PSI*mining*
The Digital Mine
High-Level SCADA-System
for Mine Operators

Content

PSI*mining – The Digital Mine*

High-Level SCADA-System for Mine Operators

Characteristics of PSI*mining*

PSI*mining* is a factory-level SCADA system (Level 3) designed to supervise, control and automate mine operations.

Besides SCADA-functionality PSI*mining* supports full Workforce Management for various tasks.

Synergy effects of this combination are:

- Increased quality of workforce management
    - Shortest possible reaction time on unplanned events
    - Minimized maintenance time for mine equipment and infrastructure
    - Increased planning quality
    - Higher OEE (Overall Equipment Efficiency)

- Reduced operational costs
    - Reduction of standstill-time and standstill events
    - Better coordination of production (stabilize output, manage unforeseen events)
    - Optimize material logisitcs
    - Improve storage capacity utilization

All aspects like accurate control of machinery and infrastructure, improved workforce management and reduced operational costs contribute to higher output and revenue and ensures a return of investment within short period of time.

Currently, PSI*mining* is the only mining SCADA system in the world with the capability to integrate all processes related to mining activities into one single SCADA. Furthermore it is the only system world wide which optimizes selected processes in real-time like bunker loading/unloading mining output control, etc. to achieve i.e. optimized shaft-loads.

It combines geological data with associated machinery and plant data from different areas. For high level automation PSI*mining* uses the control functions

from the existing subordinate machinery, such as PLCs, rather than replacing them. Investements done are safe.

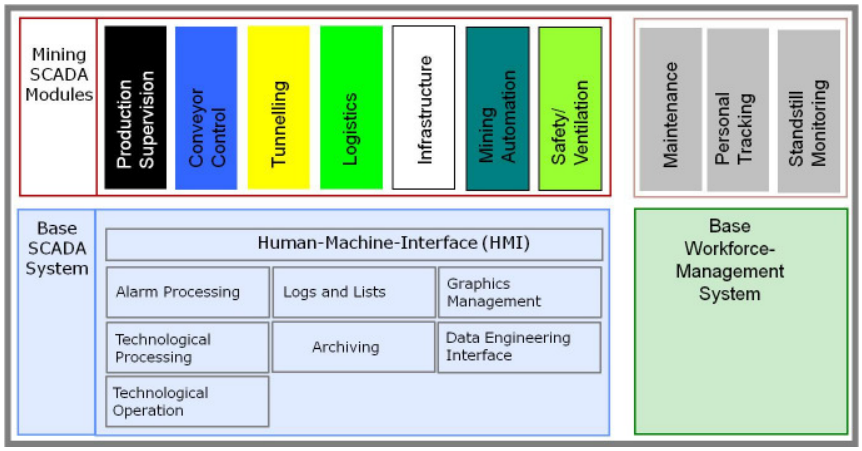
PSI*mining* provides the following unique features, capabilities and advantages:

- Full-Integration System Concept
- Integration of all mining specific tasks in one SCADA system
- Distributed Operator Stations
- Location-independent operator stations (remote operator stations)
- Redundancy concept
- Highly sophisticated Human-Machine-Interface (HMI) with automated operator guidance
- Interpretative graphical data engineering
- Geographical / Geological views in process oriented SCADA Online / Offline data model concept
- Energy management functionalities (EMS) for load forecast and load calculation
- Topology for analysis in pipeline- and electrical networks
- Secure data interfaces to external systems such as ERP or GIS in the corporate environment
- Automation beyond machines and equipment
- Standstill management, event handling and workforce management

Other SCADA systems need a number of different systems and installations dedicated to certain sub-processes for their visualization and control. Thus they are unable to cross-sector supervision, control and automation.

PSI*mining* provides all standard SCADA functions ready to use. Mining-specific features can be added as dedicated modules which will be fully integrated. In addition, PSI*mining* provides system-wide, consistent and active operator guidance for navigation in geographic overviews, schematics, lists, protocols, curves, etc. Active means, that in case of events or alarms the system takes the operator to the point-of-interest.

Furthermore, the typical Level 3 SCADA task "Manufacturing Operations and Control" (detailed production scheduling, dispatching production, reliability assurance, etc.) is fully implemented.



