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Demonstration of process optimization for increasing the efficiency and safety by integrating leading edge electronic information and communication technologies (ICT) in coal mines

(OPTI-MINE)

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Demonstration of process optimization for increasing the efficiency and safety by integrating leading edge electronic information and communication technologies (ICT) in coal mines

(OPTI-MINE)

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1 Final Summary

WP0: Project coordination

WP Leader: Evonik on behalf of RAG-A (Partners: DMT-TFH, SUT)

Specific objectives

- To monitor and guide the project activities and the cooperation between the partners corresponding to the Technical Annex and the project objectives.
- To organise administrative requirements e.g. concerning technical and financial reporting and coordination meetings.
- To ensure the communication between the project consortium and the Commission
- To synchronize the complex demonstration activities at the several sites, eliminating any risks of separate developments and overlaps by independent consulting, evaluation and recommending.

Task 0.1 - General coordination (Evonik)

The main general coordination activities were supervision of deadlines of deliverables, of contributions to reports, of agreed data as well as information exchange between the beneficiaries and editorial revisions of reports and publications. A Grand Agreement Amendment request was prepared. Technical reports of other relevant research and development projects were obtained.

Task 0.2 - Prepare and chair project coordination meetings (Evonik)

Six coordination meetings were organised, prepared, chaired and followed-up. Coordinative and administrative activities were discussed (e.g. reporting, milestones, deliverables), performed and future activities within the WP's were presented and discussed. Furthermore, the progress of work was compared with the work schedule and corresponding decisions were made.

Task 0.3 - Reporting (Evonik)

Technical reports were produced by instructing the beneficiaries, organising and integrating their contributions, clarifying questions, editorial revision and writing the comprehensive parts. The coordinator presented the project reports at the annual TGC1 meetings.

Task 0.4 - Synchronizing the technical concepts of the different mines (DMT-TFH, SUT)

As the geological and operational conditions of the engaged mines cover a wide range, DMT-TFH checked the technical concepts to ensure a standardized application and an exchange of information. The evaluation of the concepts demonstrated, that the capability of the proposed network infrastructure was appropriate. It can be stated that modern ICT technology has been successfully installed at all mines and put into operation. In addition to the locally limited networks of the mines PRV, KWSA and OKD spatially extended complex networks have been realized on the mines RAG-A and HUNOSA. All mines have achieved considerable technical progress which may certainly affect future investment in ICT-technology.

Task 0.5 - Monitoring and adjusting at the installation phase and operation (DMT-TFH, SUT)

The mayor objective of the project was to adapt standardized information and communication technology commonly used on surface to the specific technical requirements of underground mining for process optimisation. As part of the project the latest suitable components for ICT systems were modified and approved to ATEX. Existing approved stand - alone applications were successfully coupled to the new advanced communications network via interfaces. The features of the new ICT have met the high demands of the mining industry. For technical and operational reasons, the initial designs had to be slightly modified, for example an altered layout of the fiber optic network (HUNOSA), locomotives instead of a shearer for machine communication (OKD), a non-standardized data format for tracking (HUNOSA) and a reduced area of application (KWSA). While running the OPTI-MINE project the integration, installation and operational usage of the latest ICT applications have been successfully demonstrated on an industrial scale.

WP1: Innovative components for system integration of applications

WPL: MT (Partners: Aitemin)

Specific objectives

- To develop interfaces for networking / networked devices that will allow its central management and configuration
- To perform the adjustments in central software for management and operation of networking / networked devices
- To adapt and integrate wireless tracking and positioning systems
- To development an RF based belt skew sensor representing a new generation of intelligent networked sensors

Task 1.1 - Production of firmware and tools for central device operation and configuration management (MT, Aitemin)

Fail safe update routines for intelligent underground network computers were successfully integrated and enable the full remote management of the underground devices. This does not only cover the configurations – which is state of the art for any electronic device, and which usually survives an update failure – but also the operating systems and other firmware of the remote network nodes. This functionality was also successfully integrated into the network environments of the using mining companies. This was demonstrated successfully together with the corresponding central systems in the mining WP's.

Interfaces for central operation and configuration management, firmware downloader, etc. were implemented and an Ethernet bridge developed.

Task 1.2 – Adjustments of central operation management and remote maintenance tools (MT, Aitemin)

Demands from the demonstration users as defined in their respective technical concepts regarding different kinds of central server functions were collected. Interfaces and software were implemented, e. g. for remote diagnostics of RELIA-AV systems.

Server based tools were developed to reliably manage the underground network devices from above ground and remotely through the manufacturer. Underground mining specific challenges were successfully met in order to be able to comply with production specific constraints like specific time slots for updating certain areas or the reachability of devices in case of network configuration updates to prevent certain areas to become locked off.

Also further central software was during the demonstration work adjusted to better meet the needs of the production environment and to increase usability. This relates the servers for tracking of people and assets ("TrackCenter"), the processing of text messages ("PagerCenter"), the digital loudspeaker line communication center ("VoIPCenter") and the location based mine management software ("ViewCenter"). For the ViewCenter a new technology was used and tested which after closure of the project could be developed into a very promising product, very welcomed by the mining industry in certain presentations.

Task 1.3 – Implementation of new standardized data formats for underground tracking information (MT, Aitemin)

Together with the central server, standardized protocols following the International Rock Excavation Data Exchange Standard ("IREDES") were successfully used for the communication of tracking information and text messages. This was the world's first full scale implementation of these two draft standard profiles which made the OPTIMINE project an important opportunity to establish these formats globally and to provide global market advantages for the participating system integrators. The demonstration in different mines at RAG-Anthrazit, OKD, Premogovnik Velenje and KWSA also showed the universal usability of the standard.

Task 1.4 - Integration and adaptation of wireless tracking and positioning systems (MT, Aitemin)

The integration of the tracking functionality with the network devices was successfully completed. In addition, the acquisition of tracking information from an RFID reader connected to a network device was performed. All tracking information is communicated by the standardized protocols from task 1.3. It was used in the demonstration at RAG-A, KWSA, OKD and PRV. For the demonstration at HUNOSA the development of ATEX (I.S.) ZigBee-Ethernet Network Bridge, including firmware and Atex approval was completed and the improvement of the OPC server for personnel tracking, adding IP connectivity.

Task 1.5 – System integrative development of an RF based belt skew sensor (MT)

Due to the lack of availability of a fully contact less failsafe conveyor belt skew sensor, the related device was developed during the project. The prototype uses a Radio Frequency technology to detect the moving belt within a certain proximity. A test installation was set up above ground at RAG-A which showed excellent results. During all test period, no erroneous triggering was observed, while all imitated skew situations were successfully detected under all conditions.

WP2: Demonstration of process optimization in a very deep, advanced, wide spread mine (DE)

WPL: RAG-A (Partners: MT, Aitemin)

Specific objectives

- To optimize the overall mining process in a remote production area by unified personal communications
- To speed up and optimize material logistics by introduction of a network integrated automatic material tracking system
- To improve mining process efficiency by optimized conveyor belt skew sensorics and integration of controls
- To enhance mine safety by unified network communications and by using the network for a later integration of results from the RFCS EMTECH project.

Task 2.1- Network Infrastructure (RAG-A, MT, Aitemin)

A redundant network with meshed ring structure and use of standardised network components (switches) with ATEX approval in u/g area was built-up. After elimination of the initial difficulties it was fully functional and could be reliably operated. It formed the basis for installation and demonstrative operation of the different applications described in tasks 2.2 to 2.4. With this new network a higher system stability concerning data transfer and control of production facilities could be demonstrated.

The network will now be exploited for the regular operation in the production area Beustfeld and technically adjusted to future changes. Due to the successful demonstration of the network operation, an essential uncertainty for other domestic and foreign companies (coal/ ore mines, tunnel construction, etc.) to invest in this technology has been cleared. Also inside the RAG group, future dissemination of this technology would be reasonable, but are to be scrutinised due to the political decision to close all German hard coal mines until 2018.

Task 2.2 - Optimisation of material logistics (RAG-A, MT)

On the basis of the network infrastructure (task 2.1) and by the deployment of standardised network components, with standardised RFID and WLAN components inside the MIC's developed the company MineTronics, IT-systems for container tracking, material tracking, container management and for loco information could be built up and successfully operated.

Thereby a higher transparency regarding locations of operating resources in the logistics field could be demonstrated. In connection with that results a higher logistics efficiency and respectively cost reductions due to an optimised use of transport units and transport means.

As described at task 2.1 for the network, the system for optimisation of material logistics will now be used for regular operation in this production area. Via the project partner MineTronics a dissemination to other potential users is possible.

Task 2.3 - Personnel communication and information (RAG-A, MT)

By using the network (task 2.1) a system was created, by which both logistics information (from task 2.2) as well as CH4 data can be transmitted to PDA's and thus provided to underground personnel.

Thereby transparency concerning material tracking is also for the u/g personnel guaranteed at any time. The same applies to the information of personnel about the current CH4 values, which enhances the safety.

Also this system will now be used in the regular operation in the Beustfeld production area of the mine. Via the project partner MineTronics a dissemination to other potential users is possible.

Task 2.4 - Conveyor belt skew detection (RAG-A, MT)

By using the ring structured network built up in task 2.1, so far underground implemented longwall controls could be successfully displaced to above ground and their operation could be tested successfully. It could be demonstrated that a minimization of the installation, maintenance and investment costs can be achieved.

As described at task 2.1 for the network, the longwall control from above ground will now be used for regular operation. Via the project partner MineTronics a dissemination of the technology to other potential users is possible.

Regarding the belt skew monitoring an above ground test installation in cooperation with company MineTronics was successfully executed. A result exploitation, primarily in the form of an ATEX approval could be carried out by the partner MineTronics.

WP3: Demonstration of voice communication and automation in a highly branched mine with single entry faces (ES)

WPL: HUNOSA (Partners: Aitemin, MT)

Specific objectives

- Extending the networking infrastructure available above ground to the underground mine using optic fibre
- Installing Network access nodes (wired / wireless) at any important point of the mine
- Connecting to the new Network all legacy (existing) automation and environmental control gear
- Implement advanced belt conveyor supervision, including IP Cameras
- Deploying a VoIP-based voice communication subsystem with wireless features
- Deploying a system for tracking personnel
- Implementing some system for tracking materials, spares and supplies

Task 3.1 – Network Infrastructure (HUNOSA, Aitemin, MT)

- Installed and commissioned a communications network, composed of 20 Km of 50/125 MM Optical Fibre, with ring topology, and ATEX certified media converters. These allowed the connection of devices with copper ATEX (Ex i) Ethernet interfaces to the Fiberoptic network.
- The network was composed of a main ring and several sub-rings. Managed switches were used, allowing switching the direction of traffic in milliseconds in case of failure in any part of the installation.
- In the surface, a media converter with ATEX optical connections was developed to interface with the surface networks, while maintaining the safety of the underground side.

Task 3.2 – Environmental sensoric integration (HUNOSA, Aitemin, MT)

- The ATEX Ethernet bridge for legacy devices was installed underground. It required implementing certain modifications to the Media converters, mainly related to adding the possibility of providing power through the Ethernet interface (Pseudo PoE).
- Supporting software and special SCADA functions were implemented.

Task 3.3 – Belt and steel conveyor monitoring via the unified network (HUNOSA, Aitemin, MT)

- Support for remote monitoring of armoured conveyors managed by legacy controllers was added to the SCADA system in use in HUNOSA.
- The monitoring of belt conveyors was enhanced through the use of an ATEX IP camera, developed and certified for use underground. Video monitoring and recording system is fully operative.

Task 3.4 – Personnel tracking (HUNOSA, Aitemin, MT)

- After a successful pilot test, a full installation of a personnel tracking system using ZigBee technology was deployed and commissioned. In it, were used the ZigBee-Ethernet bridge and the enhanced OPC server developed under Task 1.4. It has been operating satisfactorily for some months after the end of the project.

Task 3.5 - Personnel communication and information (HUNOSA, Aitemin, MT)

- It was implemented the user interface for the VoIP phone embedded in RELIA AV Master Controller, allowing its connection to VoIP Private Branch Exchanges (PBX). Interoperability tests with the new HUNOSA's PBX were performed satisfactorily.
- A 2 channel digital voice over field buses, using DIGICOMS was implemented. It is possible to establish a private (point to point) call and a public (classical intercom) broadcast call simultaneously.
- It is also possible establishing a call to the surface from any DIGICOM. For this purpose, a simple exchange software was implemented.

Task 3.6 - Optimisation of material logistics (HUNOSA, Aitemin, MT)

- Prototype of the tag for locomotives and personnel, which make full use of the features of the personnel tracing system implemented in Task 3.4.

WP4: Demonstration of personel communication and mine safety integration in an underground lignite mine with very thick seam and large production capacity (SI)

WPL: Pr. Velenje (Partners: MT, Aitemin)

Specific objectives

- Optimizing the underground mining process by personnel communication and the mobile availability of messages and operational information.
- Reduction of machine and production downtimes and resulting cost by fast access to specialists.
- Safer underground mine operation by additional information features and external interfaces.
- Smoother and more efficient mine operation.

Task 4.1 – Network Infrastructure (Pr. Velenje, MT, Aitemin)

Coverage and propagation test results we used for detail concept engineering for our network infrastructure. We selected and purchased equipment for our network infrastructure. To establish wireless network our first step was building local fiber-optical network. We accomplished physical installation of MICs (WLAN access points), power supply units, antennas and cabling in coal face F k.-65 and established wireless network coverage. Special attention was assigned to antennas different polarization. After end of the coal face operation we moved entire network infrastructure successively to the next two coal faces. Coverage with wireless signal was also extended to part of main belt transport system and main shaft area. With installation of network infrastructure equipment, testing and using WLAN devices we got knowledge and experience how to make optimal concept and installation of wireless networks in coal mines. In future we intend to continue with installation of fibre optic and wireless networks in new coal faces.

Task 4.2 - Personnel communication and information (Pr. Velenje, MT)

Wireless network infrastructure was precondition for all other tasks and activities in the project. SIP server was installed and integrated into PRV's telephone network. We made communication and information performance tests with available PDAs, WLAN mobile phones and pagers on established wireless networks on surface and underground. To identify impact of use of ICT on coal faces we performed response tests and made evaluation of Key performance indicators (KPI). We determined a decrease of time to reach a person in a coal face of >80%, but also that coal face efficiency depends more on geological conditions and face parameters than on use of ICT. We also connect mine analog communications devices (phones, intercoms) over the fiber optic network to communication center on surface. Due to positive results, increasing the number of mobile phones and PDA's is intended.

Task 4.3 - Personnel tracking (Pr. Velenje, MT)

We defined concept for personal tracking together with our project partner Minetronics. We use their TracServer application for tracking all WLAN devices used in our coal mine (PDAs, pagers and WLAN mobile phones). For visualization of tracked devices at mine 3D map we use ViewCenter application. For the future we have planned to install WLAN tags in miner's lamps and to transporting cars to enable tracking of all people and logistic in our coal mine. To implement this goal we have to extend wireless network infrastructure and coverage to the greater part of the mine. Knowledge and experience from this project task will be significant to achieve this goal.

Task 4.4 - Environmental sensoric integration (Pr. Velenje, MT)

For environmental sensoric integration control unit Aitemin RTU-40 is used as I/O device. This unit was connected to established fiber optical network on coal face. Modbus TCP is used as communication protocol on single mode fibre optic network. We use ATEX M1 power supply device with UPS to power on control unit. On control unit we connect standard sensors in our coalmine (Woelke CH_4, CO_2, CO, pressure, temperature…). We made evaluation of collected information on remote device. The environmental data are also used as input for the safety related add-ons (task 4.5).

Task 4.5 - Safety related add-ons (Pr. Velenje, MT)

We established alerting of people in endangered area through different means of communication. Concept of common platform for emergency situation handling based on environmental information from control center on surface, location information from TrackCenter, evaluation of safety according to Mine Rescue and Emergency Plan and suggestions to responsible person to approve/trigger planned actions.

We can use pager system, text messaging and composed voice messages dialled to defined phone numbers over SIP server. Signalling RGB lamps on control unit will be also used to differentiate information.

WP5: Demonstration of network Communications and modern material logistics in a high capacity hard coal mine under modernization (CZ)

WPL: OKD (Partners: MT, Aitemin)

Specific objectives

- Upgrade the underground infrastructure as a precondition to optimize mining processes finally leading to an overall increase of operational efficiency.
- Optimize the material supply and logistics processes in order to reduce production downtimes, to shorten supply processes and to minimize the number of transport units needed.
- Improve safety by application of selected network based safety support functions.

Task 5.1 – Network Infrastructure (OKD, MT, Aitemin)

The network is built on the Gigabit Fiber Optic network, which so far is the only intrinsically safe network available, utilizing intelligent network nodes that automatically switch to redundant network lines and that can ensure numerous other additional functions of the mine infrastructure (e.g., tracking). The network inclusive all devices was installed as well as the servers and central software systems, e. g. for remote support, communication, visualization etc.. Finally it was commissioned and used to demonstrate process optimization by the different applications described in tasks 5.2 to 5.5.

Task 5.2 – Material logistics (OKD, MT)

This task included concept and design work for the use of RFID technologies, logistics and IT as well as integration of RFID-tags into the container metal structure and testing. Locomotives and wagons have been equipped with both active and passive RFID tags. PDA's have been used to assure a precise material tracking.

The material tracking data are based on the new mining industry standardized IREDES tracking profiles enabling the use of different equipment in a mine wide tracking installation (Task 1.3). These formats are now available to the IREDES standardization community and all interested users.

Task 5.3 – Machine communication for mobile transport machines (OKD, MT)

In a train based coal transport level, digital voice communication between dispatcher and train drivers as well as tracking of the trains using both active and passive RFID technology has been implemented. In order to enable audio communication, the locomotives are equipped with associated WLAN communication unit on the VoIP basis. The operators of the dispatcher's office obtained the possibility to monitor passing of the locomotives through the RFID readers along the tracks. All locomotive drivers and the dispatcher are permanently connected in one communication group. By monitoring the WLAN audio unit an additional tracking is possible, enabling consistent checking and increased reliability.

Task 5.4 – Machine communication for Locomotives (OKD, MT)

A technical concept was elaborated and agreed between the locomotives manufacturer and data transmission system supplier. After that the devices were ATEX certified. Locomotives were equipped with WLAN communication devices for collection of data from the locomotives and the devices were installed into the electronic control units of the selected locomotives. This configuration of equipment finally allowed the dispatcher to monitor the technical data from the locomotive (e.g. speed, engine hours, level status of oil and other liquids, engine temperatures, etc.).

Task 5.5 – Personnel tracking (OKD, MT)

For personnel tracking, two systems have been realized and used. One is an ISI system already existing in the mine and using dedicated active UHF tags. It has been combined with the OPTI-MINE network. The other one is tracking any WLAN devices (e.g. mobile phones or PDA's) by the new network system, where the base stations provide already built in WLAN access points at no extra hardware cost. The dispatcher's office personnel can track the position of personnel at the transportation gateroads. This allows informing the locomotive driver on personnel moving or staying on the tracks.

WP6: Demonstration of network communications and safety support systems in a high capacity Polish hard coal mine (PL)

WPL: KWSA (Partners: MT, Aitemin, SUT)

Specific objectives

- Extending the networking infrastructure available to the underground mine using optic fibre cable
- Installing of infrastructure for access to wired and wireless networks at representative points of the mine
- To enhance mine safety by unified network communications and by using the network for a later integration of results from the RFCS project EMTECH

- To speed up and optimize machines logistics by introduction of a network integrated automatic machines tracking system
- Tracking and location of machines (SMT Scharf) on railway routes

Task 6.1 – Network Infrastructure (KWSA, MT, Aitemin, SUT)

The backbone of the whole ICT infrastructure is fiber optic cable deployed from the central mine area to currently operating mine production area - total length of fiber optic cable is around 6km. All equipment has been manufactured in agreement with ATEX IM1 protection degree of at least IP54 or IP66. The network infrastructure of the staff monitoring system has been limited to two areas of wireless communication and a control group of 30 communication devices. The NetCenter, TrackCenter, ViewCenter and PagerCenter software packages were installed on server located in the Geophysical Station of the "Bobrek-Centrum" mine. All components of wireless network have been installed and configured. The ICT system network infrastructure has been fully operating since June 2013. The results of demonstrational application will be helpful for further development of ICT based systems in other mines of KWSA.

Task 6.2 – Transport machine communication (KWSA, MT, SUT)

There are no separate technical solutions used for machine communication. This functionality is achieved by using the equipment for the personnel tracking system. Nevertheless, opportunity to use pagers as communication devices requires access to WLAN network, that requires covering of the whole operating area of "Bobrek-Centrum" with wireless network signal. Additional functions of the personnel tracking devices associated with communication functionality at the current state of system development are limited to message receiving and broadcasting. But the principle feasibility of this application was tested successfully. However, an operational use of those basic communication functions (alerting, messaging, etc.) requires constant or at least frequent access to WLAN network.

Task 6.3 – Personnel tracking (KWSA, MT)

The staff monitoring system has been limited to two areas of wireless communication and a control group of communication devices. Personnel tracking function is performed using WLAN access points as control gates and client end mobile devices as personal identifiers. The current stage of the system allows registering presence and communicating wirelessly with a group of selected staff members in an area covered by signal from two access points units. Two MIC100 main units with two directional antennas (used for detection of presence and direction of motion) and third omnidirectional antenna (used for broadcasting text messages) create wireless access points, which were installed at the entrance to the current operating mine production area. Advantage of this solution is low equipment costs and time efficient implementation, which has made implementation within the project budget and time frame possible.

WP7: Assessment of performance and project results

WPL: SUT (Partners: DMT-TFH, MT)

Specific objectives

The objective of this WP is to prove and quantify the achieved process optimisation and reliability and the effects on the efficiency of mining operations as well as on mine safety, occupational safety and health and environment. This is an important prerequisite to make a European wide and quick implementation of the innovative ICT applications possible, which is a main objective of the whole project.

To achieve the objective, the neutral partners SUT and DMT-TFH will perform in close cooperation independent and scientifically based assessments.

Task 7.1 – Key Performance Indicator (KPI) specification and assessment methodology (SUT, DMT-TFH, MT)

The academic partners SUT and DMT-TFH defined the general requirements, which suitable KPIs had to fulfill. Due to the specific ICT installations, varying operational objectives and the local conditions, for each mine individual KPIs have been designed. Finally a number of 15 KPIs have been declared, three for each mine. The selected KPIs covered the accuracy of the ICT system, the efficiency of the hauling, maintenance and production process and improvements concerning the logistics underground.

In addition to the selection of KPIs the basic requirements for data collection have been set by the academic partners. Having collected the data at the mines SUT and DMT-TFH checked these findings with regards to accuracy and plausibility. 11 KPIs documented reasonable, mostly positive results, two KPIs didn´t met the requirements due to other main factors and 2 KPIs couldn´t be calculated as the operational setting has changed.

Task 7.2 – KPI-based performance assessment (SUT, DMT-TFH, MT)

For the majority of the KPI's the results give clear evidence that the new enhanced ICT positively impact mine productivity and safety. In some cases it was not possible to clearly assess the effect of the ICT and only in one case the need of further technical development of a particular subsystem was obvious.

For example at RAG-A a mayor improvement gained by the ICT technology have been made visible by the KPI "TPI" (Specific Transport Performance Indicator) which indicates a 30 % increase in productivity. Due to the installation of IP cameras and monitoring the Sueros belt system, Hunosa reported a very positive impact on coal quality with regards to water and ash content. Comparing the first half year 2013 and the equivalent period in 2014 the coal washery efficiency have been raised by 19,75 %. At the PRV Velenje mine, another example, the communication between mine personnel at the longwall face and the surrounding workings have been essentially improved by the WLAN infrastructure.

Task 7.3 – Assessment of additional criteria and effects (SUT, DMT-TFH, MT)

SUT and TFH evaluated additional benefits according to the application of risk management tools. An evaluation form has been designed to structure the individual findings and to enable a standardized summary. Each cluster of the project structure covers a specific process where the new ICT technology is expected to gain improvements. For each cluster the project partners determined the additional criteria and after implementing the new ICT technology its contribution to the additional criteria in the specific cluster has been estimated by the project partners and the academic partners. The rating system covers a spread from no to essential improvement. After assessment the scoring is presented in a matrix sheet, which indicate the improvements regarding the additional criteria in the specific cluster and in general.

WP8: Dissemination and Knowledge Exchange

WPL: Evonik (Partners: all)

Specific objectives

- Create wide visibility of the project achievements already during the project lifetime,
- Disseminate knowledge about the technologies demonstrated in the project,
- Enable cross fertilization with ongoing and related RFCS projects (EMINSAR, EMTECH, MINTOS)
- Provide from an early lighthouse application, the learning experiences and the positive impacts of the ICT technologies demonstrated e.g. on reliability, efficiency and H&S.
- Respond to the experiences, needs and feedback of the mining community,
- Encourage close contact between European coal mining companies and the experts involved in the project.

Task 8.1 – Classical measures of knowledge transfer (Evonik, all partners)

Within the project period seven public presentations at conferences in six different countries have been made by several beneficiaries and one article was published in an international professional magazine. Copies of the performed presentations and of the published article are available at www.opti-mine.eu.

Task 8.2 – Online dissemination (Evonik, all partners)

As planned, a public project website was set up it was updated according to new publications, presentations and the OPTI-MINE Industry Forum events.

The public project website offers the to the public features like description of the project and its objectives, project participants with contact details and links to their websites, a download area for all public presentations and other dissemination documents. During the project period it also informed about coming OPTI-MINE presentations at conferences and the OPTI-MINE Industry Forum events.

Task 8.3 – Opti-Mine Industry Forum (Evonik, all partners)

The project consortium arranged three Industry Forum events as dissemination activities. External potential users of the demonstrated IC-technology were invited to participate. At the events they could benefit at an early stage from installation and application experiences and results related to reliability, difficulties and impact on mine operation efficiency, occupational Health & Safety and environmental issues in the demonstrating coal mines. The possibility of underground visits at the project demonstration areas was offered as well. Documentations of the OPTI-MINE Forum events are available at www.optimine.eu.

Task 8.4 – Transferability Study (SUT)

Use of mechanization, automation, information and communication techniques depends on mine size. Main limitations concerning small mines are costs and lack of sufficient knowledge and know how, due to these limitations small mines have to take over already developed mining and IT technologies. OPTI-MINE results allow smaller mines to adapt the low cost IT solutions based on open Ethernet underground communication platform. Transferability studies carried out by SUT assess how easy innovative technologies can transfer to other (smaller and less technologically advanced) mines.

2 Scientific and technical description of the results

Objectives of the project

OPTI-MINE is a demonstration project, which aims at integrating, installing and operating newest ICT applications in industrial-scale and bringing together all the technical and economic data in order to make a European wide implementation in the mining industry possible at minimum risk. Not only the new ICT applications itself will be demonstrated, but by integrating the ICT systems, into one common Ethernet (TCP-IP) based open network platform of high bandwidth and standardised configuration (Internet technology), information can be exchanged between all applications and processes. Thus the processes as a whole are optimised and the efficiency and safety of mines is increased considerably.

The demonstration covers the leading edge ICT for the underground mining processes logistics, transport, personnel communication and information by voice and data, machine communication, staff localisation, guidance, etc. Individual components developed within the recent years will be integrated into a comprehensive system. The benefits demonstrated by this comprehensive optimisation of mining processes are related to considerable improvements of efficiency, mine safety, occupational safety and health and environmental impacts.

Specific objectives WP0, project coordination

- To monitor and guide the project activities and the cooperation between the partners corresponding to the Technical Annex and the project objectives.
- To organise administrative requirements e.g. concerning technical and financial reporting and coordination meetings.
- To ensure the communication between the project consortium and the Commission
- To synchronize the complex demonstration activities at the several sites, eliminating any risks of separate developments and overlaps by independent consulting, evaluation and recommending.

Specific objectives WP1, Innovative components for system integration

To develop interfaces for networking / networked devices that will allow its central management and configuration

- To perform the adjustments in central software for management and operation of networking / networked devices
- To adapt and integrate wireless tracking and positioning systems
- To development an RF based belt skew sensor representing a new generation of intelligent networked sensors

Specific objectives WP2, demonstration at a mine of RAG-A (DE)

- To optimize the overall mining process in a remote production area by unified personal communications
- To speed up and optimize material logistics by introduction of a network integrated automatic material tracking system
- To improve mining process efficiency by optimized conveyor belt skew sensorics and integration of controls
- To enhance mine safety by unified network communications and by using the network for a later integration of results from the RFCS EMTECH project.

Specific objectives WP3, demonstration at a mine of HUNOSA (ES)

- Extending the networking infrastructure available above ground to the underground mine using optic fibre
- Installing Network access nodes (wired / wireless) at any important point of the mine
- Connecting to the new Network all legacy (existing) automation and environmental control gear
- Implement advanced belt conveyor supervision, including IP Cameras
- Deploying a VoIP-based voice communication subsystem with wireless features
- Deploying a system for tracking personnel
- Implementing some system for tracking materials, spares and supplies

Specific objectives, WP4, demonstration at a mine of PRV (SI)

- Optimizing the underground mining process by personnel communication and the mobile availability of messages and operational information.
- Reduction of machine and production downtimes and resulting cost by fast access to specialists.
- Safer underground mine operation by additional information features and external interfaces.
- Smoother and more efficient mine operation.

Specific objectives, WP5, demonstration at a mine of OKD (CZ)

- Upgrade the underground infrastructure as a precondition to optimize mining processes finally leading to an overall increase of operational efficiency.
- Optimize the material supply and logistics processes in order to reduce production downtimes, to shorten supply processes and to minimize the number of transport units needed.
- Improve safety by application of selected network based safety support functions.

Specific objectives, WP6, demonstration at a mine of KWSA (PL)

- Extending the networking infrastructure available to the underground mine using optic fibre cable
- Installing of infrastructure for access to wired and wireless networks at representative points of the mine
- To enhance mine safety by unified network communications and by using the network for a later integration of results from the RFCS project EMTECH
- To speed up and optimize machines logistics by introduction of a network integrated automatic machines tracking system
- Tracking and location of machines (SMT Scharf) on railway routes

Specific objectives, WP7, performance assessment

The objective of this WP is to prove and quantify the achieved process optimisation and reliability and the effects on the efficiency of mining operations as well as on mine safety, occupational safety and health and environment. This is an important prerequisite to make a European wide and quick implementation of the innovative ICT applications possible, which is a main objective of the whole project.
To achieve the objective, the neutral partners SUT and DMT-TFH will perform in close cooperation independent and scientifically based assessments.

Specific objectives, WP8, dissemination

- Create wide visibility of the project achievements already during the project lifetime,
- Disseminate knowledge about the technologies demonstrated in the project,
- Enable cross fertilization with ongoing and related RFCS projects (EMINSAR, EMTECH, MINTOS)
- Respond to the experiences, needs and feedback of the mining community,
- Encourage close contact between European coal mining companies and the experts involved in the project.

Description of activities and discussion

WP0: Project coordination

WP Leader: Evonik on behalf of RAG-A (Partners: DMT-TFH, SUT)

Task 0.1 - General coordination (Evonik)

The first main activity was the conclusion of the Grant Agreement inclusive Annexes IV, which are the accession forms of all beneficiaries. The replacement of AGH University of Science and Technology in Cracow by SUT in April 2011 caused KWSA to reconsider their participation in the OPTI-MINE project. As soon as the coordinator was informed about this issue he started intensive discussions and negotiations with KWSA at several management levels. SUT and MT supported that substantially. Finally the management board of KWSA decided to stay in the project and signed Annex IV of the Grant Agreement at 29 September 2011. During the whole time the coordinator kept in close contact to the Commission and to the other beneficiaries. The Grant Agreement was finally concluded at 20 October 2011.

The main general coordination activities were supervision of deadlines of deliverables, of contributions to reports, of agreed data as well as information exchange between the beneficiaries and editorial revisions of reports and publications. Six coordination meetings have taken place within the project period. Three technical reports were produced and presented at the annual TGC1 meetings. Also the mid-term financial statements of the beneficiaries were submitted. Some administrative questions were clarified like how to account interest of bank accounts, limited deviation of personnel costs, weekend shifts.

The coordinator supported intensively OKD at their request for changes in their own cost breakdown without affecting their total budget. This was finally accepted by the Commission in February 2013. A change of OKD’s legal details required a formal request for a grant agreement amendment. The amendment was issued in October 2013.

A further activity was to obtain all technical reports of the running RFCS projects EMTECH, EDDAFIC and EMIMSAR, which are relevant for OPTI-MINE. They were used mainly in WP 0 (task 0.4) and WPs 1-6 at setting-up and updating the technical concepts of the mines.

Task 0.2 - Prepare and chair project coordination meetings (Evonik)

Six coordination meetings were organised, prepared, chaired and followed-up.

