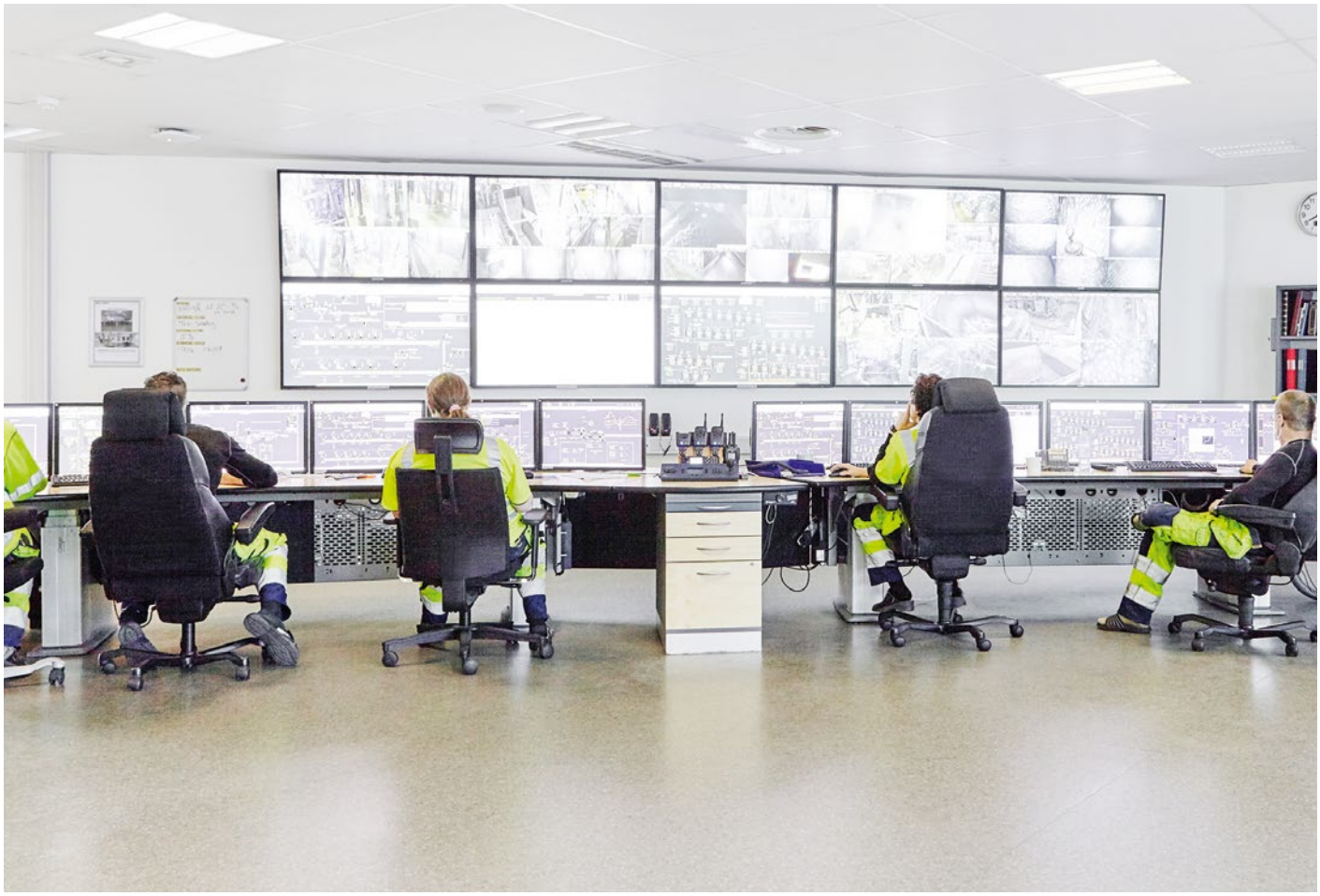
White Paper

# Next Level mining
## Securing the future through integrated operations & information technologies



Power and productivity
for a better world™

# Next Level mining

## Table of contents

# Executive summary

The mining industry needs to innovate or risk its long term viability. In today's rapidly changing and uncertain times the status quo will not deliver desired shareholder returns.

Mining leaders need to think ahead and work out how technology will transform the basics of their operation, their customers and their supply chain. They need the vision to see how technology can increase sales and profits by synchronizing the demand chain and improving customer service, while reducing operating costs from operations through to suppliers. The future of mining belongs to those advanced companies able to recognize today the benefits that automation technologies will bring to the entire mine operation.

# 1.0 Evolving market dynamics: an even greater shift in productivity needed

The last century saw tremendous improvements in the mining and minerals sector. However, given evolving market dynamics, said gains are insufficient to ensure long-term growth and productivity.

Figure 1 outlines the four step-changes which have seen radical productivity gains.

For example, the gradual mechanization of underground mining in the first half of the 20th century, including the development of conveyors, loading machines and drill rigs, dramatically increased tonnage per worker.

More recent advances like long wall mining equipment, driverless trucks and recent developments in remote operations and control systems, enable today's miners to produce many times the ore with fewer workers and under safer conditions than ever before.

The difficulty now is the fact that the first three step-changes have been exhausted: haul trucks are already big, pits are supersized and infrastructure is being pushed to its limits. Future mines will need to adapt significantly in order to address today's formidable market conditions.

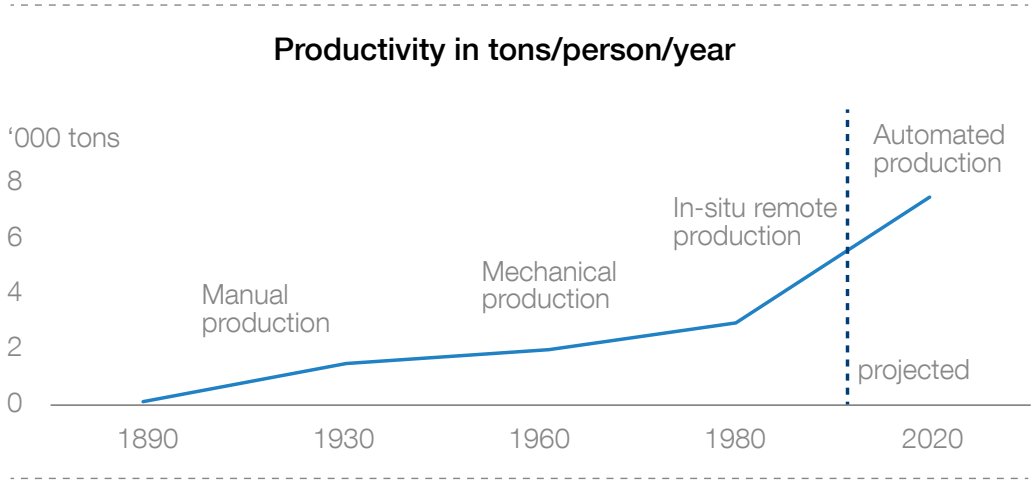



**Figure 1. The productivity shift.**

| Labor-intensive | Mechanization of key processes | Limited automation | Mines of the future |
|---|---|---|---|
| Hardly any value chain visibility | Limited value chain visibility due to manual & paper based processes<br><br>Equipment operation still requires human interaction | Some degree of automation driven by labor shortages and remote mining locations<br><br>Greater visibility into parts of value chain<br><br>Ability to mine remotely given more information coming back from plant & equipment | Integrated modeling and planning generating higher quality mineral yield<br><br>High levels of visibility across value chain and across operations with artificial intelligence<br><br>Bottlenecks limited by adopting more continuous processes |

# 2.0 Challenges facing the mining industry

The mining industry faces many external market and internal business challenges.

### 2.1 External market challenges

Changing market dynamics are driven by:

**Harder to reach deposits**

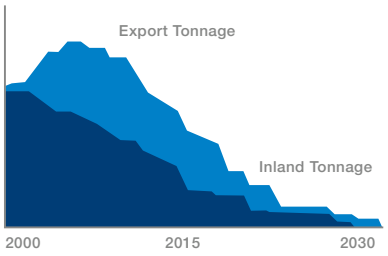
The easily accessible deposits are being rapidly depleted. New ore reserves are more technically challenging to extract and are located in remote or politically complex regions. Getting to this ore means going deeper. As costs go up, so must productivity if mining companies are to stay profitable. Furthermore, going deeper carries more risk and the fewer people that work at depth the better it will be for mine safety. Technology is evolving rapidly, bringing the ability to extract more from less and to go significantly deeper and more profitably than ever before.

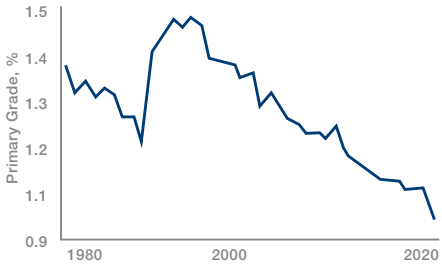
**Increasing commodity prices**

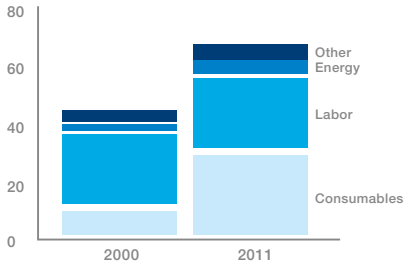
Over the past five years commodity prices have remained reasonably flat, or have declined. High price volatility caused, in part, by supply disruptions, tight markets and new pricing systems, is also having an impact.

**Rising demand**

Continued growth in demand, due to factors such as the increased industrialization of China, means that mine operators need highly flexible infrastructure in place so they can raise production quantities when needed. Even a modest three percent growth per year results in a doubling of demand in just over 20 years — not a long time in the framework of mining.