Due to this fact, the cross-sector supervision and control enables the mine operators to implement straight-forward pull strategies for the overall production process (mining, coal preparation, coal loading up to transport logistics).

SCADA-Functions of the Base System

Human Machine Interface

The Human Machine Interface (HMI) is a PSI in-house development and therefore unique! The objectives for the design and implementation of PSI*mining*'s HMI are:

- High degree of flexibility in graphics design. It is possible to display any type of object which supports any kind of future system extension.
- The HMI software is designed as an open system. All common graphics standards are supported or can be added later. PSI*mining*'s HMI is multilingual.
- Conceptually, the HMI supports an unlimited number of objects. The only limiting factors are hardware and operating system constraints.

Highest performance is ensured for all functions using the HMI. PSI*mining* provides the fastest control system HMI available.

The HMI provides a number of special features which support the operator in navigating large graphics such as geography-oriented graphics of mine buildings.

- Drag & Drop
  Elements can be dragged from a graphics element or log line and dropped at any location of the available displays.
- Navigation frame (Picture-in-Picture)
  For large and geography-oriented graphics, the navigation frame supports the operator during navigation within the graphics.
- Panning of selected graphics via mouse functions or scroll bars.
- Zooming and Decluttering
  Stepwise and continuous zooming with free selection of zooming centers is available. Depending on the zoom level, detailed information is automatically displayed or hidden (decluttering).
- Graphics selection
  Direct graphics selection by menu graphics buttons as well as predefined links between system devices and associated graphics.
- Polygon tracking

In complex and large graphics, it can be difficult to track a specific line, such as power line or pipe. Using polygon tracking, the user can "snap" the cursor to the line or route and follow it throughout the graphic.

- Multi cursor functionality (Tandem)
- Geographical large overview picture (GEO)
  The GEO picture is a large graphic consisting of all mine building elements (galleries, conveyors, belts, shafts, coal faces etc.) as well as the associated safety-related equipment (CO, CO^2, CH4).

Alarm concept

Operator prompting

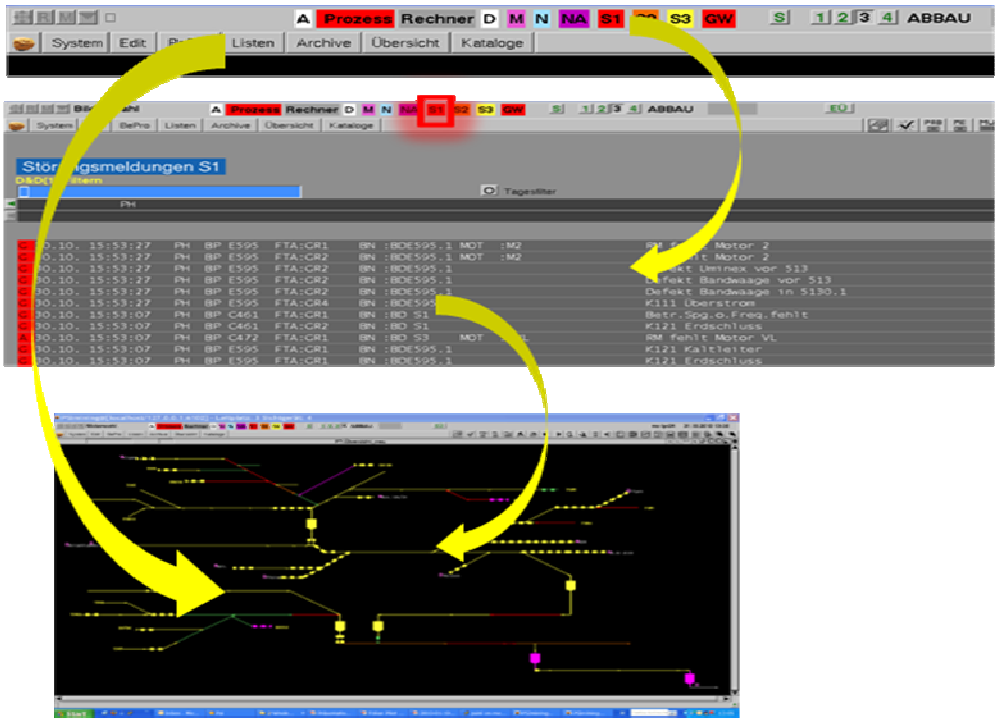
The described graphics and alarm hierarchy allows an operator to switch quickly from the global overview to the corresponding detailed pictures. This ensures consistent and reliable operations. Important basic tasks of operations are:

- Alarm signaling which leads to the corresponding pictures in the graphics hierarchy,
- Intuitive guidance within the operation dialogs,
- Display of current deviations from the normal state.