- 1st coordination meeting (kick-off) at DMT-TFH in Bochum, DE, 14 July 2011
- 2nd coordination meeting at SUT in Gliwice, PL, 8 February 2012
- 3rd coordination meeting at HUNOSA in Oviedo, ES, 26-27 September 2012
- 4th coordination meeting at MineTronics in Osnabrueck, DE, 17 April 2013
- 5th coordination meeting at Aitemin in Leganes/Madrid, ES, 29 October 2013
- 6th coordination meeting at RAG-A in Ibbenbüren, DE, 23 April 2014

At the meetings coordinative and administrative activities were discussed (e.g. reporting, milestones, deliverables), performed and future activities within the WP’s were presented and discussed. Furthermore, the progress of work was compared with the work schedule and corresponding decisions were made.

Task 0.3 - Reporting (Evonik)

Three technical reports were produced within the project period by instructing the beneficiaries, organising and integrating their contributions, clarifying questions, editorial revision and writing the comprehensive parts. They were submitted in time to the Commission and the respective TGC1 members. The coordinator presented the project reports at the annual TGC1 meetings.

The coordinator also advised the beneficiaries on the mid-term financial statements and collected and submitted them inclusive preparing a summary of project expenses.

Task 0.4 - Synchronizing the technical concepts of the different mines (DMT-TFH, SUT)

Work performed

The technical concepts of the different mines cover a wide range of applications and are individually designed. The geological and operational conditions of the industrial partners are the main reason for the multi-layered approach in this project:

- Small capacity, steep seams, single entry faces, highly branched (ES)
- Medium capacity, very deep, high-tech, high seam density (DE)

- Large capacity, medium depth (CZ, PL)
- Very large capacity, lignite, very thick seam (SL)

Additionally, official regulations in the involved countries vary in certain aspects. As a consequence the project involves the need for a detailed assessment of the technical concepts. This exercise should ensure that the technical concepts developed by the five involved mines are in line with a jointly agreed technical approach and include standardized applications.

In a first step the individual technical concepts have been analyzed with regards to their objectives. The individual activities of the five coal mines can be clustered as follows (**table 0.1**).

<table>
<tr><td colspan="2">Network Infrastructure
2.1 RAG-A 3.1 HUN 4.1 PRV 5.1 OKD 6.1 KWSA</td></tr>
<tr><td>Optimization / Installation of material logistics
2.2 RAG-A 3.6 HUN 5.2 OKD</td><td>Integration of environmental monitoring
3.2 HUN 4.4 PRV</td></tr>
<tr><td>Personnel communication and information + safety related addons
2.3 RAG-A 3.5 HUN
4.2 PRV 4.5 PRV</td><td>Machine communication for transport / haulage
5.3 OKD 5.4 OKD 6.2 KWSA</td></tr>
<tr><td>Personnel tracking
3.4 HUN 4.3 PRV
5.5 OKD 6.3 KWSA</td><td>Conveyor monitoring
2.4 RAG-A 3.3 HUN</td></tr>
</table>

Table 0.1: Activity Clusters

In a next step bilateral talks and exchange of technical data have taken place to check the individual concepts in detail. The suitability of the technical approach, the usage of standardized applications and technical recommendations have been discussed and jointly agreed.

As expected and to be seen in table 1, the cluster activity “Network Infrastructure” is present at each mine and it is the backbone of all concerned project activities. Due to operational, financial and other reasons the existing network infrastructure of the mines is quite different. At RAG-A the mine is already equipped with a sophisticated network using fiber optic cables. The new production area Beustfeld will be integrated into the existing network of the mine and new network components and ICT applications will be installed. At the mines of other partners common copper cable networks are in place or two different independent networks for diverse applications. One mine does not have any suitable network infrastructure at all. Despite the individual design and status of the five coal mines all partners will use a fiber optic backbone with standardized ICT-components.

Regarding the cluster activity “Optimization / Installation of material logistics” the objectives of the three involved mines differ, too. For example RAG-A required a gapless automatic tracking system to trace the material from surface down to the working place underground. The Hunosa application was unique only to materials and spares transport by underground railway. In contrast to that OKD has focused on coal train tracking as the efficiency and availability of the coal transport system was a crucial issue.

For personnel communication different methods or technologies have been applied and connected to individual existing systems. Personnel communication at RAG-A was set up using pager devices and mobile PDA's and as soon as they were available also ATEX certified smartphones for people working underground. At Hunosa Mine a VoIP-based voice communication subsystem with wireless features has been deployed, making use of the fiber optic network. PRV now uses the WLAN capability of the standard optical fibre network for VoIP telephony. This VoIP telephony facilitates communication of the miners among each other as well as with the control room.

Concerning personnel tracking the regulations of the national authorities are very different as well as the specific conditions in the underground mines. Staff tracking ranges from full coverage to surveillance only at the face entries. Hunosa has placed control points only in the lamp room, in the access to shafts, to main roadways and to faces. The tags are placed in the cap lamp and provide some information about activity parameters of its wearer who again is able to receive visual or audible warnings and voice messages. OKD uses and tests two systems, one using dedicated a*ctive* UHF tags and corresponding readers which are identical to the active readers used in the train material logistic task. The second system relies on the new fiber optic network with integrated WLAN access points.

For environmental monitoring at the Hunosa mine there is a legacy system in place, which is based on applications developed by two manufacturers. These existing devices have been integrated into the fiber optic Ethernet network using intrinsically safe Ethernet bridges underground. The considerations of PRV are concentrating to use features of the fibre optic network nodes like flashlights to inform personnel about extraordinary operation conditions like gas in proximity etc. As ventilation monitoring data are very sensitive with regards to safety both mines will rely on the existing and certified equipment. The data transfer between underground probes and the control room with monitoring and storage capabilities will be organized via the fiber optic backbone.

In the cluster "Machine communication for transport / haulage" the suitability of wireless data transmission and communication via fiber optics and WLAN-technology has been closely evaluated. KWSA has concentrated its efforts on monorail machines while OKD additionally covered monorails and coal train locos as well. It was decided on the basis of operational experience whether WLAN standardized frequency ranges and broadband propagation was suitable to the different conditions at the involved mines.

Regarding "Conveyor Monitoring" Hunosa Mine integrated the existing control systems for belt conveyors into the fiber optic Ethernet network. Additionally Atex IP cameras have been installed for video surveillance of transfer points from any point of the mine or the surface. At RAG-A the skew detection in the recent years has caused a lot of concern as no really reliable system for skew detection was available. Therefore within this cluster a new radio frequency based skew detection sensor has been tested and integrated into the demonstration to proof its reliability.

Main results

Having analyzed the concepts in summary it can be stated that the new standardized ICT technology fits to the different conditions of the mines and leads to further improvements. The involved hardware and software developments are compatible or adaptable to many applications. Existing communication devices have been integrated into the new ICT network via interface modules. In consequence the new data transmission network has been implemented without removing essential existing equipment from operation. The cluster activities executed by the individual mine have been designed for their specific demands in order to avoid needless overlap of the activities.

The specific findings of the synchronizing exercise have been recorded in the Deliverable

0.4, Evaluation Report on the ICT Concepts.

Task 0.5 - Monitoring and adjusting at the installation phase and operation (DMT-TFH, SUT)

Work performed

It was assumed that during installation and operational usage deviations may occur which should be analyzed and considered. SUT and DMT-TFH executed this task in bilateral discussion with the involved mines, but also during the coordination meetings. The status and modifications of the individual activities until 31st March 2013 have been documented in the Deliverable 0.5 "Report on Concept Updates during ICT Installation". Significant findings of the whole project phase are mentioned below, despite the general judgment, that the amount and number of deviations and additional adjusting measures is considerably low.

The final topology of the Gigabit Ethernet network by RAG-A consists of a redundant ring. In total, about 5000 m of fiber optic cables as well as the corresponding fiber optic distributers have been installed. IPC-PLC controls for operational applications and MICs (Mining Infrastructure Computer) for the network infrastructure (switch technique) as well as for logistics were assembled.

For realization of the material tracking system the applied underground MICs were equipped with RFID readers to ensure the detection and utilization of the passive tags which are affixed to the transport units.

PDAs equipped with WLAN and barcode readers have been used for several applications, such as the registration of materials at the transfer points and general access to the central data store. By now these PDAs are linked to the newly installed WLAN technique of the MICs and their network structure, which offers 'just in time' information about transport units and transport activities.

In the field "personnel communication and information" existing analog phones were coupled to the communication network via VoIP gateways. With the help of the PDAs, it was possible to implement an information service for the miners. The miners will be automatically notified about the CH_4 concentration in their specific working area. In addition the system provides information about CH_4 concentrations in other areas.

A new radio frequency based belt skew detection sensor has been integrated and tested to prove its reliability. In addition to the original work program a further application of the new ICT has been realized. For the first time an IPC longwall control have been displaced from underground to the surface and successfully put into operation. This new setting grants several cost benefits as it requires no explosion protection on surface and lowers maintenance costs.

The actual 100 Mbit/s network infrastructure in Hunosa consists of a 20 km single ring closed on surface at two places, shaft San Nicolas and shaft Montsacro. Additionally, there is a small subring in the east area, linked to the main ring, as well as an inner cross cut in the center of the ring, allowing further path duplication. At the end of 2013 the commissioning of the fiber optic network has been completed. All media converters (copper / fiber optic) and adapted IP cameras with ATEX-certification have been installed. For the environmental sensor integration a Serial/Ethernet- Bridge has been developed.

After successful pilot installation and testing, Hunosa acquired new equipment in order to expand the personnel tracking system and to fully equip the main levels of Sueros Colliery. The new equipment covers 550 caplamps equipped with zigbee transmitters for radio transmission, complemented with 66 fixed beacons.

The requirements regarding material tracking are at a low level. For tracking locomotives the hardware of the mentioned caplamps has been modified. The actual tracking device isn´t based on the IREDES standard, the common standard in the mining industry. The manufacturer of the tracking system didn´t show any interest in implementing the IREDES standard and preferred to apply the already existing OPC based technology. The conveyor belt monitoring system employing IP cameras has been developed and commissioned successfully.

The network infrastructure concept of PRV consists of a modern communication infrastructure with a fiber optic backbone Gigabit Ethernet system, based on MICs. At first, the local wireless network did not cover the whole proposed area, yet was considered to be sufficient for the demonstration purposes within OPTI-MINE. However, the coverage was extended in a later phase.

PRV has been set to use the WLAN capability of the standard optical fiber network for VoIP telephony. After successful performance tests with available PDAs, WLAN mobile phones and pagers on wireless networks, phones were used in regular production operations.

As the company Minetronics is a partner in the project, PRV has installed a personnel tracking system using “Minetronics TracServer” application. This system tracks existing WLAN devices which are now already in use at the PRVs coal mine (PDAs and WLAN mobile phones).

In close collaboration with the project partner AITEMIN a hardware platform and communication protocol has been defined. An RTU-40 unit with single mode optical interface has been used. Sensor applications being connected cover CH_4 and CO_2 sensors, pressure sensors and signaling lamps (Safety related add-ons).

OKD did not have any fiber network based underground communication at the start of the project. The ICT-concept comprised a standard single mode fiber optic Ethernet network with WLAN base stations. The fiber optic cables have been laid including the required fiber optic distributers. The MICs for the network infrastructure and the RFID-readers have been installed. Above ground the servers for management, communication, visualization of coal trains location and for staff tracking by the means of active tags have been set up.

This system aims to cover the area necessary for locomotives and material tracking between two sites of the CSM mine. The network stations in the coal train tracking demonstration area are equipped with RFID readers for passive as well as for active RFID tags, which have already been tested at OKD for personnel tracking. The locos and the wagons have been equipped with both active and passive RFID tags, PDAs have been purchased for different OKD mines to assure a precise material tracking.

Digital voice communication between dispatchers and train drivers as well as tracking of the trains has been the main application. Therefore, the locomotives have been equipped with mobile communication units, which are capable of providing voice communication to the driver. These units rely on the standardized WLAN features of the MIC network nodes and their built-in WLAN access points for transmission.

KWSA did not have any network based underground communication at the start of the project. The ICT-concept comprised a standard single mode fiber optic Ethernet network in the longwall area with WLAN base stations. After a partial installation of the fiber optic cable, the initial concept had to be revised. Due to high levels of mining induced subsidence the company management decided to abandon and seal off this particular mining area. Currently the fiber optic cable extends only to the entrance of the longwall area.

KWSA intended to use the personal tracking capability of the WLAN system which is included in the fiber optic network. In the finalized solution the functionality and the area of application have been significantly limited: only two MICs and a control group of 30 staff members have been equipped with suitable communication devices. The main objective of the current system is to gain operational experience and get familiar with wireless communication based on WLAN standards and used for exchange of information and staff monitoring.

To start the task “Machine communication for transport / haulage”, the third MIC was installed at the loading station of the monorail serving the longwall operations and the drivers were equipped with pagers. This action has expanded the overall functionality of the communication system.

Main results

Modern information and communication technology has been successfully installed at all mines and put into operation during the project. In addition to the locally limited networks of the mines PRV, KWSA and OKD spatially extended complex networks have been realized at the RAG-A and Hunosa mines. RAG-A Ibbenbüren achieved important transport related advantages and an increase of safety as the actual CH_4-content is forwarded to operational staff members immediately. Additionally economic benefits could be conceded by replacing special underground PCs by standard hardware on the surface. At the Hunosa mine the belt monitoring system applying IP cameras proved to gain positive impacts on coal quality. The mines PRV, KWSA and OKD reported considerable technical progress and the positive experience with the new technology will certainly influence future investment.

WP1: Innovative components for system integration of applications

WPL: MT (Partners: Aitemin)

Task 1.1 - Production of firmware and tools for central device operation and configuration management (MT, Aitemin)

Work performed

Central configuration tools are needed for the underground electronics in order to maintain and update software and configurations without any need to bring them to the surface. For the networking equipment used underground, existing tools needed to be adjusted basing on the industrial scale application experience gained within the project. These tools were mainly to update configurations at predefined times, the central firmware and configuration storage and to provide failsafe update routines so the devices are always in a usable status.

These functions were implemented for the network devices used during the demonstration as well as for a number of mobile device types like Pagers and machine communication devices. A number of changes needed to be made to increase usability and assure scalability in large scale applications.

For the OKD application, the network nodes were equipped with a second RFID-reader interface requiring some software development and a hardware modification to the MIC devices used.

Further technical challenges were discovered during the demonstration workpackages in terms of network integration and different network administration policies of the participating mining companies. These administrative challenges were leading to a most universal and flexible layout of the configuration of the underground networking devices.

Figure 1.1: Screenshot of update screen for network device

Underground Control Systems currently deployed by HUNOSA are based in RELIA-AV technology, in which several Underground Master Controllers (RELIA-AV Master Stations) manage a set of Slave Controllers (dubbed UCR-AV), to which sensors and actuators are connected, and Digital Intercoms (DIGICOM). Up to 120 of these slave devices (UCR-AV + DIGICOM) can be connected to a given Master Controller.

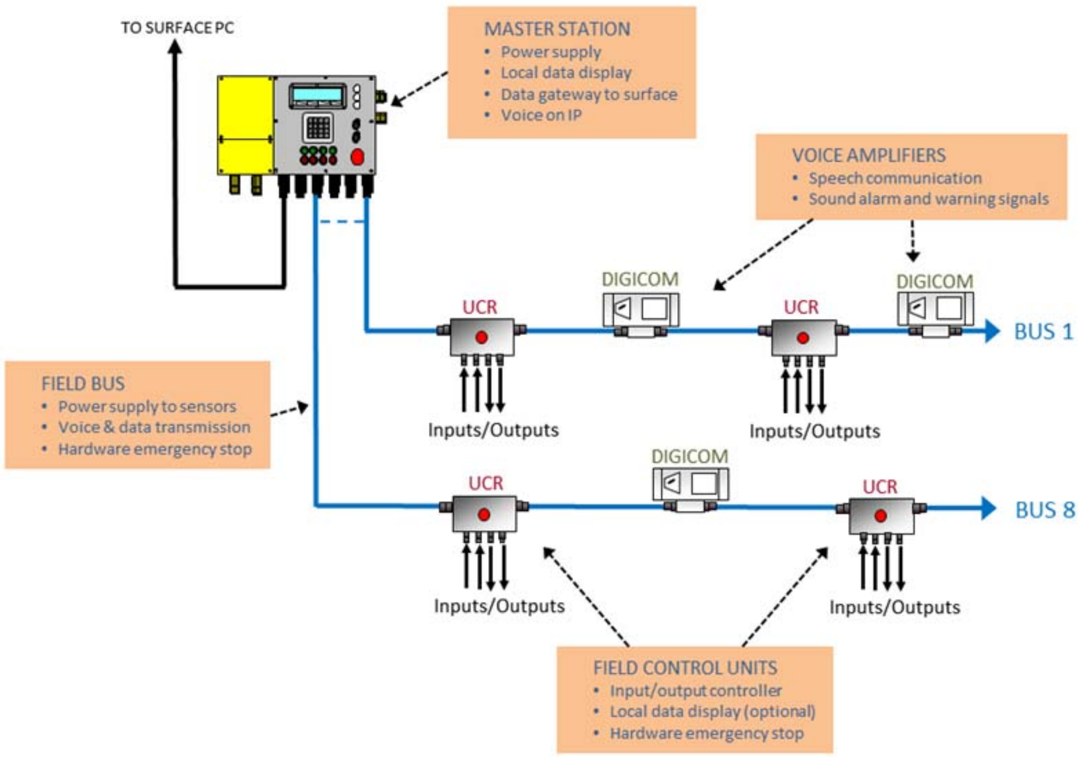

Figure 1.2: Underground control system at HUNOSA

In the case of AITEMIN the activity in this task was focused on the development of a tool for downloading new firmware to underground slave control devices: UCR-AVDIGICOM. For this purpose it was developed a firmware downloader for both UCR-AV and DIGICOM, complemented by a downloader manager in the Master Station. This last splits into 255 byte packets the new firmware, and manages its transmission in chunks of that size to the slave device. In turn, the downloader in the slave device assembles the packets into memory and flashes the new firmware into non-volatile memory.

The firmware downloader is launched manually opening a direct command line interface window in the Master Station from the surface. The reason for choosing a manual launching is that the operation of a pair of buses, and that of part of all machinery controlled by the master controller is interrupted while updating firmware. As it takes around 2 minutes to update each device, a full update can take up to 4 hours, so this operation should be planned in advance and having the possibility of interrupting it, if needed.

An additional activity was the development of an Atex serial-Ethernet bridge, needed for connecting legacy equipment to the new fiberoptic network.

The bridge was implemented on a common platform (Dubbed MP-40) that can be used for bridging Ethernet to other physical data transmission media other than Fiberoptic: Serial (RS-485), ZigBee and WiFi. It also has capability for connecting external sensors and actuators, working as an Atex Ethernet-enabled data collection unit.

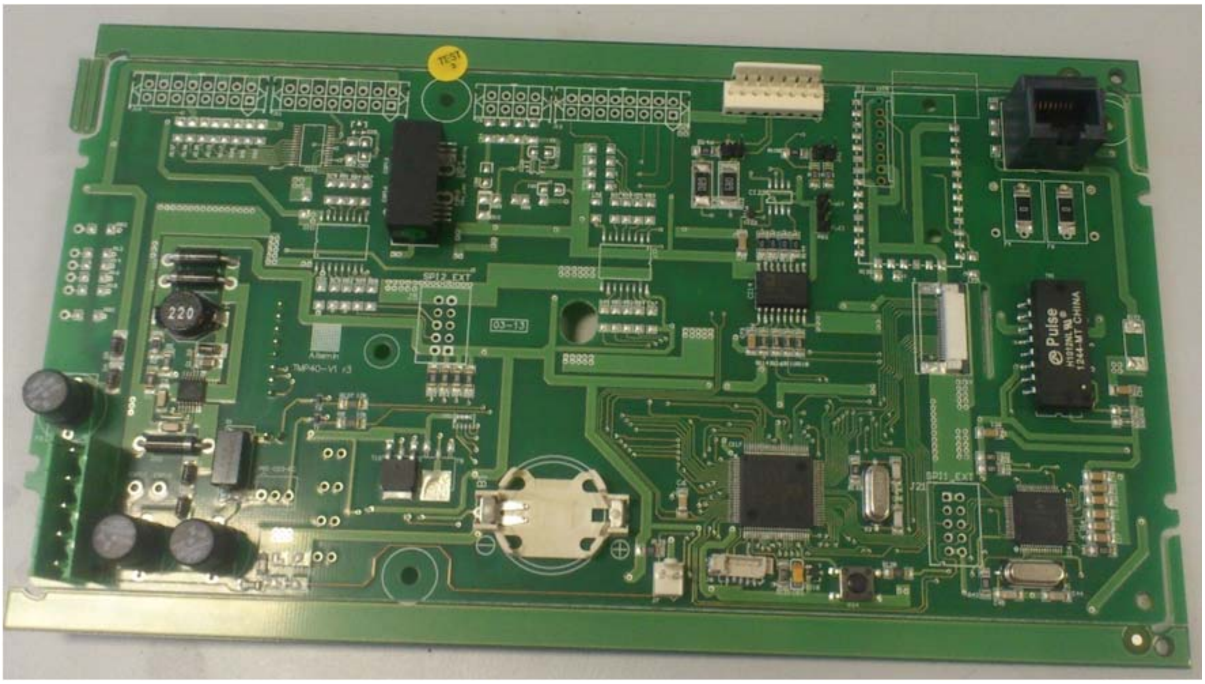

Figure 1.3: Barebones MP-40 (Only core components for minimal functionality are installed)

The development of hardware was completed, Atex approval was obtained and firmware development was completed. Finally, modifications to the OPC server that links underground equipment with surface SCADA system were made in order to support direct TCP/IP connections to the legacy equipment.

Main results

The main innovations made by MT in this task consist of the fail safe functions for remote update of entire intelligent devices. This means that the remote devices do not fall into a situation where they cannot be recovered remotely, even after an operating system update.

The innovative and integrative functions were successfully demonstrated during the demonstration WP's. In this context it proved to be an advantage to develop this functionality during a demonstration project as the entire integration into the production environment was essential for the successful implementation.

Related to Aitemin main results are all components of a firmware downloader, composed of a receiving part, implemented in UCR-AV and DIGICOM, and of a downloader manager implemented in RELIA –AV Master Stations.

Further an Atex serial-Ethernet bridge, including firmware, supporting software and ATEX certification; intended for connection of legacy equipment.

Task 1.2 – Adjustments of central operation management and remote maintenance tools (MT, Aitemin)

Work performed

As central software for the remote administration of underground devices and for information exchange with the underground processes, a number of central server software tools were adjusted by MT in their general functionality during the project and for continued use after the project is finished. The main focus of this work was on the industrial usability and the integration into production environments.

The related servers are used for the following functions:

- NetCenter for configurations and firmware update status
- TrackCenter for tracking of assets and people
- PagerCenter for the exchange of structured text messages
- VoIPCenter for handling of VoIP based phone calls and loudspeaker systems
- ViewCenter for location based visualization of the underground operations

For the **NetCenter**, the central functions for configuration handling and scheduling of firmware and configuration updates had to be adjusted. As these functions heavily interact with the local IT, these works covered significant effort for network integration and adjustment to specific IT policies. In this context it should be mentioned, that major parts of this work related to the fact, that big companies often use network and IT equipment of big suppliers, who bind their customers by proprietary functions and "add-ons" to the known international networking standards. Especially the use of such proprietary functions often causes difficulties when purely standard conformant devices of different manufacturers have to be integrated, like in this case the intelligent underground network nodes.

The **TrackCenter** was already basing on the use of IREDES standardized protocols. This feature was updated and extended during the project as well as specific software components were added to the TrackCenter in order to use the tracking information provided by the pagers (KWSA) to determine the number of people in a potentially dangerous area, or to show the trains along tracks (OKD) in order to use the information to organize train traffic.

The **PagerCenter** was configured and integrated in KWSA to transmit text messages to workers in a longwall area.

The **VoIP Center** was prepared for initial use, but not used later in the project as the mines decided to use their VoIP PBX systems for simple telephony so no central dispatch with the integration of loudspeaker lines was needed.

The **ViewCenter** for visualization of operations in location based context using a true digitized mine map was extended with components for the applications at KWSA, RAG-Anthrazit, OKD and Premogovnik Velenje with different applications:

In KWSA, the ViewCenter showed the access to a potentially dangerous longwall area in the mine requiring additional windows for showing the number of people entering and leaving the zone.

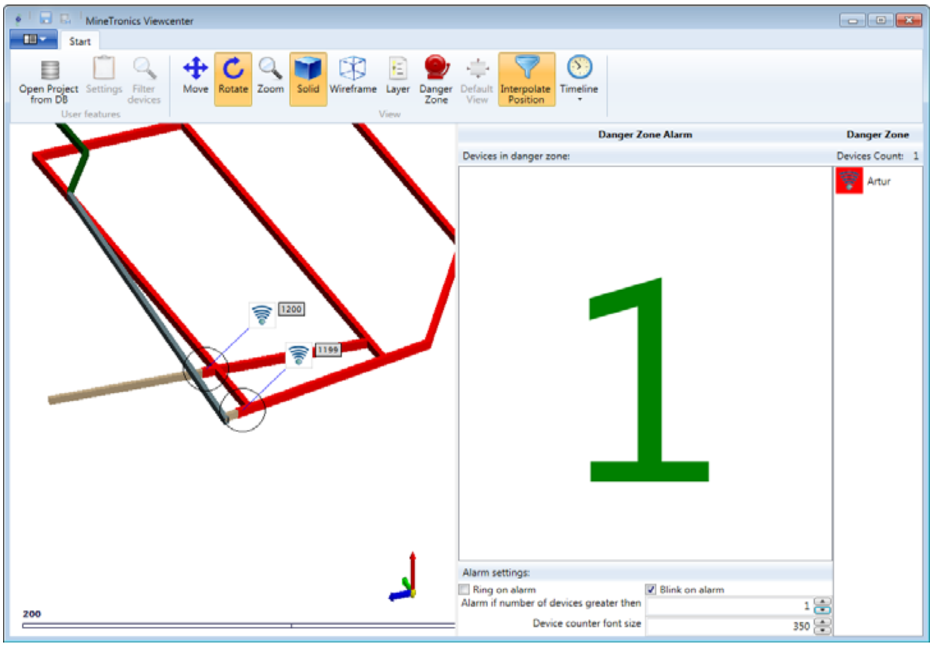

Figure 1.4: Screenshot ViewCenter KWSA

In OKD, the ViewCenter showed the train transport area with the locations of the trains incorporating the challenge that two tracks had to be displayed in a single tunnel. This required related software modifications.

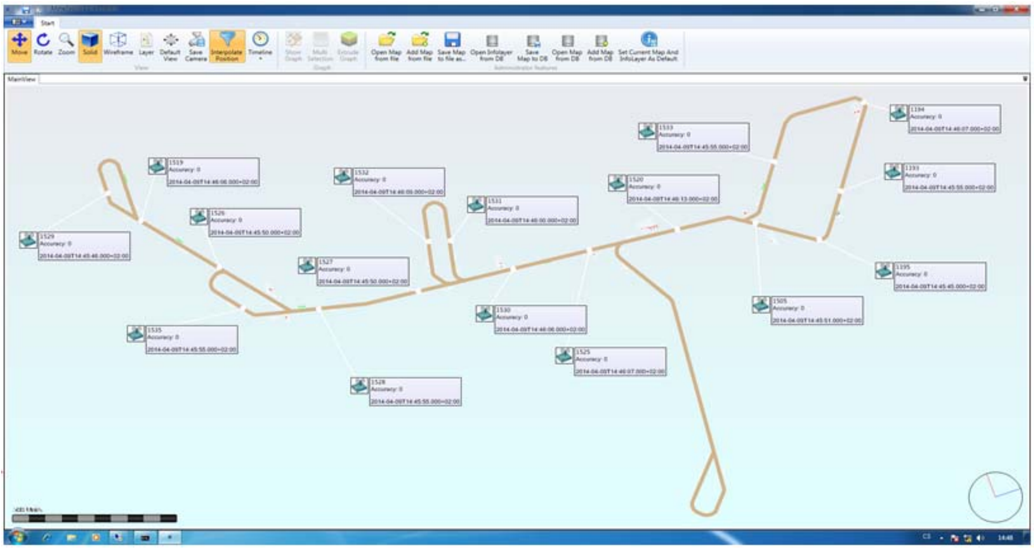

Figure 1.5: Screenshot ViewCenter OKD

Premogovnik Velenje uses the ViewCenter to track devices and to show the network in the mine.

In any case, the digital mine model had to be imported from CAD, which in this version of the View Center also required some manual interaction.

These experience with the ViewCenter was leading to the decision to use a different and more modern software platform in the future requiring less customization and less effort for configuration. The OPTIMINE project with the extensive demonstration experience helped significantly in deriving the new specification and determining the right technological platform.

Extensive support was carried out at the project partners RAG-A, OKD, KWSA and Premogovnik Velenje to integrate the systems into the local environments and to help with startup, configuration and operations.

The customization of specific server functions to individual mines was carried out in the mine specific work packages.

In HUNOSA, it was implemented a method for remote monitoring all important operational and maintenance-related parameters of underground control systems based in RELIA-AV. For this purpose, it was necessary modifying the transmission protocols for including more status information from underground devices, like power supply status, voltages, current consumption of sensors, machine controller subroutines status, environmental alarms shutting down machinery, etc.

Figure 1.6: Monitoring screen showing parameters of underground control systems

These functions were added in dedicated monitoring screens in Win CC SCADA, which are generated automatically by WinCC scripts after each system reconfiguration.

It was implemented supporting software for recording, managing and display operational variables transmitted by underground control systems, both legacy and new.

The display of information in other computers connected to the network was implemented using “Web Navigator”. For this purpose, automatic configuration scripts were developed, automating the generation of the web-server pages displayed by remote computers after each change in configuration.

A user manual (in Spanish) of the software has been produced. In it, full details of the new functions are available.

Main results

The server systems available at the start of the project were in a final development stage but never had been used in industry scale projects.

The adjustment of the systems to the industry scale applications in WP 2-6 was performed successfully and mostly in line with the project plan. However it can be concluded that these adjustments required more effort than originally planned, especially also unplanned visits at the participating mines to support installation, startup and operation.

Full status and information needed for maintenance of the systems is transmitted, displayed and recorded in surface computers.

Discussions during the OPTIMINE forums and with potential users showed that the innovative use of the central ViewCenter software would be to display the ongoing operations in real time and in location based context. In the end of the project and beyond, these ideas were leading to a study of a software extension developed by MineTronics with the name “MineOpt-MRP” whereas MRP stands for “*Mine Resource Planning*”. This software combines functionality as shown above with a scheduling and planning component in order to show the ongoing operations on a timeline together with the location based context. This enables the shift managers e.g. to determine upcoming problems without delay and quickly access the closest person or machine to solve a sudden problem. MineTronics plans to use this indirect research result of OPTIMINE in commercial projects already in 2015.

Task 1.3 – Implementation of new standardized data formats for underground tracking information (MT, Aitemin)

Work performed

All information exchange using the network based communication within the project was carried out using the international IREDES standard (www.iredes.org). Some new IREDES profiles were prototyped and successfully implemented within the project like the Tracking profile and the profile for exchange of text messages.

The Tracking Profile was already in a draft stage when the project started, however there was no industrial application yet. During the project the initial application was performed in four of the participating mines with completely different applications. During this work also changes and add-ons to the standard have been made which only could have been detected in a large scale application.

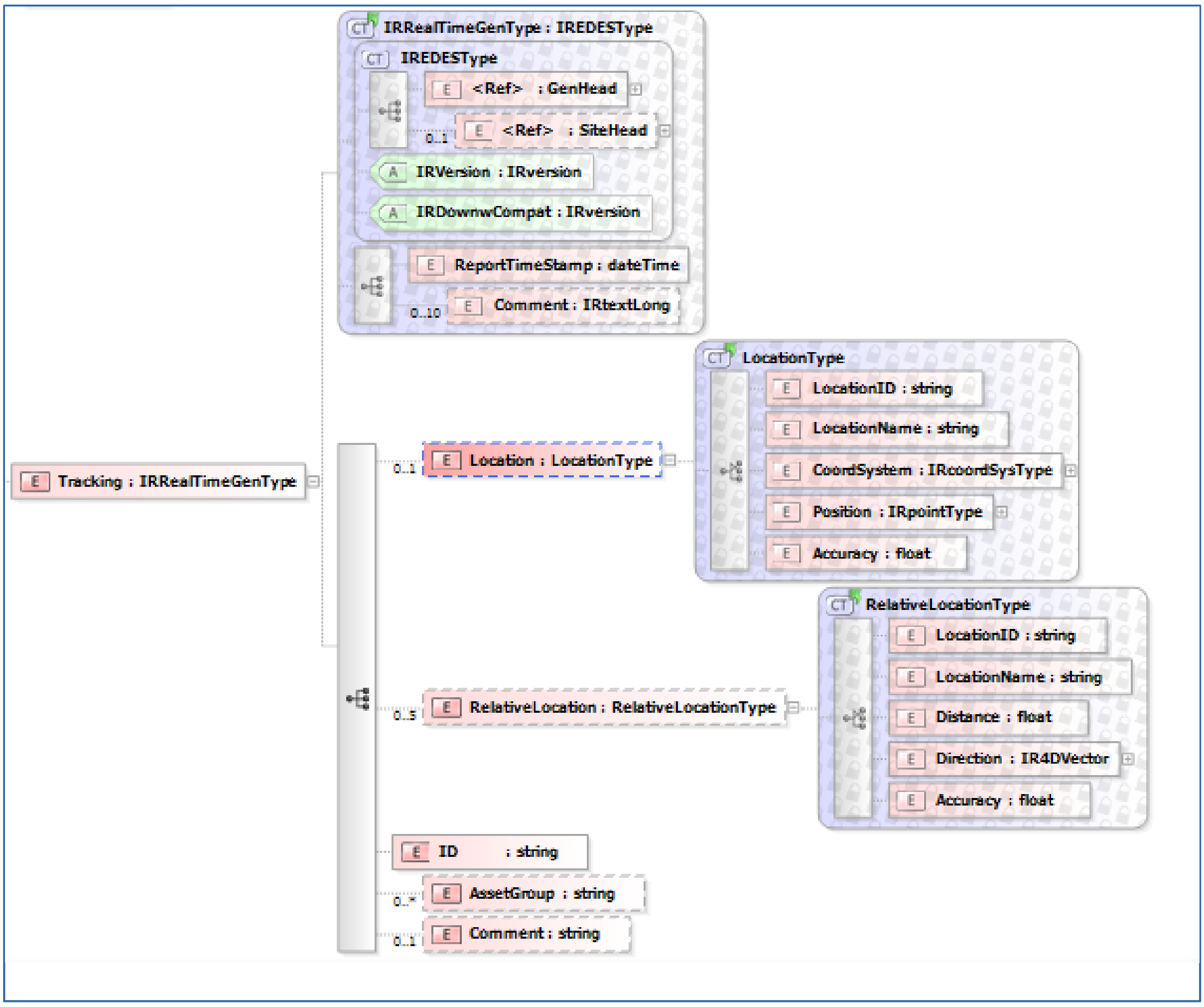

Figure 1.7: IREDES tracking profile structure and content

The second IREDES profile used for the first time in an industrial scale was the Messaging Profile for the exchange of text messages between a central dispatcher and the underground workers or between the workers underground.