**Source:** Xstrata Copper

Reserves are depleting in some commodities. Assets and ore bodies are becoming more complex

Ore grade quality is declining

Labor is more costly, energy costs are going up and doing business in new markets is putting pressure on margins

**The bottom line: continuing to deliver high shareholder returns in changing times**

**Figure 2. Mining industry trends.**

# 2.0 Challenges facing the mining industry

### 2.2 Internal business challenges

The industry is being driven by a plethora of business hurdles including, but not limited to:

- Fragmented communication
- Lack of collaboration between different departments and across the supply chain
- Maximizing aging capital assets
- An aging workforce
- Improving safety
- Energy volatility

The careful integration of technology can help overcome these challenges by increasing visibility, improving communication and eliminating duplication, all of which has a positive impact on the bottom line as well as employee safety and morale.

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.1 Overcoming disjointed communication and information silos from within the mines** | – Many independent pieces of equipment and systems, each with its own data and interfaces<br>– Duplicated activities and costs<br>  – Different sites and departments run their own procurement activities<br>– Difficulty making timely, effective decisions to manage disturbances due to lack of common visualization of mines<br>  – Technology has grown in a diverse and chaotic way resulting in fragmented islands of automation where:<br>  – Operators and control room staff view different screens and have separate pieces of information at hand<br>– Managers feel they are drowning in data but are unable to find the answers they need<br>– Insufficient real-time data<br>– Over-reliance on operator skill<br>  – Production scheduling is manual, reliant on the skill of the scheduler and often carried out without due consideration to the overall supply chain | – Changes how miners view and interact with their operations and markets<br>  – Allows greater visibility of operations by integrating information technology with that of operational technology<br>– Helps overcome inefficient scheduling, waste and labor intensive activities<br>  – Scheduling integrated from mine operation to shipping, including blend design and dynamic order book allocation to stocks in the system wherever they are<br>  – Mine/plant throughput maximized given production supervisors can now use technology to juggle many more variables than before<br>  – More strategic and better integrated procurement programs<br>– Enables mines to be more responsive and flexible<br>– Enhances delivery performance<br><br>As a result mines benefit from:<br>– Increased production and revenue<br>– Reduced operations cost and improved margins<br>– Better return on capital employed |

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.2 Leveraging collaboration across the entire supply chain** | – Elements of the supply chain are isolated from each other<br>  – Suppliers, customers and partners rarely interact<br>  – Mining teams in remote locations hardly ever talk with a central control room or other mines<br>– Missed opportunities to develop novel approaches to operational challenges<br>– Insufficient sharing of best practice<br>  – Reinventing the wheel time and again | – Enhances productivity and performance<br>– Helps resolve common issues more quickly and effectively<br>  – Shared knowledge can result in more accurate plans (eg, forecasting)<br>– Allows teams to communicate and collaborate across the enterprise including multiple mines and sites with activities being coordinated through a central control room or location<br>– Potentially builds customer loyalty and may identify new revenue streams<br>  – Due to technology, innovation and R&D being shared more easily and frequently throughout the company and with partners, vendors, suppliers, customers and other supply chain parties where appropriate |

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.3 Managing aging assets to minimize downtime risk and its impact on profitability** | – Reactive and time-based maintenance are dominating maintenance strategies<br>  – As a result of a fragmented approach to asset management<br>– Lack of data acquisition systems and real-time data complicates more proactive strategies<br>– Every moment of unplanned, reactive downtime is costly, not just for the repair itself, but also because the asset is down and not producing revenue with potentially disastrous effects on profitability<br>– Performed separately across sites or geographies often involving manual or unconnected information, processes and systems<br>– Isolated from other business planning functions | – Reduces time, expense and downtime through real-time condition and health monitoring<br>  – Assets are instrumented, interconnected and intelligent, reporting their location, status and other key metrics remotely and automatically<br>– Facilitates preemptive condition monitoring using systems with predictive data modeling to trigger maintenance orders and prevent breakdowns before they happen<br>– Helps determine the optimal way for these assets to behave and interact with each other by providing a view of the entire asset management life cycle<br>– Asset management is integrated with other business functions and systems such as enterprise resource planning and documentation thereby enabling better control over costs |

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.4 Dealing with an aging, difficult-to-replace, workforce** | – More than third of the industry relies on human intelligence to optimize its value chain<br>– Much of the workforce is retiring<br>  – Transferring their knowledge and experience to the new generation is a challenge, especially as the experts are dispersed and often unavailable<br>– Difficult to recruit and retain competent staff to run mining operations in remote and inhospitable locations<br>– Newer employees have different attitudes and expectations | – Expedites execution thereby generating higher productivity and margins as knowledge is captured and delivered to the right workers at the right time<br>– Optimizes expertise of global workforces through virtualization and remote operations<br>– Promotes an optimized management set up with centralized organization and reduced cost structure via efficient and rapid decision-making<br>– Streamlines administration to reduce costs<br>– Makes mining appear an attractive career option for high-tech graduates by demonstrating industry focus on environmentalism and corporate responsibility |

# 2.0 Challenges facing the mining industry

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.5 Improving safety through better prevention and quicker ability to address problems effectively** | – Dangerous conditions for workers, contractors and visitors especially in underground areas<br>  – Hazardous environments<br>  – Possible collisions and accidents with machinery<br>  – Potential mine collapse and ventilation failure resulting in exposure to toxic mine gases, explosive gases and dust | – Detects and avoids collisions through smart programs and technologies such as location awareness, GPS and radio frequency identification<br>– Tightens site security by deploying automated identity and security management programs that centrally track employees' access rights, location, duration, training, safety certification, permissions and compliance<br>– Cuts downtime, insurance costs and litigation, while improving employee retention, recruitment and morale by reducing injuries and fatalities |

| Challenge | Issues | Benefits of technological approach |
|---|---|---|
| **2.2.6 Coping with energy volatility** | – Increased government regulations globally:<br>  – Australian Emission Trading Scheme<br>  – European Union Emission Trading Scheme<br>  – Kyoto Protocol<br>– Manual management of carbon, water, energy and waste with currently little automation or integration<br>– Perception that mining is environmentally unfriendly<br>– Little or no integration between the processing and power parts of many mine operations, making it difficult to determine where energy is actually used | – Current technologies and programs track and monitor carbon, water and fuel from end to end and extend to footprint management, waste management, ecosystem risk management, mine closure and re-habitation, tailings placement management and stewardship management<br>– Technology helps reduce energy expenditure and regulatory costs<br>– Processes, information and analytical tools are used proactively to manage environmental and energy consumables, such as modeling carbon trade-offs, carbon trading, water management, fuel optimization and waste control<br>– Reduced management costs and improved effectiveness in the control of consumables that impact the environment (e.g. carbon, water, energy, waste)<br>– Tighter compliance with regulations and reduced costs of meeting/monitoring regulations |

# 3.0 The future vision for mining

All of the competitive pressures facing the mining industry (see section 2.0) are driving mine operators to find new ways to increase the production rate of their operations, reduce the cost per tonne produced and extend the life span of mine sites or establish new ones. These factors are fast becoming critical competitive differentiators.

Mine operators need to change totally from the model of digging out the ore and putting it onto the market to one where they respond quickly and efficiently to customer relationships and demands, providing the ore where and when it is needed. They need to be capable of rapidly responding to new opportunities by becoming fluid, flexible and agile.

The vision is one where, in the future, mines will have equipment closer to and people further from the processes. Technology, machinery and robotic automation will be doing the routine and repetitious jobs, while personnel attend to more strategic tasks.

Taking people away from the process will reduce cost, increase productivity and enhance safety by enabling remote monitoring, diagnostics and interventions. It will see a skeleton on-site workforce collaborating with external specialists and supervisory staff based in remote operations centers.

This will be achieved by moving automation and electricity to where the ore is extracted, minimizing haulage and transport. It will see a plethora of technology to assist miners in their roles such as fully and semi-autonomous robots, increased use of artificial intelligence, 3-D and 4-D printing and ever more innovative technologies that allow remote operations.

Soon mine workers will be using big data, analytics and real-time information to guide and inform their work. Their clothes, tools and surroundings will all contain technology, each specific to a data collection task, but collectively amassing information on the miner and the mine's condition, work completed and yet to be finished as well as the mine surroundings and with the sophistication to adjust work conditions and tasks accordingly.

The solution to all these challenges, and thus the future of mining, lies in the automation and integration of information - and the use of that knowledge for real-time optimization of the mining processes.

# 3.0 The future vision for mining

### 3.1 Bringing together information and operational technologies

All of this is enabled by greater integration, visibility and intelligence within and among the operational technology (OT), production control systems and information technology (IT) that manage the company's critical assets, logistics, planning and operations. The result is unprecedented agility in operations and to both supply and demand fluctuations.

As the convergence of IT and OT brings more information from real-time systems into IT software, the following are among the four "must-have" benefits that will enhance efficiency, responsiveness and profitability across the mining value chain:

- Smart production
- Intelligent response to critical asset condition
- Demand-driven planning
- Reduced energy consumption and waste

Yet a major challenge for mining companies to reach their goals is a lack of integration between IT and OT systems. A growing number of mining companies see the single leading benefit of IT/OT data integration as optimizing for cost and efficiency. This directly addresses the challenges of:

- Managing ever increasing costs
- Controlling energy expenditure and efficiency
- Optimizing or maximizing production

Unfortunately, many companies have little or no data integration across the value chain and still operate in silos, with data not being shared with other departments. Many still rely on spreadsheets combined with human expertise for crucial decision support.

But, things are changing with several companies now taking steps to implement IT/OT data integration. These companies have a consolidated view of production systems and the most advanced these can dynamically view and adjust operations across the value chain.

