Mining in the Future

– A FULLY INTEGRATED PROCESS

Future mining will use fewer workers for manual jobs and more qualified operator xperts for product and process optimization, maintenance planning and environmental control. The operator experts will need to interact with each other to cover the complete value chain.' The central mine control room' will be the objective and future solution. And operator experts will perhaps be able to control several mines.

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Photo: Atlas Copco

Mobile equipment will be integrated with the production control systems.

Mining companies in general has come to a level of automation where sub operations in a mine are often automated, but the integration of the sub operations and the information they are holding are poor or lacking. This has a tendency to drive towards operations where sub optimization is frequently encountered and where the organization has a heterogeneous perspective of what the process is all about.

Full control and overview of all the different operations in a mine has been hard to achieve. There has been a lack of communication infrastructure, wireless as well as wired, in underground environments. The level of automation and integration of information in the underground mining environment has not been matching the corresponding level of other industries such as oil and gas or pulp and paper.

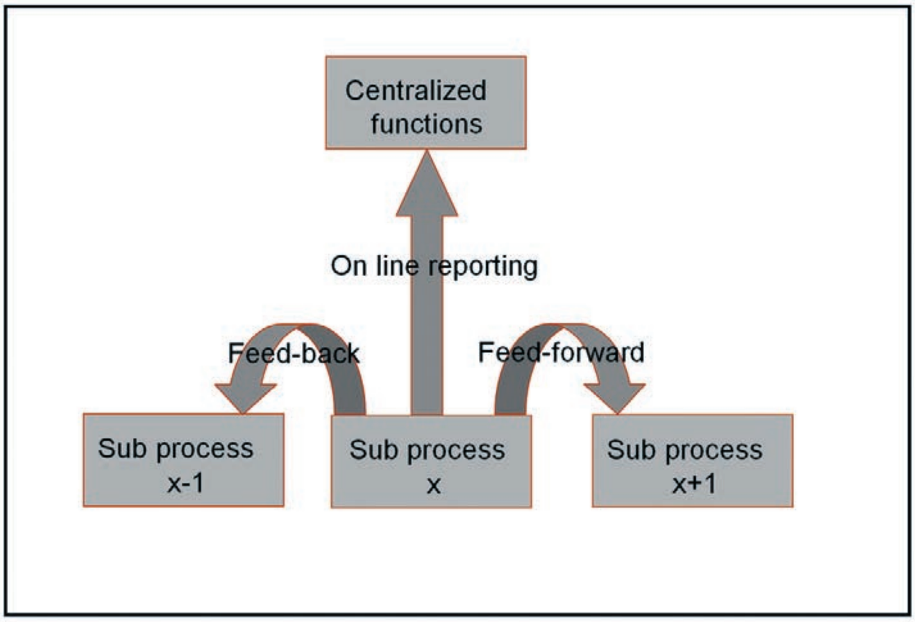
A mining factory

The way processes interface with each other, or maybe even the lack of interfacing, leads to inefficiencies and lost production. The question is how to move into an environment where mining operations are more of a mining factory. Where different sub operations will supply relevant data and where on-line analysis applied upon that data will be the base for decision support or automated decision making.

Sub operations in mining have been looked upon as separate production units. Different solutions, different choice of equipment and no unified ways of forwarding data to and from the sub operations has ended in a situation, where parts of the operation are isolated islands. Operation, supervision and data storage is often managed locally. The reporting and propagation of data to neighbouring and superior systems is limited and not in real time. Diagnostics functions and maintenance aspects are also catered for locally, which disables the possibility to perform remote diagnostics by the plant organization and by experts from the outside.

To make intelligent decisions in a consistent way, all data from the all sub operations will be needed. However, it will be of limited use if the data is only of a historical character, usually found in reports. All data must be available for on-line use in order to perform on line analysis.

So, the different sub operations should have ways to:
• propagate real time data to neighbouring systems,
• propagate real time data to superior systems and central control room functions,
• enable remote diagnostics.



Sub operation data distribution.

A uni ed view of the process

Users working within one sub operation often have a different perspective of the process than users working within another sub operation. This may cause problems when it comes to co-operation. Issues will be interpreted differently depending on which user group is handling them, and different user groups may have a hard time agreeing upon the nature of issues. They may have an even harder time agreeing on solutions to problems that cross the boundaries and needs to be solved.