This profile was implemented in the pager devices used in the KWSA demonstration WP together with the above ground *PagerCenter* (see above). The pager is equipped with a small matrix display (monochrome) with RGB background illumination and an acoustic alarm.

In order to allow the underground workers to use such device in the simplest most way, there is no (alpha-) numeric keyboard integrated. The user selects a message to be sent from a list of general or work specific messages, potentially together with setting related variables. For this, the use of four arrow keys and a central "OK" button is sufficient. When he receives a message, he is also able to select and acknowledge in the same way.

A message received may also contain a list of possible answers. The recipient of the message simply selects an answer from this list and returns it.

This kind of dialog is simple to be performed and it can be fully reproduced electronically as each message and answer can be electronically identified. By running statistics on these messages, an operating mine is able to discover operational bottlenecks and thereby further optimizes it's operations.

Figure 1.8: Pager device

The original idea of integrating the pager into a caplamp was not implemented as the manufacturer of the caplamp was not willing to integrate the electronics into his device.

This success was also pushing ahead the use of this standard and enabled a participating SME to offer Standard implementations and software on a global marketplace

Main results

The IREDES tracking profile was initially and successfully tested in an industrial scale application with good result.

The prototype of the IREDES Messaging Profile was also tested successfully in an industrial scale implementation together with intelligent devices and a central messaging server.

The OPTIMINE project thereby helps to support the broad use of this global industrial standard. It also provides a market advantage to the technology integrators

Task 1.4 - Integration and adaptation of wireless tracking and positioning systems (MT, Aitemin)

Work performed

Within this task, different wireless tracking systems were integrated into the application during the demonstration work packages.

This relates to the passive RFID system used successfully at RAG-Anthrazit for the material tracking and optimization of the logistics and to wireless LAN based tracking of different standard WLAN devices.

The work related to this task covered the integration of passive RFID readers into the intelligent network nodes and the related transformation of the RFID reader generated data stream into IREDES tracking telegrams. For this purpose, a software component was developed to run on the network nodes.

The specific requirement of OKD to use two RFID readers attached to a single network node in order to detect two trains on different tracks required an additional extension of the software and hardware of the network nodes to enable this request.

In other applications (KWSA, Premogovnik Velenje), the tracking information is generated by reading the association of mobile devices to the WLAN accesspoints of the network nodes. This functionality was already available prior to the project and has been adjusted to the industrial scale application.

For the personnel tracking at HUNOSA a bridge Ethenet-ZigBee, using the MP-40 core mentioned in the section devoted to Task 1.2 was developed. The bridge was dubbed BZE-40. This bridge is necessary for connecting the personnel location system being deployed in HUNOSA (it is based on ZigBee tags installed on Caplamps) to the surface using the new fiberoptic network.

The wireless location system uses the so called "sink nodes" to collect data on the personnel present in a given area. Data so collected were transmitted to the surface using a serial port, which is not directly connectable to the fiberoptic network, and hence the need of developing a bridging device.

Activities included the mechanical design of the enclosure, implementation of a quasi-PoE power supply system, and the development of specific firmware for bridging to Ethernet the ZigBee module embedded in the apparatus, which was configured as area data sink. It was also necessary making a modification to the OPC server in order to allow multiple IP connections, instead of the single serial connection available initially.

Finally, ATEX approval (Certificate) was applied for and obtained.

Note: More details on the location system are given in WP3 summary.

Figure 1.9: BZE-40 apparatus just after assembling

Main results

The main results are the successful integration of different tracking hardware into the network based universal systems at RAG-A, OKD, KWSA and PRV, using standardized IREDES protocols.

Results concerning HUNOSA are an Atex bridge for bridging ZigBee networks to Ethernet, including its ATEX certification, firmware for the above bridge and an OPC server for the location system, enhanced for operating on IP networks.

Task 1.5 – System integrative development of an RF based belt skew sensor (MT)

Work performed

A prototype of a new, contact less belt skew sensor was developed (see picture). This sensor uses radio frequencies to detect objects in a near field (<10cm) in front of the sensor surface. These objects may be of different material, so also the detection of rubber conveyor belts is possible. In contrast to sensors traditionally used, this sensor cannot be mechanically blocked. It is thereby manipulation safe.

Within this task, the electronics was developed and assembled into a prototype housing. The unit was tested successfully in an above ground conveyor belt installation at RAG-Anthrazit.

Figure 1.10: New Belt Skew sensor in test installation

Main results

New Radio frequency based Belt skew sensor successfully developed and tested as prototype. The device is ready for a following commercialization.

WP2: Demonstration of process optimization in a very deep, advanced, wide spread mine (DE)

WPL: RAG-A (Partners: MT, Aitemin)

Task 2.1- Network Infrastructure (RAG-A, MT, Aitemin)

Work performed

The network structure expansion with fibre optic cables (FOC) in the production area Beustfeld was carried out. In total, around 5000 m FO cables were laid (24 FO cables, 12 FO breakout cables with and 12 without plug) and 20 required FOC distributers were installed underground (**figure 2.1**).

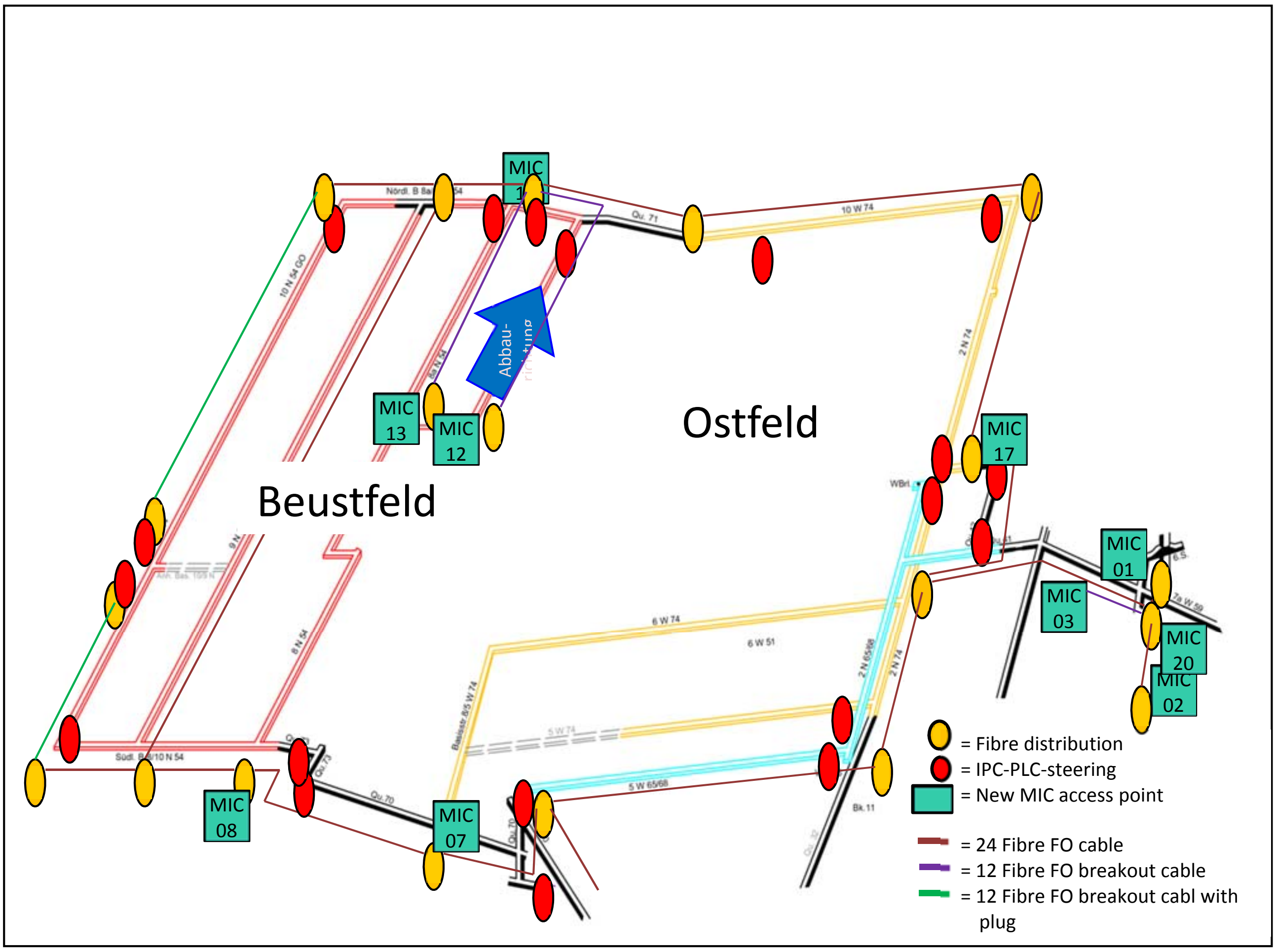

Figure 2.1: Expansion status of production area Beustfeld, 30 Oct 2014

Moreover, 19 IPC-PLC (Industrial grade PC – Programmable Logic Controller) controls for operating facilities and 10 MIC's (Mining Infrastructure Computers) for the network infrastructure (switch technique) as well as for logistics (RFID, WLAN) were assembled in the area Beustfeld/ Ostfeld.

The topology of the gigabit Ethernet network consists of a redundant ring. The ring stretches out underground over Shaft North, area Ostfeld to Shaft Oyenhausen and back again to Shaft North. An additional ring connects on surface Shaft Oyenhausen with Shaft North over 6 km distance.

The whole underground network structure is connected to the surface network by redundantly designed Cisco switches on surface (located in four buildings called Shaft North, Shaft Oyenhausen, HVT, BÜT). It is divided into three logic virtual networks: VLAN process and control net, VLAN camera net and VLAN logistics net.

At the underground test operation of the MIC's with several modules (switch, RFID, WLAN) high temperatures arose initially and led to technical problems inside the MIC's. This problem was solved within the project by installing of additional copper panels.

After solution of the mechanical problem, the network was tested at operational stability. Here excessive data streams appeared sporadically, which caused network errors. To eliminate the network errors, all MIC's 100 were updated to the latest firmware version 1.4.3.

At the same time, some MIC's 100 were adapted to the successor model MIC 150 of the company MineTronics. Both activities formed also the basis for the network visualisation software of MineTronics, which was implemented within the project.

Further details on task 2.1 are given in the appendix "Further information and details".

Main results

After elimination of the initial difficulties (like overheating, excessive data streams), as they appear usually at the introduction of new unproven technologies, and after optimization the network was fully functional and could be reliably operated.

By the set-up as redundant network by a meshed ring structure and use of standardised network components (switches) with ATEX approval in the underground area, a higher system stability concerning data transfer and control of production facilities, compared to the previous star structure, was demonstrated.

Moreover, it met the expectation to enable operation of several different IT applications using different kinds of hard- and software, also from different manufacturers, only within one universal network system (s. tasks 2.2 to 2.4).

Task 2.2 - Optimisation of material logistics (RAG-A, MT)

Work performed

The applied underground MIC's are equipped with RFID readers. Thereby it is possible to detect and utilise the passive tags, which are affixed to the operation facilities (transport units, transport means, etc.).

Based on the experience of a former RFID project and in the course of the project OPTI-MINE, the MIC's positions and thereby the RFID readers positions were optimised.

The access points / MIC's (RFID readers) are distributed in the shaft area Shaft North and in the production area Beustfeld. The south part of the mining field is only partly equipped with this technique. In the shaft close-up range, at the different levels (draw point 45/48, 5th level, 6th level) the RFID readers could be straightened out. Multiple readings at shunting of locomotives are thus eliminated.

Container tracking above and underground:

After commissioning the ordered material in the SAP system, the material is loaded into transport units. After loading the transport units are pushed over the track harp through a building (linking station) and arrive at the shaft. In the linking station an RFID reader detects the container tag.

Thus the stored container number and the container type are known. At the same time a barcode reader records a barcode label on the container, which indicates the commission number. Thereby the information on material content, destination and transport unit are brought together and thus content and destination of each unit is known. Each transport unit is detected via RFID at the shaft entrance and shaft exit. Analogically the detection at the stations of the different floors takes place during the transport to the winning operations and preparatory workings.

For linking optimisation a further linking station for linking of container tags and commissioning numbers was installed at the shaft shunting site and the container management software was developed further.

Currently the software basically performs the following analyses.

- Access point scheme (illustration 'when' an access point reported last time.
- Tracking of the individual containers, respectively container types, e.g. district container (**figure 2.2**).
- Current loco information and their transport units.
- Analyses of transport volume / container types at shaft entry / shaft exit.

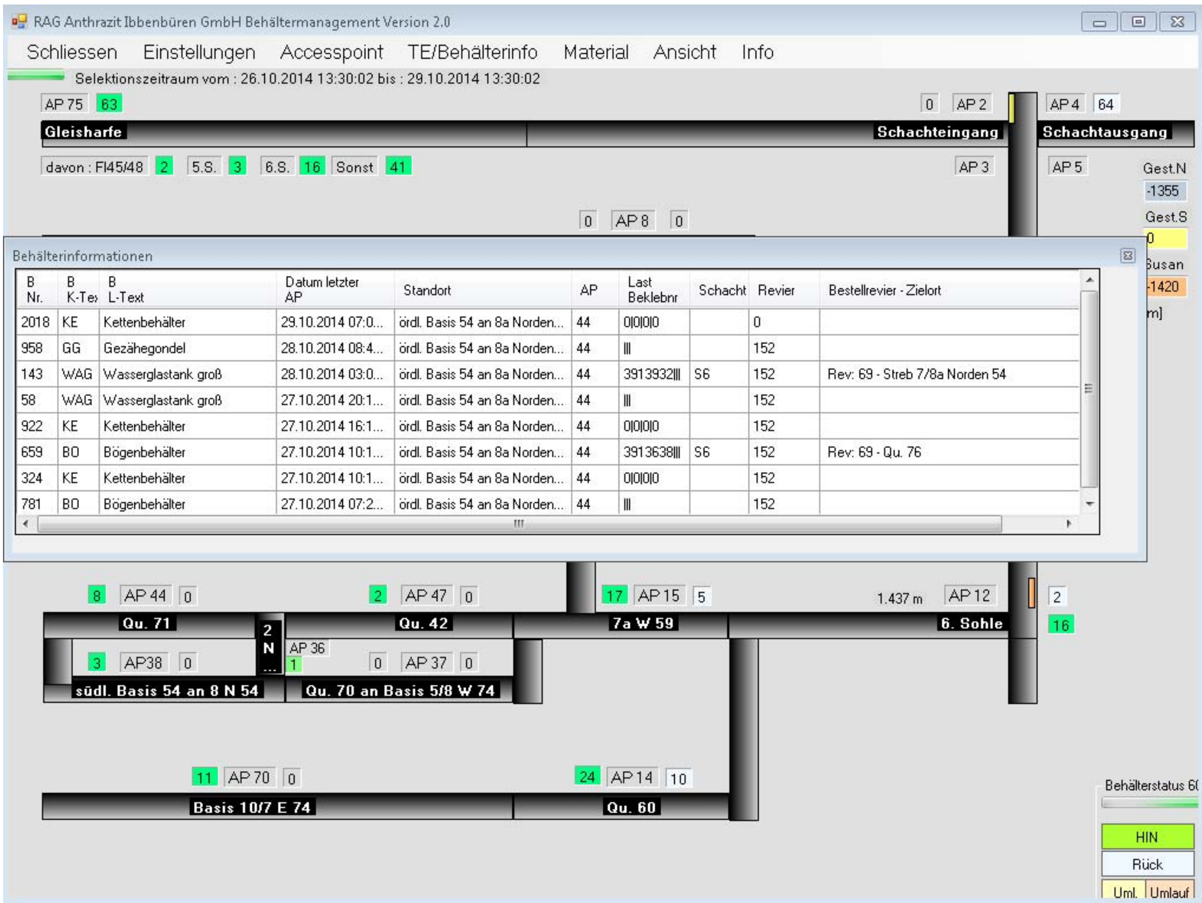

Figure 2.2: Information about a district container
(in the background the schematic illustration of the mine layout and access points)

Further details on task 2.2 are given in the appendix "Further information and details".

Main results

On the basis of the network infrastructure (task 2.1) and by the deployment of standardised network components, with standardised RFID and WLAN components inside the MIC's developed the company MineTronics, IT-systems for container tracking, material tracking, container management and for loco information could be built up and successfully operated.

Thereby a higher transparency regarding locations of operating resources in the logistics field could be demonstrated. In connection with that results a higher logistics efficiency and respectively cost reductions due to an optimised use of transport units and transport means.

Task 2.3 - Personnel communication and information (RAG-A, MT)

Work performed

At RAG Anthrazit Ibbenbüren GmbH certified ATEX M1 approved PDA's (Pocket PC's) equipped with WLAN and barcode reader have already been in use. They have a logistics software of an existing logistics system installed (TS/4) and use now additionally the newly installed WLAN technique of the MIC's and their network structure (VLAN-logistics net), which makes 'just in time' information about containers and transport activities possible (**figure 2.3**).

Revier:	69	**Zielort-Text:**		**Transportart:**	T
Zielort:	7471	**Transportweg:**	S6	**Von Ort:**	9000
Ursprungs-KZ:	T	**Ursprungs-TA:**	TS/4		
Warennummer-Text:	Einheitsverbindung G 34-44 600 Nm				
Zusatztext:					
SAP-Reservierung	0019535187	**ME:**	ST	**Serial-Nr.**	
SAP-Kontierung	100145969	**Charge:**	BK0	**Schwertransport**	
Warennummer:	3369500	**Lagertyp u. Lagerplatz:**	21-999999		
		Korrektur aus Transportraumdisposition		**Korrektur nach der Verladung**	
Erfassdatum:	24.10.2014	**Korrektur KZ:**		**Korrektur KZ:**	
Menge angefordert:	128	**Menge K Dispo:**	0.0	**Menge NL Verladung:**	0.0
Menge verladen:	16	**Menge NL Dispo:**	0.0	**Menge K Verladung:**	0.0
Korrekturdatum:					
Verladedatum:	24.10.2014	**TE Typ:**	BO		
Verladezeit:	21:17	**TE Typ-Text:**	Bogenbehälter		
LL-Position:	1806779	**Erfasst-Zeit:**			
Komm-Nr.:	3913627	**Standort:**	9000		
TE:		**Standort-Text**	Angekommen		

Loknr.	T.-Art.	Startort	Startortzeit	Zielort	Zielortzeit	Status
32	N	Str. 2 Norden 65/68 n. N.	27.10.2014 08:07:00	Strecke 7a Osten, Fl. 74	27.10.2014 10:54:51	A

Datum	AP	Startort	Komm1 NR.	Komm2 NR.	Komm3 NR.	Komm4 NR.
29.10.2014 05:57:27	15	7a Westen 59 an westl. Basis FL. 59	3913627			
29.10.2014 04:27:38	14	Qu. 60 unten	3913627			
27.10.2014 08:31:47	14	Qu. 60 unten	3913627			
27.10.2014 08:13:25	15	7a Westen 59 an westl. Basis FL. 59	3913627			
24.10.2014 19:33:24	75	Gleisharfe	3913627			

Figure 2.3: TS4 intranet with electronically recorded additional information

The lower display part in **figure 2.3** shows the electronically recorded additional information of the transport mean (loco number) and the way of the transport unit until the destination.

By the same communication technique (PDA and WLAN) it was possible within the project to deploy, test and demonstrate the CH_4 data transfer from the safety control room (= Sicherheitswarte, SIWA) to the PDA's. This way it is possible to avoid CH_4 shut-offs and to enhances the safety by real time CH_4 course monitoring at relaxation drillings.

The measured analogue data are transferred by a carrier frequency to the safety control room. They can be retrieved and forwarded to the PDA's by an OPC-interface and a TCP/IP-server.

As well, the functionality regarding Voice over IP (VOIP) was tested basing on the network infrastructure described in task 2.1. For this a standard server above ground was equipped with a publicly available telecommunication software '3CX' of the company Innovating Communication (telephone conference installation with standard SIP protocol). For the connection of standard mobile phones to the TC installation, a standard WLAN access point was installed. After set-up of the telephone subscribers in the TC installation, VOIP could be successfully tested (figure 2.4).

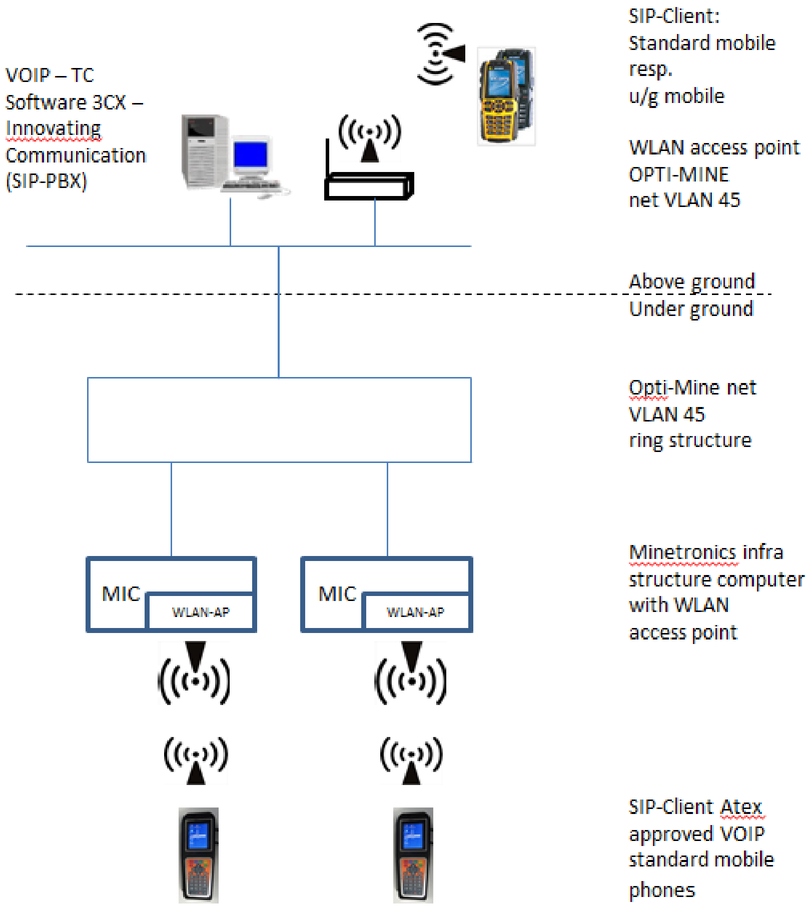

Figure 2.4 VOIP – test installation

Further details on task 2.3 are given in the appendix "Further information and details".

Main results

By the installation of the network and logistics infrastructure, described in tasks 2.1 and 2.2, an existing material information system (TS4) could be supplemented by many further electronically recorded logistics data. Thereby a direct nearly real time material tracking from order until delivery could demonstrated.

The same technique allows also a nearly real time transfer of analogue CH_4 graphs to PDA's, by which unnecessary CH4 shut-offs could be avoided and safety enhanced.

The system for providing information to underground personnel could be reliably operated and complies with the expectations.

Concerning voice transmission it was determined after the testing, that transmission via the installed underground network infrastructure as well as from above ground to underground was of good quality. This was also the case at the maximum distance of 150 m from an MIC. Due to the run-off process, closure of the German hard coal mines until 2018 and the economic conditions connected with that, this application is not anymore scheduled to be deployed at RAG-A. For further findings, an operational long term test and with that a verification of stability and economic viability in different application areas like e. g. logistics would be necessary.

Task 2.4 - Conveyor belt skew detection (RAG-A, MT)

Work performed

The test operation of the conveyor belt skew detection was cleared with the company MineTronics, which developed the detector within the project (s. task 1.5), and it was tested at a belt conveyor in the above ground coal preparation plant. Details of the belt skew sensor development are presented in deliverable D1.5 of MineTronics.

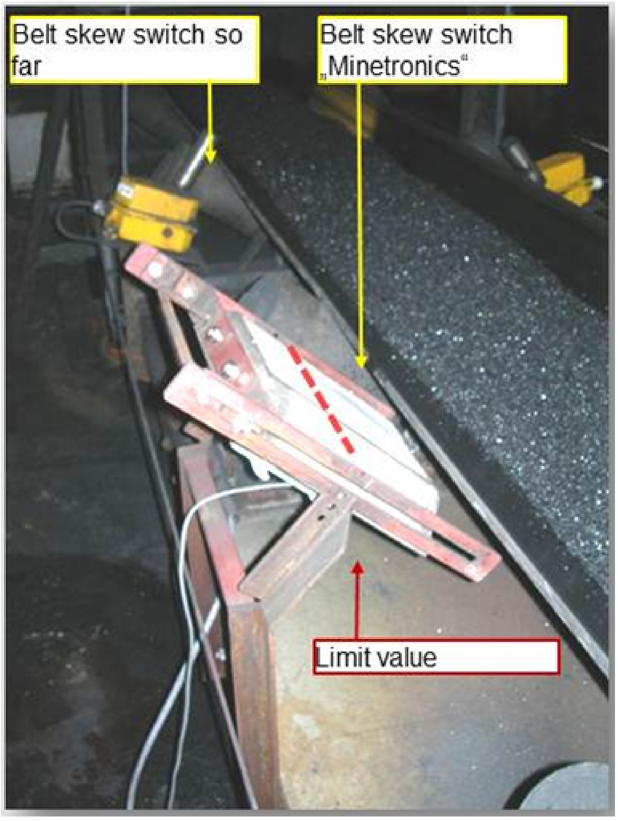

Figure 2.5: Belt skew sensor test intallation at the coal preparation plant

Figure 2.5 shows the above ground test installation of the belt skew sensor developed by MineTronics and at the same time one advantage compared to the previously used technique. At the previous technique belt skew switches had to be installed at both sides of the belt, which is not necessary with the new technique. Further benefits of the new technique consist in the possibility of continuous and contact less monitoring of the lateral conveyor belt movements.

Integration of controls

Additionally to the original work programme a further application of the new ICT was realised. For the first time a longwall control could be displaced from underground to the surface and successfully put into operation, thanks to the redundant network ring structure.

The topology of the so far existing control of underground longwall equipment is as follows. The IPC longwall control was connected by a FO cable coming from the process level on surface. The underground control of the longwall installations, switchgears, support shield control etc. was carried out via a 500 m up to 10 km long PROFIBUS (Process Field Bus, copper line), depending on the underground local conditions.

The above ground control of the longwall installations is carried out in the following way. By using the redundant network ring (Shaft Oyenhausen, Shaft North) and optical PROFIBUS converters, the ATEX approved IPC could be replaced by a standard processor (19” rack) and displaced to the surface. At the same time the PROFIBUS length (copper line) to the motors, switchgears, support shield control etc. was reduced to 250 m.

This resulted in essential benefits:

- Cost saving of around 40 k€ by IPC’s displacement to the surface.
- Higher resilience by redundant FOC ring structure.
- Lower maintenance and installation costs at the longwall due to reduced PROFIBUS lengths.
- Lower installation cost due to easier installation on surface compared to underground installation.
- Lower maintenance cost on surface due to better accessibility and air conditioned computer room.

Due to the positive experience with the first above ground longwall control, the three further longwall control installations of the mine were displaced to above ground and are generally to be operated in future above ground. For that purpose the longwall installations were connected by a FO cable with the network of the production field ‘Beustfeld’.

For further details on task 2.4 see appendix ‘Further information and details’.

Main results

By using the network infrastructure built up in task 2.1, so far underground implemented longwall controls could be successfully displaced to above ground and their operation could be tested. It could be demonstrated that a minimization of the installation, maintenance and investment costs can be achieved.

Regarding the belt skew monitoring an above ground test installation in cooperation with company MineTronics was successfully executed. Currently an underground ATEX approved system is not existing. As soon as MineTronics can offer the system with ATEX approval, it could be implemented in underground coal mines.

WP3: Demonstration of voice communication and automation in a highly branched mine with single entry faces (ES)

WPL: HUNOSA (Partners: Aitemin, MT)

Task 3.1 – Network Infrastructure (HUNOSA, Aitemin, MT)

Work performed

Activities started with the installation of a small fiber optic ring close to S. Nicolás shaft, for testing the operation of the concept. This installation was successful, and so it was decided to progress in the deployment of the full network.

However, the deployment activities were delayed due to the miners' strike already mentioned, and fiber optic was not fully laid out until the end of 2012. In the meanwhile, Atex approval of all networking gear was obtained and new analyses on how to implement practical connection details were completed. Moreover, additional considerations on network redundancy were made, leading to a change in the concept of the whole installation.

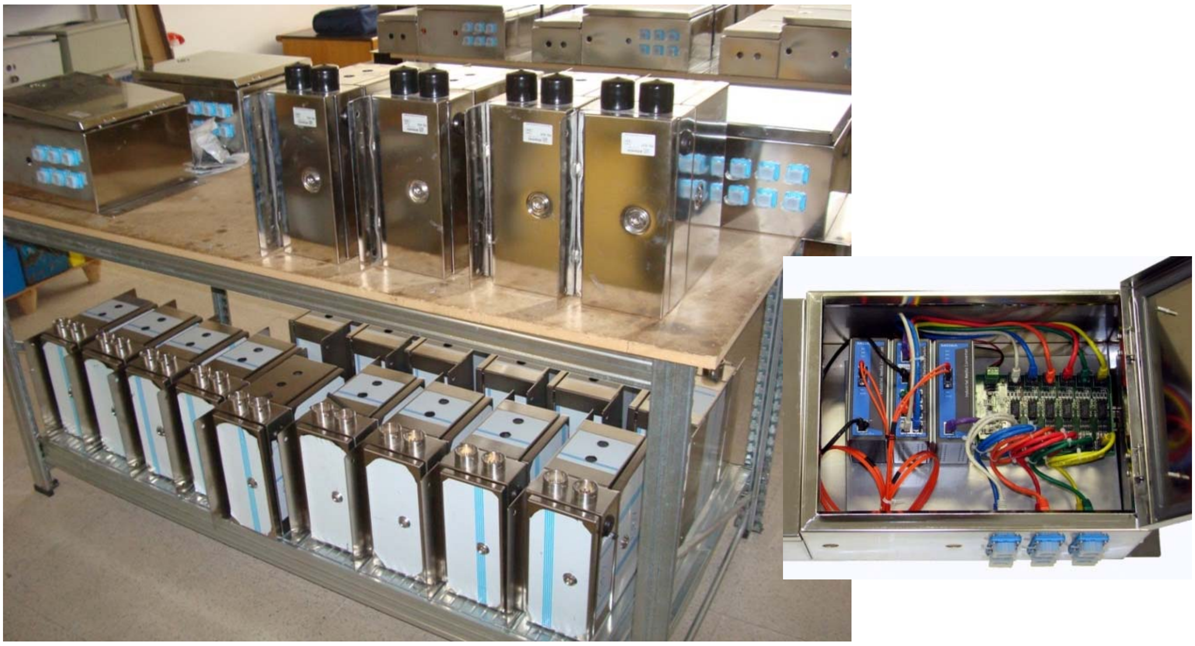

Figure 3.1: Networking gear almost ready to ship. Detail of Media converter

Furthermore, a decision was taken on purchasing a fiber splicing apparatus by fiber fusion, and not relying on external contractors. This also caused additional delays in commissioning, for the procurement procedure is quite slow.