It would appear that a growing number mine operators understand that IT and OT cannot operate in silos if they are to continue to deliver good shareholder returns in light of increasingly difficult extraction realities.

Many are coming to the realization that, to address emerging challenges effectively, operators need an integrated solution which provides remote asset diagnostics, continuous automation and production optimization.

ABB has been working for over 10 years to develop and enhance process control systems, communications solutions, sensors and software for the Internet of Things, Services and People. These technologies enable customers in industry, power generation and infrastructure to analyze data more intelligently, optimize their operations, boost productivity and enhance their flexibility.

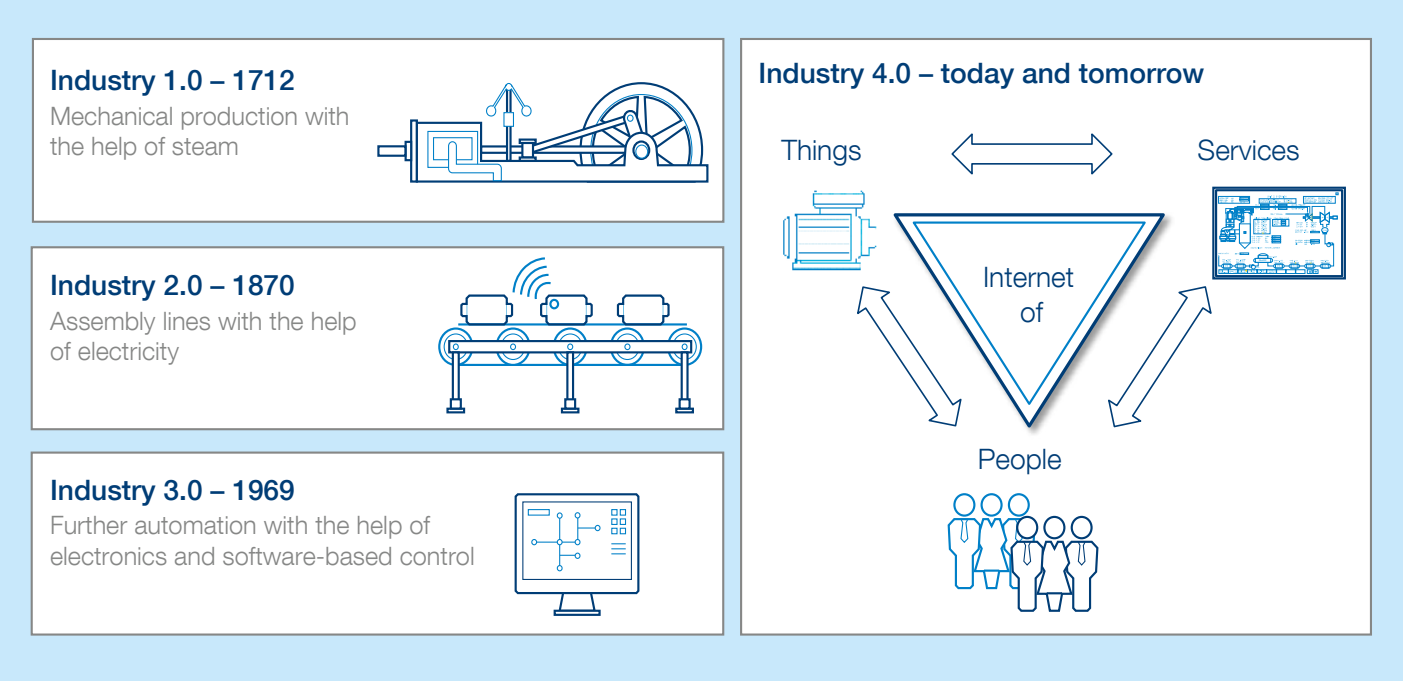



**Figure 3. Industry's evolving future.**

# 4.0 Optimizing the entire value chain

Today a typical mine and process operation has various areas in which operators run their own machines, often independently and without much communication or collaboration between them. There is rarely any integration between equipment and systems resulting in what is now frequently being referred to as islands of automation.

The challenge is to optimize the entire value chain, so that there is a complete and unified view of production, from raw material to processing, stock pile and delivery.

Integrating IT and OT helps close gaps in the value chain. For example, with good communication, blasting and crushing in the mine can be optimized together with the grinding process in the concentrator as a whole.

Automating every part of a mine brings significant benefits including:

– Higher productivity, enhanced collaboration
– Holistic commercial view of the whole enterprise
– Increased energy efficiency
– Improved safety

The future of mining lies in bringing equipment, systems and people together; the technology that can achieve this is automation.

### 4.1 Uniting the islands of automation

Taking the mine mentioned above, with its various independent islands of automation, the idea is to bring them together so that they talk the same language and are integrated into one system where all information is available. While local control rooms may still exist, the trend is towards centralized operations.

With modern control room designs, people with different roles can work together in the same environment. Barriers are torn down, control rooms are consolidated and experts can collaborate in one place.

Such extended automation closes gaps in the value chain and creates a safe, reliable and predictable production process with better visibility from mine to concentrator, smelter and stockyard.

The result is an optimized operation from mine to port.

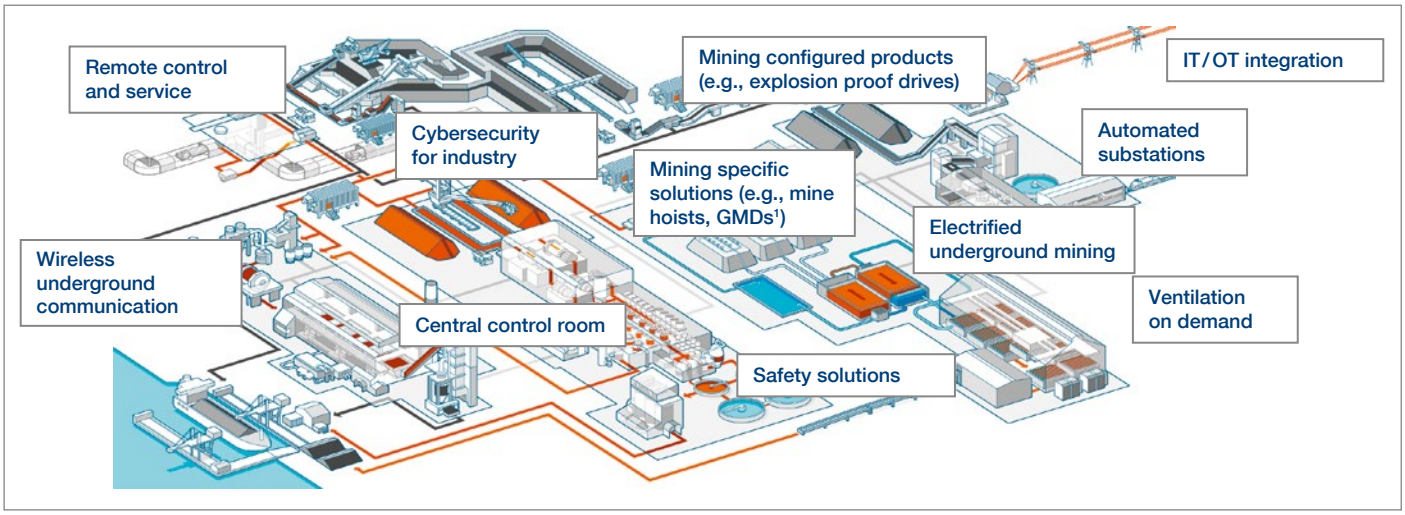



**Figure 4. Automation touches every aspect of a mine.**

# 4.0 Optimizing the entire value chain

### 4.2 Case study: Boliden Garpenberg mine

Boliden's Garpenberg mine has embraced the integration of automation and data to claim the mantle of the most integrated power and automation mining solution in the world. This facility recently underwent expansion of its underground mine that will see capacity rise from 1.5 million metric tonnes per/ year to 2.5 million.

To meet this demand, ABB has delivered an integrated power and automation control system across the value chain from mine to mill including:

- IT / OT integration, advanced process control
- Remote monitoring capabilities
- High-, medium-and low-voltage electrification, motors, and drives

And energy efficiency solutions that include:

- Ventilation on demand, smart switchgear
- Mining specific drive-motor packages

Along with a service agreement, based on preventive and condition-based maintenance.

The entire mine is now operated from a control center equipped with System 800xA, which controls most of the equipment and systems required to automate production and some of the business processes.

The Garpenberg mine is the first to integrate mine hoists, mine ventilation and the monitoring of underground mine vehicles. An integrated maintenance system allows for remote solutions for the control of the entire mine. In particular, Boliden uses mobile AF devices to supervise the production process and shorten the time for decision making.

"It's not a coincidence that ABB became one of the main suppliers", says Lars Brännström, Strategic Account Manager for Boliden. "Together with the customer, we discussed and developed the best solutions for the mine." Lars emphasizes how important it is to work closely with the customer to understand their needs, to listen carefully and to be flexible and make necessary changes during the project.

**Facts about Boliden Garpenberg:**
Boliden has invested 3.9 billion SEK to almost double the annual production by the end 2015. When under construction, it was one of the biggest construction sites in Sweden with over 700 people working on the project.

Dating back to the 1200s, Garpenberg is Sweden's oldest mine which is still in operation. Today, Garpenberg mine produces complex ores containing zinc, lead, silver, copper, and gold.

The project started in 2011 and this expansion will increase production from 1.4 million tons of ore per year to 2.5 million by 2015.

**Figure 5. System 800xA on a mobile device at Boliden.**

# 5.0 ABB's enabling technologies

ABB is ideally positioned to assist mining companies achieve the productivity transformation they are looking for with solutions spanning hardware, control and smart mining software.

