quality, costs, time frame and other factors. Engaged mining equipment is of various types. Different manufacturers with different dimensions and technological capabilities, various operational lives, relative outdated of some units and other factors are largely contributing to the complexity of maintenance and management system.

Equipment maintenance in mining industry must be based on advanced management process, predictive analytics and monitoring, including in-time, accurate and relevant data, to ensure equipment maintenance process within sustainability limits and for the purpose of achieving mining targets. These tools are the framework of the technological operations and production. Maintenance strategy during mine planning must be based on: budget, asset management, operating equipment and required resources.

The purpose of the mine, its production and technological sector including working environment, are having strong impact on all segments of the mine for achievement of the target. All these factors must be taken into consideration during design process, mine planning, operation and optimization of asset management function of the mine. Organizational

goals of the mine are in direct correlation with asset management, i.e. achieved profit. Nature of the profit depends on these goal, as well as nature and purpose of the mine, requirements and expectations of specific interest groups which defined the market. Value of the profit can be linked with economic, ecological, social and other outcomes. Complexity of mine's organizational schemes, especially large systems, can lead to more difficult asset and equipment management processes.

Material handling systems in the coal mining industry are often comprising of very different devices and systems for the uptake, transport, storage and handling of overburden and coal. The equipment and plant complexes are exposed to high loads and must be available in a 24 hour operation and should ensure compliance with parameters such as durability, capacity and budgets for the operation. Downtime means in all cases, costs for the maintenance and often much higher costs of lost production or unacceptable shortage. Performance programs and lifetime extensions are currently in the current difficult economic environment challenges for plant manufacturers and operators but also for the plant service.

Modern plant asset management systems support the operator in organizing and managing the processes of plant operation supervision of the technical diagnosis of maintenance and repair to the forecast of the necessary measures and budgets for the conservation of plant function. Basis for asset management defining at the mine is following:

- Error detection using system diagnosis,
- Directing attention for service personnel,
- Support of inspections, maintenance and troubleshooting,
- Optimal resource management,
- Plant and spare parts documentation,
- Optimized maintenance according to the plant load,
- Complete systems and component lifecycle,
- Asset and process optimization,
- Asset management.

The above represents some characteristics of the system to management mine plants, which are proven at international level in the production of coal and copper. These are resulting from the definition of mine maintenance processes. The development plan for the mining equipment maintenance in the course of definition mining technology and basic operations is shown on Figure 1.