On the other hand, the delays have a positive side effect: Some important ongoing mining development works were finished, so the installation can be commissioned in its final shape right from the beginning.

Initially, the concept was quite simple: Two rings of twelve fibres (6 circuits) were to be laid out, one to the East and the other to the centre zone. The final concept was more complex, including several subrings. This in turn created the need for Media Converters with three fiber-to-Ethernet converters, which were not planned initially.

The main change consisted in shifting from a two ring topology, one for the East area and another for the central one, closed on the surface in S. Nicolas shaft, to a single ring topology, closed in the surface at two places, shaft S. Nicolas and shaft Monsacro. Attached to the main ring there is a small subring in the East area, as well as an inner cross cut in the center of the ring, allowing further path duplication.

Finally, the decision of taking the fibers to the surface in Monsacro was taken in order to use the fiber optic backbone for transmitting to S. Nicolas shaft automation data from the main fan, pumping system, compressor, etc. placed around Monsacro shaft. This centralization of data will allow personnel cost savings and a better management of the whole plant.

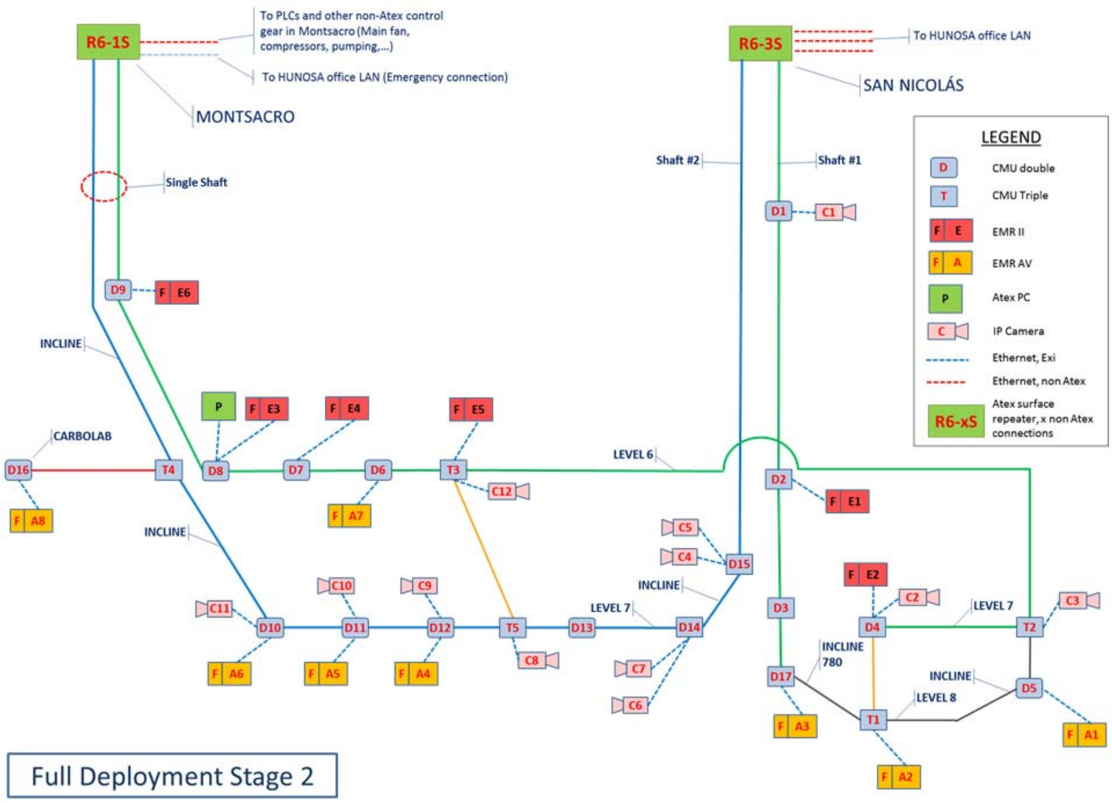

Figure 3.2: Final Layout

As said before, it was necessary modifying the CMU (media converters) to allow the implementation of a "T" topology, but it was also decided the implementation of Pseudo-PoE in all wired Ethernet connections, the substitution of a 1.8 PSU for the original 1.0 A one, and the procurement of two sets of Atex Media converters to close the fiberoptic rings in both S. Nicolás and Monsacro shafts.

Also the methods for fiberoptic splicing and connection were fully developed. A standardised fiberoptic junction box was specified and implemented, the procedures for the use underground of the fiberoptic fusion machine were developed, and a time domain reflectometer for finding faults was also procured.

The above actions and activity allowed the implementation, testing and commissioning the fiberoptic network, which is now fully operative. Further details in relation with this activity can be found in Deliverable D3.1, in which full details on the implementation of this task are given.

Main results

Fiber optic network with ring topology, installed, commissioned and fully operative.

Task 3.2 – Environmental sensoric integration (HUNOSA, Aitemin, MT)

Work performed

Activity in this task in the hardware side was focused mainly in the planning, design and commissioning area, for most of the related work, the development of a serial-Ethernet Atex bridge for connection of legacy equipment, was done against Task 1.1. As result of this work, some modifications to the media converters (adding support for quasi-PoE) were designed.

On the software side, the situation was a bit more complex. For connection to AITEMIN-made equipment, it was decided to implement a direct IP connection (through sockets) to legacy devices. For this purpose, the configuration software and the OPC server was modified (as reported under T1.1). These modifications were implemented after the firmware for the Serial-Ethernet Bridge was completed.

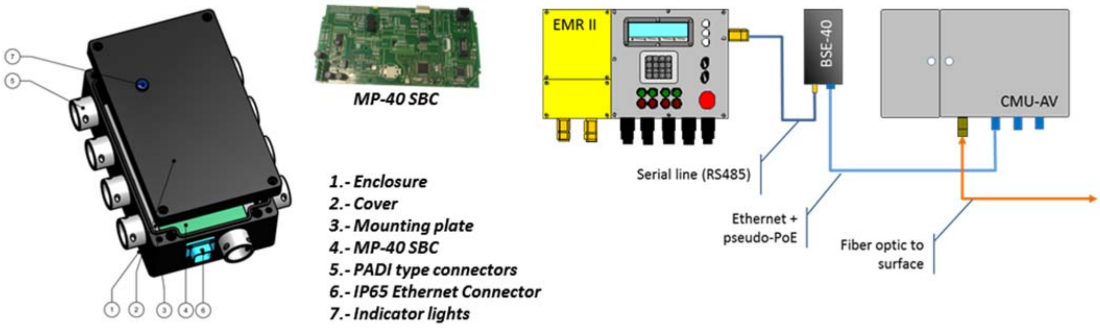

Figure 3.3: Serial Ethernet bridge

The bridges were supplied after obtaining the Atex approval, it its operation tested in the surface; and its installation underground started immediately after.

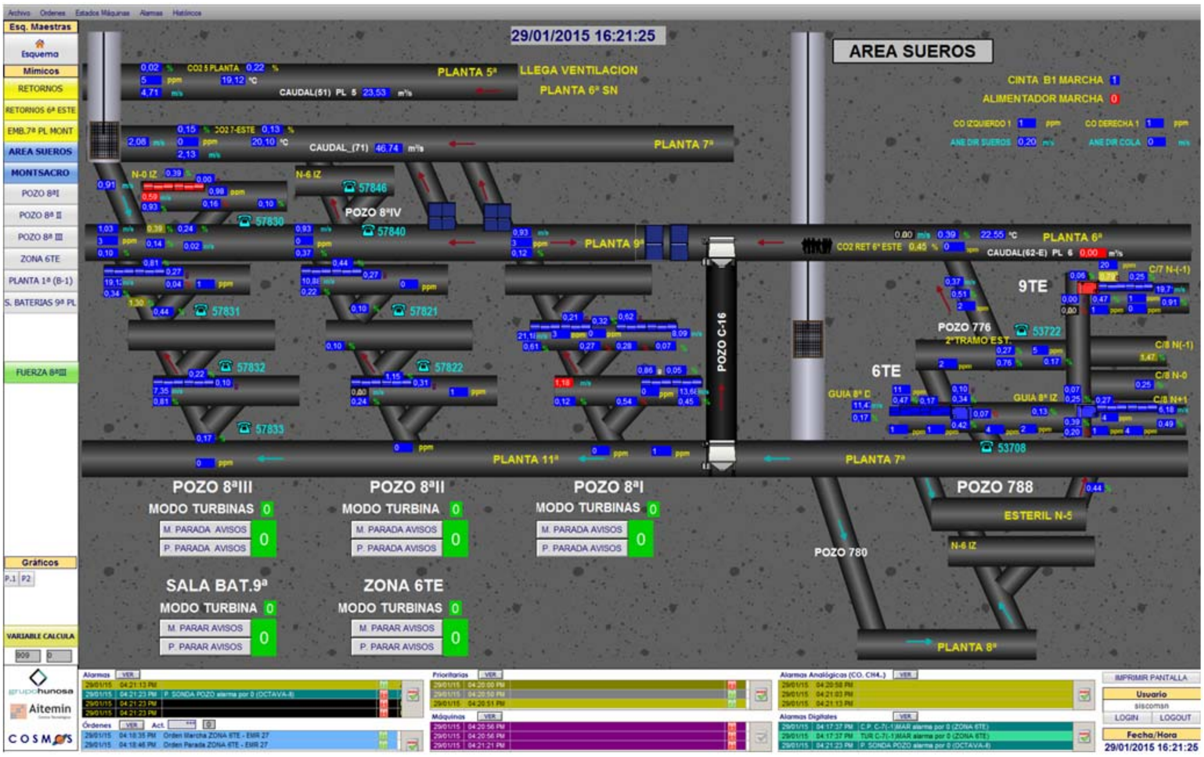

Figure 3.4: Environmental monitoring screen

These bridges were powered from the same Atex PSU as the media converters (CMU) to which they were connected, through the Pseudo-PoE installed in them. Once the data were put into the fiberoptic network, it was immediately available at the supervision computer, where it was displayed and recorded. A sample of the environmental monitoring screen is presented in **figure 3.4**.

Main results

Modifications in the design of Media converters.

Serial-Ethernet bridges to integrate legacy environmental monitoring equipment into the network, tested and commissioned

Task 3.3 – Belt and steel conveyor monitoring via the unified network (HUNOSA, Aitemin, MT)

Work performed

One part -or component- of this task is to some extent connected to Task 3.2, for the interface to the legacy devices controlling the steel (armoured) conveyors are the same used in that task. Therefore, the considerations made above on this connection are valid here: After the connection was established using the serial-Ethernet bridge, and then the fiberoptic network, the monitoring of these was done through the SCADA (WinCC) in use in the mine. Full details are given in the User Manual of the System, referred to in T1.2 description of work, from which the following sample monitoring screen was extracted:

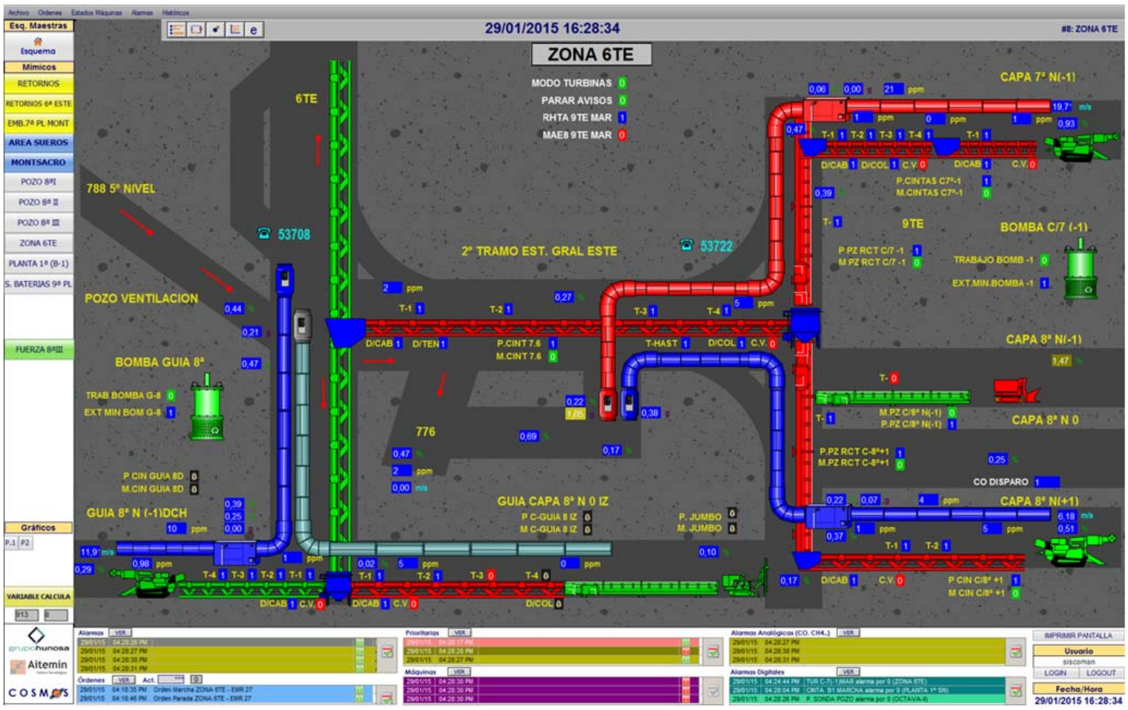

Figure 3.5: Conveyor monitoring screen

A second component in this task was the monitoring of Conveyor belts -especially the transfer points- by using IP Cameras. The procurement of these was launched early in the project, but no suitable camera was found. Some cameras with fiberoptic or twisted pair were offered, but they were not true IP cameras; having in the best case the Video to IP converter installed in a rack in the surface. For this reason, it was decided to develop a new IP Camera, based on a commercial one, adding the elements necessary to Atexize it (Power limiters, etc.)

Figure 3.6: Atex IP camera

This IP camera has a quasi-PoE interface, in which Atex power is supplied through the Ethernet cable, although it is not a true Power over Ethernet. Design was finished by mid-2012, and Atex certificate was obtained soon after. Immediately after its obtainment, manufacture of Cameras was started, and they were supplied to the mine.

They were tested in the surface, and then installed and commissioned underground. For the purpose of visualization and recording of the images generated by the cameras, commercial software was purchased from Axis; being now the system fully operative.

A picture of one camera installed underground, and other of the monitoring screen are presented below.

Figure 3.7: Camera installed underground

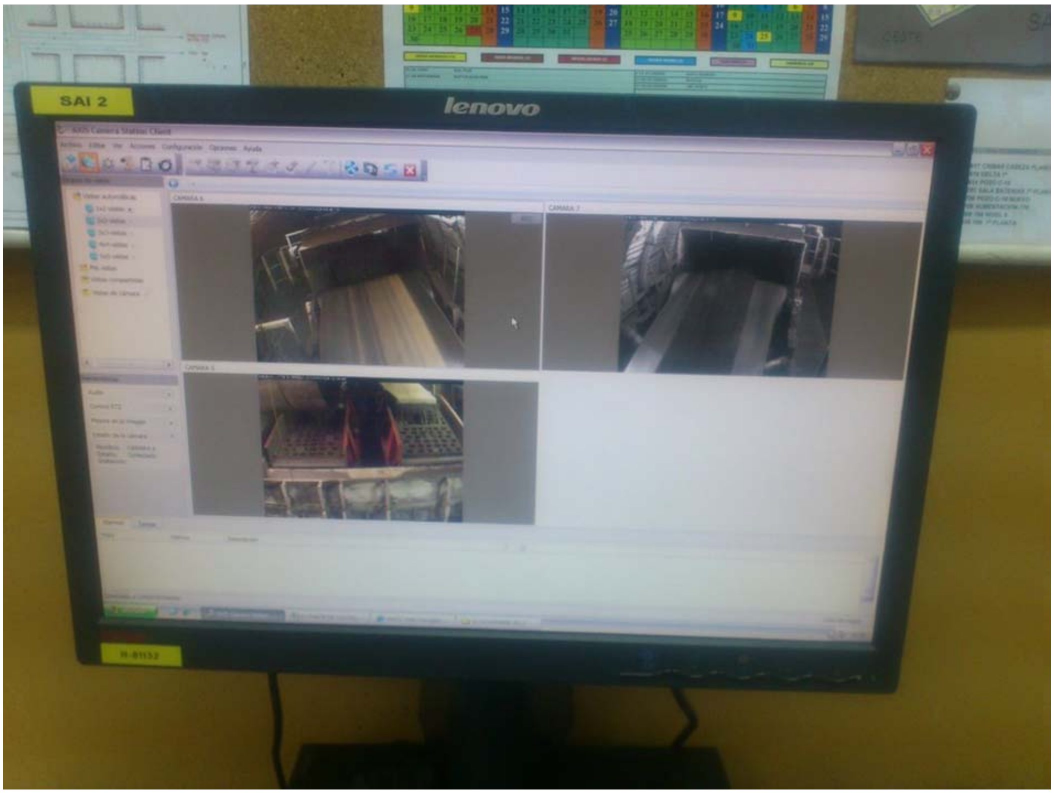

Figure 3.8: Monitoring conveyor belts transfer points

Main results

- IP Atex camera design finished.
- Video monitoring and recording system operative

Task 3.4 – Personnel tracking (HUNOSA, Aitemin, MT)

Work performed

Starting from month 1, the deployment of a pilot installation of a caplamp-based personnel locations system was carried out. Commercial name is AWL, manufactured by ADARO Tecnología using technology originally developed by AITEMIN in RAINOW project.

Figure 3.9: Caplamp with integrated tracking device

The system has a user interface based on WinCC, of which a screenshot is shown below:

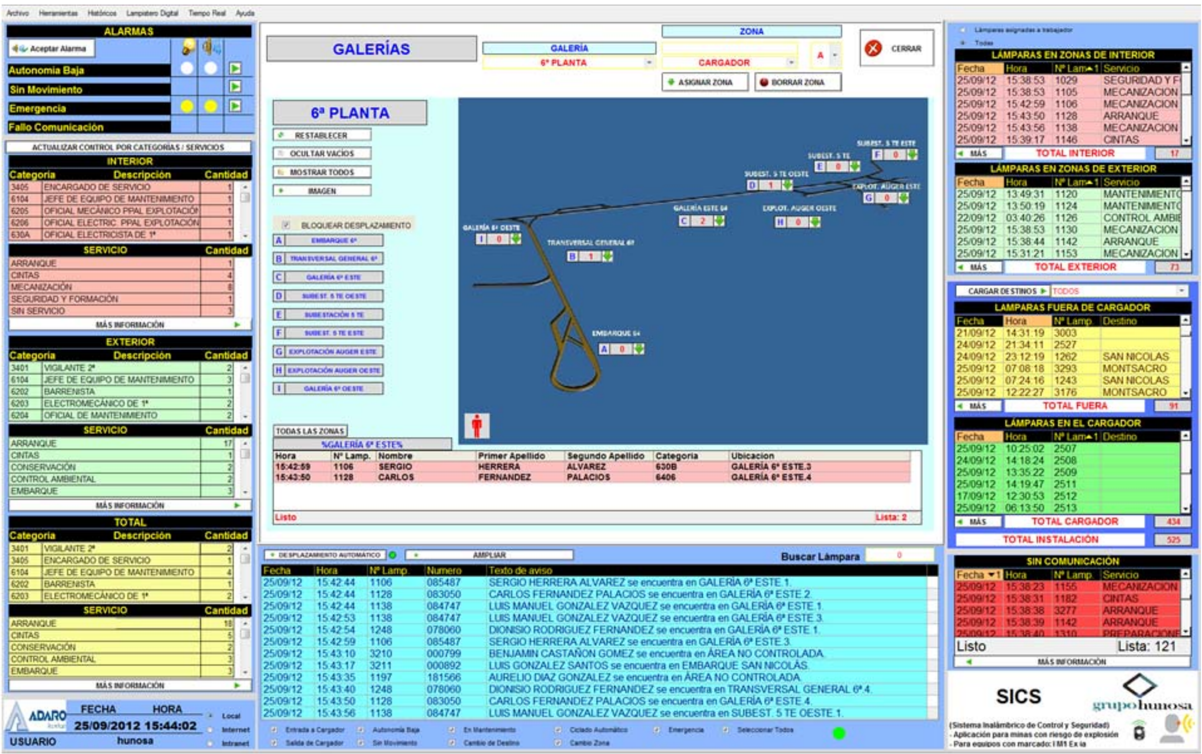

Figure 3.10: Screenshot of user interface

The performance of the pilot installation, deployed in an area of the mine separated from the main production areas was satisfactory, so it was decided to implement the full system in the mine.

Figure 3.11: Underground control point

This was completed with the procurement and supply of some 400 caplamps equipped with zigbee transmitters, complemented with around 50 fixed beacons, and the commissioning of the system.

Main results

System for underground personnel tracking, fully operative.

Task 3.5 - Personnel communication and information (HUNOSA, Aitemin, MT)

Work performed

Activities in this Workpackage were intended to provide digital voice communications to most points in the mine.

HUNOSA was by that time implementing an upgrade program in which its analog Private Branch Exchange (PBX) was being replaced by a VoIP telephony System. This upgrade was easy in the surface, but complex underground, where a lot of analog Atex phones are already installed.

As a solution to this issue, it was suggested replacing these old analog phones by digital voice technology already built-in in RELIA-AV Systems.

Digital voice in RELIA-AV systems is implemented using two technologies that currently are independent, and indeed –and unfortunately- very difficult to integrate.

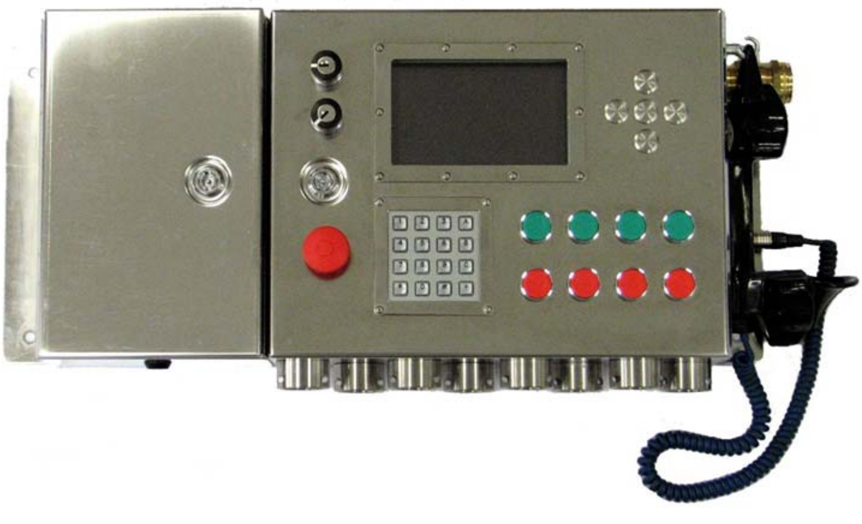

Figure 3.12: EMR-AV, RELIA-AV master Controller with its embedded phone.

The first is the VoIP phone included in each EMR-AV [Estación Maestra RELIA - Alta Velocidad, RELIA Master Unit – High Speed]. It uses a SIP protocol, and can be connected to any VoIP PBX that uses that SIP protocol. This functionality was tested in the lab, and after demonstrated in HUNOSA, using a small SIP server, and command line interface for managing calls.

This functionality is native to the master processor used in RELIA Master Controllers, so only the user interface using the hardware available (dialing, signaling incoming calls, etc) had to be developed. The software managing these functions was developed and fully tested during the time span of the project, allowing the use of the phone integrated in the EMR as a regular VoIP extension.

Digital Intercoms use a different technology, due to the need of inserting them into fieldbuses. This causes two issues: The first is that they shall use the same transmission protocol (a non-IP one) as the slave data collection units (UCR-AV). The second is the limited bandwidth, dictated by both the cable characteristics and their data processing capabilities.

These factors prevented the implementation of a true VoIP protocol in the DIGICOM, so a simplified digital voice protocol was implemented.

Voice transmissions use the bus on a shared basis with the stream of sensor data. The bandwidth available allows the simultaneous transmission of one data and two voice streams. Of these, one is public, which is, a broadcast channel, while the other is used for establishing private or point to point links between two DIGICOM.

Figure 3.13: UCR-AV and DIGICOM

Activity in this field was implementing the time sharing schema in DIGICOM, UCR AV and EMR-AV, implementing call management software (Dialing, signaling private incoming calls, etc.) in all elements, and implementing voice transmission between different fieldbuses.

However, this technology has some limitations. The first and principal is that there is no easy way to take this digital voice out of a given installation, that is, out of the DIGICOM network managed by a single EMR-AV Master controller. Voice streams can be transmitted between DIGICOM and to the surface, but there is no mechanism in place to manage DIGICOM calls in and out of the eight fieldbuses managed by that Master Controller. The consequence is that DIGICOMS cannot be used as extensions of a VoIP PBX.

The best solution to address this issue would be implementing a transcoding function and protocol conversion in EMR AV, but it has been found that it lacks the processing power needed for implementing this function.

After analyzing protocols and processing requirements, it was concluded that the development of a VoIP bridge and a complementary virtual Private Voice Exchange (PBX), acting as satellite of the main PBX would be the only viable possibility.

Several architectures were considered, and a specification issued. However, the effort and time needed for its implementation makes unviable its inclusion in Opti-Mine framework. Most possibly, the aforesaid developments will be done as a standalone custom development, or in other R&D project.

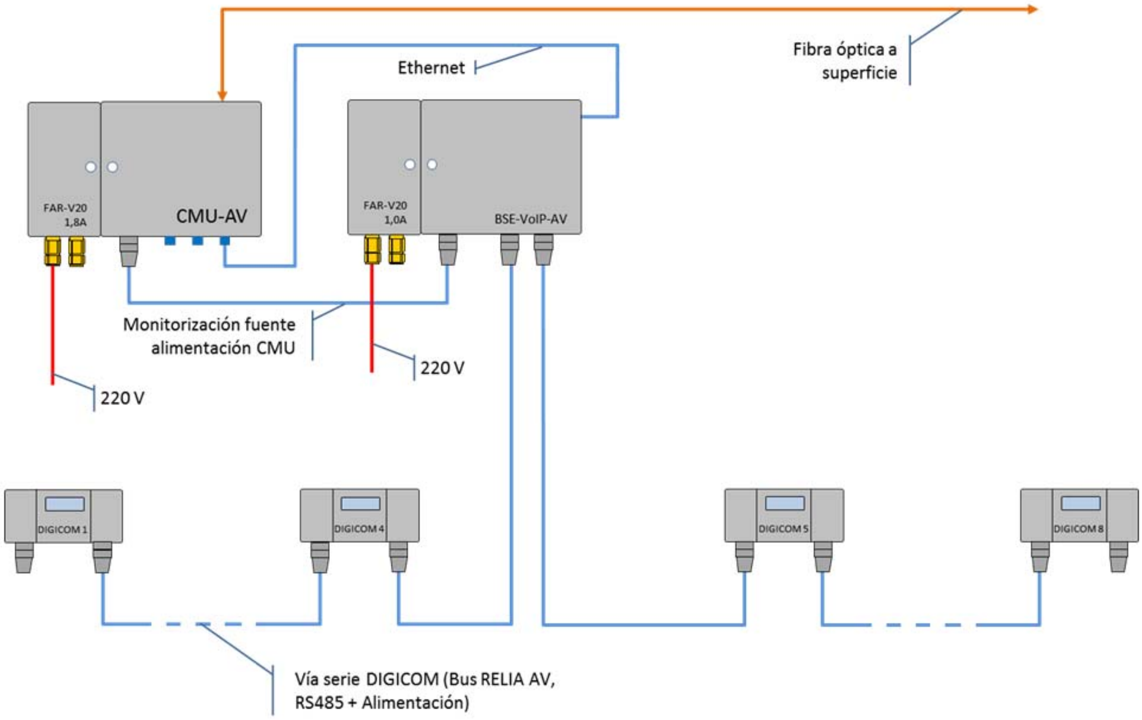

Figure 3.14: Foreseen architecture for a DIGICOM-VoIP bridge

A second part is related to VoIP telephony between EMR-AV controllers and other surface telephones. The development was completed and successfully tested, but the IP addressing policies in HUNOSA make difficult –if not impossible- its integration in the VoIP telephony system that was recently deployed in the company.

The issue is that two different IP addresses would be required in the EMR-AV controllers, one for process monitoring, and a second one for VoIP telephony. But the controllers only have a network card and a single IP address.

This fact prevented the direct integration, which was left in standby.

Main results

- VoIP phone embedded in RELIA AV Master Controller fully tested, including user interface for managing the above phone and interoperability with standard PBX.
- 2 channel voice over field buses implemented using DIGICOMS
- Possibility of point to point calls with DIGICOMS.
- Possibility of Calling to the surface from DIGICOM. Simple exchange implemented.
- Specification (in Spanish) for a DIGICOM-VoIP bridge

Task 3.6 - Optimisation of material logistics (HUNOSA, Aitemin, MT)

Work performed

Activities in this task started in the last quarter of 2012, drafting the procurement requirements for 8 Atex PDA, and analyzing the supporting hardware and software needed for its operation. The intended use of these devices was to allow managers underground using them for accessing logistic data.

However, while the procurement was being done, it was notified the discontinuation of the manufacture of e-Com Atex PDA; making impossible to complete its procurement. As an alternate solution, it is being considered the possibility of installing Atex terminals / computers in selected points of the mine; but their purchase was not completed in the time span of Opti-Mine project.

On the other hand, the amount of material being moved in HUNOSA mines is not very high. Therefore, the needs in the field of material tracking are not large, and it is not necessary implementing a sophisticate tracking system; for a quite simple one will suffice, being the most prominet need that of tracking locomotives. Therefore, the activity was focused on designing a special tag for this use. It is based on the hardware of the cap lamp mentioned in T3.4, from which LED lamps were removed, while an emergency button was added.

This device was intended to be placed on Locomotives, on the last carriage of a train and in general on any mobile vehicle, so that some kind of tracking material can be implemented.

This approach has the advantage of being integrated straightforwardly in the personnel tracking system (SICS), having high synergies and scale gains through sharing most software components.

Also this device can also be used by staff from aboveground, or alternatively, by underground staff that use lamps that does not include a tracking system.

Figure 3.15: Prototype of tracking device for locomotives and surface personnel

Main results

Prototype of the tag for locomotives, mobile machinery and personnel.

WP4: Demonstration of personnel communication and mine safety integration in an underground lignite mine with very thick seam and large production capacity (SI)

WPL: Pr. Velenje (Partners: MT, Aitemin)

Task 4.1 – Network Infrastructure (Pr. Velenje, MT, Aitemin)

Work performed

For the installation of the underground network in PRV first Wireless LAN coverage tests were carried out successfully. We analyzed coverage and propagation test results and we made detail concept engineering for our network infrastructure. After detail network concept engineering we searched market for available and suitable equipment for our project tasks. Basing on the coverage design the locations of network nodes (MICs) were determined and the infrastructure installed by the mine. During operation in the demonstration phase certain improvements have been made to the infrastructure hardware and software as well as to the network integration and the related central system.

To reach the project objective, a most modern communication infrastructure was installed in the mine's main galleries which are used for material and people transportation, along the coal conveyor belt line and in one coal face at the time. For the project, about 20 intelligent, multifunctional network nodes (market available customized units consisting of application CPU, switches and access points) were installed.

Main results

In December 2012 we established wireless network coverage on coal face F k.-65, which is one of three longwall production areas in our coal mine. The entire area of the coal face is covered (tail and head gallery, longwall …). Within the area coverage was not total, but we covered most of it. This coverage degree was considered to be sufficient for the demonstration purposes within OPTI-MINE at this stage.

To establish this wireless network our first step was building local fiber-optical network. For this local fiber-optical network we used single mode optical cables with 12 fibres (type DQ2YZNY 01x12E9/125) and suitable optical connection boxes. This local fiber-optical network is in connection box connected to our fiber-optic backbone.

Next task was physical installation of MICs (WLAN access points), power supply units, antennas and cabling in coal face area. Locations of those elements are present in **figure 4.1.**

Special attention was assigned to antennas different polarization. We use results from our WLAN coverage and propagation test, which we made.

After end of operation of coal face F k.-65 we installed entire network infrastructure on next coal face E k.-65 (June 2013), coverage with wireless signal was also extended to part of main belt system, along belts 70P and 71P and area close to main shaft. Locations of installed WLAN AP’s are presented in **figure 4.2**.