Users of different categories benefit from sharing the same unified view of the process. Examples might be how the Electrical and the Instrument group will enhance their co-operation when information regarding equipment of the different disciplines is viewed in a unified way. Other categories such as Process development and Maintenance development have the same possibilities of reaching synergies and common perspectives.

Examples of use would be how maintenance related issues will be used as a natural input when taking decisions on changes in the process. Another example would be how maintenance users would be able to view the underlying data when examining the natures of maintenance orders received in the maintenance system.

Find all relevant data

In order to provide an environment in which various user groups may interact on and make use of the information provided by data from the production system, the very first thing to do is to get hold of all the relevant data.

There are pitfalls to be aware of along the way. Availability of data from 'black box-systems' or hard coded communication data may cause restrictions to the quantity of data available, and demands for new data are likely to occur. As all parts in the plant over time may be subject to modifications, preparations must be made to provide not only maintenance, but also application modifications and tuning of the installed systems. Data initially not taken into consideration may be cumbersome to provide at a later stage.

Data quality is another crucial issue. All data will be used as a basis for building information for important decision making. When data is converted into information and further refined into process knowledge, lack of data or false data will cause the knowledge achieved to drift away from the real mine situation. This may very well lead to wrong business decisions. To make data available and quality assured, we will need to integrate equipment and systems, and the data related to them, into one common platform. This must be done in ways that conform to the main objectives:

• Data availability
• Data quality

Integration of all systems

From bottom up, the equipment for various functions in the field is integrated using standardized field buses such as Profinet, Profibus, Fieldbus Foundation or other integration concepts such as IEC61850 for the integration of power systems.

Mobile equipment is integrated using standards such as OPC or IREDES.

In the upper part of the system architecture maintenance and business system are integrated using standards such as ECS, ISA-95 and OPC.

This means that relevant data from various pieces of equipment are available within the system boundaries by using ▶

open and standardized protocols and that data quality can be assessed. Information can be supplied to different users in a unified way. Data are also available in ways that makes further analysis, manual or automatic, applicable.

If advanced analysis is applied to data, which are false or incomplete, decisions made based upon these data will be correspondingly false or incomplete.

Handling process data

The purpose of collecting data is to obtain information of the process and build a knowledge base. This base will be used in order to make optimal decisions, short term as well as long term. The way data transforms into knowledge and business decisions are not always obvious.

When data is being integrated in the ways described above every conceivable thing can be measured, propagated and presented. New technologies will make more data from a wider range of data providers available. Human system interfaces such as Smart Phones and PDAs provides ways for interacting with the data in flexible ways wherever the user is situated.

A common misconception is that making all data widely available will make users actively choose what they need from it. This presumption ignores that people in different roles and at different levels of the organization have unique information requirements. In short, people do not have the time to seek out the information relevant to them. They need specific information regarding the types of decisions they are set to make. Providing vast amounts of undifferentiated information (not user role-specific) backfires and is costly as well as counterproductive.

Business measures

The design and implementation of systems, including the selection and direction of information to drive business performance, is a critical source of competitive advantage. Knowing what to measure, the purpose of key performance indicators and how to act on metrics is as basic to mining as it is to any other business. The key questions arise:

- What information is crucial to the business output?
- What information is critical to each user group?

The first question should be addressed by referring to the business value chain – the sequence of activities in a business that progressively adds value to the saleable product of the business. The generic mining industry value chain illustrates the structure of mining operations. Value is gained and lost along the chain of activities from the mine to the market from an economic perspective. Key performance indicators typically set the focus on:

- Efficient use of input resources.
- Effectiveness of each link in the chain.
- Opportunities to minimize waste output.

It is important that different sub operations contribute with complementary data to these measurements.