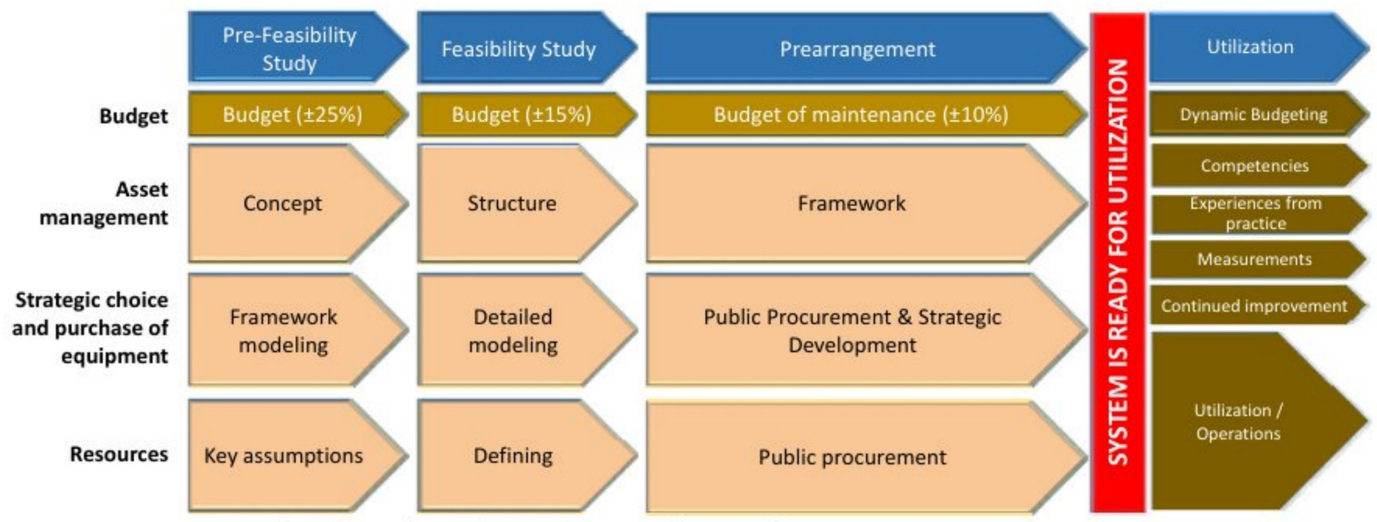

Fig.1 The development plan of maintenance system

The maintenance strategy should be developed in the course of defining mining operations. The good maintenance strategies must sublimate all relevant factors into an overall mine strategy, vision and management policy, like all other units that deal with care and use of property (objects, plant, equipment, reliability programs, requirements for documentation, drawings, spare parts and material, manual and automated systems of maintenance management, safety, health and environmental, control, maintenance, planned and time resources, lifecycle maintenance management, organization and human resources). If all levels of decision making in a mine complementary around the main goal (production with maximum equipment utilization and minimum/optimal costs), if there are no disagreement between the mine management, production and maintenance, maintenance strategy becomes a living, utilized document. This is due asset management policy and great dedication of care to all mine assets.

Mine maintenance assets is a part of asset management, therefore, is the maintenance part of production. When that is recognized and exercised within the acceptable tolerances, advantage of sustainable production in longer period will be implemented.

The maintenance of mines has traditionally been to margins (more mechanical and less electrical part), the so-called "necessary evil". Maintenance always have to follow the needs of mining operations, production is always a priority, in many cases, regardless of the cost. One way of approaching the 'opposing' sides is the application of assets management strategic goals (equipment). Asset management is a much larger extent than the maintenance process that is closer to the understanding of the mine purpose. Good management optimizes conflicting priorities of use/operation and maintenance/care in the mine. Optimizing the equipment existing performance and long-term sustainability, represents the relationship between large capital

investment and subsequent operating costs, risks and performance. Optimized proposal for the mine maintenance organization is shown on Figure 2.