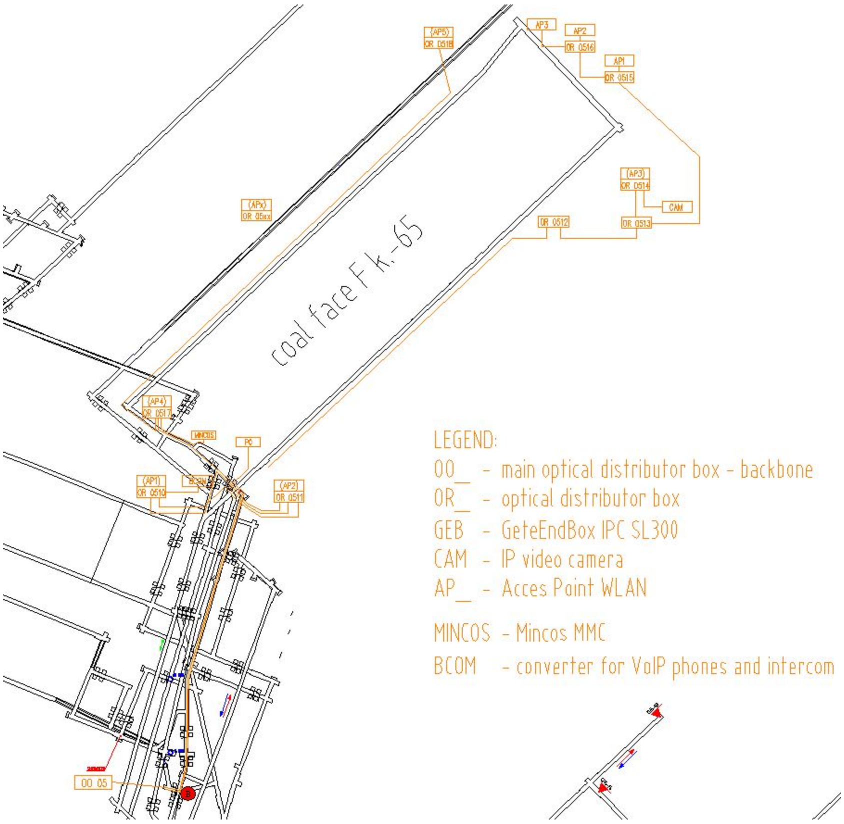

Figure 4.1: Situation of elements for fiber-optic and wireless network

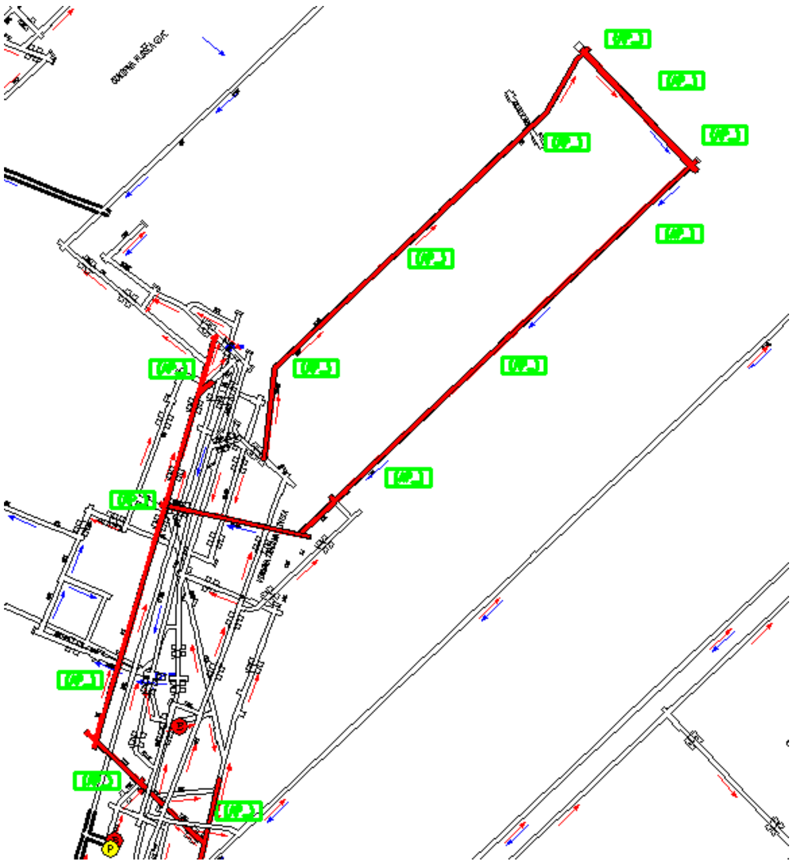

Figure 4.2: MIC installed on face E k.-65 and belts 70P and 71P

Additional WLAN AP’s were installed in the area of important underground installations, like main water pumping station and hydraulic high pressure pumping station. Also some existing non Atex AP’s used for material tracking application were reconfigured with proper secondary SSID to be accessible with WLAN phones and PDA’s. With those actions coverage was extended also to the area under main shaft (**Figure 4.3**).

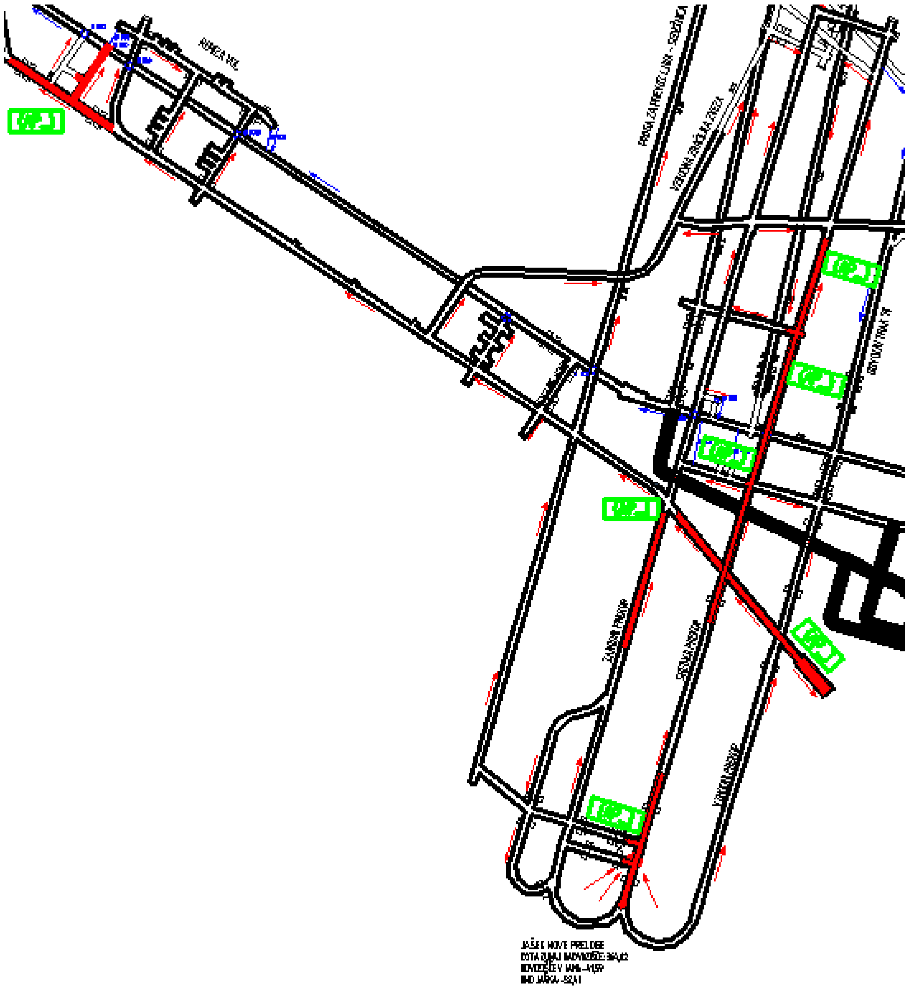

Figure 4.3: WLAN AP's and coverage in shaft area

After end of operation of coal face E k.-65 we installed entire network infrastructure on next coal face CD1 (January 2014), coverage with wireless signal was also extended to the part of main belt transport system, along belts 1CD, 2CD, 70P and 71P. Locations of installed WLAN AP’s are presented in **figure 4.4**.

With reinstallation of all necessary equipment from one to another coal face, with installation of new AP’s in the area of important underground facilities and with reconfiguration of existing non ATEX AP’s we established wide areas covered with wireless signal. And this was precondition for all other tasks and activities in the project. In the future we will continue with installation of wireless network infrastructure in new coal faces.

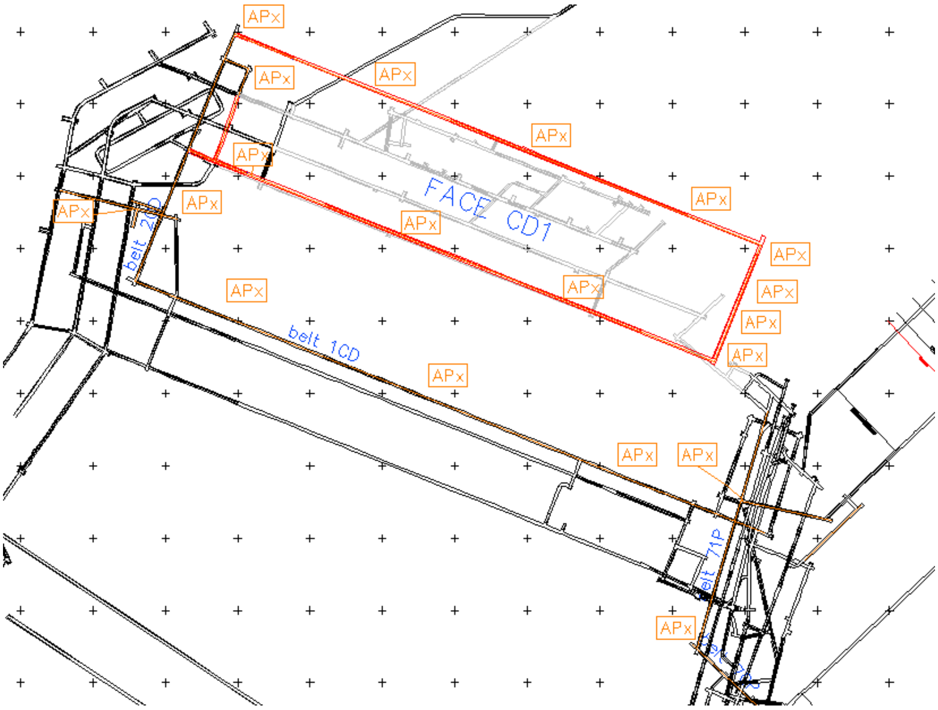

Figure 4.4: WLAN AP's and coverage in coal face CD1

Task 4.2 - Personnel communication and information (Pr. Velenje, MT)

Work performed

We made communication and information performance tests with available PDAs, WLAN mobile phones and pagers on established wireless networks on surface and underground. SIP PBX open source Asterisk based server has been installed and integrated into PRV’s telephone network. Integration of office computers and office WLAN mobile users – smart phones with SIP clients has been implemented.

WLAN VoIP phones Minesite MP70 and Becker, ATEX M1 certified, were used for underground voice communication and messaging.

Figure 4.5: WLAN Minesite and Becker phones

With using MIC’ VOIP modules and BCom units we also connect mine analog communications devices (phones, intercoms) over the fiber optic network to communication center on surface.

We installed Pager Center software for paging and tested communication with pager devices.

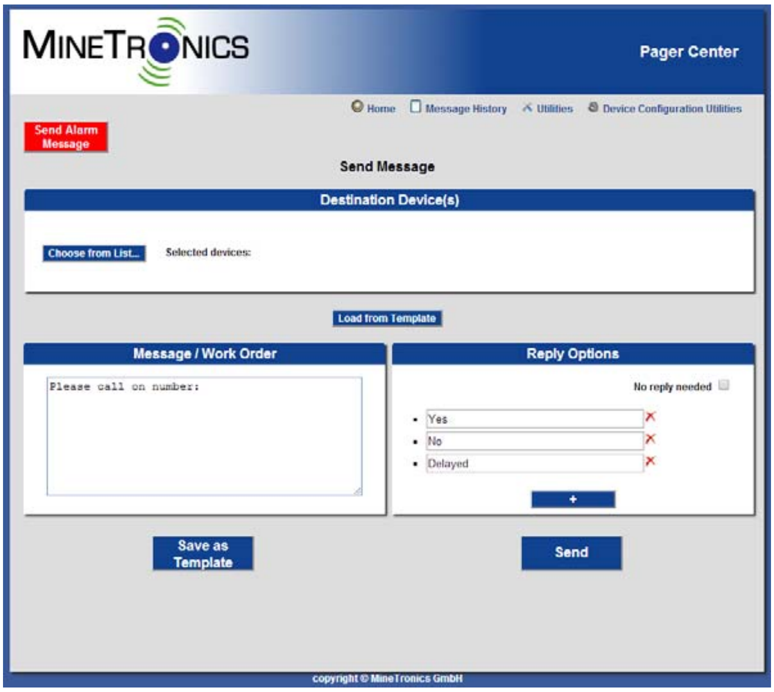

Figure 4.6: Pager Center software for paging

Different possibilities for remote access to SCADA systems with PDAs were tested.

Figure 4.7: Remote access to SCADA on PDA

Application for maintenance and supervision of main high pressure hydraulic pumping station with PDA was developed and deployed.

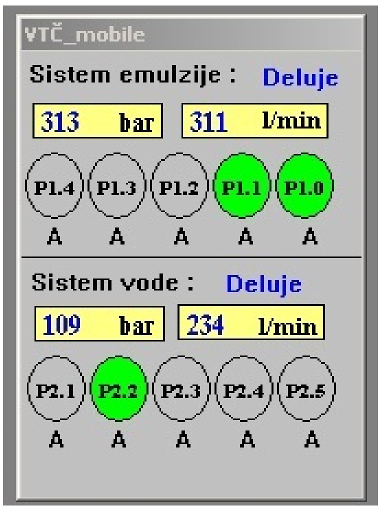

Figure 4.8: Application for High pressure hydraulic pumping station

Different SIP clients were tested for VoIP functionality on PDAs, together with Bluetooth headset.

On established wireless networks we also carried out successfully wireless data transfer from shearer SL 300 and roadheader GPK-PV.

Main results

The performance tests with available PDAs and WLAN mobile phones on networks on surface and underground were successful. Experience was gained on how to integrate them into the network and how to use them. Phones were used on established underground wireless infrastructure in regular production operations.

Results of time to reach from control center on surface an electrician via phone calls on two different faces at the same time were obtained for evaluation of Key performance indicators (KPI). We collected data in two cycles at four different coal faces, two coal faces with ICT and two without ICT. First cycle lasted from December 2012 to May 2013 on coal faces F k.-65 and G3/C. **Figure 4.9** presents time to reach an electrician via phone calls on those faces at the same time. Face F k.-65 had WLAN coverage, face G3/C was without it.

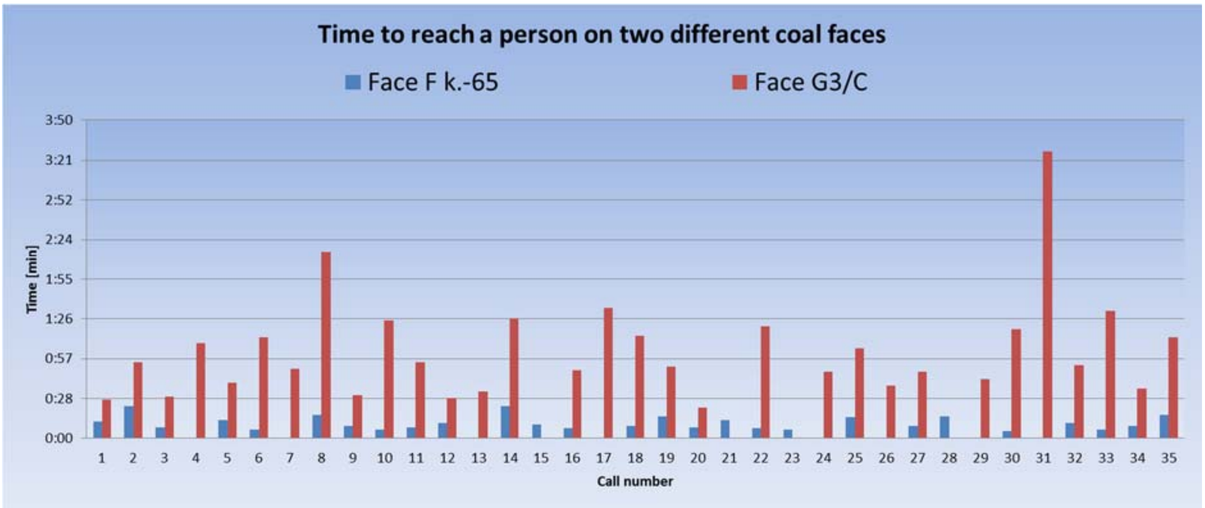

Figure 4.9: Results of data collection on coal faces F k.-65 and G3/C

Second cycle lasted from September 2013 to February 2014 on coal faces E k.-65 and B k.-65. **Figure 4.10** presents time to reach an electrician via phone calls on those faces at the same time. Face E k.-65 had WLAN coverage, face B k.-65 was without it.

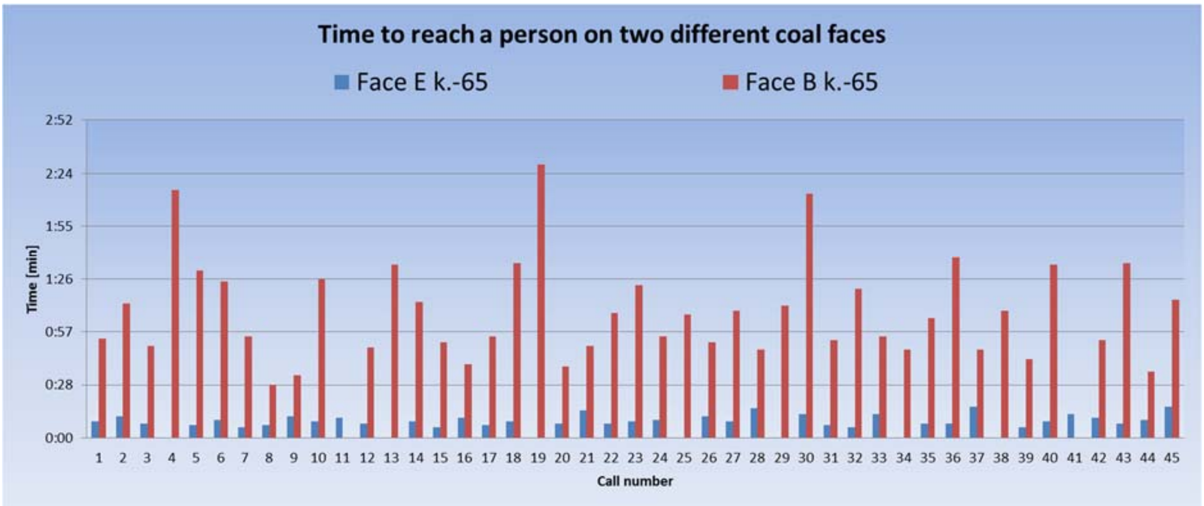

Figure 4.10: Results of data collection on coal faces E k.-65 and B k.-65

With collected data we determined the following KPIs:
ATR_F – avarage time to reach a person from coal face F k.-65
ATR_G – avarage time to reach a person from coal face G3/C

DTR – decrease of avarage time to reach a person with using ICT
$$D_{TR} = \left(1 - \frac{ATR_F}{ATR_G}\right) \cdot 100\%$$

AC – number of all calls
SC – number of successful calls

R_{SC} – ratio of successful calls with WLAN phones
$$R_{SC} = \left(\frac{SC}{AC}\right) \cdot 100\%$$

We also collected data and made comparison of efficiency on those coal faces at the same time. In the next table are shown KPIs and coal faces parameters for both cycles.

	Face Name	ICT equipped	Face Width [m]	Panel Length [m]	Average Thickness [m]	Average Efficiency [t/man/shift]	ATR [min]	DTR [%]	RSC [%]
Cycle 1	G3/C	NO	177	675	5,14	145,15	1:03		
	F k.-65	YES	154	480	6,2	111,93	0:11	82	77
Cycle 2	E k.-65	YES	140	328	7,11	128,66	0:10	85	84
	B k.-65	NO	168	633	14,28	184,47	1:09		

Table 4.1: KPIs and coal faces parameters

Conclusion from data in table is that geological conditions and coal face parameters have much larger impact on coal face efficiency than use of ICT. However, we can conclude that use of ICT increase equipment availability with possible quick maintenance response.

Task 4.3 - Personnel tracking (Pr. Velenje, MT)

Work performed

Together with our project partner Minetronics we defined concept for personal tracking in our coal mine. For tracking all WLAN devices which we now already use in our coal mine (PDAs, pagers and WLAN mobile phones) TrackCenter and ViewCenter software from Minetronics is used. It was implemented as virtual machines on existing hardware of HewletPackard's WMware vCenterServer. We use IREDES tracking profile.

Tracking was implemented in areas where we installed wireless network infrastructure and we have WLAN coverage. At this stage we decided that there is no sense for coal mine full coverage due the high costs of network infrastructure equipment. So we covered main points in coal mine, entries, exits, coal faces, shaft area, pump stations etc.

Main results

We successfully implemented all activities to achieve tracking of WLAN devices in our coal mine. On the next picture you can see ViewCenter software interface which is used for visualization of tracked devices in coal mine.

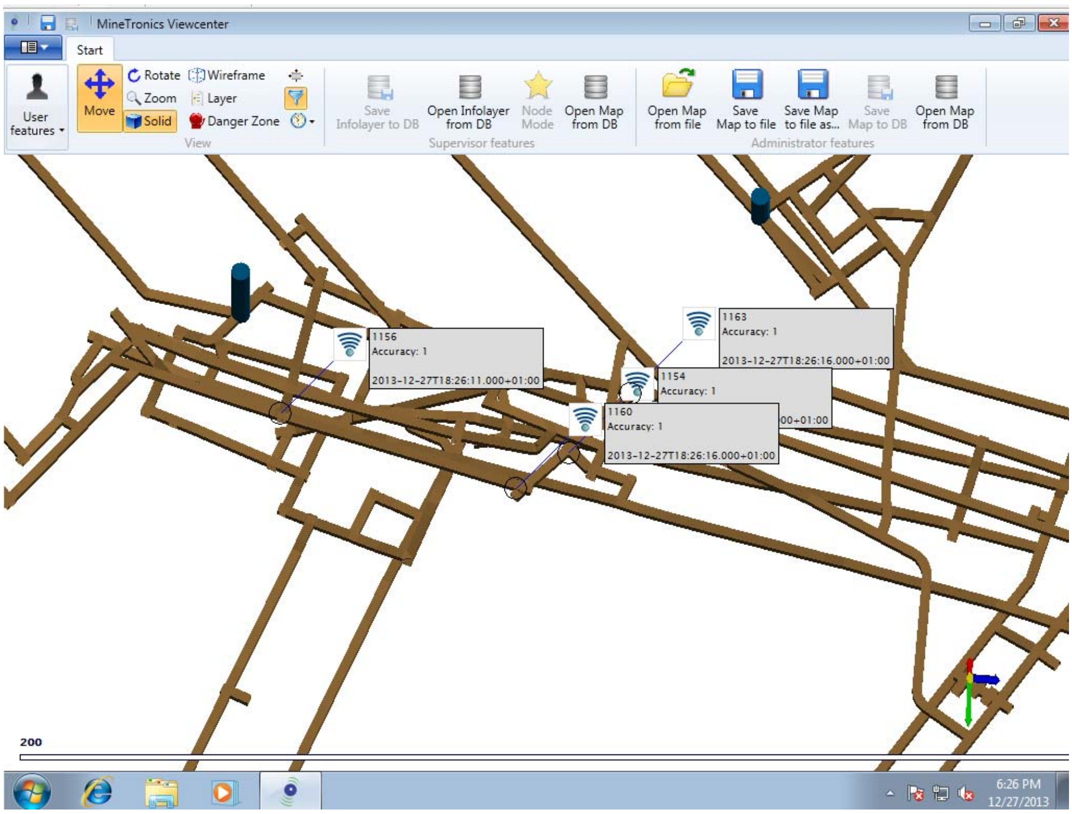

Figure 4.11: ViewCenter tracking interface

In the future we intend to install WLAN tags in miner's lamps to enable tracking of all people in our coal mine.

Task 4.4 - Environmental sensoric integration (Pr. Velenje, MT)

Work performed

Appropriate input/output device was selected together with project partners Aitemin and Minetronics. MP40-RTU unit with single mode optical and copper interface was selected. Device acts as TCP server over Modbus TCP protocol, supplied with uninterruptable power source FAR-V20. It consists of 4 current (for Woelke environmental sensors CH4, CO2 and CO) and voltage analogue inputs, frequency inputs for standard mining analogue 5-15 Hz sensors (pressure, flow, temperature…), 4 outputs with possibility to be configured as digital (on/off) or frequency 5-15 Hz output, which is used mainly for RGB signalling lamp SB-RGBW. Extensive laboratory testing in different configurations and scenarios was performed on PRV (**Figure 4.12**).

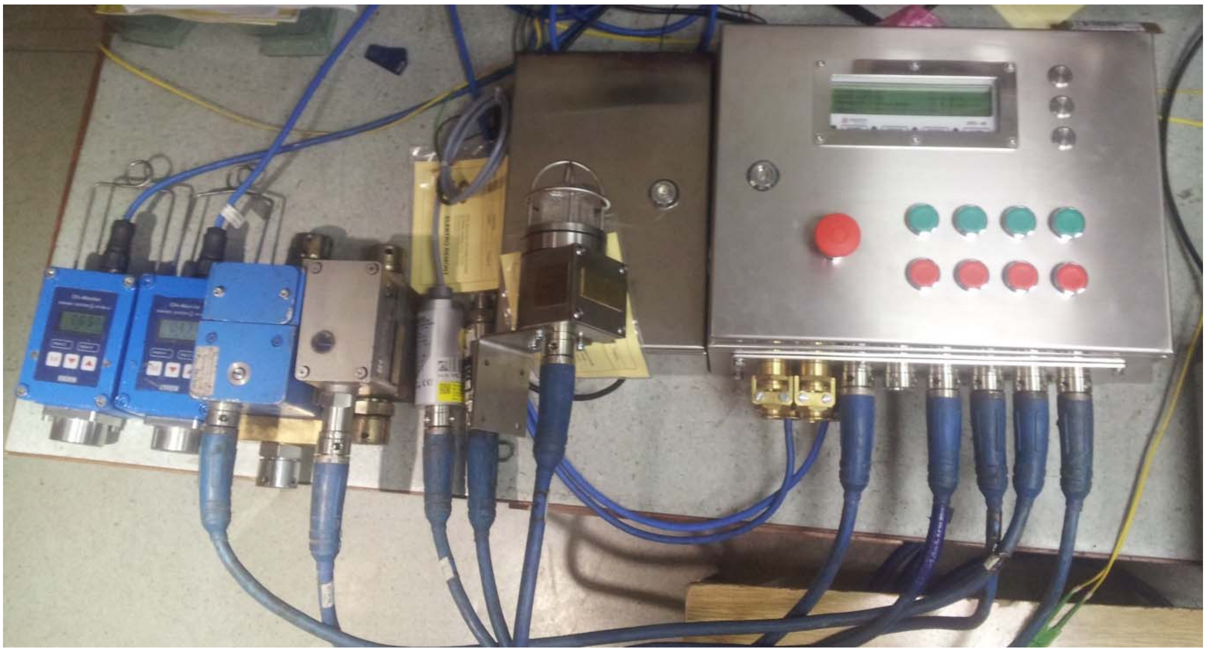

Figure 4.12: Laboratory testing

Some library modules for IPC SPS IEC 61131 Multiprog were developed to simplify integration of unit into control systems (**figure 4.13**).

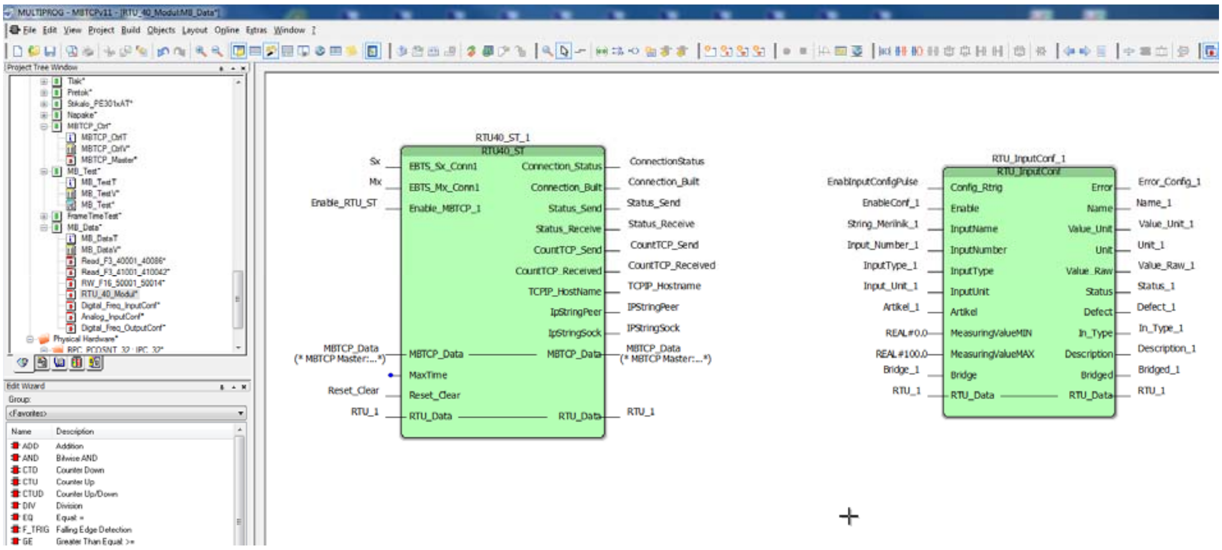

Figure 4.13: Software libraries for MP40-RTU unit

For underground test installation one Woelke CO2 sensor together with SB-RGBW signalling lamp and pressure sensor for water pressure was selected. Information of measured values is transferred to M1 IPC controller device or to surface IPC controller out of Ex area. Same information is also transferred to control room, SCADA etc... Information from CO2 sensor is evaluated and in case of exceeded values appropriate output signal is transmitted to I/O units, which trigger signalling lamps to selected operation mode (different colours and blinking modes).

Main results

MP40-RTU Ex M1 certified remote I/O unit proved to be very useful for different applications especially where we can transfer "intelligent" functionality to remote or even surface IPC controller. There should be also some improvements regarding functionality of unit in offline mode – when communication to control system is lost.

Task 4.5 - Safety related add-ons (Pr. Velenje, MT)

Work performed

PRV established alerting of people in endangered area through different means of communication. This includes the following features.

- Pager messages are composed and sent through PagerCenter to people in endangered areas. Responds are collected and presented.
- SMS messages are composed and sent to WLAN phones underground through Asterisk Messaging module.
- SMS text messages for GSM phones and email.
- Recorded and composed voice messages are dialled to defined phone numbers (stationary and mobile, WLAN) and intercom lines true Asterisk VoIP PBX. Also feedback from phones is collected and presented.
- Actions to trigger visual alarming with RGB flashlights (Task 4.4) over TCP/IP connection to SPS controller with MP40-RTU.

In case of high gas concentration people are informed and guided with rescue action instructions.

In addition PRV decided to do steps into concept of a comprehensive safety application, wherein many more safety features are integrated:

- Integration of environmental data from control room
- Integration of mine emergency rescue plan (rules and actions in case of exceptional events)
- Support to control room personal's emergency decision making process
- Tracking of people and assets
- Alerting of people in endangered areas with rescue action instructions
- Overview of Mine with respect to:
    - Location and status of environmental sensors
    - Location of MIC access points
    - Tracking of personnel through TrackCenter
    - Possibility for integration of RFID tracking
    - Status of underground areas according to emergency rescue plan

When exceptional event from emergency rescue plan is detected, planned actions are suggested and offered for approval/triggering to control room personnel. Application is developed with Visual Studio C# and runs on Internet Information Server platform.

This is of course a longer lasting activity beyond the scope of OPTI-MINE and it has been continued after the end of the project period without financial contribution of the RFCS programme.

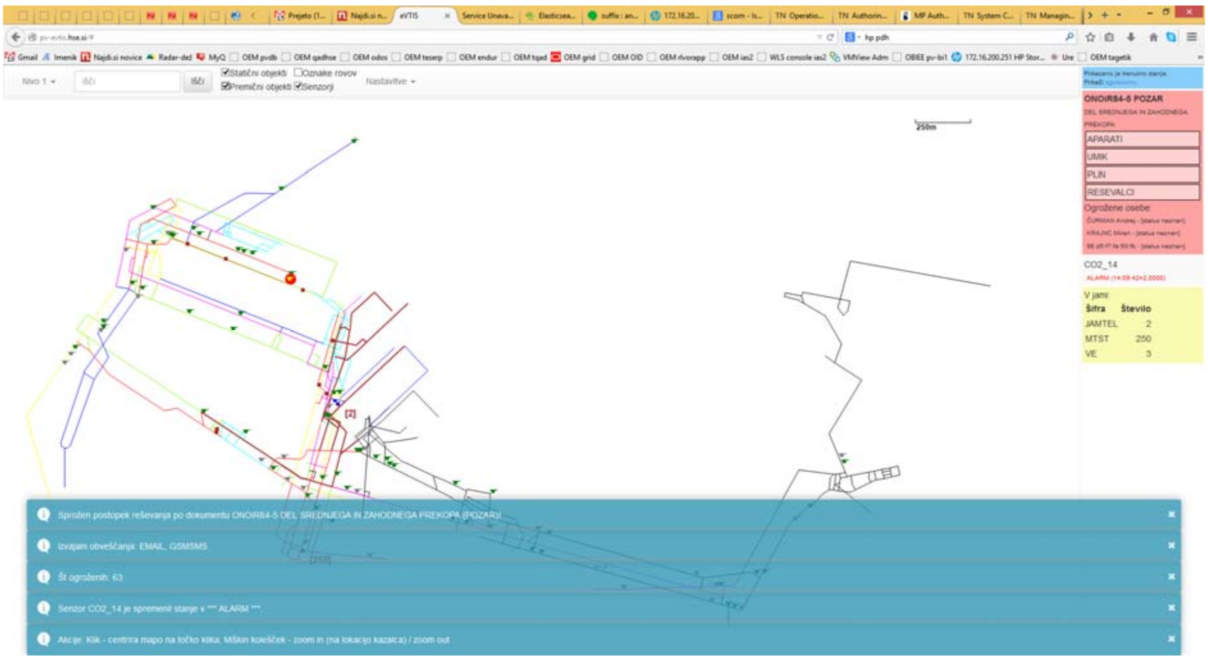

Figure 4.14: Application for Safety related add-ons

Main results

Application with described functions is partially developed and is under testing (**figure 4.14**).