ABB has been at the forefront of automating mining technologies - such as ultra-long-distance conveying and super-sized processing plant technologies - necessary to drive major physical infrastructure improvements. ABB has pioneered some of the world's most exciting technological advances in mining control systems and is a leader in the design and development of remote operations centers for some of the world's largest mining companies.

Going forward ABB's holistic approach to the entire mining operation will feature smart devices and equipment - enabled for autonomous configuration, efficient operation and self-diagnostics – as well as software that delivers total, real-time transparency for the operators. This will provide visibility of resources across the mine; intelligent production based on near real-time demand, market conditions and available ore types; and an optimal response to critical asset conditions.

By harnessing the full potential of extended automation and by bringing people, equipment and systems together in a fully integrated environment, ABB firmly believes that mining companies can vastly improve productivity, workforce satisfaction and safety.

**5.1 System 800xA**

A report by ARC Advisory Group shows that ABB has retained its leading position in the worldwide distributed control system market. According to the study, ABB is the regional market share leader for Latin America, Europe, Middle East and Africa (EMEA) and the worldwide leader in key global verticals including oil and gas, pulp and paper, mining and metals. It is a pioneer of integrated power and automation control and process application software. For over 100 years ABB has provided the mining sector with fully engineered products, systems and solutions for process control, safety, instrumentation, plant electrification and energy management.

The key to the future of mining lies in the total integration of data and work processes to achieve a process management that runs in real-time. For example, with a modern automation platform such as ABB's System 800xA, an entire mining operation can be controlled. Thus the blasting and crushing can be optimized together with the grinding operation and the concentrator as a whole, closing any gaps in the value chain. Harnessing the full potential of extended automation brings people, equipment and systems together in a fully integrated environment.

The System 800xA automation platform can handle traditional process control systems, distributed control systems (DCSs), safety systems and electrical equipment such as drives and motors, as well as production planning, power management, maintenance, asset management, enterprise resource planning and documentation systems. These can be integrated into a single control environment. The system can integrate different users, live video, voice and public address systems, plus web applications and devices. As well as ABB products, third-party pieces can be integrated into the process workflow.

With the System 800xA all information is available to all users, locally and centrally as well for mobile operators with iPads or smartphones.

By bringing together the islands of automation and ensuring that everyone has access to all information in real-time through the same viewing platform, there will now be one way to handle all functions and interface systems, one common language and one way of working with resultant efficiency benefits throughout the process.

# 5.0 ABB's enabling technologies

### 5.2 Extended operator workplace (EOW)

The EOW is a modern cockpit for mining operations. System 800xA ensures that information is available centrally to all users and locally, using mobile devices such as tablets or smartphones.

An EOW avoids the cluttered and scattered overview that operators currently endure. This environment can result in poor collaboration in which operators never have a true overview of the process and are more likely to make mistakes.

In fact the global process industry loses $20 billion, or five percent of annual production, due to poor quality and unscheduled downtime. Consultants from the ARC Group estimate that almost 80 percent of these losses are preventable and 42 percent are primarily the result of operator error.

Integrating the data and presenting it through an EOW will enhance efficiency, responsiveness and profitability across the mining value chain. Integration on this scale will become the norm for all leading mining companies over the next few years — indeed, some are already well down this path.

### 5.3 Enterprise software

The 2010 fusion of leading mining software company Mincom into ABB created a dynamic entity with the technological know-how to supply the solutions needed to help mine operators make a step change.

The software solutions include planning, logistics, sales and marketing, asset management and business analytics software, covering the entire mining life cycle. The availability of leading-edge hardware, operational and information technologies from one global vendor has opened new horizons for mining companies looking to embark on productivity transformations.

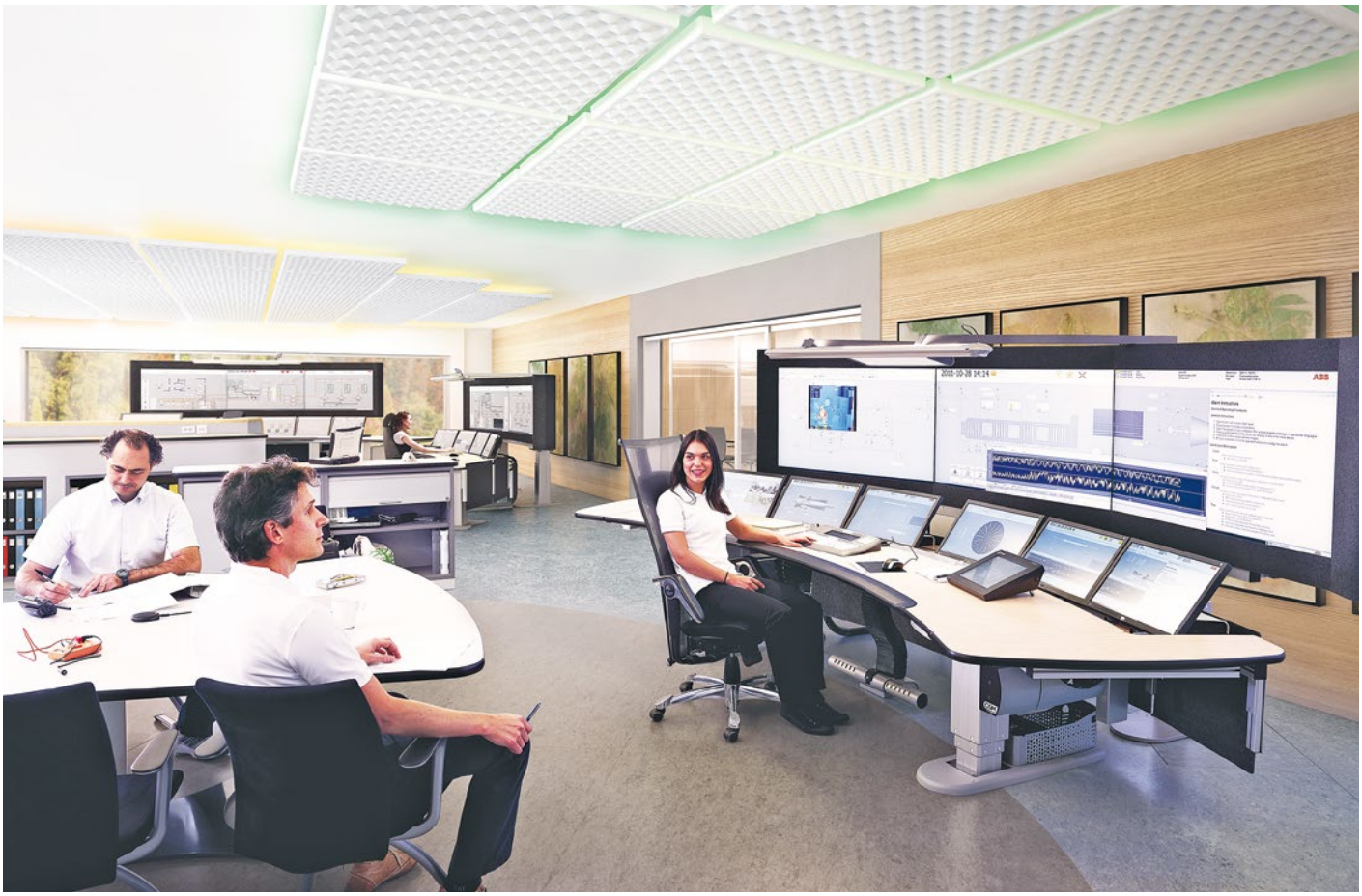


**Figure 6. Remote operation center: The EOW enables true collaboration.**

# 6.0 Areas of automation

ABB's position in mining is to supply the complete data integration solution and many of the elements crucial for mining, such as gearless mill drives, hoists, complete plant electrification, ultra-long-distance conveying, super-sized processing plant technologies, integrated process control and optimization solutions, motors and drives systems as well as instrumentation and analyzer systems.

As a technology company with a long history of providing advanced technology to the mining sector, ABB is well aware of the major leaps in innovation that are now needed in the business. Due in part to the very harsh conditions encountered underground, mining has lagged other sectors as far as technology and automation is concerned, but ABB's experience in areas such as oil and gas, automotive, and pulp and paper brings a deep understanding of how challenges can be overcome, and allows the creation of a vision and a technology road map for the future of mining.