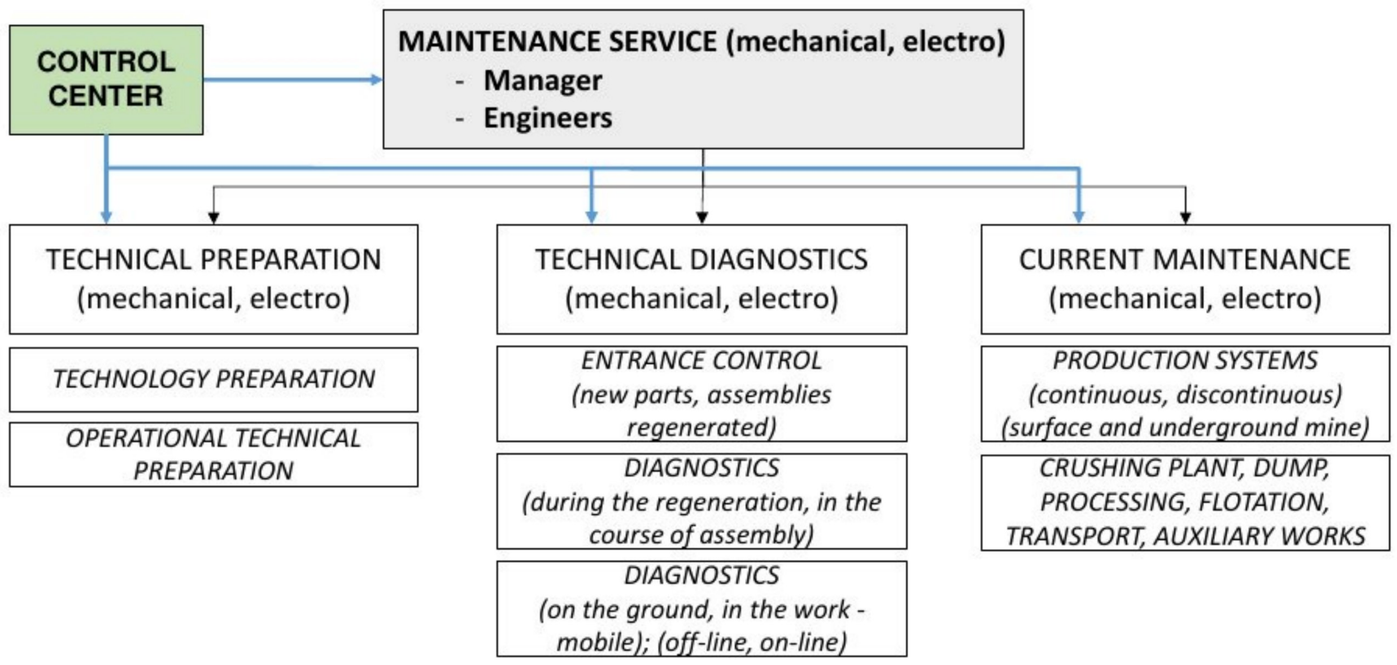

Fig. 2 Organization of the mine maintenance

3 Condition monitoring at surface mining equipment

Maintenance management is at the moment one of the most complex parts of industrial management, in mining industry in particular. One of main prerequisites of quality management is comprehensive logistic support, mainly related to permanent monitoring and parameter and performance evaluation of maintenance system. Also, it is necessary to know the processes of work and maintenance, including its history. This is specific task of maintenance information system.

Main goals of information system at open cast mines could be defined as follows:

- Permanent monitoring and proper data recording, enabling later analysis for obtaining suitable information on each relevant performance of technical system regarding its maintenance as well as operation as direct consequence of maintenance activities. In specific, monitored performances could be: achieved production and other results, reliability, maintenance ability, costs, components of logistic support, etc.
- Provision of complete "history" i.e. data base of monitored technical system. This data base enables analysis of maintenance system and also has crucial impact on development of new systems of same or similar purpose, but with improved properties.

Control and management system developed for modern control centers at open cast mines is highly integrated, enabling process

management and system monitoring, and it is based on client-server architecture. System is capable for integration of various control sub-systems into the structure. General scheme of open cast mine control system is shown on Figure 3.