WP5: Demonstration of network Communications and modern material logistics in a high capacity hard coal mine under modernization (CZ)

WPL: OKD (Partners: MT, Aitemin)

Task 5.1 – Network Infrastructure (OKD, MT, Aitemin)

Work performed

The objective of this task was to build a universal Gigabit Fiber Optic network in OKD's CSM-mine, where complex train transport takes place between CSM South and CSM North. The network forms the common basis for process optimisation by train tracking, voice communication, machine communication and personnel tracking.

A flexible and scalable network design consisting of fiber optic backbones was set up in ring structures. These rings can be interconnected even between two different mines creating additional communication redundancy. The logical networks are segmented into process control network, Video supervision network and IT/voice network and in the future also safety networks.

Part of the design also was a WLAN site survey to gather detailed information about the radio frequency behaviour of the specific tunnel environment. The results of this survey which was performed together with the partner MineTronics were taken into account when defining the placements of the network nodes and the antennas.

The installation of the network was performed in two stages. Stage I included building of the backbone fiber optic network and the first section of the network infrastructure. Stage II included completion of the network infrastructure and verification of the function.

In more detail, stage I included installation of surface switchboards with the servers and the mine switchboard. This was followed by construction of the backbone fiber optic network from the phone exchange room on the surface, through the shaft to the assembly room on the 4th floor of the 5th mining siding. The work also included installation of 4 pieces of MIC access points while one of them was designed for reading of passive and active tags and also construction of the fiber optic network connecting these access points with the backbone fiber optic network in the shaft. This established the Gigabit Fiber Optic backbone network and Wireless LAN. Stage II included the delivery and installation of 8 pieces of MIC100 access points with the accessory, 5 pieces of MIC100 access points with the accessory and with RFID readers (later replaced for MIC150). Then the installation of the delivered fiber optic cables and completion of the Gigabit Fiber Optic backbone network and Wireless LAN. The work included building of two branches of a circular topology ring within a single fiber optic cable.

For data administration, data collection, and for visualization the system requires central computer systems.

These include mainly:

NetCenter for administration and supervision of the network and for remote support

TrackCenter for processing of all types of tracking data required from various sources

VoIPCenter for coordination of the communication groups and individual VoIP calls and to provide the audio communication interface for the dispatchers

ViewCenter for the 3D mine visualization software

ISICenter for processing of the data from active readers type A71.

The TrackCenter is expanded with software functions specific for train tracking.

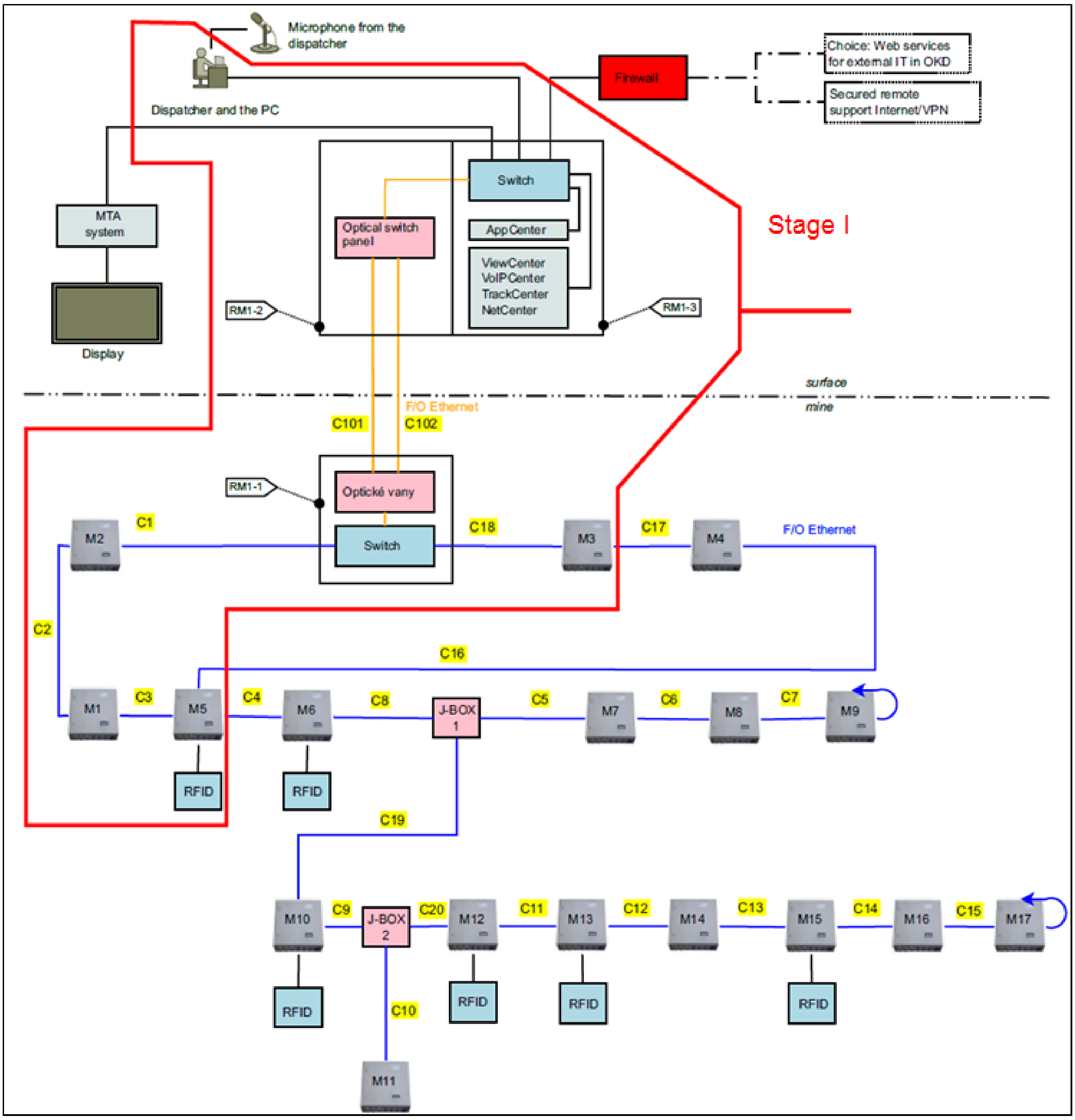

Figure 5.1: Block diagram of the Opti-Mine data network (Stage 1 -in red frame, stage 2 -the rest)

Visualization of train positions and other tracking information as well as visualization of the condition of the network equipment is implemented by means of the proven ViewCenter software. This is a universal software for processing and displaying of locally stored information – static information and real-time information – so that all underground mining processes are optimized.

Main results

- Network and application design was carried out including a WLAN site survey
- Network installed including fiber optic lines, main distribution boxes in the mine and at the surface, access points with switches, antennas for the WIFI network, readers for the active tags, readers for the passive tags.
- Installation of servers and central computer systems (NetCenter, Trackcenter, VoIPCenter ViewCenter, ISICenter)
- Network commissioned and used to demonstrate process optimisation by the applications of tasks 5.2 to 5.5.

Task 5.2 – Material logistics (OKD, MT)

Work performed

The network stations in the coal train tracking demonstration (task 5.3) are equipped with RFID readers to read passive RFID tags as well as they are connected to active RFID readers in order to read active tags, which already have been tried in OKD for tracking of people.

As both physical principles of RFID tracking have certain advantages and disadvantages, OKD decided to implement both in the train project. This also gives a good basis for comparison of the technologies by the accompanying academic institutes.

The same RFID technology is prepared in larger scale for the material tracking in other OKD mines. This comprises not only train tracking but also tracking of the different materials in the train (e.g. construction material, machine parts, tools, etc.), which may have different destinations. Such kind of tracking is not appropriate for the coal trains.

For this task, preparations were carried out by Minetronics as system integrator together with a manufacturer of containers and transport cars. A trial of the integration of passive RFID tags into the container metal structures was carried out in February 2012. This test showed good functional results with reading ranges of up to 3,5 meters. However it showed that the biggest challenge is to find a mounting point inside the structure of the containers which always is in an identical height in order to achieve optimal reading results. However this can be solved by the combined use of tags embedded into the structures and such which are mounted on the container surface like those used at RAG-Anthrazit.

A concept for material and container handling as well as for the entire optimization of the logistics processes has been carried out by OKD in a separate project.

The material tracking data are based on the new mining industry standardized IREDES tracking profiles enabling the use of different equipment in a mine wide tracking installation (Task 1.3). These formats are now available to the IREDES standardization community and all interested users.

Components necessary for material logistics (PDAs and related components) were bought and intensively tested.

Main results

- Concepts and design work for the use of RFID technologies in the OKD mines as stated in the technical concept.
- This is supplemented by fully commercial design work for the logistics and IT part of material logistics.
- Results of tests with RFID-tags integrated into container metal structure.
- All the locomotives and wagons have been equipped with both active and passive RFID tags, PDAs have been bought for different OKD mines used to assure a precise material tracking.

Task 5.3 – Machine communication for mobile transport machines (OKD, MT)

Work performed

This application is run on OKD's CSM mine where the machine communication and optimized dispatch is demonstrated in the train based coal transport level, where a digital voice communication between dispatcher and train drivers as well as a tracking of the trains using both active and passive RFID technology is used. The network nodes/base stations are equipped with

- A passive RFID reader used for detection of the tracks if a train is running on.
- An active RFID reader used for train completeness detection.

The passive RFID tags (figure 5.2) were installed on the locomotive roofs allowing tracking of passing of the locomotive by the network access points. The work also included installation of active tags (figure 5.2) on the last wagons of the selected trains.

This part of the work also included commissioning of the client computer with the corresponding software equipment and visualization at the dispatcher’s office.

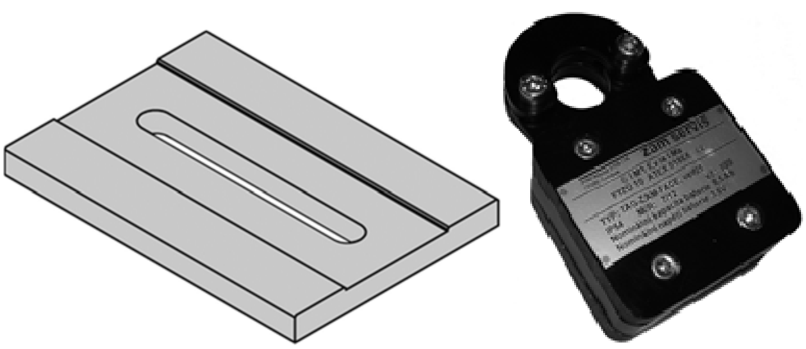

Figure 5.2: Passive (left) and active (right) RFID tags

In order to enable audio communication, the locomotives are equipped with associated communication unit on the VoIP basis. At first WLAN coverage tests were carried out to determine the range at different underground conditions (e.g. curves), the antenna setup etc. and a technical concept was made. The antennas used in this solution are robust antennas that are usually used in motor vehicles which are installed on flat metallic surfaces of the locomotive roof.

The voice communication is implemented by WLAN voice devices type TE-02 (figure 5.3) for communication of the locomotive driver with the dispatcher’s office personnel. In order to ensure proper functioning of TE-02, the Wireless LAN was upgraded by 2 pieces of concentrators type DKD11 with the accessory and by 7 pieces of communication cables type RFK-01 with the accessory.

Figure 5.3: PDA terminal type TE-02

Main results

The operators of the dispatcher's office obtained the possibility to monitor passing of the locomotives through the points along the tracks equipped with readers of passive RFID tags, see figure 5.4.

All locomotive drivers and the dispatcher are permanently connected in one communication group. When one of them presses the “talk” button, all personnel within the group will be able to hear him. This communication works when the locomotive is within an area covered by WLAN.

Furthermore, the WLAN audio unit in the locomotive is monitored by connecting the LAN wireless access point, which allows tracking as well, in fact of lower accuracy than by RFID, but it provides a further consistent checking for increased reliability.

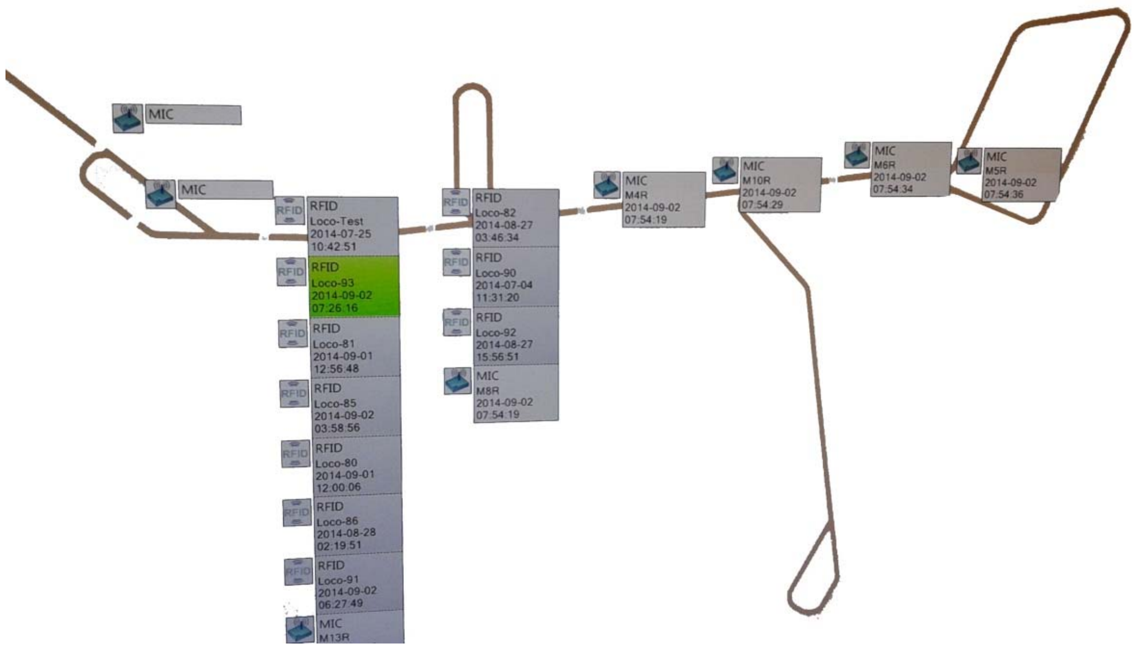

Figure 5.4: Tracking visualization in dispatcher’s office

Task 5.4 – Machine communication for Locomotives (OKD, MT)

Work performed

In the original project application it was planned to equip a shearer and longwall with a related communication system in a mine where the project is carried out.

As described in the previous reports, due to operational circumstances it was not possible to assure that such a longwall system will be available in a project mine during the performance of the project.

Therefore it was decided that the technology developed during the NEMAEQ project is being used on transport machines (monorails or floor locomotives) instead, which are subject to similar technological challenges in terms of RF communication as the shearer.

Within the reporting period a technical concept was elaborated and agreed between the locomotives manufacturer and data transmission system supplier. Before the devices could be installed, they had to be ATEX certified. The certification process was started with the appropriate authority and approval was received.

Locomotives were equipped with WLAN communication devices type TAG-ZAM-FER for collection of data from the locomotives and the devices were installed into the electronic control units of the selected locomotives. As well as at the voice communication (task 5.3), the wireless data transfer is done via the same concentrators type DKD11 and communication cables type RFK-01 mentioned in task 5.3.

Main results

This configuration of equipment finally allowed the dispatcher to monitor the technical data from the locomotive (e.g. speed, engine hours, level status, temperatures, …) in the entire area of the connecting cross-cut between ČSM North - ČSM South depending on the Wireless LAN coverage (see figure 5.5).

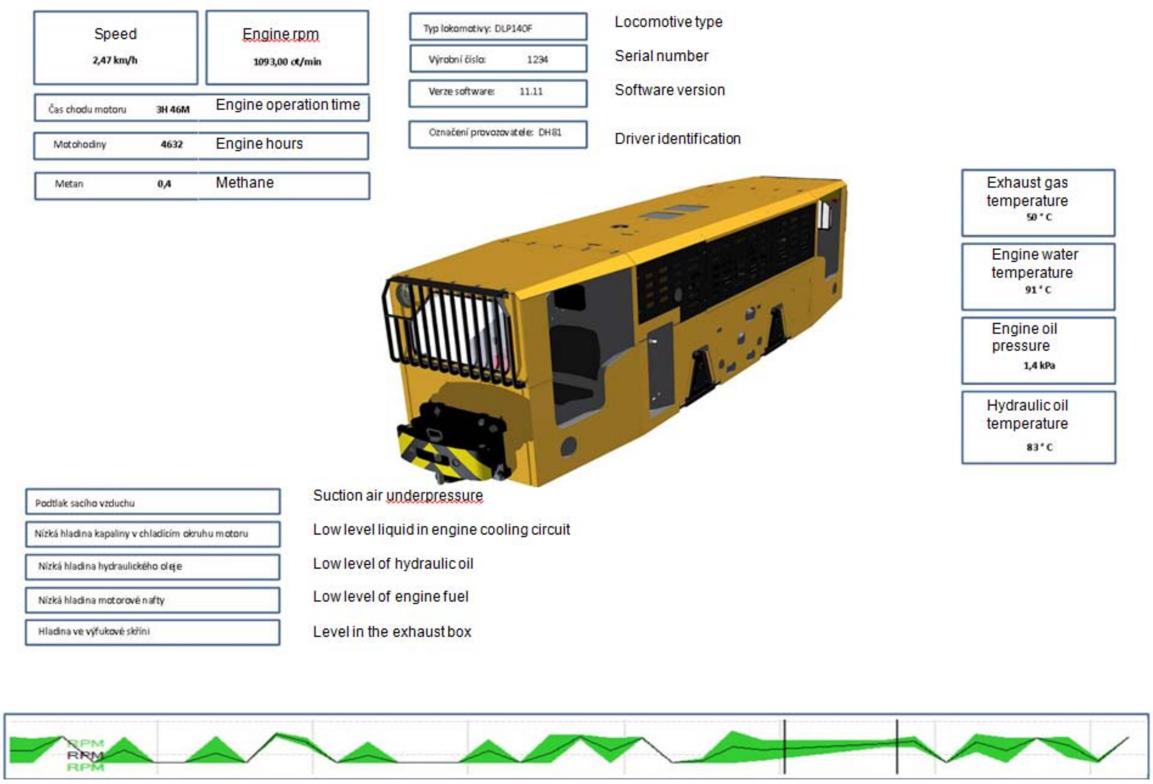

Figure 5.5: Collection and visualization of data from mobile machines

Task 5.5 – Personnel tracking (OKD, MT)

Work performed

For personnel tracking, two systems have been realized and used:

- An ISI system already existing in the mine and using dedicated active UHF tags has been combined with the OPTI-MINE network.
- Tracking of any WLAN devices (e.g. mobile phones or PDA's) by the new network system, where the base stations provide already built in WLAN access points at no extra hardware cost.

Both systems can be used in parallel, the network base stations have been equipped with a related active reader interface and a corresponding software extension so the active tags are handled identical to mobile WLAN device tracking.

For the WLAN application, nearly the same components as in Task 5.4 were necessary.

Further experience in future will show, if one of the two systems is to be preferred against the other and under which conditions.

Main results

The dispatcher's office personnel can track the position of personnel at the transportation gateroads between ČSM North - ČSM South. This allows informing the locomotive driver on personnel moving or staying on the tracks.

WP6: Demonstration of network communications and safety support systems in a high capacity Polish hard coal mine (PL)

WPL: KWSA (Partners: MT, Aitemin, SUT)

Task 6.1 – Network Infrastructure (KWSA, MT, Aitemin, SUT)

Work performed

The range of works related to the installation of network infrastructure and its components in coalmine "Bobrek-Centrum" has been thoroughly described in Deliverable 6.1 "Report on installation by KWSA".

Revision of the demonstration site localization required following installation works regarding fibre optic line:

- Delivery and installation of fibre optic cable (single mode, 36 fibres) from the "Bobrek-Centrum" central shafts mine area surface (shaft inset at the level 585) to the peripheral shaft "Witczak" inset at the same level via horizontal workings,
- Delivery and installation of the vertical fibre optic cable in the shaft "Witczak" down to the level 774,
- Delivery and installation of the horizontal fibre optic cable from the shaft inset at the level 774 to the entrance of the mining production area in the coal seam 615.

The backbone of the whole ICT infrastructure is fiber optic cable deployed from the central mine area to currently operating mine production area of longwalls no. 1 and no. 2 in coal seam 615 at the level 774m at "Centrum" mine area. Installation of the fiber optic cable included all necessary additional equipment (couplers, switches, power supply units, etc.). All delivered fiber optic cables have been manufactured in reinforced coatings for increased protection. All equipment have been manufactured in agreement with ATEX IM1 protection degree of at least IP54 or IP66. Total length of fiber optic cable is around 6km, but in terms of the OPTI-MINE project construction of the fiber optic line at such a distance was a basic requirement for any further activities related to the project. General infrastructure of the system installed at the "Bobrek-Centrum" mine has been presented in Deliverable 6.1 "Report on installation by KWSA".

The network infrastructure of the staff monitoring system has been limited to two areas of wireless communication and a control group of 30 communication devices (as described in Deliverable 6.1). All the wireless equipment has been delivered and installed in the first half of 2013. Two Mining Infrastructure Computers (MIC 100) wireless access points were installed at the entrances of the mining operations area and a group of 30 staff members were equipped with PAG 1200 individual pagers, which allow registration of entering/exiting the operation area and also allow exchange of text messages; also the recharging station with 15 induction loaders for pagers was created. The NetCenter, TrackCenter, ViewCenter and PagerCenter software packages were installed on server located in the Geophysical Station of the "Bobrek-Centrum" mine.

The ICT system was installed in longwalls no. 1 and no. 2 in coal seam 615, system achieved its full functionality in June 2013 and due to limited life-time of the longwalls was used until end of December 2013, when longwall no. 1 reached its end.

The results of small-scale application in the frame of OPTI-MINE will be helpful for further development of ICT based systems in the "Bobrek-Centrum" mine and other mines of KWSA.

Main results

Installed LAN/WLAN infrastructure with fibre optic network and industrial underground computers creates opportunities for integration of different mine information, monitoring, and communication subsystems and allows to realize the most important task of personal tracking in the hazardous zones in the longwalls no. 1 and 2 in coal seam 615.

In finally adopted solutions, the functionality and area of application has been significantly limited, in comparison to first design concepts. As it can be seen from the MT Silesia deliveries list, the staff monitoring system has been limited to two areas of wireless communication (two MIC100 main units located at the entrances to the mining operations area) and a control group of 30 staff members being equipped with PAG 1300 communication devices, which allow registration of entering/exiting the operation area, and exchange of text messages.

This means strong reduction of the functionality of the system, which originally assumed to use ten MIC-100 units along the gates in the mine production area, equipping of the all mine staff working at the area with RFID tags (200 units) with certain number of advanced communication devices for selected persons. However, the results of small-scale application in the frame of OPTI-MINE will be helpful for further development of ICT based systems in the "Bobrek-Centrum" mine and other mines of KWSA.

Task 6.2 – Transport machine communication (KWSA, MT, SUT)

Work performed

There are no separate technical solutions used for machine communication. This functionality is achieved by using the presented equipment of the personnel tracking system. Nevertheless, opportunity to use pagers as communication devices requires access to WLAN network, which requires covering of the whole operating area of "Bobrek-Centrum" with wireless network signal. Limitation of WLAN range only to the entries areas (where MIC100 units are installed) does not allow practical operation of this functionality. However, the test of the exchange of messages was carried out within the range of WLAN access points and both receiving and sending messages was performed without any problems. All individual and group messages (alerts, communicates, signals) were delivered from sender to receiver, when relevant pagers connect to a base station within the WLAN range.

Main results

Additional functions of the personnel tracking devices associated with communication functionality at the current state of system development are limited to message receiving and broadcasting. But the principle feasibility of this application was tested successfully. However, an operational use of those basic communication functions (alerting, messaging, etc.) requires constant or at least frequent access to WLAN network. That will be possible only after installation of a significant number of access points providing a full coverage of wireless network in operating area of "Bobrek-Centrum". This is, however, outside the scope of the OPTI-MINE project, but could be realized in future.

Task 6.3 – Personnel tracking (KWSA, MT)

Work performed

The staff monitoring system has been limited to two areas of wireless communication and a control group of communication devices, as it was described in Deliverable 6.1 'Report on installation by KWSA'.

MT Silesia Company delivered, installed and configured following items:

- Mining Infrastructure Computers (MIC) – MIC100 main unit – 3 units,
- PAG 1300 individual pager – 30 units,
- Induction loader for pager – 15 units,
- Power supplies for the loader – 15 units,
- NetCenter, TrackCenter, ViewCenter and PagerCenter software packages.

Personnel tracking function is performed using WLAN access points as control gates and client end mobile devices as personal identifiers. The current stage of the system allows registering presence and communicating wirelessly with a group of selected staff members in an area covered by signal from two access points units. Two MIC100 main units with two directional antennas (used for detection of presence and direction of motion) and third omnidirectional antenna (used for broadcasting text messages) create wireless access points, which were installed at the entrance to the current operating mine production area of longwalls no. 1 and no. 2 in coal seam 615 at the level 774m at "Centrum" mine area. Group of 30 staff members were equipped with client end devices (PAG 1200 individual pagers), which allow registration of entering or exiting the operation area and also allow text messages exchange. At the initial stage of OPTI-MINE project pagers PAG 1300 have been selected as personal identifiers for the tracking system.

One advantage of this solution is low equipment costs and time efficient implementation, which has made implementation within the project budget and time frame possible. Furthermore, it offers the possibility of communication by using the same device (see task 6.2). But there are also essential disadvantages. It would be advantageous to have personal identifiers for the tracking system integrated within the cap lamps, while the battery of a lamp serves as power supply and each staff member possess his lamp and takes care of it. Use of the autonomic devices creates serious additional effort in lamp houses, when all underground staff has to take another piece of personal equipment. This equipment must be loaded, maintained and controlled, what significantly increases the work of the lamp house and complicates the procedure of departing the mine staff for the work underground. However, for small mines with low number of employees, mining companies of little financial funds and in countries of low personnel costs, the solution of autonomic devices could be an interesting option.

In the first months after installation of the system in longwalls no.1 and no. 2 in 615 coal seam, the system was occasionally tested by the mine engineers, however amount of collected data was definitely too small to generate a reliable implementation report. A proposition for the "Bobrek-Centrum" mine (KWSA) has been made by the SUT, to conduct a series of test of the tracking system with the help of external persons, who will simulate exchange of shifts, and will trespass the gate area in different, controlled conditions – without interference with mine operations in the longwall area. The testing procedure can be considered as simulation of the normal motion of the mine crew. Underground test of the existing elements of mine staff tracking system in "Bobrek-Centrum" coal mine took place in two stages. Testing procedure and detailed results are presented in Deliverable

6.2 “Report on Preliminary Experience by KWSA”.

With the installed equipment, only these semi-industrial scale tests were possible. For full operational use, KWSA prefers instead of the “entry gates” system, a system covering large distances of gates in all longwall panels. More advanced tracking system, including monorails and main staff traffic on the main access roads, should extend the monitored area to all longwalls and all main transport roads.

Main results

The system was tested within the limitation of only 30 personal identifiers and 2 WLAN access points, what is far below the real requirements of the area of application. However, this semi-industrial scale of application shows the capabilities of the system. Further testing of the system will be continued as a systematic day-by-day practice with the existing limitations.

Full adaptation of personnel tracking system requires large investments in development of WLAN infrastructure (number of access points must be significantly higher). Currently available pagers PAG1300 do not meet the requirements for personal identifiers – tests show that devices operate with performance far below 100%, what is critical in terms of safety consideration. Also such an identifier should not be an autonomic device, it rather should be integrated in a cap lamp.

WP7: Assessment of performance and project results

WPL: SUT (Partners: DMT-TFH, MT)

Task 7.1 – Key Performance Indicator (KPI) specification and assessment methodology (SUT, DMT-TFH, MT)

Work performed

The academic partners SUT and DMT-TFH determined the general requirements, which suitable KPIs had to fulfill.

- Key Performance Indicators must reflect the operational goals
- Key Performance Indicators must be quantifiable by numbers
- Key Performance Indicators must be free of authoritative judgments
- Key Performance Indicators must depend on data reasonable to obtain

Due to the specific ICT installations, varying operational objectives and the local conditions, for each mine individual KPIs have been designed. Initially mining companies formulated and submitted for discussion 21 KPIs propositions (5 from each RAG-A, OKD, KWSA, and 3 from each HUN and PRV). Finally the number of KPIs has been reduced to 15 – three for each mine. The selected KPIs covered the accuracy of the ICT technology, parameters of the hauling, maintenance and production process and data concerning the logistics. Due to reasonable reformulation of KWSA involvement in OPTI-MINE project activities, it was required to adopt the KPIs to the technical capabilities of the demonstration installation at the KWSA "Bobrek-Centrum" mine.

In addition to the selection of KPIs the basic requirements for data collection have been set.

The data collection consisted of two measuring periods, one before and one after implementing the ICT technology. This was applicable for most of the KPIs. Between the two periods a sufficient testing and troubleshooting time for implementing the ICT technology had been considered. And, in minimum a number of 10 data sets have been required for each KPI. These data sets covered in minimum one month.

Having collected the data the mines calculated the specific KPIs and forwarded data and results to the academic partners. First, the academic partners checked these results with regards to accuracy and plausibility. In the next step the evaluation of the KPIs started creating preliminary and final findings. The specification of KPIs, the assessment methodology and a list of selected KPIs is the subject of Deliverable 7.1.

Main results

Regarding the determination of KPIs the assessment delivered the following results by numbers, the specific outcomes will be presented in the next chapter.

- 15 KPIs have been selected for the five mines.
- 11 KPIs delivered significant results which may indicate the success of the ICT-Technology
- 2 KPIs haven´t proved to be reasonable as some other more influential parameters have dominated the operational process.
- 2 KPIs couldn´t been determined as the production levels and the haulage process have been altered while the project was running.
- 1 additional KPI has been put in place.

Task 7.2 – KPI-based performance assessment (SUT, DMT-TFH, MT)

Work performed

Getting the data and the calculated KPIs from the mines the academic partners checked the accuracy and plausibility. 2 KPIs delivered results which have been superposed by other operational issues. The KPI "E_{TUD}" (Effort of Man-Shifts, referring to number of transport-units and transport-distances, RAG-A) wasn´t reasonable as the reported data have been hit by a singular installation of a longwall. And, as a monorail can transport up to six transport units it wasn´t possible to figure out which unit has been transported to an intermediate destination or to the final destination.

At Hunosa the KPI "D_{DT}" (Decrease of monthly downtime of production) couldn´t be determined. Due to the current low levels of output in Sueros Colliery (less than 1,000 t/day versus 2,500 t/day in 2011) the mine has barely noticed positive influences due to oversizing of the extraction system.

One KPI of PRV was the "Coal face average efficiency". Relevant data have been reported in four longwalls delivering some equivocal results. In one case the efficiency of the face with ICT system proved to be superior, in another longwall it was quite the opposite. It had to be considered that the geological conditions and coal face parameters have a larger impact on efficiency than the use of the new ICT system.

The ICT technology put in place at OKD has been assessed at a limited amount of data which had been available upon project completion. The KPI "Increase of coal output" could not be calculated as the coal haulage process was affected by mayor modifications.

Main results

At RAG-A a mayor improvement gained by the ICT technology have been made visible by the KPI "TPI" (Specific Transport Performance Indicator). The TPI for the mine in total comes to about 2,3 i.e. each man employed for transport - monorail driver, handling people etc. - moves on avarage 2,3 transport units per shift. In the Beustfeld area which has been completely equipped with the new ICT technology this indicator ranges about 3. With regards to these figures the performance in the Beustfeld is about 30 % higher than in total.

RAG-A and DMT-TFH created an additional KPI which reflects to the cost savings facilitated by the new technology. Applying the ICT technology it is possible to locate the IPC necessary for the control of the longwall faces on surface. In consequence there is no flameproof version required and maintenance etc. is less complex. The cost saving indicator $\mathbf{S}_{IPC}$ shows a saving of 85 % resp. 135 000 Euro for the installation of four longwalls. That doesn´t take into account the fairly reduced effort for installation, maintenance and the improved reliability.