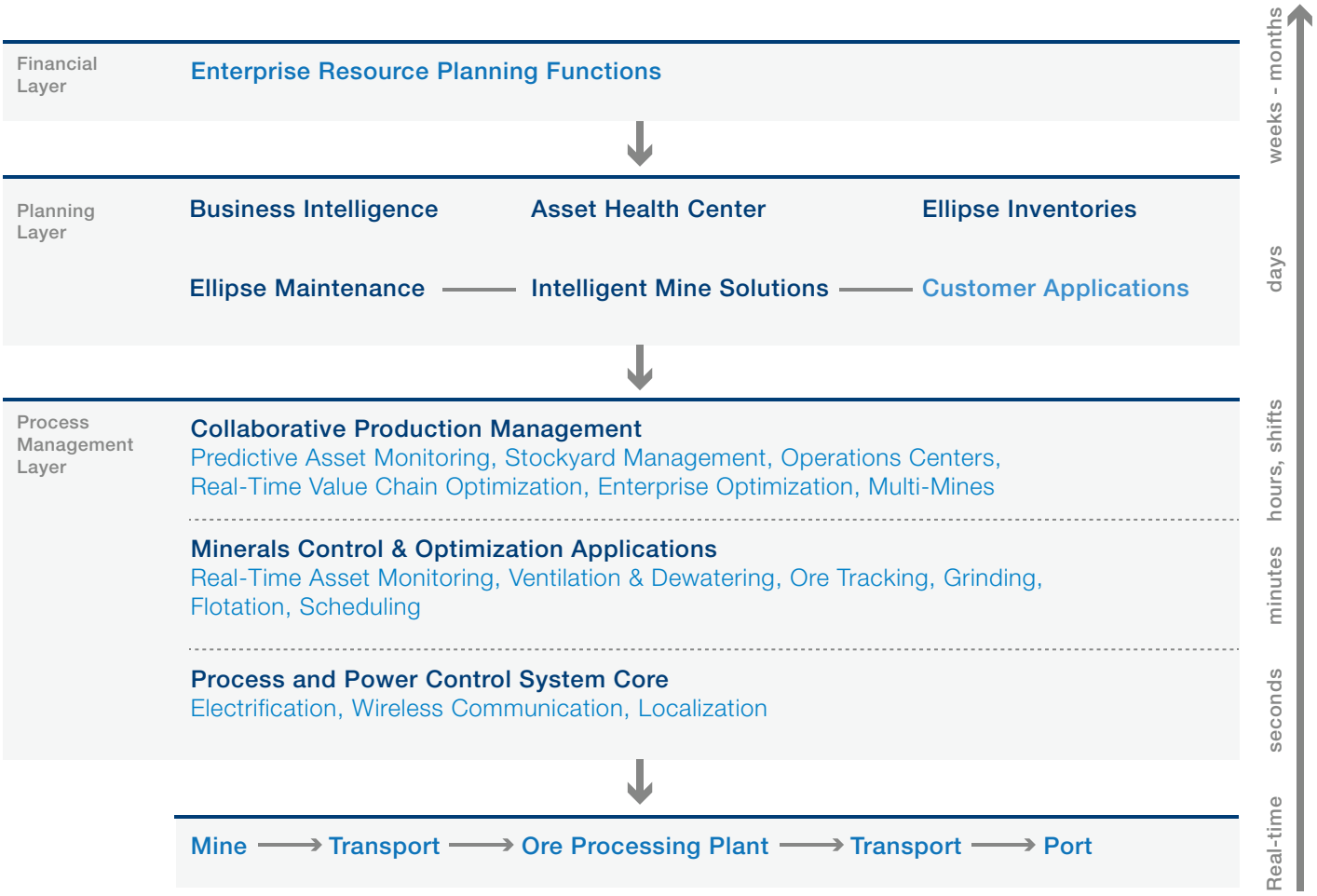



**Figure 7. ABB extended automation porfolio for mining.**

# 6.0 Areas of automation

### 6.1 Process and power control system core

With the vast power consumption of a modern mine, it makes sense to integrate the data from the electrical side with the rest of the operation. In this way, the power consumers — electrical machines, hoists, conveyer belts, ventilation, lighting and emergency systems — can work in harmony with the power supply infrastructure.

#### 6.1.1 Mine electrification and its integration with process control

By integrating the process control and power control within the same system, capital expenditure (capex) is reduced, as is the need for training, IT infrastructure and cybersecurity.

Integrating this data within System 800xA with that from other parts of the enterprise achieves tangible savings. Maintenance procedures can then be tuned to take into account the condition of the machine to be serviced along with the wider implications of taking equipment off line.  Maintenance can be scheduled when other related equipment is nearing a service interval – or perhaps when market data indicates an upcoming dip in demand.

Significant energy savings can be achieved by combining market demand and production data - allowing machine activity to be optimally scheduled. There is no point in having maximum production rates (and thus highest energy consumption) if some bottleneck elsewhere in the enterprise is throttling production requirements.

Integrating process and power automation into one single automation system like the System 800xA reduces cost, enables effective power management and provides the mine operator with the starting point to make the technology step change now required by the industry.

### 6.1.2 Wireless communications

Integration of communications improves production efficiency. Once a wireless communication infrastructure is established and the mobile and fixed equipment fleet is integrated into this network, entirely new worlds of data exchange and optimization possibilities open up.

For example, ABB and Atlas Copco Underground Rock Excavation, Sweden, have developed an innovative mobile integration involving System 800xA and Atlas Copco's mining machines. The solution is currently installed in a mine in Kvarntorp, Sweden, and features the integration of real-time data from mobile machines, fans, faces and draw points, on-site crushers, conveyor and hoisting systems.

### 6.1.3 Resource location and data integration

Results reported by mobile equipment - such as online production reports or machine telemetric information - can be retrieved and analyzed in the context of location and status, including local environmental data.

With this information, new drill plans and loading sequences for production can be calculated and supplied to the operational teams. The International Rock Excavation Data Exchange Standard and other industrial automation standards will serve here as a starting point to ensure equipment compatibility across the industry.

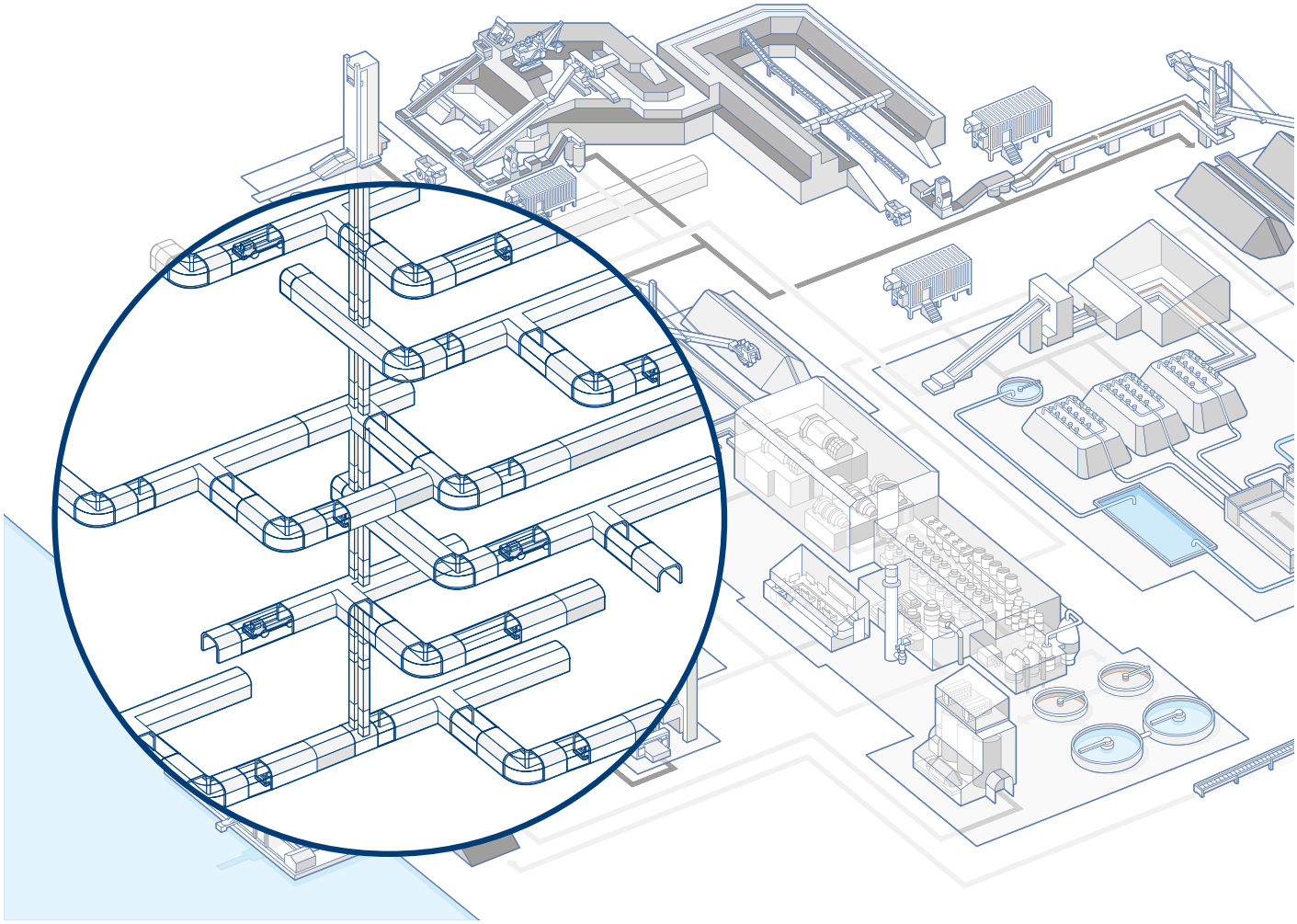


**Figure 8. Wiring the mine to the control room.**

# 6.0 Areas of automation

**6.2 Minerals control and optimization applications**
Information integration will dramatically improve production efficiency and productivity. This is particularly true when applications are created that exploit that information in the right context. The whole then becomes more than the sum of the parts. In this section a few examples are discussed.

**6.2.1 Real-time asset monitoring meets process control**
By using real-time condition data, in this case the temperature sensors on a conveyer drive, the actual condition of the asset can be detected, allowing proactive actions to be initiated automatically, greatly reducing the risk of potential failure which would cause a production loss.

There is a trend for putting planning and reporting and accounting systems more online.

**6.2.2 Smart ventilation and mine dewatering systems**
In some mines, ventilation accounts for almost 50 percent of energy consumption. Mine vehicles emit diesel exhaust gases that have to be ventilated away.

ABB's automation system knows the whereabouts of each vehicle. And, all vehicle data (including emission levels) is communicated to the system. The ventilation can therefore be continuously optimized for actual need and the air flow can be adjusted at any time.

To manage ventilation on demand, a new method for mine-wide coordinated control of fans and air regulators optimizes energy use by automatically feeding the mine with the required air. The solution relies on feedback from gas, flow or temperature sensors.

Multi-variable models describe how changes in the speed of fans affect both the airflow and the pressure across fans. The parameters in the models are obtained empirically from operational data, which makes the model easily adaptable for new conditions.