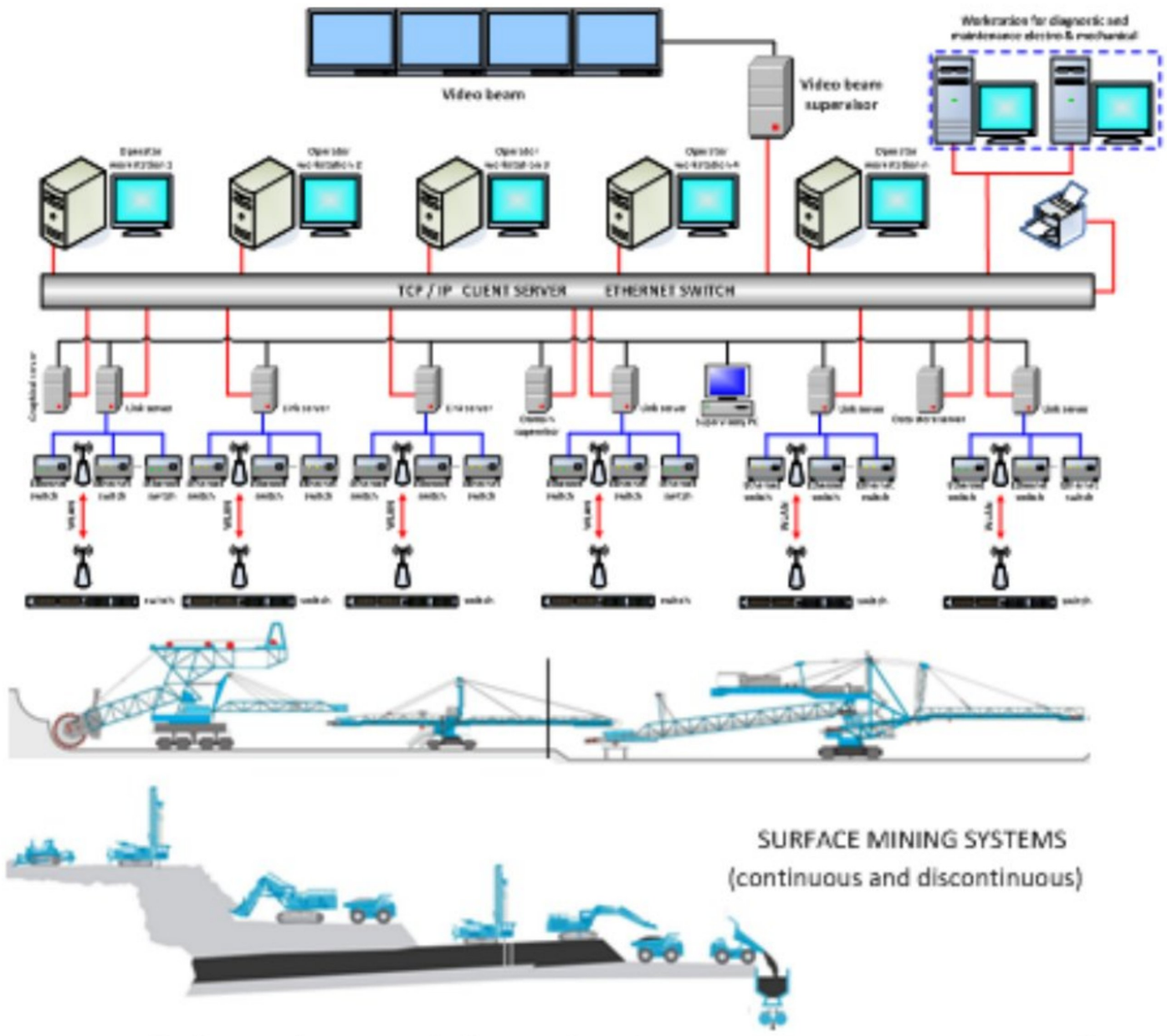

Fig. 3 Control center defining for the open pit management and maintenance

Control center also enables comprehensive monitoring of all systems on the open cast mines, including processing system (crusher, stockyard). Control center structure comprises of one OPC (Open Process Control) connection server for data exchange with PLC controllers which are controlling operation of the excavators, drive stations and stackers belonging to the system. Number of connecting servers at the control center is determined by the number of system on the open cast mine.

Data exchange takes place in both directions, thus enabling staff of the control center capability of issuing work orders (starting, stopping, etc.) besides monitoring function. Data exchange between mobile mining machines (excavators and stackers) and control center can be wireless. Communication between control center and drive stations in one system

can be via optical cables.

System also includes graphical servers for presentation and visualization of acquired data. Object OPC (Open Process Control) servers are used for this purpose. Each component (motor, frequency converter, gear reduction, bearing, switch, sensor, etc.) on individual mining machine or drive station represents an object.

Details are assigned to each object, with following information:

- Overview of program part controlling the specific component in real time, as well as overview of all inputs and outputs related to specific component. There is capability for overview of program part for all standard programming languages of controller;
- Technical drawings of the component and other technical documentation;
- Static and dynamic graphs related to technological process in which component operates;
- Reports on regular conditions and events;
- Reports on irregular conditions and events, warnings and alarms;
- Graphs of variables.

Mentioned objects can be organized into hierarchy structural models based on object's function, location and control function.

Lowest level is location structural level, showing physical distribution of objects, as basic organization component of whole system.

This means that next level in hierarchy is location distribution of main components and subcomponents of mining machine and their adjustment to proactive monitoring system.

Example of third level of organization of control-management proactive monitoring system (functional subunit) for gear-reduction of belt conveyor drive is shown on Figure 4.