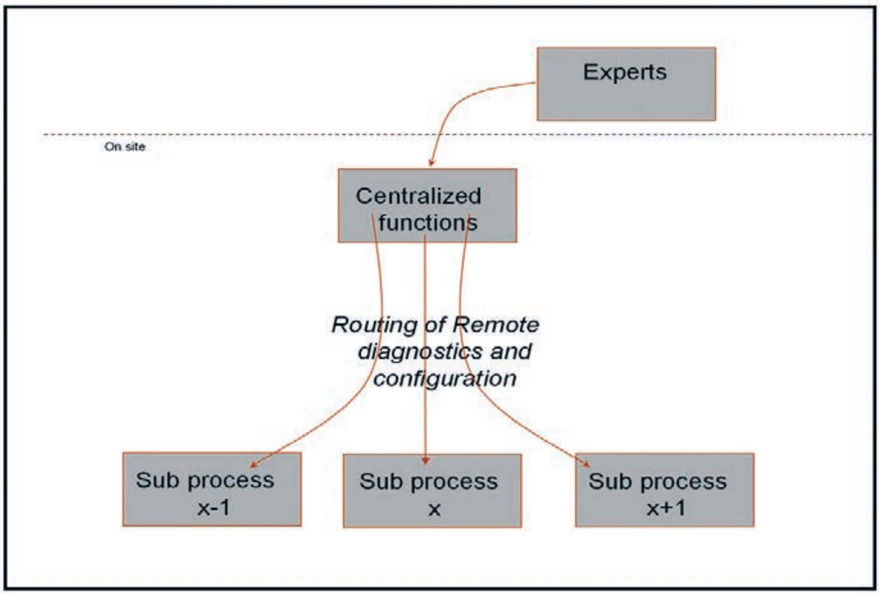
To measure performance

For performance enhancements there are mainly a number of different uses for performance information.

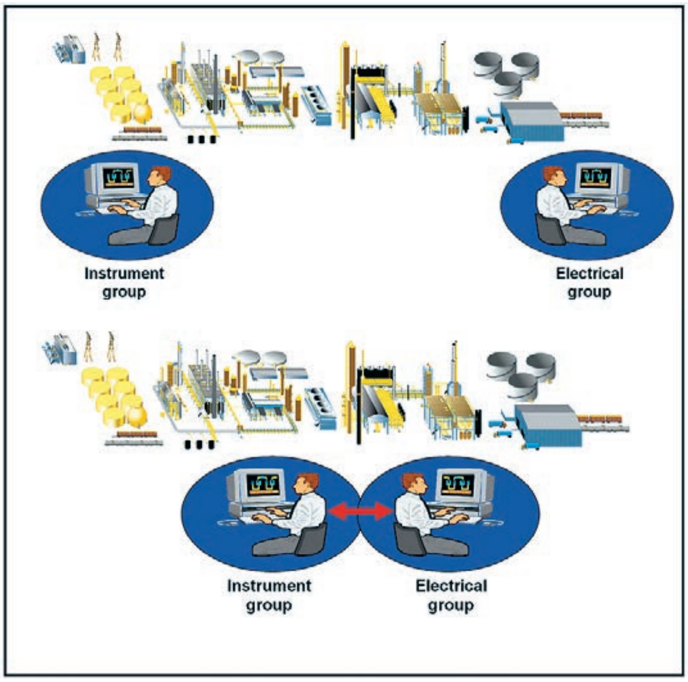
Planning/Keeping score
What happened? Are we doing well? The information typically houses scorekeeping of accumulated and dissected performance data to answer these questions, such as totals and averages during different periods.

Directing Attention
Which are the current problems to direct attention to? Variance in content of management reports directs attention to quality issues, operating problems and waste.

Solving Problems
What can be done about the problems? What action will be the best? This informa- ▶



Routing of remote services



Different user-groups

tion is most often used for long term planning such as budgeting and future projects.

Other usual cost related KPIs expected to be found are output measures of resources and activities, such as tonnage, man hours, meters drilled, meters trammed and so on. These cost indicators are basic measures of effectiveness, but can also be used to estimate resource requirements for maintenance and supply purposes.

For example, materials used in mine development can be factored on the basis of meters of development. Every meter will have a standard bill of material associated with it, a recipe. For example, every 10 meters of advance will consume:

- nn kg of drill steel
- nn litres of water
- nn kg of explosives

Likewise, every 1,000 tons of ore milled will consume:

- nn kg of grinding kWs
- nn % of lining wearage
- nn kg of froth chemicals

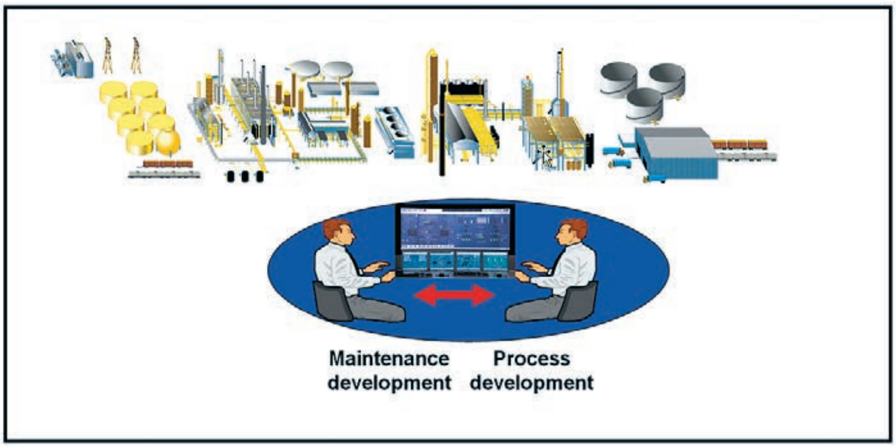
The indicators can be applied to the actual meters and tons measured each period, to estimate all the supplies and maintenance required for the ongoing support of the operation for that period. If this is done for every step in the value chain, there is substantial potential for reducing working capital through better coordination of supply and demand.

Mobile integration

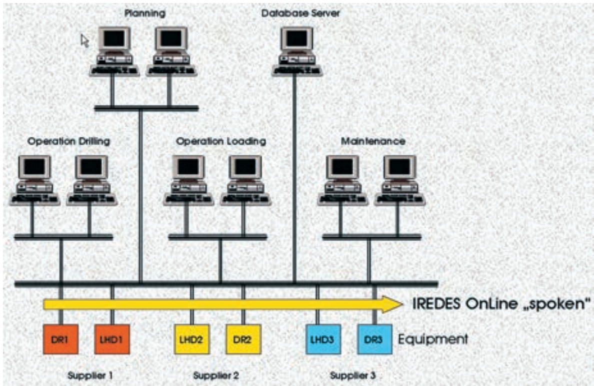
When communication infrastructure is established underground and the mobile equipment fleet is increasingly computerized, openings to exchange data with the production machines can be found. Drill plans, loading sequences etc. for the production machines will be delivered to the machines and the results of the actions reported back.

The integration with the production control systems for mobile equipment has several purposes:

- Deliver the results of the initial steps of the mining process, Geology, Ore calculations, Mine survey, Mine design and the Production planning, to the mobile equipment systems in a useful format.
- Retrieve the results reported by the mobile equipment and feed them back to the relevant users. Reports and follow up, analyses and statistics.
- Retrieve execution statistics and maintenance data from the on-board system. This information is partly used by the process control system; some information (mainly maintenance information) will be transferred to other systems.



Bringing user-groups together



Integration of mobile equipment

- On-line status of mobile equipment in the process control environment including localization information.

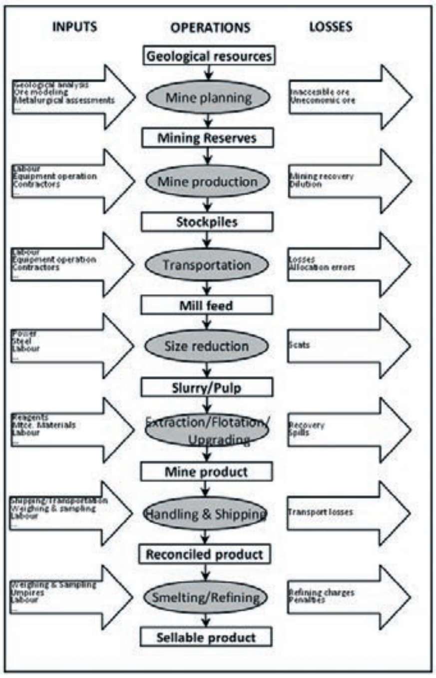
The interfaces to the production control system are based on the interfaces provided by the production control system products. The interface towards the open ABB Process Control System is OPC (DA, A/E, HDA). Data sets and naming of items are configured to conform to the IREDES standard.

Localization information of the mobile equipment is obtained through the use of information originating in the WLAN infrastructure. The localization information together with the information obtained from mobile equipment is aggregated, consolidated and available for viewing in the open ABB Process Control system.

The combined information from the mobile equipment and the localization system provides the basis for an accurate and online status of the ongoing activities. The output of the analysis is used to provide further optimization in different areas.

The ventilation is not only on demand – it is also adapted to meet the actual needs derived from the mobile equipment status.

Availability of the mobile equipment is increased when asset monitors combine data from the machines and data regarding the process environment to provide accurate maintenance at accurate intervals.



A mining value chain.