Air is provided where it is needed in the mine by adjusting the fan speed based on the air demand in various airways, properties of the fans and their motors and as well as the opening angles of the air regulators that are used to control the air flow.

Minimizing energy consumption, while preserving air quality, means great savings. With the integration of process and power automation in System 800xA, energy usage can be measured in real-time. Through the EOW operators have a single view of process and power equipment, as well

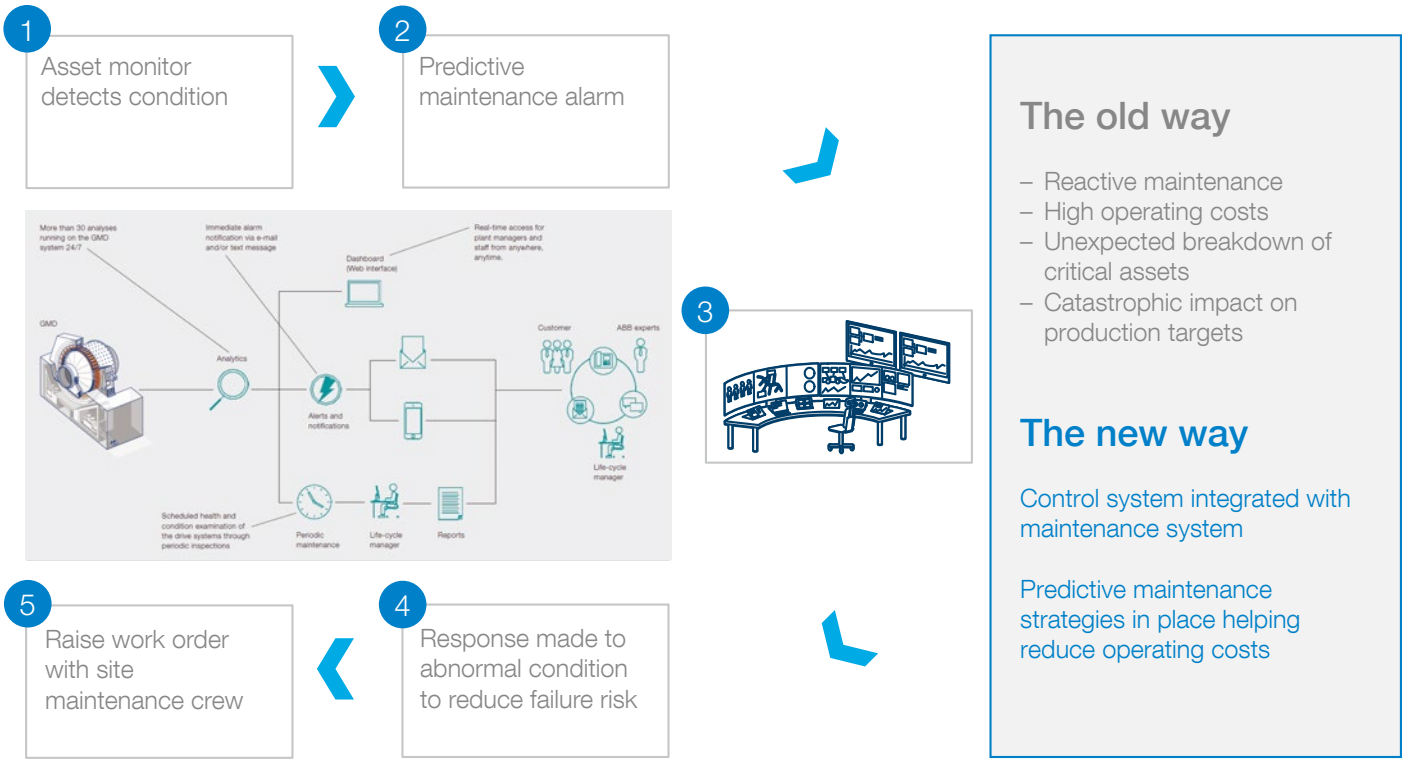



**Figure 9. Optimizing processes through real-time asset monitoring.**

as protection, switchgear, transmission and distribution equipment. The result is a reliable power supply and enhanced visibility of the usage and consumption of power in all areas of the mine.

Dewatering is another problem faced by miners both ancient and modern. Here, again, data integration can be used to great effect to monitor remotely pump condition and performance, maintenance needs, power costs and resource coordination. The energy savings to be made by optimizing pump performance in a mine can be very significant.

### 6.2.3 Ore tracking

In ore-processing plants, the largest source of uncertainty relates to the properties of the ore; plants need to be able to react quickly to any changes. Much better results can be obtained when the ore properties are quantified ahead of time.

Technology can track material movements and properties all the way from the mine to the processing plant. The software used to deliver this functionality is able to model the ore movements along the material handling system, including conveyors, silos and conic stockpiles.

Ore properties can then be logged and represented graphically, eliminating guess work. The information is available for other advanced applications, as well as to support operator's actions.

Material movements can then be automatically synchronized with inventory management systems that look after the logistics and the supply chain.

Finally, ore information can be used by process optimization controllers. They can use forecasts of the ore properties to make predictive adjustments to the grinding and flotation circuit. The result is higher equipment utilization, increased production and lower energy consumption.

Process optimization controllers exploit these forecasts to make predictive adjustments to the grinding and flotation circuit according to the now known properties of the ore. The result is higher equipment utilization, increased recovery and lower specific energy consumption. Production is within specifications, incurring no penalties yet guaranteeing customer satisfaction.

# 6.0 Areas of automation

### 6.2.4 Grinding circuit

A milling circuit is a complex, multi-variable interacting system. Dynamically changing ore conditions and wear parameters pose particular problems for grinding controllers. By integrating data, the automation system optimizes grinding controls, avoiding the need for constant manual tuning.

Again, data integration is key. The grinding process can not only be optimized within itself, but because it has access to relevant data from the rest of the mining operation, it can obtain far more leverage. Feed-forward data on ore quality and quantity, rock face production rates or market demand rates can be used to optimize the grinding stage.

### 6.2.5 Flotation circuit

Automatic control can lead to significant flotation performance improvement. The controller needs to stabilize the process and to maximize the concentrate production, while guaranteeing a minimum concentrate quality. This pushes the process to an upper limit operating point. To achieve this, optimal set points are automatically chosen by the controller. Online analyzers and blending algorithms reconcile actual feed with quality specifications for better predictability.

The mine operator can now increase plant recovery and optimize product mix by leveraging ore monitoring and advanced process control (APC) across processes and business systems. APC manages blending, grinding and flotation in real-time. Geological models and real-time material tracking provide a short-term feed characteristic schedule to the APC so it can increase performance and quality in real-time.

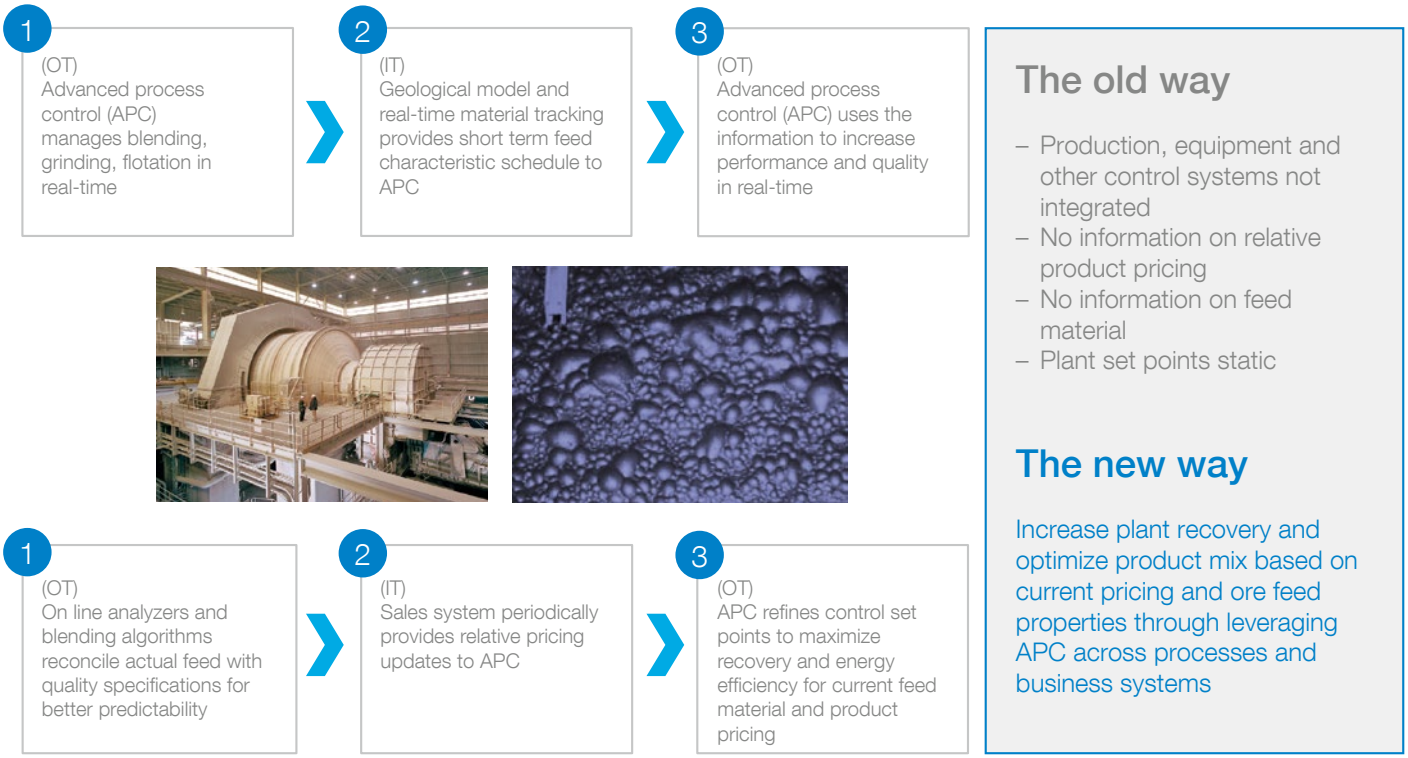



**Figure 10. Grinding and flotation advanced process control.**

### 6.2.6 Mine operation scheduling

Another typical mining scenario which could be optimized through automation is scheduling. Let us assume that a drilling cycle has missed a blast round. In this case the disturbance is putting the production at risk. With automation the local operator has a scheduling system in his workplace and gets notified immediately. The critical area is clearly marked and the cause of the problem is identified.