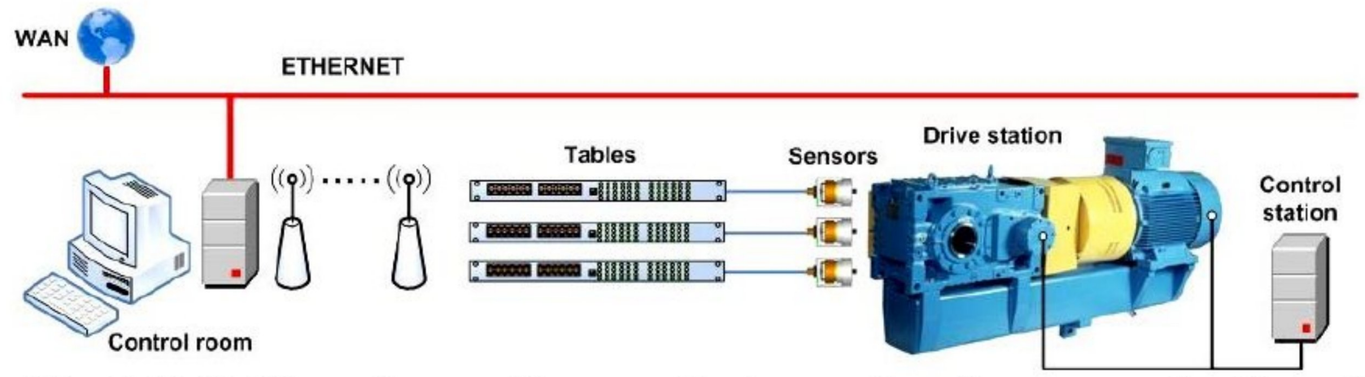

Fig. 4 Definition of proactive monitoring system for gear-reduction of belt conveyor drive (tele-diagnostics)

Operator is provided with all necessary information in form of graphical screen, alarms, list of events, graphical interpretation of current monitored values. Operator has capability, according to previously

defined authorities, to control and monitor operation of mining machines and drive stations.

Experience with open cast mine control centers in developed countries shows that one operator is in charge for certain number of technological units such as systems.

Most frequently showed information for one system are: start/stop status of controls for each unit, load of the main drive, flow of excavated mass, elevation of the excavator's beam, swing angle of excavator's beam, speed of belts on the excavator, drive stations and stacker, oil temperature in gear reductions, motor bearings and rotor/stator harness, position of switches at mid and low voltage, indication of mechanical brakes on all drives, power consumption, tension force in belts.

Current value graphs of electrical and mechanical parameters and alarms related to the equipment are considerably improving efficiency in on-going maintenance decision making.

Long term data analysis determines actions to be taken during service and repair (overhaul) maintenance.

Application of suitable hardware and software in control center enable continuous recording of large number of typical values related to operation of one system on the open cast mine.

Data base is formed on data storage server, which could have capacity for continuous recording during several months.

Analysis of recorded data at open cast mines in developed countries introduced new form of electric and mechanical maintenance - maintenance according to condition i.e. proactive monitoring system.

Analysis of alarms list by type of alarms and their frequency provides evaluation and forecast which electrical or mechanical component will fail.

4 Conclusion

Concluding remarks define recommendations for the introduction of equipment systemic management in mines. Equipment management in mines presents systematic, coordinated and practical activities. Thus mine optimal and sustainable assets management, their a total production, risks and costs throughout the life cycle for achieving organizational strategic plan - production achieved with optimal costs level (with minimal costs involvement).

Given the usual relationship between mining activities and asset management in mining, may be proposed to the asset management plan should be one of the main drivers for the mining operations and activities. If correctly implemented asset management systems and the processing

of existing business plans and achieving anticipated reliability of the mine equipment, in correlation with mine planning production, there is no reason the planned maintenance activities cannot be implement specifically. This must be part of reality, but also an imperative. Implementation of good asset management plan includes the constant improvement and updating. In the same way in every mine areas problem solves.