Due to the miner´s strike and some operational issues the assessment at Hunosa was more complex. At first, the KPI "D_{MTTR}" (Decrease of Mean Time To Repair) indicated a positive trend due to the new technology, the mine reported an improvement of 30 % in average. In the first half of 2014 they didn´t noticed positive influences due to the current low levels of production and no significant breakdowns. A clear verification is missing.

Another Hunosa KPI dealt with the decrease of monthly production loss ("D_{PL}"). As mentioned above the low levels of production seemed to skip this KPI. But installing the IP cameras and monitoring the Sueros belt system a very positive impact on coal quality occurred. The amount of water and big lumps of rock have been made visible in the control room and corrective actions took place. Comparing the first half year 2013 and the equivalent period in 2014 the coal washing efficiency have been raised by 19,75 % and the output value in Euro/t even by 45 %.

The PRV Velenje mine had installed a LAN/WLAN infrastructure to especially implement wireless communication between mine personnel at the longwall face and the surrounding workings. The KPI "D_{TR}" (decrease of average time to reach a person with using ICT) should document the success of this installation. While comparing a longwall face with and without ICT the assessment indicated a D_{TR} of 82% resp. 85%. Due to the ICT technology a call to a person at the face has been executed about six times faster than in a conventional equipped face.

The accuracy of the installation has been checked by applying another KPI. It was determined the average ratio of failed call attempts to a person being equipped with VoIP phone or smartphone at a WLAN face. In average 20 % of the calls failed, 80 % of the calls have been successful. That is a positive result, but also indicates that there is room for some improvement.

At the "Bobrek-Centrum" mine of KWSA the new ICT system consisted only of three MIC stations which was a significant reduction in relation to initial plans. As the number of pagers was limited, too, it was not reasonable to include regular mine staff in the test. Therefore KWSA in agreement with SUT decided to conduct a test of the tracking system with the help of external persons. The testing procedure has been considered as a simulation of the usual movement of the mine crew.

The KPI "R_{PT}" - the pass-through events registration reliability factor in % - should indicate the functionality of the system. With regards to all pagers and the total number of single entry events the overall efficiency equalled to 60 %.Taking into account only a reduced numbers of pagers with less errors the reliability factor rose up to 94 %. Nevertheless, it has to be stated that for this application the pager system needs some mayor development.

KWSA and SUT determined another KPI called "R_{MD}" - the message delivery reliability factor. All individual and group messages (alerts, communicates, signals) should be delivered from a sender to the receiver when, of course, relevant pagers are connected to a base station in the WLAN range. During the tests of new ICT system in total 76 messages (group and individual messages) were send in both directions and all messages were correctly delivered and received. This specific KPI equalled to 100 %.

The third KPI of KWSA covered the reliability of the ICT infrastructure and it was called "B_R" - percentage of breakdown time during production time. With regards to the collected data the ICT system was down for almost 5% of the operational time as the fibre optic cable has been damaged.

Due to operational and management changes at OKD the assessment has been executed at a limited data base. The KPI "Average decrease of the transport-time for a total round" delivered positive results and indicated an improved efficiency of 5,5 %. Concerning the downtime of the coal train operation a similar trend couldn´t be demonstrated. The mean downtime didn´t change and still covers a level of 21 and 35 %.

For the majority of the KPI's the results give clear evidence that the new enhanced ICT positively impact mine productivity and safety. In some cases it was not possible to clearly assess the effect of the ICT and only in one case the need of further technical development of a particular subsystem was clearly obvious. Deliverable 7.2 provides the detailed information.

Task 7.3 – Assessment of additional criteria and effects (SUT, DMT-TFH, MT)

Work performed

SUT and TFH evaluated additional benefits according to the application of risk management tools. The course of action was executed as follows:

An evaluation form has been designed to structure the individual findings and to enable a standardized summary. Each cluster of the project structure covers a specific process where the new ICT technology is expected to gain improvements. For each cluster the project partners determined the additional criteria i.e. mine safety, occupational health, environment and operational management. After implementing the new ICT technology its contribution to the additional criteria in the specific cluster has been estimated by the project partners, i.e. the involved coal mines and the academic partners. The rating system covers a spread from 0 to 3 (no, minor, medium and essential improvement).

Main results

After assessment the scoring is presented in a matrix sheet, which indicate the improvements regarding the additional criteria in the specific cluster and in general.

Mine	Cluster	Additional criteria			
		Mine Safety	Occupational Health	Environment	Operational Management
RAG-A	C2: Material Logistics	1	0	1	**3**
	C3: Personnel Communication	1	0	0	2
HUNOSA	C3: Personnel Communication	**3**	1	0	**3**
	C4: Personnel Tracking	**3**	1	1	**3**
	C5: Environment Monitoring	**3**	1	2	**3**
	C7: Conveyor Monitoring	**3**	0	**3**	**3**
PRV	C3: Personnel Communication	2	1	0	2
	C4: Personnel Tracking	**3**	1	0	1
	C5: Environment Monitoring	1	1	0	0
KWSA	C4: Personnel Tracking	**3**	1	0	2

(0 no, 1 minor, 2 medium, 3 essential improvement)

Table 7.1: Assessment of additional criteria

WP8: Dissemination and Knowledge Exchange

WPL: Evonik (Partners: all)

Task 8.1 – Classical measures of knowledge transfer

Work performed

Within the project period a handbook was produced and many public presentations at conferences were made by several beneficiaries and one article was published in a professional magazine.

- Presentation by DMT-TFH at the Moscow State Mining University, Mining Week, at 30 Jan 2013
- Presentation by PRV at the Energy & Responsibility (EnRe) 3rd International Conference in Velenje, Slovenia, 21 June 2013
- Presentation by Aitemin at the 35th International Conference of Safety in Mines Research Institutes (ICSMRI), London, 15 - 17 Oct 2013
- Article in International Mining magazine, Dec 2013
- Presentation by DMT-TFH at the meeting of the R&D steering committee of the German Engineering Association, Bochum, Germany, 10 Apr 2014
- Presentation of MineTronics at the CIM annual conference, Vancouver, Canada, 12 May 2014
- Presentation of DMT-TFH at the annual meeting of the Society of Mining Professors (SOMP), Sandton, South Africa, 29 June 2014
- Two presentations of MineTronics and DMT-TFH at the Aachen International Mining Symposia, AIMS 2014, Aachen, Germany, 11 June 2014

Main results

Copies of the performed presentations and of the published article (see deliverables D8.1a) and a handbook (D.8.1b). They are available at www.opti-mine.eu.

Task 8.2 – Online dissemination

Work performed

As planned, a public project website was set up and the OPTI-MINE website was updated according to new publications, presentations and the OPTI-MINE Industry Forum events.

The public project website offers the following features to the public:

- Distinctive domain name (www.opti-mine.eu)
- Description of the project and its objectives
- Project participants with contact details and links to their websites
- Download area for all public presentations given by the partners
- Area for dissemination of publishable project results
- Indication of events at which project participants will hold presentations
- Hyperlinks to useful websites including links to related RFCS projects
- Indication of dissemination events (as the Industry Forum described below)

The following picture shows a screenshot of the OPTI-MINE website (***Figure 8.1***).

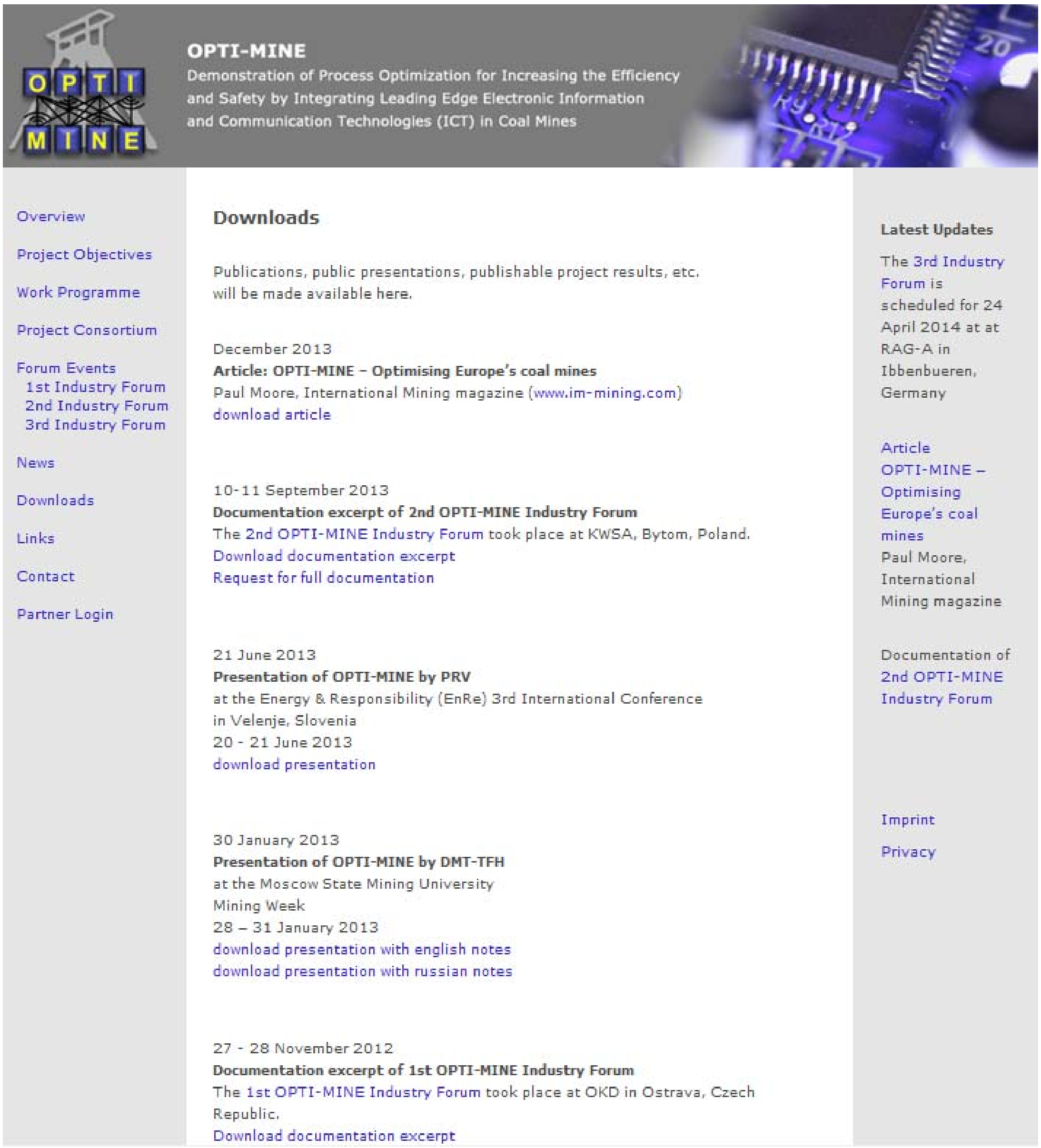

Figure 8.1: OPTI-MINE website, page 'Downloads'

Main results

Updated OPTI-MINE website www.opti-mine.eu

Task 8.3 – Opti-Mine Industry Forum

Work performed

The project consortium arranged three Industry Forum events as dissemination activity. External potential users of the demonstrated IC-technology were invited to participate. This included 18 European underground mining companies and several mining equipment suppliers. The European Association for Coal and Lignite (EURACOAL) supported by distributing a part of the invitations. Additionally, the allocated TGC1 experts of the RFCS programme, the project officer, representatives of the currently running European projects FEATureFACE (RFCS) and I2Mine (EU-FRP7), mining service providers and a professional mining journal were invited as well.

At the meeting, the external potential users could learn about the experience and the project's aim to demonstrate underground process optimisation by operating high-bandwidth information and communication technologies (ICT) in several European underground mines using a common open architecture network.

Participating in the OPTI-MINE Forum events offers in detail the following benefits.

- To get information on state-of-the-art ICT in other coal mines,
- to get knowledge about the project objectives and technologies to be developed and demonstrated,
- to benefit at an early stage from application experiences and results related to reliability, difficulties and impact on mine operation efficiency, occupational Health & Safety and environmental issues in the demonstrating coal mines,

- to influence solution processes for occurring technical problems and further developments,
- to get in close contact to other European coal mining companies and experts,
- to get to know the Research Fund for Coal and Steel of the European Union.

Furthermore, the Forums offer to the project consortium discussions with the external potential users, to learn their opinion, ideas, demands, experience and advice concerning the use of modern ICT in underground mines.

As OPTI-MINE is funded by the European Union's Research Fund for Coal and Steel (RFCS), participation could be offered free of charge. The external participants had to bear only the costs of their travel, accommodation and subsistence.

The first Industry Forum took place in Ostrava (Czech Republic) on 27 November 2012 and focused on the basics of process optimisation by modern ICT and on material logistics as one application field. This field was demonstrated at OKD (Czech Republic) and RAG Anthazit Ibbenbüren (Germany).

The second one focused on personnel tracking and access control and took place at the "Bobreck-Centrum" coal mine of KWSA in Bytom (Poland) on 10 September 2013. The coal mining companies KWSA and HUNOSA (Spain) presented their project activities and experiences in this field.

The third Industry Forum took place at the coal mine 'Ibbenbüren' of the mining company RAG Anthrazit Ibbenbüren GmbH (RAG-A) in Ibbenbüren, Germany on 24 April 2014. It focused on the field 'personnel communication and information' presented by the mining companies HUNOSA (Spain), Pr. Velenje (Slovenia) and RAG-A (Germany). Additionally, RAG-A presented their progresses in the fields 'Material tracking and logistics', 'conveyor monitoring' and 'longwall control'. Furthermore, preliminary results of the performance assessment using key performance indicators (KPI's), were presented by the scientific partner TFH University of Applied Sciences.

All three forum events included as well the possibility of an underground visit at the project demonstration area.

Main results

Documentations of the OPTI-MINE Forum events are available at www.optimine.eu.

Task 8.4 – Transferability Study

Work performed

Generalizability and transferability are very important elements of any research and demonstration projects. Increasing efficiency and safety by integrating leading edge electronic information and communication technologies (ICT) in coalmines is main result of OPTI-MINE project. SUT and DMT-TFH in an academic setting generalized the result obtained by all partners and defined it as the extension of research findings and conclusions form OPTI-MINE beneficiaries to the coal mine industry at large. Because generalizability and transferability requires data on large populations, quantitative research and experiments SUT had to analyse all data obtained from all partners and elaborate transferability study.

Transferability is applied by the readers of research, and they need to make a connection between elements of a study and their own experience. A transferability study carried out by SUT assesses how the innovative ICT technologies demonstrated in OPTI-MINE can be transferred into other mines of similar technological status and geological conditions. At the initial stage of the project the transferability study assumed presenting the possibility of transferring OPTI-MINE experiences to the mines of National Hard Coal Company (NHCC) (Romania) as an exemplary case, although the NHCC was not the official project partner they have agreed to provide SUT with all information and data required (see Letter of Intent), but unfortunately, due to changes in management board and changes in company development prospects related to the current situation in the mining industry in Europe NHCC did not provide any data and showed no interest in further participation in OPTI-MINE project. Due to this situation SUT decided to assess the general case of transferability study, but also in cooperation with MT have tried to find new partners interested in transfer of the technology and experience. SUT and MT began talks with many companies related to coal industry, these discussions resulted in a number of meetings with the management and engineers and technicians form Jastrzebska Spolka Weglowa (JSW SA) who is interested in the development of modern ICT systems in their mines. During three meetings in JSW both SUT and MT presented equipment used and results of OPTI-MINE common open Ethernet based underground communication platform that promises low cost of adaptation. Representatives of JSW noticed the potential of new ICT and so far everything indicate that in the near future they will be interested in further more detailed analysis of the possible transferability.

SUT also presented the possibilities of result transferability and OPTI-MINE results itself to representatives of the mining industry during the 15th International Technical and Scientific Conference KOMTECH 2014: Innovative techniques and technologies for mining – safety, efficiency and reliability, which took place in Zamek Kliczkow, Poland on 19-21 November 2014.

Main results

Generalizability and transferability of the OPTI-MINE project result to a wide audience associated with the mining industry. Transferability study shows that the findings can have applicability in other mines, but require additional analysis of condition and also comparison and connection of their own experiences with project results.

Each time we are talking about transferability SUT suggest that the general comparative analysis have to be done in all five fields:

- Geological-mining conditions
- Material resources (equipment, technologies, infrastructure)
- Human resources (amount, skills, specialists)
- Health & Safety
- Economics, finances

Generally the transferability requires the identification of the local conditions and strongly depends on those conditions. The range of the OPTI-MINE results transferability is as follows:

- Definition of the prerequisites in terms of mining equipment and staff knowledge
- Definition of the minimal level of Information and Communication Technology (ICT) for the basic implementation (both hardware and software)
- Definition of ICT modules for further growth
- Maintenance of the ICT system
- Advices for an ICT introduction strategy
- Estimation of cost and benefits in terms of economics

Conclusions

WP0, technical project coordination

One mayor objective of the project was to adapt standardized information and communication technology commonly used on surface to the specific technical requirements of underground mining in order to optimise the whole production process. As part of the project the latest suitable components for ICT systems were modified and approved to ATEX. Existing approved stand - alone applications were successfully coupled to the new advanced communications network via interfaces. The features of the new ICT have met the high demands of the mining industry. For technical and operational reasons, the initial designs had to be slightly modified. While running the OPTI-MINE project the integration, installation and operational usage of the latest ICT applications have been successfully demonstrated on an industrial scale.

WP1, Innovative components for system integration

This work package successfully created the technological preconditions to perform the demonstration work packages with excellent results.

Furthermore it was leading to the new belt skew sensor prototype as one main innovation. The second innovation is the specification and functional drafting of new mine scheduling and visualization software as a post project innovation resulting from the experience gained during the project.

WP2, demonstration at a mine of RAG-A (DE)

The following technical systems were successfully planned and in the area (Beustfeld) of the mine Ibbenbüren, which was selected for demonstration operation, installed, tested, optimised and operated. In doing so experiences were gained how the systems are to be designed in detail and how they can be operated successfully. Finally, the technical operational capability of the systems mentioned below could be achieved and demonstrated.

- Universal, standardised ICT network with enhanced resilience
- System for material logistics optimisation (material- and container tracking, logistics management), which enhances transparency and safety.
- Information system via PDA for the underground personnel for CH_4 measured values as well as logistic information, which enhances transparency and safety.
- Longwall control from above ground, by which costs can be reduced.

To evaluate the systems' capability and their contributions to process optimisation (WP7: Assessment of performance and project results), data of the demonstrative operation were given to the partner DMT-TFH.

Moreover, VOIP voice transmission via the network and a novel belt skew detector for conveyor belts developed by MineTronics were successfully tested. To achieve operational capability of the belt skew sensor, further activities by MineTronics are necessary (e. g. ATEX approval).

WP3, demonstration at a mine of HUNOSA (ES)

The implementation of this WP, in despite of the miners' strike and other development issues, is considered satisfactory. Most activities gave significant results, among them the deployment and commissioning of the fiberoptic network and personnel location system; the development of a tracking device for locomotives and other machinery, the development of an Atex IP Camera for conveyor monitoring and the implementation of digital voice subsystems.

The ring fibre optic network guarantees the communications in case of collapse roadway, explosion or fire. In case of accident, emergency or rescue, the wireless personnel location is critical and may save human lives.

The Cap lamp-based personnel wireless location system helps to coordinate the jobs and the workers teams by knowing their positions of all personnel, and of course, the actual working time of each worker.

Over-viewing, through the IP cameras, all conveyors helps as well to coordinate the jobs and the workers teams in order to decrease the production loss, mean time to repair and minimize breakdowns. Due to the belt monitoring by IP cameras a very positive impact on coal quality with regard to water and ash content was observed, by which the coal washing efficiency raised considerably (see WP7 for more details).

RELIA AV Master System can convey much more information and faster than its predecessor, which improves e.g. maintenance efficiency. The fast and effective means of communication and information for the expert staff helps in troubleshooting the non-expert staff (Remote Assistance).

WP4, demonstration at a mine of PRV (SI)

Because of eligible reasons we started with project activities quite late, but we caught up the plan. We made WLAN coverage and propagation test with our project partner Minetronics in our coal mine. After analyzing coverage and propagation test results and equipment purchasing we established wireless network coverage on our coal face. Coverage degree of this first coal face area was considered to be sufficient for the demonstration purposes. On second coal face we have increased the coverage area also to part of main belt system and area close to main shaft. After that we moved all network infrastructure to the third coal face and this process will go on in the future. Network infrastructure was precondition for all other tasks and activities in the project.

We tested different possibilities of voice communication and data transfer over wireless network. We use WLAN mobile phones, PDAs and pagers in regular production operations. Measurements showed a decrease of time to reach a person in a coal face of >80%. We also transferred data from shearer and roadheader.

We successfully implemented and tested software applications for SIP open source server (Asterisk), paging (Pager Center), for remote SCADA on PDAs, for tracking (TrackCenter and WiewCenter) and for safety related add-ons.

In network infrastructure we integrated remote I/O control unit, which proved to be very useful. On this unit we connected different environmental sensors and warning lamps.

As upgrade of all previous tasks we made concept and tested safety related add-ons such as support to emergency decision making process, alerting of people in endangered areas with rescue action instructions, overview of mine with respect to environmental sensors, tracking, status of underground areas according to emergency rescue plan etc.

WP5, demonstration at a mine of OKD (CZ)

As a result of the project, the cross-cut between ČSM North - ČSM South has been equipped with the components creating the Gigabit Fiber Optic backbone network and Wireless LAN allowing tracking of the locomotive position based on the RFID technology, i.e., tracking the position of passive and active tags, tracking the position of the last wagon, i.e., checking the integrity of the whole train on the basis of tracking the active tags, collection of the data from the locomotives and voice communication. The surface worksites, i.e., the server station and the dispatcher's station have been equipped with components that ensure the above-mentioned functions, i.e., the servers, software, Infrastructure, and the dispatcher's office has been equipped with a workstation. The dispatcher's office personnel can see the movement of the locomotives on the workstation screen showing the identification of the locomotives, position of the last wagons, the dispatchers can view the locomotive technical data (speed, engine hours, level status, temperatures, …), and they can communicate with the locomotive driver.

Due to combining the system of the Opti-Mine project and the ISI system, which is already in operation at the ČSM mine, the dispatcher's office personnel can track the position of personnel at the transportation gateroads between ČSM North - ČSM South. This allows informing the locomotive driver on personnel moving or staying on the tracks. Based on the above-mentioned functions, this system allows the dispatcher's office personnel to improve organization of transport at the connecting cross-cut between ČSM North - ČSM South and thereby to reduce costs. In case of need (an accident, danger, …) it also allows the dispatcher to provide faster and more specific information to the personnel on site or to the rescue teams regarding the place where their services are required and the person requiring their services.

WP6, demonstration at a mine of KWSA (PL)

Full adaptation of personal tracking system in longwall areas of "Bobrek-Centrum" mine requires large investments in development of fibre optic infrastructure, due to large mining area and distribution of mining operations areas over long distances, what results generally from the age of the mine and limitations of mining under urbanised areas.

Installed LAN/WLAN infrastructure with fibre optic network and industrial underground computers creates opportunities for future integration of different mine information, monitoring, and communication subsystems, however the personal tracking related to the hazardous zones in the longwalls areas is the most important task to be solved as soon as possible.

Number of access points must be significantly higher and their distribution must be relatively dense to achieve full monitoring of the mine crew in the crucial areas.

Currently available pagers PAG-1300 do not meet requirements for personal identifiers in a tracking system. Conducted tests show that these devices operate with performance far below 100%, what is critical for the safety considerations.

For the bulk usage such an identifier should not represent an autonomic device, rather it must be a component of a cap lamp. Currently adopted solution is very fragile on variable external conditions and position on a body of a miner. Integration with a cap lamp is also necessary from the point of logistics – full application of such a system in conditions of "Bobrek-Centrum" mine requires to handle over 1000 units of personal identifiers.

Use of additional functions of the personal devices like alerting, messaging etc. at the current state of spatial development of the system is premature. Use of these functions requires easy and frequent (or constant in certain areas) access to WLAN, which will be possible only after installation of significant number of access points.

WP7, performance assessment

For the majority of the KPI’s the results give clear evidence that the new enhanced ICT positively impact mine productivity and safety. In some cases it was not possible to clearly assess the effect of the ICT and only in one case the need of further technical development of a particular subsystem was obvious.

For example at RAG-A a mayor improvement gained by the ICT technology have been made visible by the KPI “TPI” (Specific Transport Performance Indicator) which indicates a 30 % increase in productivity. Due to the installation of IP cameras and monitoring the Sueros belt system, Hunosa reported a very positive impact on coal quality with regards to water and ash content. Comparing the first half year 2013 and the equivalent period in 2014 the coal washery efficiency have been raised by 19,75 %. At the PRV Velenje mine, another example, the communication between mine personnel at the longwall face and the surrounding workings have been essentially improved by the WLAN infrastructure.

Concerning the additional criteria like safety, health, etc. almost all mines indicated the essential improvement of operational management, as the new ICT technology allows better overseeing and controlling the process of production, what results in more efficient productivity. Applying new ICT technology for clusters C3: Personnel Communication and C4: Personnel Tracking highly increase the mine safety, what is not surprising and almost all mines indicate essential improvements in this area. The majority of coal mines indicated no or minor influence of applied ICT technology on “Environment” criterion, the only exception was HUNOSA, which indicated medium and essential improvements of “Environment” criterion in cluster C5: Environment Monitoring and C7: Conveyor monitoring, as new ICT allows using wider range of different sensors to monitor more environmental parameters. A criterion regarding “Occupational Health” practically was not indicated or it has minor influence in any cluster of activities.

All partners indicate essential improvement for at least one of the additional criteria. The most important improvements after implementing the new ICT technology were noticed first for “Operational Management” and secondly for “Mine Safety”

WP8, dissemination

Manifold dissemination activities were implemented, many publications like presentations at conferences, an article in International Mining Magazine, a project website, and Industry Forum events. Also the transferability of the process optimisation technology to other mines was assessed and the study is available for the public.

Generalizability and transferability of knowledge is a key result of OPTI-MINE project. Dissemination of results to a wide audience associated with mining industry allows transferability, which is applied by the readers of the demonstration project publications, who need to connect elements of project results and their own experience. The transferability study shows the general comparative analysis has to be done and that transferability strongly depends on local conditions.

Exploitation and impact of the research results

WP0, project coordination

Results of WP0 served for administrative and scientific/ technical project management. Exploitation is limited to publications, teaching/ lectures and further research.

WP1, Innovative components for system integration

The work package results were exploited in the demonstration work packages 2-6 and are now directly applied to future commercial projects in the European Union and on a global marketplace.

Numerous publications have been made by MineTronics and others which cover the innovations of this work package. Product demonstrations have also been carried out at conferences and during direct customer contacts. Further commercial applications for the hardware used in the project and for the central system software are already started or expected to be started during 2015. In all of these applications, the demonstration project was essential as reference during marketing.

Concrete exploitation examples

Results of task 1.2 concerning the ViewCenter are exploited for software extension developed by MineTronics with the name "MineOpt-MRP" whereas MRP stands for "Mine Resource Planning". This software combines functionality as shown above with a scheduling and planning component in order to show the ongoing operations on a timeline together with the location based context. This enables the shift managers e.g. to determine upcoming problems without delay and quickly access the closest person or machine to solve a sudden problem. At presentations, this was very welcomed by the mining industry as a very promising product, developed on the basis of OPTI-MINE results. MineTronics plans to use it in commercial projects already in 2015.

The demonstrative use of the IREDES tracking profile (task 1.3) helps to support the broad use of this global industrial standard. It also provides a market advantage to the technology integrators.

It is intended to get the novel belt skew sensor ATEX certified and to commercialise it.

WP2, demonstration at a mine of RAG-A (DE)

All mentioned systems, of which technical operational capability could be demonstrated, will now be used in regular operation and technically adjusted, modified or extended where necessary.

The positive project results show that the technology has the potential, to allow process optimisation as well as cost reductions. The actual economic feasibility depends of course on the economic, technical, geological and other conditions in the individual case. Indeed, the universal and integrated network technology can be adapted quite flexibly to the individual conditions of mines.

Possibly patentable technical project results would belong to the technology partners MineTronics or AITEMIN and corresponding IP rights can be applied by them, subject to agreement with the other partners.

The project findings of RAG-A as well as of the other partners were multiply disseminated and the published documentations are still available for interested parties, in particular via the website www.opti-mine.eu (s. WP8).

Primarily the technology partners MineTronics and Aitemin will certainly in their own interest, subject to agreement with the partners, further disseminate to the mining industry the findings and publications of OPTI-MINE, in order to encourage them to corresponding investments. More on that, see WP1.

Inside the RAG group a report was disseminated as well. Future investments of RAG mines in this technology would be reasonable, but are to be scrutinised due to the political decision to close all German hard coal mines until 2018.

By the affiliated company RAG Mining Solutions, which markets worldwide the German hard coal mining Know-how and services like consulting, engineering and trainings, the know-how gained in OPTI-MINE could be disseminated in the context of contracts also beyond 2018.

WP3, demonstration at a mine of HUNOSA (ES)

It is planned to connect to the ATEX fiber optic network the SIEMENS PLCs which control the pumps located in 5th and 7th main levels of San Nicolas Pit and the TV cameras located in the landing stations of both shafts, and for this purpose it is being developed new equipment that allows connection of non-ATEX equipment to the ATEX fiber optic network, all in order to concentrate in the control room located in San Nicolas Pit offices all information, data, images, etc. that are generated in Sueros Colliery.

However, in general, the end of the life of underground coal mining in Western Europe, makes the extension of the systems to other mines in the Company unfortunately very unlikely. There are ongoing marketing activities in emerging markets. However, in despite of the value of the technology developed, the current situation of the commodities markets and specially the oil and gas ones, make very difficult the marketing of products with the level of sophistication present in the systems developed in the project. Ongoing efforts are focused to the design of derivative products with reduced functionality and cost, in order to make easier the penetration in the aforesaid emergent markets.

WP4, demonstration at a mine of PRV (SI)

With coverage and propagation test results, with installation of network infrastructure successively on three different coal faces and other areas, with testing and using WLAN devices we got knowledge and experience how to make optimal concept and installation of wireless networks in coal mines. In future we intend to continue with installation of fibre optic and wireless networks in new coal faces.

With using WLAN devices for communication and integration with existing systems we recognize all benefits and also limits of use. Due to positive results, increasing the number of mobile phones and PDA's is intended. To enable tracking of all people in our coal mine, we intend to install WLAN tags in miner's lamps and to extend the network. It is also envisaged to equip transport units with WLAN tags for tracking and to continue the work on the safety add-ons application. All this will increase safety level, improve logistic operations and increase production efficiency.

At the Energy & Responsibility (EnRe) 3rd International Conference in Velenje, Slovenia, June 2013, we presented our paper "Use of wireless networks for communication and data transfer within the European development project OPTI-MINE". Further presentations will possibly be done at suitable events.

WP5, demonstration at a mine of OKD (CZ)

Due to the positive experiences during the OPTI-MINE project, OKD is interested to expand this universal ICT network technology to other areas of the mine and also to install and use it in other OKD mines. The project results show that the technology can improve the mining processes, safe costs and increase safety. The benefit of the different applications (e.g. train tracking, voice and data communication from transport machines, personnel tracking) and their concrete design depends on the conditions and needs of the individual mines.

OKD intends to investigate which applications would be the most beneficial in which mines or mine areas. However, possible future investments depend on availability of financial resources, of course.

OKD has hosted one of the OPTI-MINE forum events and presented their work and projects results (see work package 8). Further presentations will possibly be done at suitable events.

Filing of patents is in most cases up to the technology partners and suppliers like e.g. MineTronics.

WP6, demonstration at a mine of KWSA (PL)

The results of small-scale application in the frame of OPTI-MINE will be helpful for further development and integration of ICT based systems in the "Bobrek-Centrum" coalmine and other mines of KWSA.

For an operational use of the basic communication application (alerting, messaging, etc.) a significant number of access points are necessary. This could possibly be realized in future. However, a management decision about this option has not yet been made.

As reported, the technical solution of personnel tracking needs further development due to limited reliability and practicability. This could be tackled in a future development project, possibly in cooperation with MineTronics and/or other technology partners.

WP7, performance assessment

Exploitation by the academic partners (DMT-TFH and SUT) for publications, teaching/ lectures and further research.

After project end one conference presentation has already been made by SUT at the 15th International Technical and Scientific Conference KOMTECH 2014: *Innovative techniques and technologies for mining – safety, efficiency and reliability, which took place in Zamek Kliczkow, Poland on 19-21 November 2014.*

Exploitation by the technology and design service providers (MineTronics and AITEMIN) for their marketing activities.

WP8, dissemination

All dissemination documentations are available at the OPTI-MINE homepage (www.opti-mine.eu) for interested parties like mining companies as potential users. They also serve as material for the marketing activities of the beneficiaries and technology providers MineTronics and Aitemin.