Operators and production management can discuss among themselves and run what-if analysis to simulate different solutions. Since all staff see the same information, they can jointly decide what actions to take.

Everything is done in real-time; no need to wait until the end of the shift.

With access to data from other parts of the operation, mining methods can move toward a large-scale, continuous mine operation that can be run as a normal factory.

The extended automation infrastructure created brings visibility and transparency to operations. The modern operator can act as a dispatcher or “flight controller”. This operator knows the daily and weekly plan, which resources are in place and has decision-support tools to optimize the usage of these resources to fulfill the production plan more effectively. This system allows the operator to detect anomalies faster and re-assign resources in order to minimize any impact.

Effectively, ABB is enabling manufacturing processes in the mining environment. This brings improved safety, higher production and better productivity.

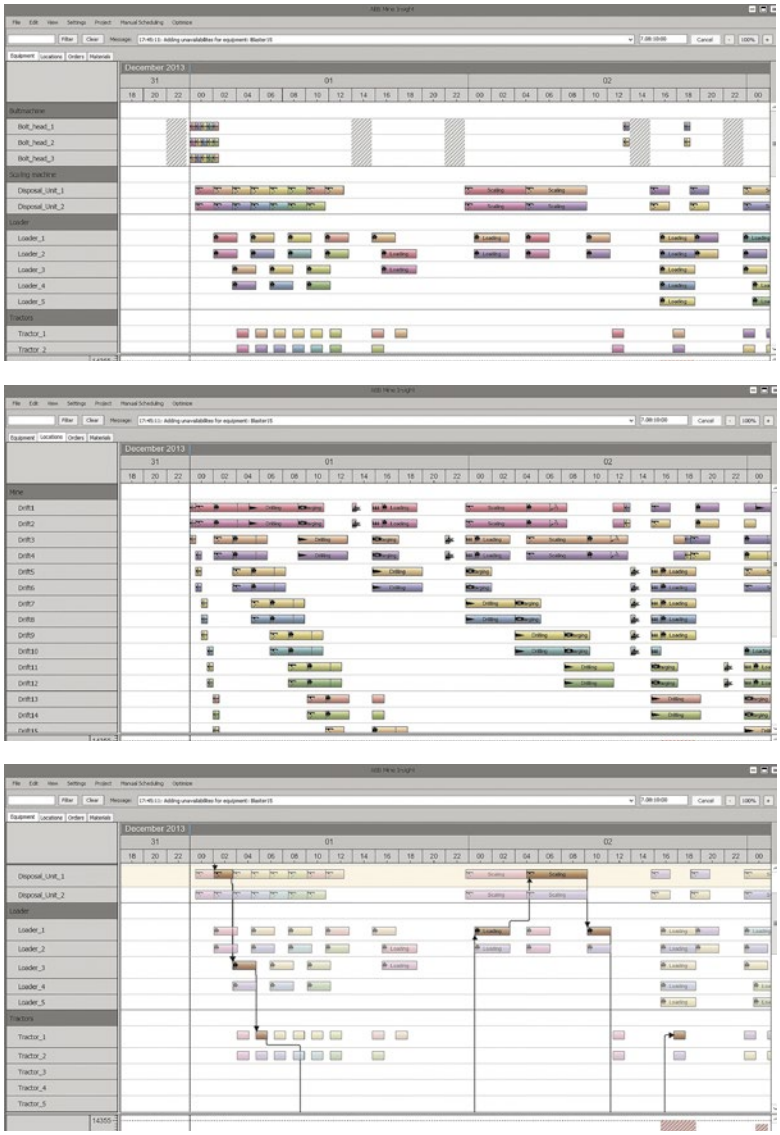


**Figure 11. Integration of key information facilitates effective decision-making.**

# 6.0 Areas of automation

### 6.3 Collaborative production management: integrated-mine-to-port value chain operations

Automation is not new to mining, but the automation employed in mines is generally more basic than in other industries. It is often limited to simple control of motors, equipment or certain parts of processes. Further, mines tend to have a large number of independent pieces of equipment and systems from different suppliers. Each of these “islands of automation” can have its own data, data format and interfaces, and operators and control room staff must scrutinize a multitude of conceptually disconnected screens in order to coordinate different parts of the process.

#### 6.3.1 Predictive asset monitoring

A modern asset optimization system can help mines to go from reactive to predictive maintenance strategies, avoiding unnecessary maintenance and reducing operating costs.

Extended automation solutions such as System 800xA can integrate modern maintenance systems from suppliers such as IBM, SAP and Ellipse from Ventyx.

A good example of this is the integration of IBM Maximo at Boliden’s Aitik mine in northern Sweden. With System 800xA, the operator is alerted by a predictive maintenance alarm if equipment needs repairing. They can access the maintenance system, see all upcoming work orders and easily add new orders. The field engineers can view the same information on their mobile devices and together they can decide on the optimal maintenance plan.

Continuous and consistent asset monitoring brings maintenance management to the operator environment and provides a single-window interface for all operations related to asset management. This allows plant personnel to collect, compare and monitor asset data and thus accurately assess equipment conditions in real-time.

System 800xA’s asset monitoring functions for mining combine automation architecture with advanced information technologies, including integrated fieldbus. Called AssetVista™, the function monitors all plant assets in real-time. This includes field devices, control systems and automation elements, as well as major assets such as heaters and generators.

The AssetVista™ architecture and functionality promotes the creation of complex asset-specific monitors that not only makes use of the raw device data itself but also integrates it with process and environmental information to put the data into context and deliver more precise condition statements.

This concept can be extended to complete production areas such as hoists, conveyors, mills and grinding and flotation circuits, thus creating a new level of insight into plant performance.

System 800xA AssetVista™ can thus help end users sustain asset management improvements and improve return on investment. It is a single point of contact to find the asset management solution that best fits user needs.

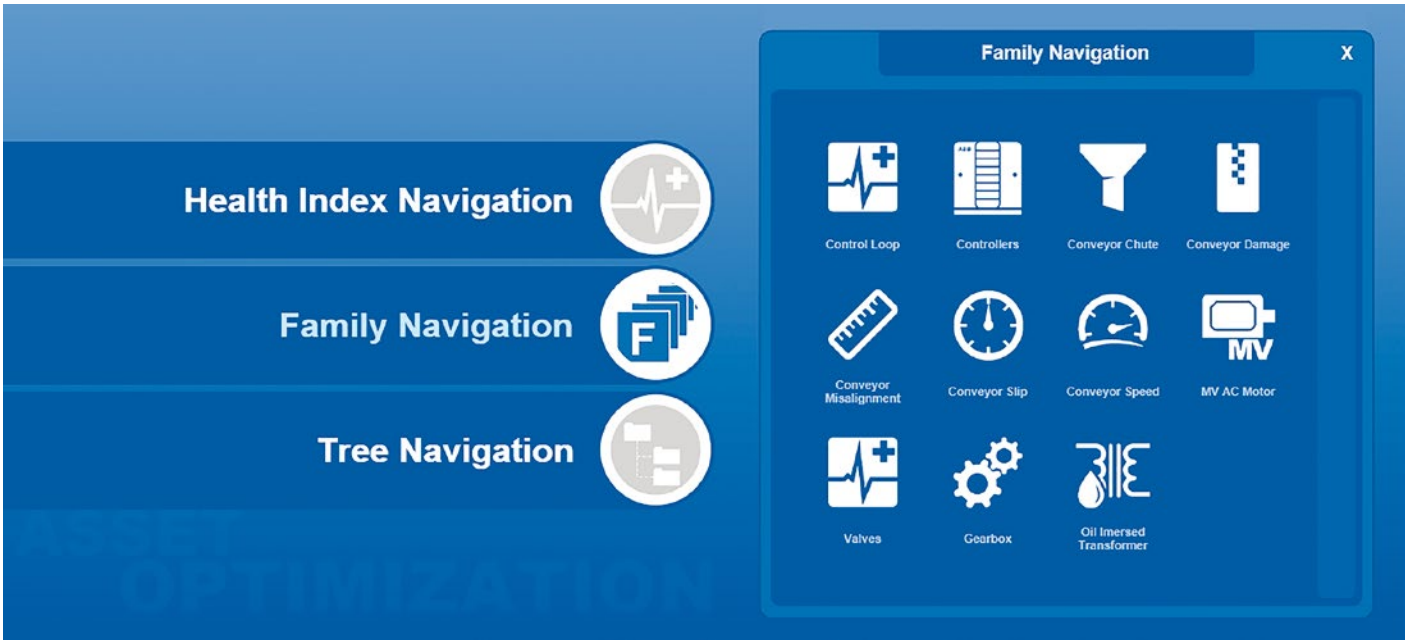



**Figure 12. 800xA AssetVista™ dashboard.**

### 6.3.2 Stockyard management system

Bulk material handling facilities transport material from one of several locations, such as a mine, to a destination. Often, bulk material is temporarily stored in stockpiles or stock yards. Stockpiles are used in many different areas, such as mines, ports, refineries, power plants or manufacturing facilities.