Fault processing

Messages (faults, indications, etc.) due to spontaneous events are:

- Process indications, such as switching device state changes or fault and operation indications
- Indications created or derived by the system, such as violations of limit values or General Interrogation failure
- Indications of the information network, such as Telecontrol - or Data connection or transmission errors or other important system error messages



The operator is alerted by means of acoustic and optical signaling. Further alarm signaling is performed via global indicators, summary indicators or display of system elements or individual indications.

The alarm signaling of the system giudes the operator exactly to the alarming element.

Technological processing

Processing of indications

The processing of indications can be configured project-specifically. The types of indications are Indications of the process, Indications of information technology and Indications derived from PSI*mining*.

Measured or Counter value processing

After arrival of a telegram, the received raw measured values are converted into the corresponding scaled values and made available in the control system for further processing and calculations, including calculation of virtual values. After

arrival of a counter value telegram, the counter increment is calculated. If the counter has rolled over, additional processing is performed. Then the associated quantities can be calculated based on the counter parameters.

Output processing

Both operator-initiated commands and command steps from a switching program or sequence are processed identically. If a corresponding feedback has been defined for an output, the software monitors whether the feedback is received in time. The monitoring time is be specified in the definition of the process elements in Data Engineering.

Interlock checks

Many process operations and functions use some type of interlocking. An interlock is a condition that needs to be fulfilled for the execution of an operation. If the condition is not fulfilled, the execution of this action is not permitted and will not be complete.

Technological operations

Login

Every operator will be identified by the system. The operator has to log in to the system by entering his/her name and the personal password. Passwords are entered in "blind mode". Each login and logoff is logged in the operations log of the information network including operator name, time, and operator workstation.

When the operator workstation is logged off, it exits the current operating mode and enters the "Idle" state, i.e. no operation except login is possible. In this state, each operation automatically initiates the display of the password dialog.

Responsibilities and authorizations

In the control system, responsibilities are defined in order to clearly specify the scope of duties. Responsibilities take into the account requirements related to normal working times, as well as nights and weekends. The responsibilities are divided into command authority and alarming responsibility.

Every operator workstation of the control system can be made responsible for a certain area of command and alarms. An area comprises a defined number of process objects and can be created by combining assigned indication sources.

Interrogations

General Interrogations (GI) for head-stations can be triggered by operators or automatically by the control system. A General Interrogation obtains the current complete state of the process from the head-stations. During the General Interrogation, the received telegrams are checked for completeness, i.e. whether the expected information has been received. If one or more telegrams defined in the Interface Computer System fail to arrive within a configurable timeout, the General Interrogation will terminate with a corresponding error message. The chronological sequence or the failure of a General Interrogation will be logged.

Event and alarm Acknowledgement

The information presented to the operator by the HMI has different degrees of operational importance. For this reason, a distinction is made between Indications which have to be acknowledged, and Indications which do not have to be acknowledged. In Data Engineering, it can be freely defined which indications have to be acknowledged. Usually, acknowledgments are required for all alarms, Spontaneous state changes and all setting changes other than the expected feedback to a telecontrol operation.

Special operating modes

Operator workstations can work in the following operating modes:

- Operations mode for all mining specific tasks
- Data Test mode for data test without affecting the operational work
- Data Engineering for data entry, data maintanence and picture construction
- Post Mortem mode for the detailed post-analysis of high important or security related events during the daily operation

Each operating mode is indicated by a specific window color. A workstation can run two different operating modes at the same time, such as Operations and Data Engineering. Each mode must be assigned one or more monitors.