For quality implementation of the asset management system, maintenance managers must respond to the following questions:

- Which assets parts would be most critical and why;
- Which jobs need to be done on the existing assets that it could reliably and securely to fulfil its objective function;
- How to be confident will the work to be done on time;
- As necessary executors/men to be done needs a job;
- Knowing which skills are needed to carry out certain activities;
- Which necessary spare parts and materials for implementation of maintenance activities are needed;
- What is the maintenance budgets, operational and capital;
- What is a critical way into implementation of maintenance activities;
- What are the costs entire life cycle;
- Does costs are reduced to a minimum of the ownership total cost;
- Whether they are bookkeeping real value of the spare parts as determined by risk assessment;
- How to record downtime and followed define report;
- Whether there is quality plan for elimination of faults/defects;
- Whether there are real resources to ensure continuous improvement;
- Whether there is a quality information system of management.

The mine will optimally perform its function if the goal has a positive and progressive attitude toward all these issues.

Existing maintenance systems should be improved by elimination of weak spots, mainly by more rational on-going, service and repair (overhaul) maintenance. Introduction of new maintenance system (maintenance according to condition or predictive maintenance) above mentioned system requires some preconditions – existence of unified information system (control-management system) with diagnostics of condition and behaviour of components of mining machines. Quality monitoring system for operation of all open cast mine systems is necessary for introduction of efficient and modern maintenance system. More complete and comprehensive monitoring system enables organization of more efficient and quality maintenance.

Preconditions for introduction of monitoring system on the open cast

mine and its application for the purpose of maintenance are:

- Capability of controlling machines by programmed logic controllers (PLC) for operation and monitoring and with integration, connection and remote control capability (via Ethernet);
- Sufficient number of sensors on the machines for data acquisition on condition and behaviour, which can be transferred to the main control center;
- Network infrastructure for data transfer from the machines to the control-management center;
- Control-management center with necessary equipment;
- Sufficient trained personnel, capable to use information and manage maintenance on the open cast mine.

The balanced structure of asset management and its realization in mining is shown on Figure 5.

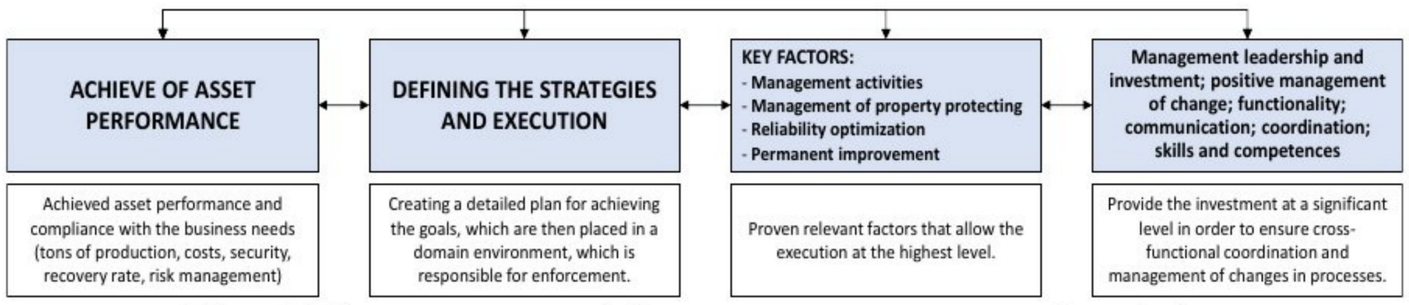

Fig. 5 The structure of the asset management in mining

Basic guidelines for the introduction of asset management system provides a standard ISO 55000, i.e. ISO 55001 provides a minimum set of requirements for quality asset management, and ISO 55002 provides guidance on the application of these requirements. An asset management system is a set of interrelated elements of the mine, which establishes policies and objectives of asset management and processes necessary to achieve those objectives. An asset management system is not just an information system - it includes the organizational structure, roles, responsibilities, business processes, plans, work, etc. Asset management is a complex activity and covers all parts of the organization mines. Assets may serve more from one purpose, and can be used in many different functional places. Establishing a system of asset management should be a strategic decision for mine.

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