To increase production efficiency, optimize process output and reach an accurate and transparent input/output balance, a high degree of operator support and automation is necessary. This can be provided by a stockyard management system (SMS). An SMS is an integrated part of the overall stockyard management and control system and it includes instrumentation, electrification and scope for automation of operator-controlled stockyard machines.

A SMS organizes the stockyard in real-time based on job definitions generated by production management. The SMS merges data on incoming material quantities with additional information such as quality data, ownership of material and localization and visualization aspects to provide a comprehensive picture. An “anti-collision system” at the control level provides for safe operations.

### 6.3.3 Remote operation centers: visibility and collaboration

The mining industry is gradually moving towards mine control through remote operations centers that coordinate multiple areas within an operation and even across multiple sites.

Local control rooms may still exist in the future, but the trend is overwhelmingly towards centralized operations — often in company headquarters. With modern control-room designs and extended automation, people with different roles can work together in the same environment.

Control-room consolidation means that barriers are torn down and experts can collaborate in one place.

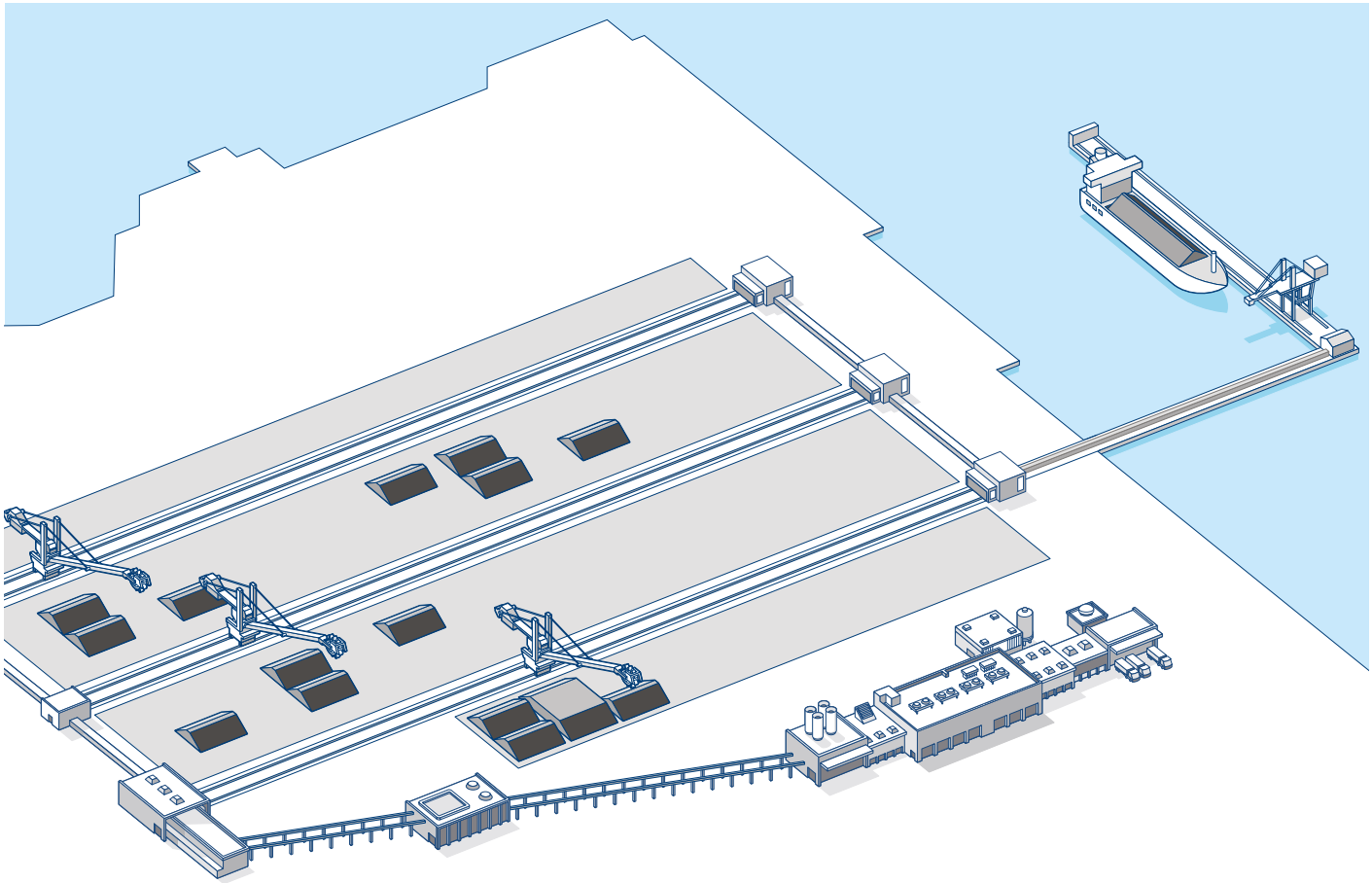


**Figure 13. Stockpile management system.**

# 6.0 Areas of automation

As all information from local mine sites is available, this facilitates collaboration in production planning, resource planning, specialist support, inventories and spare parts, allowing resources to be optimized across multiple sites.

Data from all parts of the operation can now flow together to allow precise and optimized management of mining - from rock face to end customer - across multiple sites. This collaboration between systems, equipment and people enables information to be shared without barriers and empowers operators to perform optimal control actions and to take sound business decisions.

**6.3.4 Real-time value chain optimization**

The mining value chain extends from the extraction of raw materials through the transport of product to the end customer. To achieve production and productivity targets, mining companies need to achieve high operational performance and efficiency across supply chain processes.

Among the principal causes of supply chain bottlenecks are difficulties in inventory planning, output planning and demand forecasting. These challenges in marrying supply to demand often result in inefficient production flow, large stockpiles and the inability to provide customers with the product grades they desire.

Better integration and automation across processing plant operations, mine planning and asset maintenance/ management offers visibility into all production variables including delivery contracts, current inventory, mine plans, equipment availability and transport schedules and will guarantee the right product is available at the right time. It will also make sure that customer orders are accepted only when the supply chain can deliver, improving negotiating power and risk management. Real-time material tracking and geological modelling can provide short-term input to rock face operations. In addition, this unified view ensures that equipment maintenance can be planned to suit increases or decreases in demand.

To further anticipate demand, information can be supplemented by market-based demand information such as stock levels, customer demand trends as well as fuel and commodity pricing. In a coal mining value chain, for instance, visibility into real-time conditions can be provided by online coal quality analysis sensors.

When these indicate that the actual blend deviates from the target, a control sequence could automatically be triggered that interrogates the inventory data. Based on stockpile information, reclaiming can then be automatically adjusted so the customer's specification is met. The result is production within specifications, with no penalties and guaranteed customer satisfaction. This holistic view enables the full implications of short-term, medium-term or operation-recovery decisions to be understood, improving the overall performance of the entire operation.

**6.3.5 Big-data-based enterprise optimization**

The underground environment takes its toll: the utilization rate of mobile mining machines can be as low as 20 to 25 percent, that of open faces as low as 20 to 30 percent and some machines can have a mean time before failure as short as eight hours.

Failure of a critical production asset can have a catastrophic impact on production targets and profits. The loss resulting from a main conveyer failure, for example, can run into hundreds of thousands of dollars per hour.

A modern asset optimization system can help mines to go from reactive to predictive maintenance strategies, avoiding unnecessary maintenance and reducing operating costs. In future, online access to experts 24/7, online integration of relevant information and online integration of tools and inspection devices will be taken for granted. System 800xA can integrate modern maintenance systems from relevant suppliers. Real-time data on asset conditions can then be used to streamline maintenance effectiveness and enable condition-based monitoring.

In the case of a conveyer system, say, if an asset monitor were to detect an abnormal condition, an alarm would be generated and the control system could slow the drive to reduce failure risk. Once integrated, these systems would connect directly into the IT systems and automatically raise a work order with the site maintenance crew. When the crew completes the work, this could be instantly reported, allowing the control system to return systems to normal in the shortest possible time.

In future, the equipment across a company's mines will be completely standardized. This not only makes life easier for operations and maintenance staff, but also it makes a lot of sense now that each piece of equipment can be included in the big picture back at the remote operations center.

**6.3.6 Multi-mines**

Mining companies have become multinational giants with mines scattered all around the world.

With System 800xA all information from local mines can also be available and consolidated into corporate headquarters. This facilitates collaboration across mines. Production planning, resource planning, specialist support, inventories, spare parts, etc can be optimized.

By harnessing the full potential of ABB's extended automation, mining companies can raise their productivity and safety, and achieve a more efficient and profitable mining operation.

# Conclusion

ABB is committed to the mining industry and has a research program that aims to extend automation and integration to even more complex mining scenarios. For instance, research is underway on the next generation of networking technologies to enable tracking and communication of production equipment in open pit and underground operations. New sensor technology is being developed to detect mass flow and quality variations more quickly and accurately across a range of commodities. Meanwhile, advanced process control models are being explored that will improve energy efficiency while new asset health monitoring technology is set to detect more proactively actual and predicted capacity loss.

A holistic approach to the entire mining operation will feature smart devices and equipment — enabled for autonomous configuration, efficient operation and self-diagnostics — as well as software that delivers total, real-time transparency for the operators. This will provide visibility of resources across the mine; intelligent production based on near real-time demand, market conditions and available ore types; and an optimal response to critical asset conditions.

By harnessing the full potential of extended automation and by bringing people, equipment and systems together in a fully integrated environment, ABB firmly believes that mining companies can vastly improve productivity, workforce satisfaction and safety. The automation journey for the mining industry has just begun.

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