Logs and lists

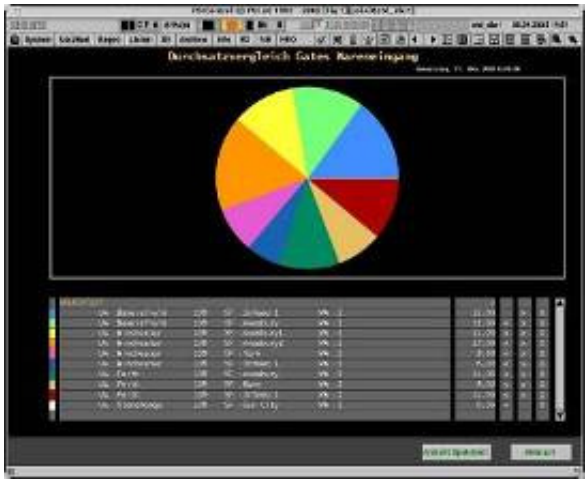
PSI*mining* provides logs and lists. All logs and lists are defined network-specific. The user interface for the different log and list types is generally similar. The display forms and operational procedures are homogeneous

throughout all networks. Log and list types in the operations management system are chronological logs, state lists, list of comments, object lists and static lists.

Cyclic archives

Archiving stores process information over defined periods of time with fixed time patterns. Typically, this information consists of measured and counter values with minimum, maximum, and average values. Other information such as statistics or schedules can be archived as well.

The archives are configured according to the project requirements. The parameters (Cycle, period, Number of variables, compression, updating, definitions) can be set.



Workforce Management

PSI*mining* contains the two PSI core technologies PSI*control* and PSI*command*. PSI*control* manages the device data properties, and locations as well as the measured values and counter values. PSI*command* manages actions to be taken in the case of breakdown of devices and planning data for preventive maintenance. Thus, PSI*command* implements the workforce management for different areas of activities like maintenance, operations, logistics, etc..

In PSI*mining*, information describing the properties of devices contained in the hierarchical data model is automatically made available to Workforce Management. No additional data maintenance or transfers to the Workforce Management system are required.