How the mobile equipment relates to the activity planning can be updated online and deviancies used as input for recalculating the activities.

Further along the line there will be possibilities to close the loop and provide different methods of automatic redirection/ ▶

replanning of mobile equipment when needed. Already information regarding the surroundings (traffic situation, status of production equipment etc) can be compiled and made available for mobile machine operators. This will increase their possibilities to make intelligent decisions when things turn out to differ from original plans. And in mines they often do!

Multi facet ways of using data

The user categories and the main purpose of the integration of information are:

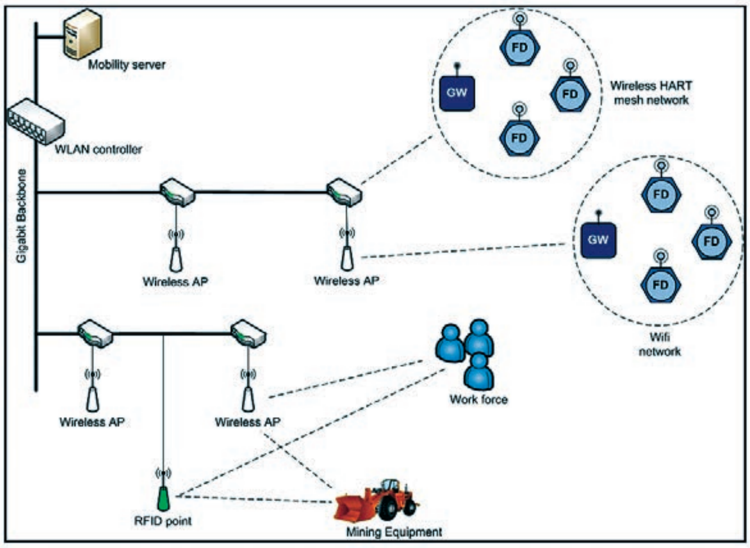
Operations
• On-line visualization of production status for a responsibility area.
• Sufficient view into neighbouring areas.

Maintenance
• On-line fault reporting to the maintenance environment is created by the operators and automatically generated by the system.
• Possibility to view data related to maintenance orders such as historical trends, alarm and events.
• Remote diagnostics of all equipment.

Engineering
• Remote configuration.
• Remote calibration.
• Remote fault tracing.
• Process development. KPI related to process status, throughput/h etc.
• Maintenance development. KPI related to maintenance status, wearage/ton etc.
• Business development. KPI related to business figures, cost/ton etc.
• Management. KPI on overall performance

When the users have access to all data they need they will also have the tools to work their own tasks. But in the same way as operators must co-operate with at least the neighbouring sub processes, the different disciplines must also co-operate. Operators must generate work orders to maintenance in ways that are consistent, clear and rich in background information.

Maintenance must co-operate with the engineers to have control of the equipment; not only in productive ways, but also in ways that causes as little maintenance as possible. Engineers must interact with the process engineers to feed back knowledge about less useful process designs. Maintenance development engineers must co-operate with the process development engineers in order to make up a process design where maintenance aspects are taken into consideration. Business development will need to co-operate with process development in order to make changes in the process.



WLAN infrastructure and integration with Atlas Copco mobile machines


Control room collaboration example

These are merely examples. There will be lots of interactions between various users and operations going on all the time.

One control room

The experts will need to interact with each other both within their own disciplines and on an inter-disciplinary basis. A new trend is to consolidate the operator environment into fewer control rooms, maybe just one. Thus all the experts running the online operations are brought together. Around this hub of operations other persons such as maintenance experts, engineers and process developers, could gather to interact and make useful business decisions with the help from experts from the outside.

In the future the mining industry will have fewer hands for manual work. These will be covered by fewer, but more qualified, experts.

One control room is the objective and the future solution. This control room receives online processed information that makes it possible to control and fine-tune the complete operation from resource characterization to the final product. And the experts working in the control room will become more competent and dealing perhaps with several mines. Due to the progress of communication technology, the overall control centre can theoretically be located anywhere in the world enabling experts to co-operate. Once an organization is brought into this level of integration a platform is established from where the operation can be monitored and run in ways serving the entire value-chain. There is also a situation where the operation is constantly undergoing real time analysis leading the way to intelligent business decisions.

This article is based on exper iences gained empirically when implementing au - tomation solutions mainl y at Boliden AB (1980-) and LKAB (1990-). ■