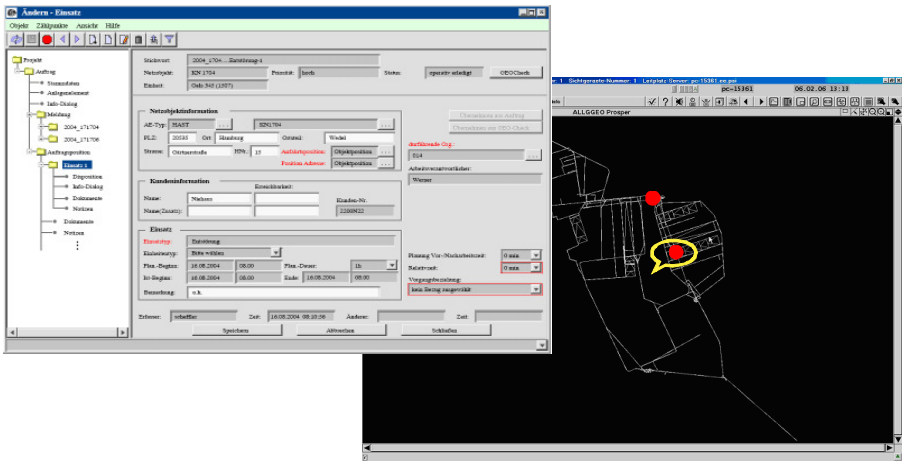


Figure 1: Workforce Management template for maintenance in PSI*mining*

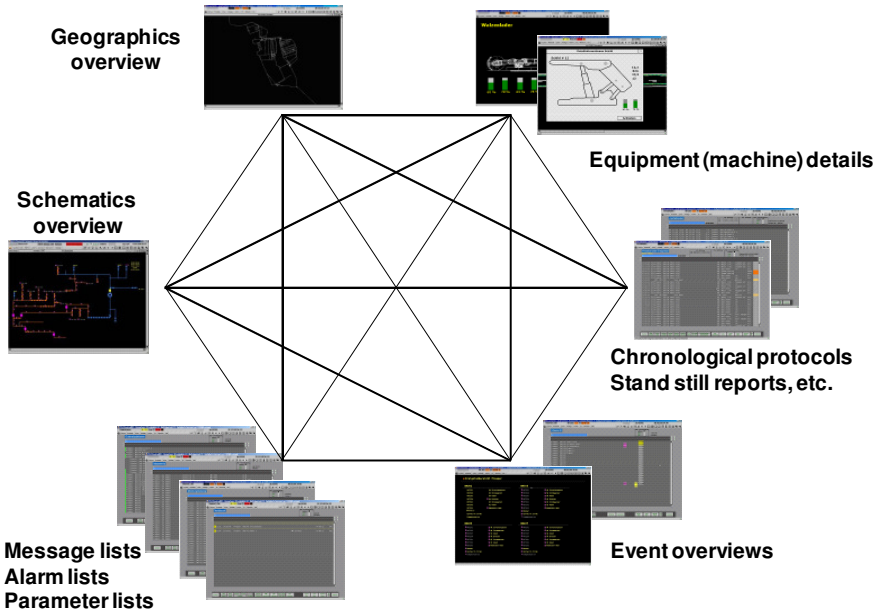
Management of views and pictures

The PSI*mining* graphics concept is distinguished by multiple levels
The overview level consists of geographic or schematic network graphics as well as event overviews.

The subordinate level for detailed graphics provides equipment-related information to the operator, for example process information for plough/shearer or similar devices.

The next lower level provides detailed process information from the machine level such as values and messages for selected motors, pumps, etc. This level also contains the process-related logs, reports, and alarm lists.

Each graphic can be linked with other graphics from the same or another level. The operator can “jump” between these graphics via Drag & Drop by one click.



Mining SCADA functions

Conveyors and bunkers

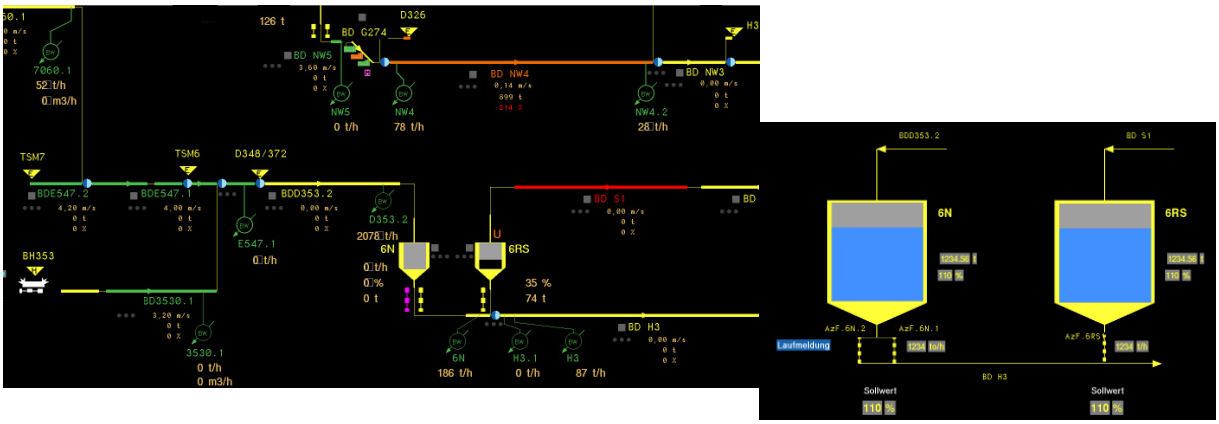
The schematic conveyor graphics provides a general overview of the entire conveying system including bunkers and their related process states (On, Off, Fault, etc.). The operator can select any graphics via Drag & Drop to get more specific value and state information for the selected device (belt, bunker, etc.).

Material flow control, simulation, and optimization

Material flow control has multiple purposes:

- Continuous material flow (coal, stone) while reducing peak loads
- Reduced peak load allows design of smaller conveyor systems
- Reduced load factor for the entire conveying system contributes to longer life-time
- Guarantee the required quality of coal
- Process improvements by achieving continuous belt-loads in order to avoid bottlenecks at critical locations.

- Closed or open loop control of the mining process manages the entire production based on required product output
- Management of failure situations and failure costs (unplanned standstills)



Mining automation and roof support control

Analysis of sloughing

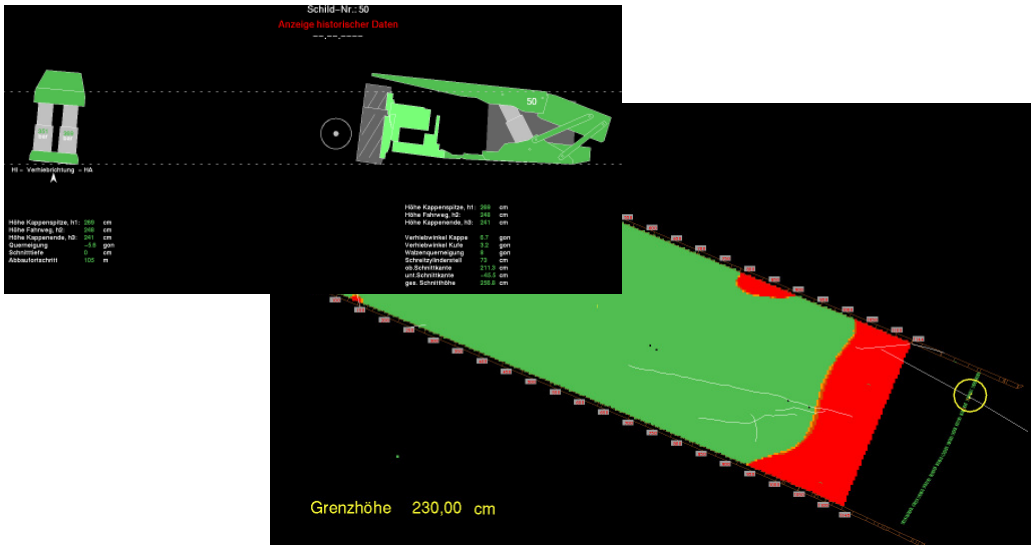
The result of this analysis is the view of areas in which sloughing was detected and the related height. At the same time the expansion of additional sloughing areas can be localized and appropriate action can take place.

Seam view and analysis

When the minimum system-height of shield/shearer is higher than the seam thickness, cutting into the foot wall occurs. This can be avoided by closed-loop control of the winning machine. The visualization requires surveyor data such as thickness, coal/stone ratio, and tectonic faults in sufficient resolution.

In the geography-based seam overview, the entire seam with the ratio of coal/stone (dark/light gray), galleries, the roof support locations (green), and the current position of the shearer or plough will be displayed. The tectonic faults are displayed as a white line. Bubble-help provides additional information such as thickness, height, or coal/stone ratio for the selected seam area.

By zooming into the graphics, the shield and shearer position view becomes more detailed. Each shield can be selected individually by Drag & Drop to display related detail information.



Mining closed-loop control

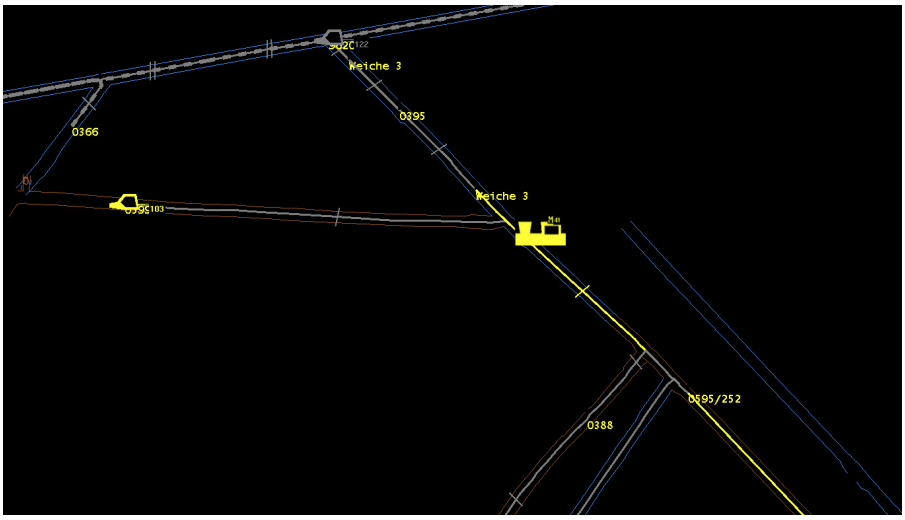
Prior to PSI*mining*, the control inertia of the shearer and the limited possibilities of closed-loop control by the PLCs prevented an optimized cut related to the face and to store former cuts into a memory. This meant that abrupt changes in the geological conditions of the seam caused deep cuts into the stone which resulted in unnecessary volumes of stone and increased stress on the machinery.

For the optimization of this aspect, complex and sophisticated closed-loop algorithms were developed. These algorithms combine roof support/shield data (angles, heights, positions, etc.) with the provided shearer data. Based on those data, future cutting templates are calculated and provided as setpoints to machine PLCs for optimization of the cutting profile related to the face.

Material Logistics

The transportation logistics application supports to manage the transportation network of monorails, locomotives, and other vehicles in geography-oriented graphics. The application incorporates the following features:

- Vehicle location using positioning systems
- Avoiding of oncoming traffic
- Staff/people tracking
- Status messages concerning vehicles, transported material, and transportation order.
- Optimization of schedule processing and logistics processes
- Prioritization of transportation orders in case of break-downs.

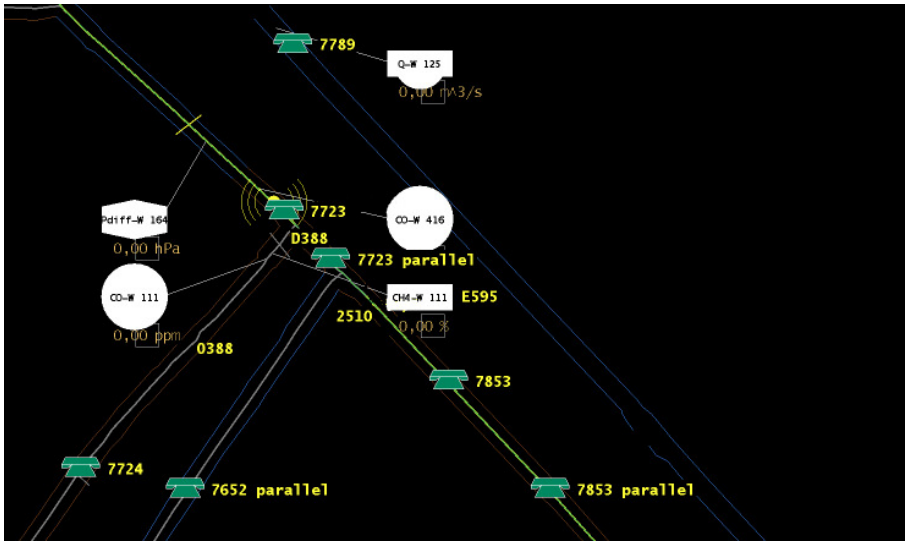


The movement of vehicles is visualized based on data provided by positioning systems using WIFI access points or RFID. By clicking on the vehicle of interest, the material transported by the vehicle and trip data (target, purpose, driver, etc.) are displayed. Rail sections can be blocked by the operator in order to avoid conflicting traffic or due to failures.

The staff tracking system is similar to the vehicle tracking system and obtains the movement data through RFID and access points

Safety and ventilation (CH_4, CO, and CO_2 monitoring)

Safety-related measuring points such as for $CO/CO_2/CH_4$ concentration and ventilation flow are available in geography-based mine overview graphics, and are displayed by zooming in. Values can easily be distinguished since they are associated with different graphics layers. If a limit violation occurs, the detecting measuring point will be colored accordingly to alert the operator. It will also be entered as an event in the respective alarm list. Since all values are archived, they can also be post-processed and displayed as trends.

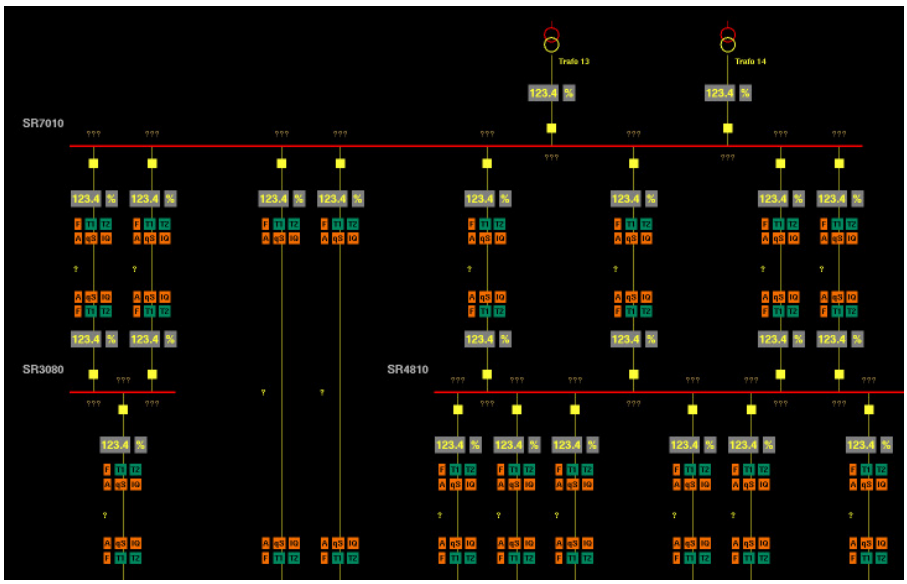


Infrastructure

The electrical network in the mine is fed from the surface and distributes power underground. Its visualization is similar to that of the mining network, and uses electricity-specific picture variables and additional functions such as intelligent network topology.

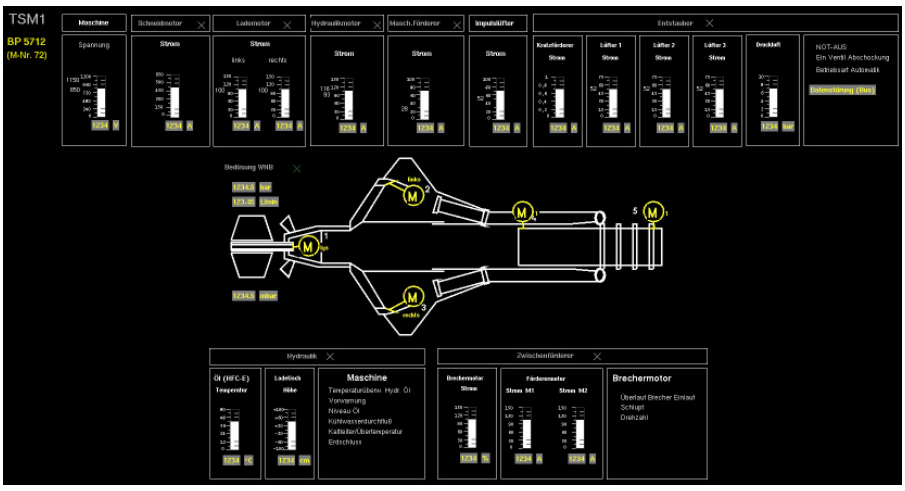
The topology diagram provides the status of each power line and related devices such as switches and transformers (energized, de-energized, fault) as well as infeeds and network state.

The operator can execute control operations to selected devices. Network application functions are available for network analysis and energy management.



Tunneling supervision

Heading and drilling machines as well as safety parameters are supervised by operators. The safety parameters include the legally required monitoring of water sprays for reducing dust and preventing gas-dust ignition.



Supply of construction material

The construction network provides a general process overview as well as various detailed plant graphics. This provides the operator with an overview of the entire process while supporting him with the coordination of the supply of construction material. When material is needed, the system will guide the operator to the related locations and information, such as bunker levels, devices status, and messages.

Additional log and statistic tools support subsequent analysis and evaluation of construction and supply operations. This information can also be made available to management via the office interface.

Conclusion

PSI*mining* is the world first factory level SCADA integrating all processes belonging to a mine operation into on single system. This offers new dimensions of control, optimization and automation.

The operator of a mine is supported by a powerful and sophisticated Human-Machine-Interface. The operator is "brought" to the points of interest in case of events, alarms, limit-violations, etc. providing a random choice of views.

The integrated workforce management prevents the support and maintenance of multiple databases. Events from the control-part can be immediately be transferred into an action with proper coordination of workforce (logistics, maintenance, operation, etc.).

The complete mine is treated as an entity so that the supervision of processes is done from a "birds-point-of-view". Impacts of events to related processes can easily be discovered and managed. The operators in the control room have at any time the complete overview on all processes.

Key to this unparalleled overview is THE DIGITAL MINE.

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