After project end one conference presentation has already been made by SUT at the 15th International Technical and Scientific Conference KOMTECH 2014, which addressed also the results transferability: Innovative techniques and technologies for mining – safety, efficiency and reliability, which took place in Zamek Kliczkow, Poland on 19-21 November 2014.

At the meetings with representatives of the coal mining company JSW SA concerning transferability, they noticed the potential of this new ICT and so far everything indicate that in the near future they will be interested in further more detailed analysis of the possible transferability.

R&D-needs arising from the project results

After the tests in WP6 performed at KWSA with the currently available pagers, no optimisation activities could be performed as the longwall reached its operational end. The conducted tests show that the system is principally working, but when the tests finished, the reliability was below 100%, which is critical particularly for safety related purposes. As the principle is working, further testing and system optimization would be needed in order to achieve and prove its reliability for safety applications.

Furthermore, for the bulk usage such an identifier should not represent a separate device, rather it should be a component of a cap lamp. The demonstrated solution is very prone to variable external conditions and by the position on a body of a miner. Integration within a cap lamp is also necessary from the point of logistics – full application of such a system in conditions of "Bobrek-Centrum" mine requires to handle over 1000 units of personal identifiers.

Thus further development is necessary to achieve a sufficient reliability of the WLAN personnel tracking devices, and to design them in a way allowing their integration into cap lamps for logistic reasons.

Another research need following from the OPTI-MINE results, is seen by AITEMIN in the direction of implementing modular control systems with small footprint, in order to facilitate the penetration in emerging countries markets. As a consequence, this topic was included in the M-SMARTGRID proposal, which is now an ongoing RFCS Project.

Exploitation and dissemination outside the project consortium

The industrial coal producers exploit the results within the mines involved in the project and partly in other mines of their company. Exploitation at other mining companies can be achieved via the technology and engineering providers MineTronics and Aitemin. This includes the items listed below. The successful demonstration of the process optimisation by the IC-network and applications within OPTI-MINE is essential to make the exploitation and dissemination of the technology in the mining industry possible.

- International marketing activities, further publications and presentations.
- Product demonstrations at potential customers and conferences.
- Current and future commercial projects at mining companies.
- Development of new products (e. g. software package MineOPT-MRP).
- ATEX certification and commercialisation of the novel belt skew sensor.
- Design of derivative products of reduced costs and functionality, in order to ease their penetration into other markets, e. g. oil and gas market.

First results of these exploitation activities are already existing. For example MineTronics developed, based on the project results a mine resource planning software, called MineOpt-MRP. It is now commercially offered to the mining industry and commercial projects are planned (see below).

Furthermore, MineTronics is entering into a strategic partnership with a worldwide leading coal mining machine manufacturer. Confidential negotiations are ongoing. They also won a new client in Poland, who is a mining machine manufacturer working in close cooperation with KGHM. A further prototyping project was agreed with a German salt mining company (Südsalz). This project includes parts of the OPTIMINE achievements as e.g:

- Information preparation and collection on field machines
- Information exchange via IREDES standardized formats
- Use of the above ground server systems
- Use of the MineOpt-MRP for optimized dispatch and management of the underground operations.

This prototyping project disseminates the project results directly to a non-coal mine showing that the results of the project are transferrable, which in turn is an important precondition for marketing the project results successfully to any kind of underground mining operations inside and outside the EU.

MineTronics intends to carry out further marketing activities in Chile, Norway, Sweden and Canada. First requests from China are already being served via partners.

After the project period, results have been presented at the KOMTECH conference in Zamek Kliczkow, Poland in Nov 2014 and at the APCOM, in Fairbanks, USA, May 2015.

However, the ongoing general shutdown of underground coal mining in Western Europe reduced substantially the size of the current markets for the products demonstrated and developed in OPTI-

MINE. Therefore, AITEMIN exploitation efforts were also focused on external markets. The activities were initially focused on the "natural" markets (Latin America), with presence in fairs in Colombia, Chile and Peru. However, the current situation in the commodities markets, with very low prices for oil, gas and coal, did freeze investments in the target markets for a while, and no fruitful outcome is expected in the short term.

In addition, marketing efforts were made in India and other emerging countries, including an strategic partnership with a manufacturer and systems integrator in Eastern Europe, including some bid and tender in non-EU countries. Confidential negotiations are currently ongoing.

All the exploitation activities mentioned above are only possible due to the results and experience gained within the OPTI-MINE project. The KPI examples of the project have demonstrated in an extraordinary form the impact and benefits arising from the use of ICT at the participating partners. The industry forums performed, showed interest from the industry, however – despite the involvement of mining media – the possibilities and resources for professional marketing related dissemination within the project were limited. In order to intensify the dissemination to the mining industry in general, potentially together with other results of the RFCS programme, more concentrated dissemination activities are recommended covering mining ICT trainings for management positions as well as for the operational engineering level together with presentations on national and international conferences as well as a close cooperation with mining media with these events. MineTronics is striving for participating in this kind of dissemination activities.

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5 List of Acronyms and Abbreviations

ATEX	**At**mosphere **Ex**plosible (series of EC directives related with explosive atmospheres)
AWL	Alfa Wireless [cap]Lamp, a trademark of Adaro Tecnología S.A.
Asterisk	A communication applications software (www.asterisk.org)
Bluetooth	Ad-hoc wireless network standard
BCom	A communication device produced by Becker Mining Systems (www.becker-mining.com)
BZE-40	An Ethernet to ZigBee bridge based on MP-40
DIGICOM	Digital INTERCOM using RELIA fieldbuses for digital voice transmission
EMR-AV	Estación Maestra RELIA - Alta Velocidad (RELIA Master Unit – High Speed)
FO, FOC	Fibre Optic, Fibre Optic Cable
HTML	Hypertext Markup Language
H&S	Health & Safety
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers (issues standards)
INTERCOM	Intercommunication station
IP	1. Internet Protocol, 2. Intellectual Property
IPR	Intellectual Property Right
IREDES	International Rock Excavation Data Exchange Standard
i.Roc	An ATEX PDA model
ISI	Information System for Identification
KPI	Key Performance Indicator
LAN	Local Area Network
M1, M2	ATEX certification classes
MIC	Mining Infrastructure Computer
MP-40	MonoPlaca Mod. 40, an Atex single board microcomputer for protocol bridging, having additionally Analog+Digital input / output capabilities (Designed and made by AITEMIN)
OLE	Object Linking and Embedding
OPC	OLE for process control (standardised software interfaces between SCADA and PLCs and other physical devices)
PBX	Private Branch Exchange
PDA	Personal Digital Assistant
PLC	Programmable Logic Controller
PoE	Power over Ethernet (A method for powering network devices through the Ethernet cable.)

RELIA	The trademark under which AITEMIN Atex underground Control Systems is commercialized. It stands for Red Local de Instrumentos Avanzados, Advanced Local Network of Advanced Instruments. Uses a Master (EMR-AV, see above) /Slave (UCR-AV, DIGICOM) technology, in which Master and Slaves are connected through an Intrinsically Safe Fieldbus.
RELIA-AV	RELIA+Alta velocidad (RELIA+High Speed) An improved version of RELIA in which data transmission between Master and Slaves is improved at least by a factor of 10
RFID	Radio Frequency Identification
SCADA	Supervisory Control and Data Acquisition (software running in computers for process supervision and control)
SICS	Sistema Integrado de Control y Seguimiento (Integrated Control and Tracking System). A personnel location and tracking system manufactured and sold by Adaro Tecnología S.A.
SIP	Session Initiation Protocol (One of the protocols used for negotiating calls in VoIP telephony)
SMF	Single-Mode Fiber (monomode optical fiber, or unimode fiber)
SPS	PLC (German: Speicher-Programmierbare Steuerung)
TCP/IP	Transmission Control Protocol / Internet Protocol
SW	Software
UCR-AV	Unidad de Control RELIA (RELIA Slave unit). A data collection and control device with 4 universal Input / Output ports.
UPS	Uninterupted Power Supply
VLAN	Virtual Local Area Network
VoIP	Voice over Internet Protocol
WinCC	Windows Control Center (A SCADA developed and sold by Siemens A.G.)
WLAN	Wireles Local Area Network
XML	Extensible Markup Language
Woelke	Manufacturer of industry electronics (www.woelke-gmbh.de/)
ZigBee	A low-cost, low-power, wireless mesh network standard, in turn based on IEEE802.15 standard.

6 List of References

There are no references mentioned in the report.
Publications made by the beneficiaries are listed in WP8.

7 Appendices

Further information and details

WP2, demonstration at a mine of RAG-A (DE)

Task 2.1- Network Infrastructure (RAG-A, MT, Aitemin)

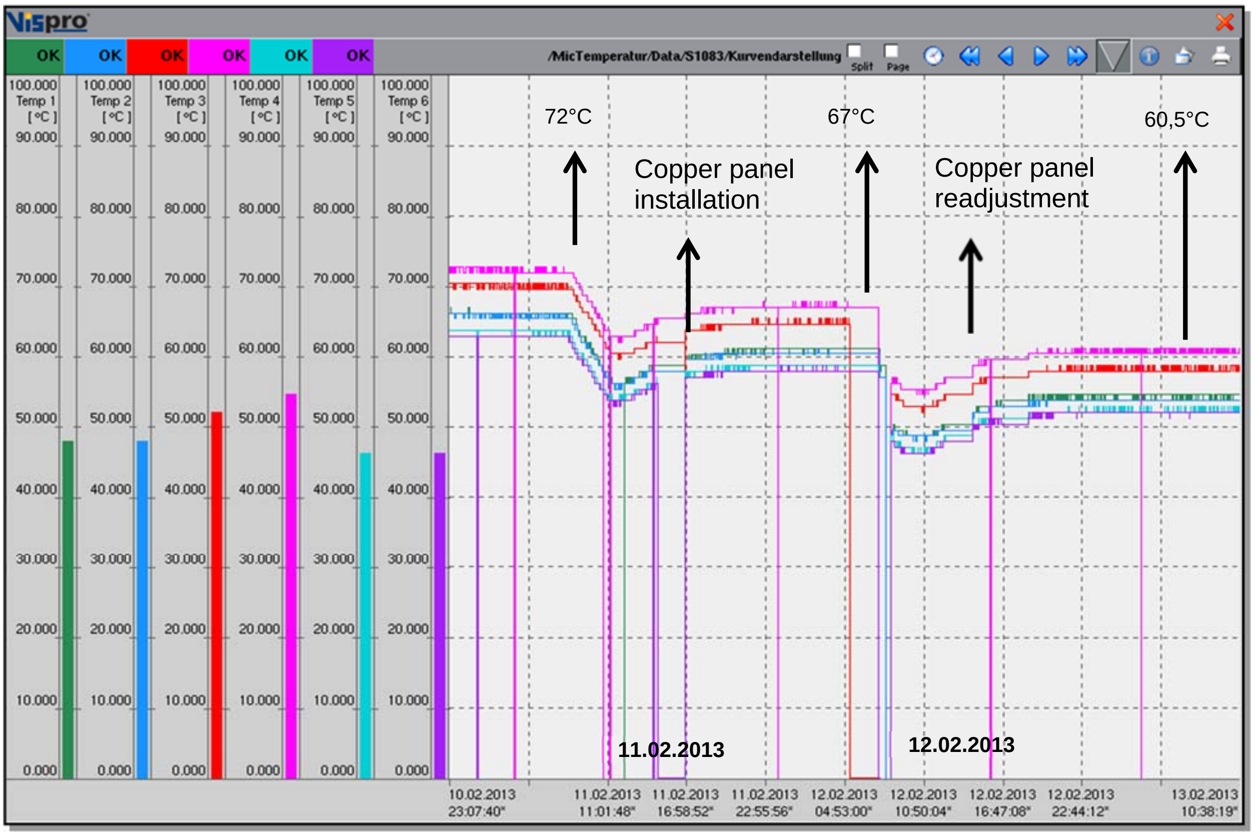

Figure 1: Temperature course MIC after installation of copper panels

Task 2.2 - Optimisation of material logistics (RAG-A, MT)

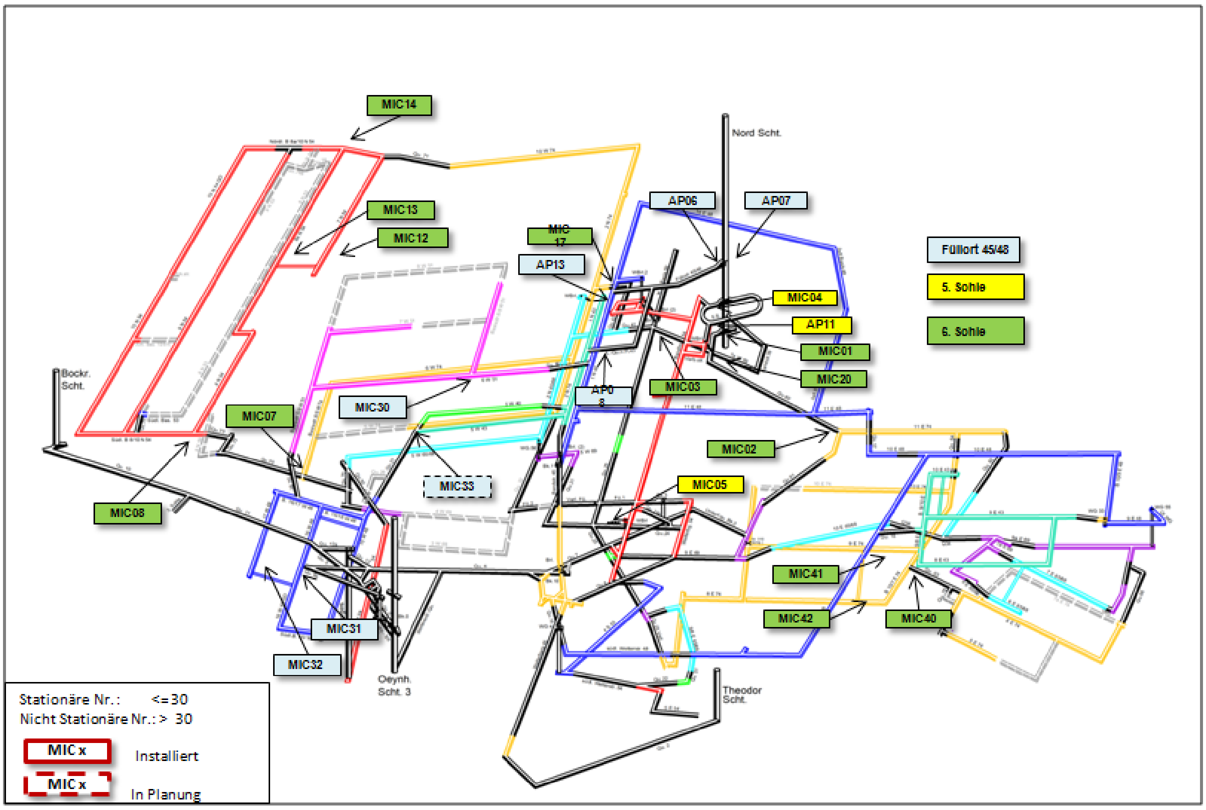

Figure 2: Accesspoints / MIC's (RFID-reader) positioning

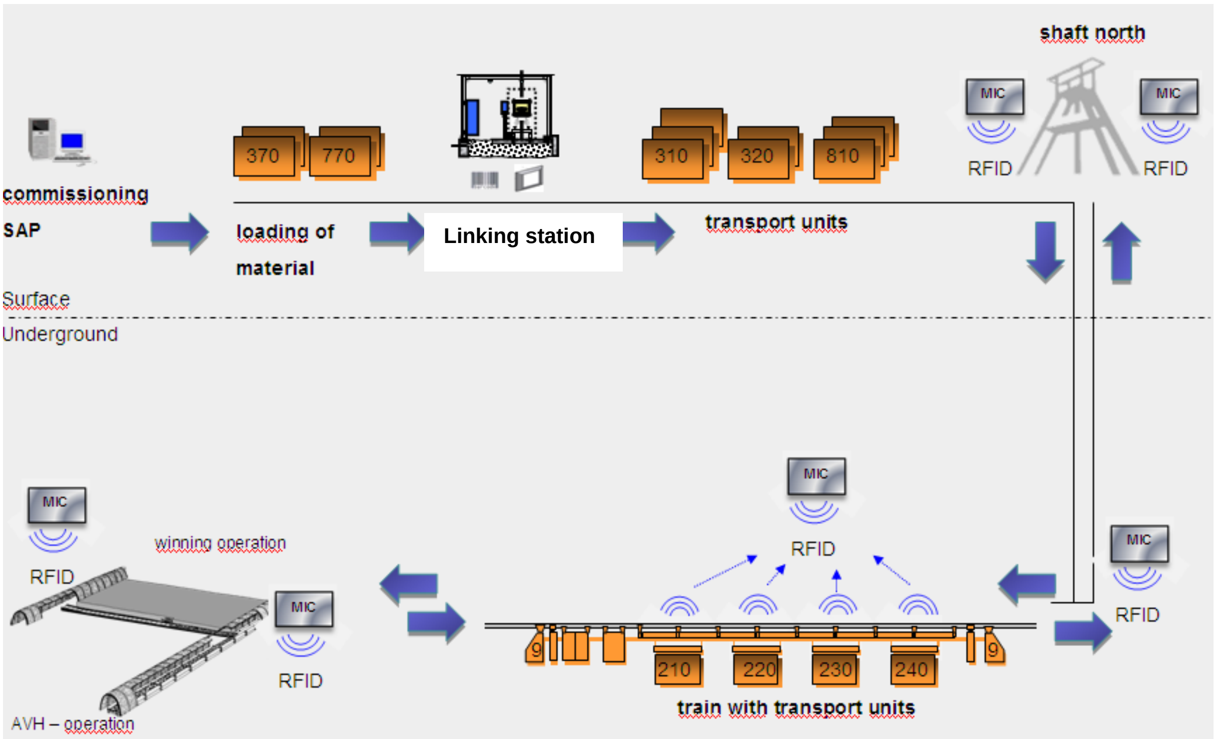

Figure 3: Container tracking

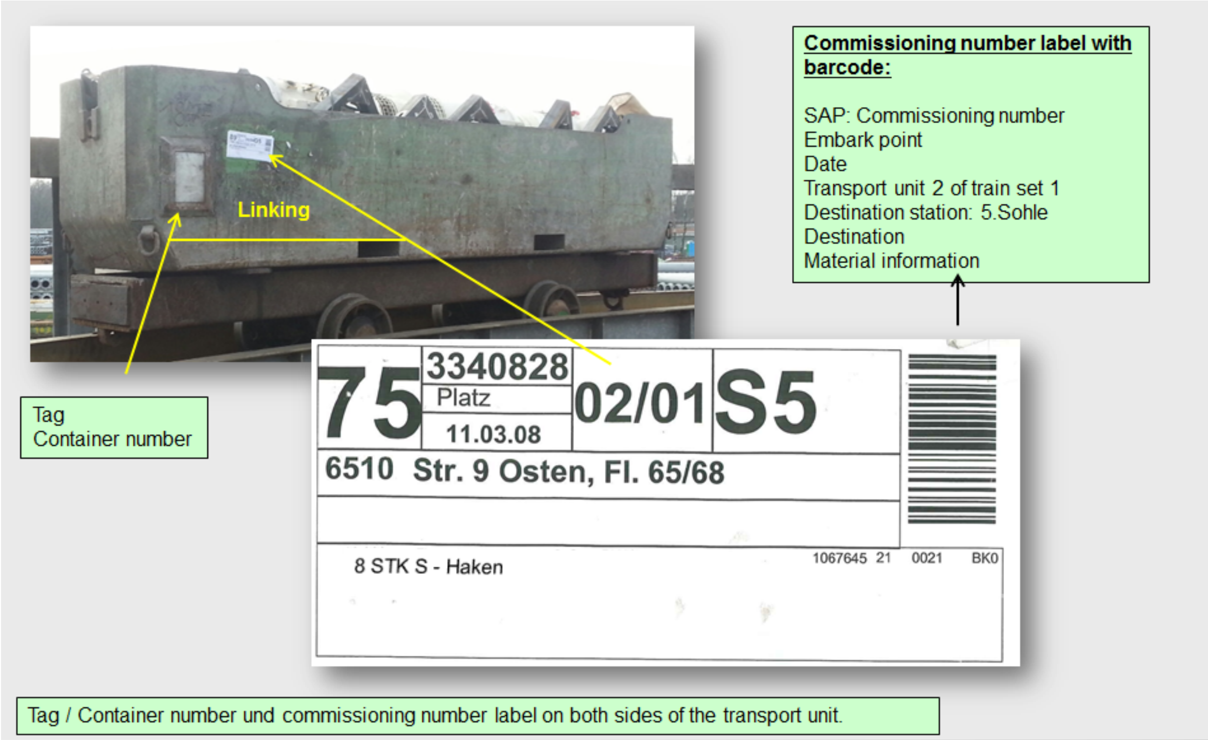

Figure 4: Transport unit and commissioning number label

Figure 5: Linking station – exterior view

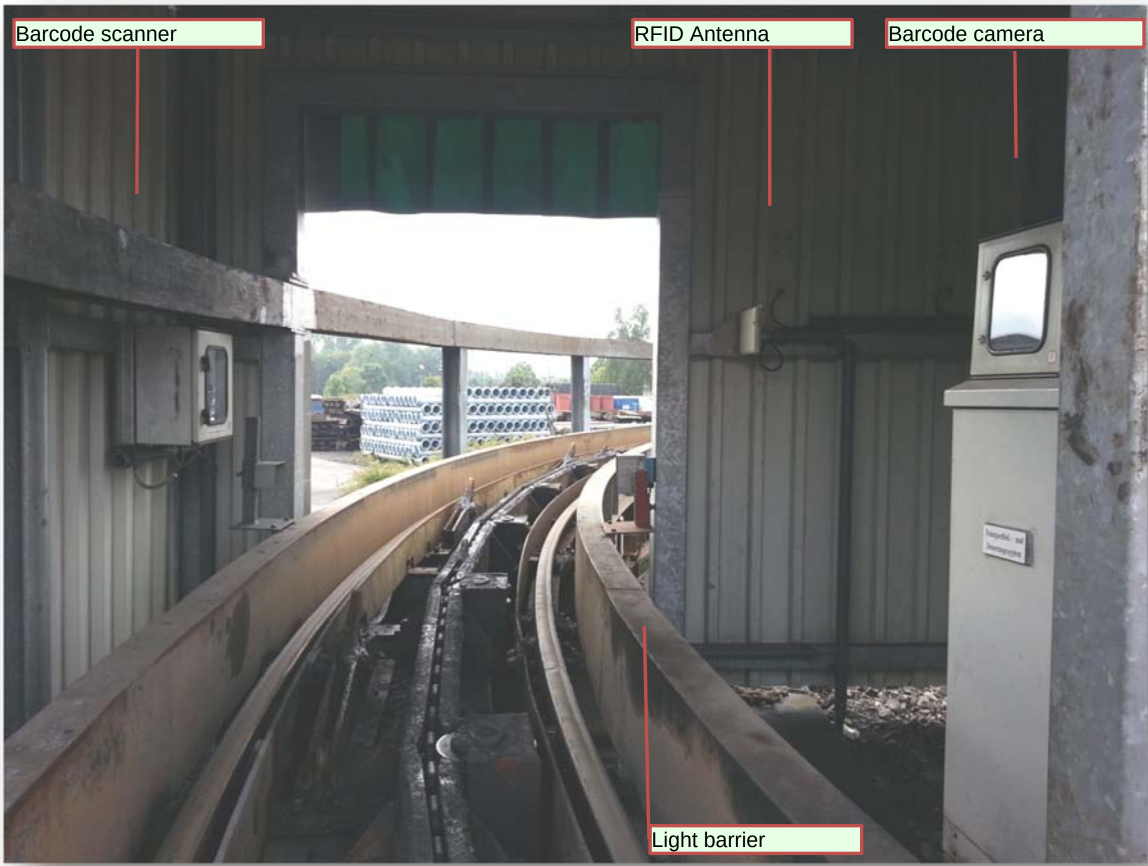

Figure 6: Linking station – interior view (after technical optimisation)

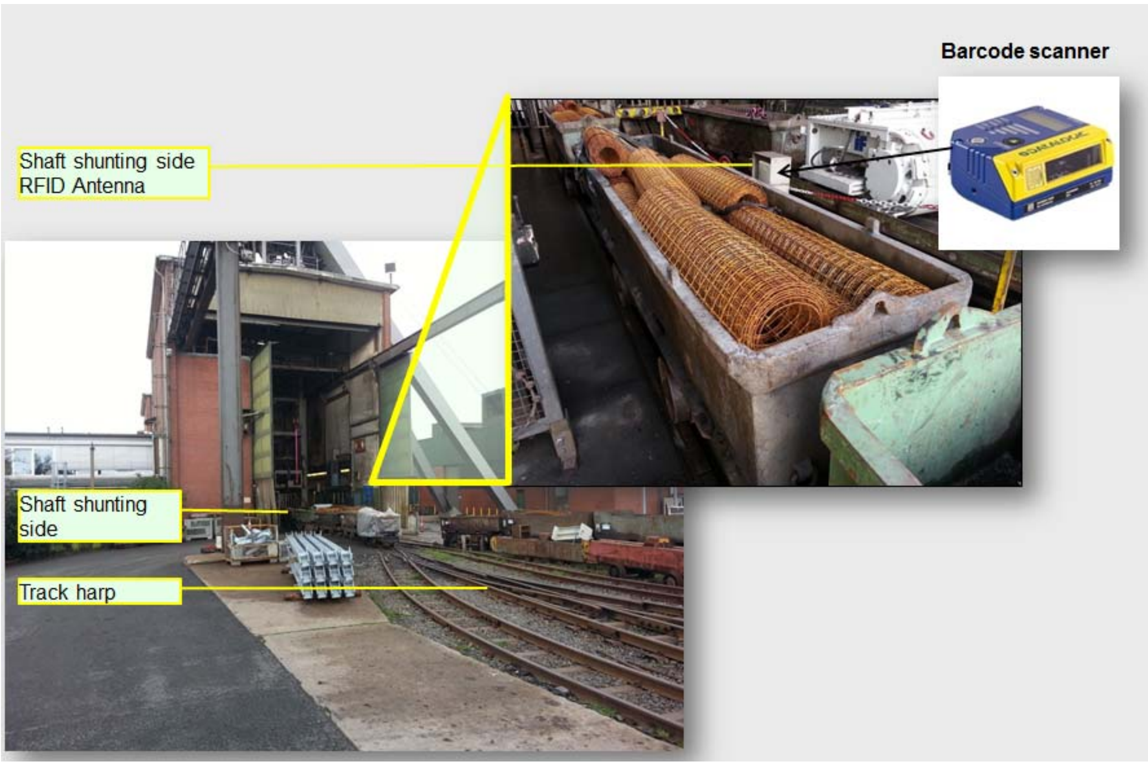

Figure 7: Linking at the shaft shunting side

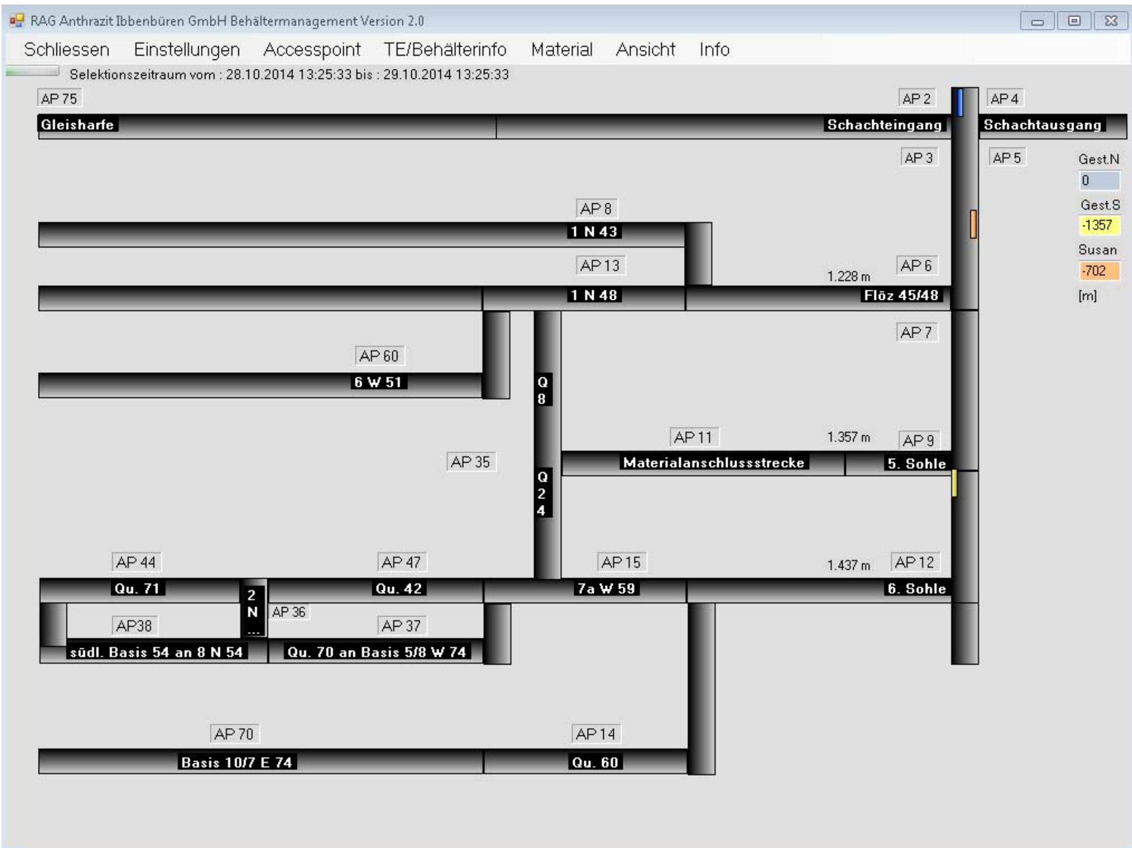

Figure 8: Container tracking / management

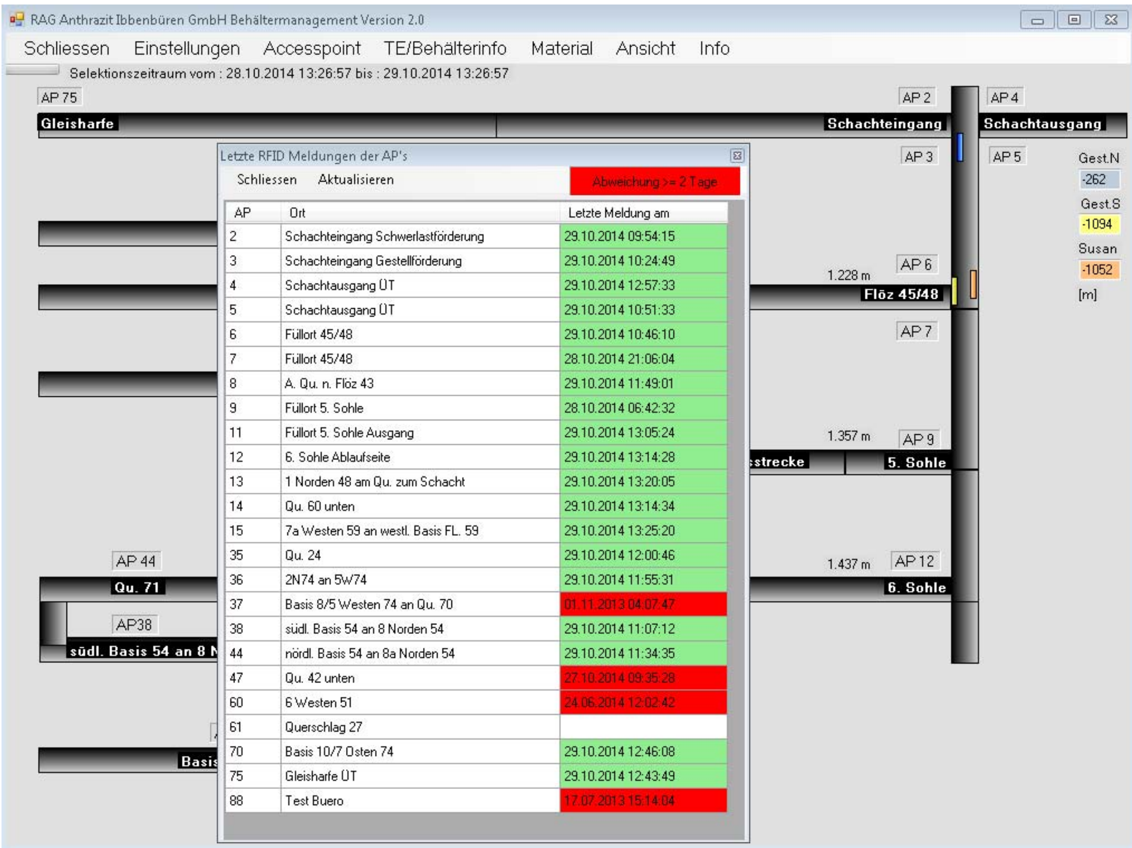

Figure 9: Access point scheme

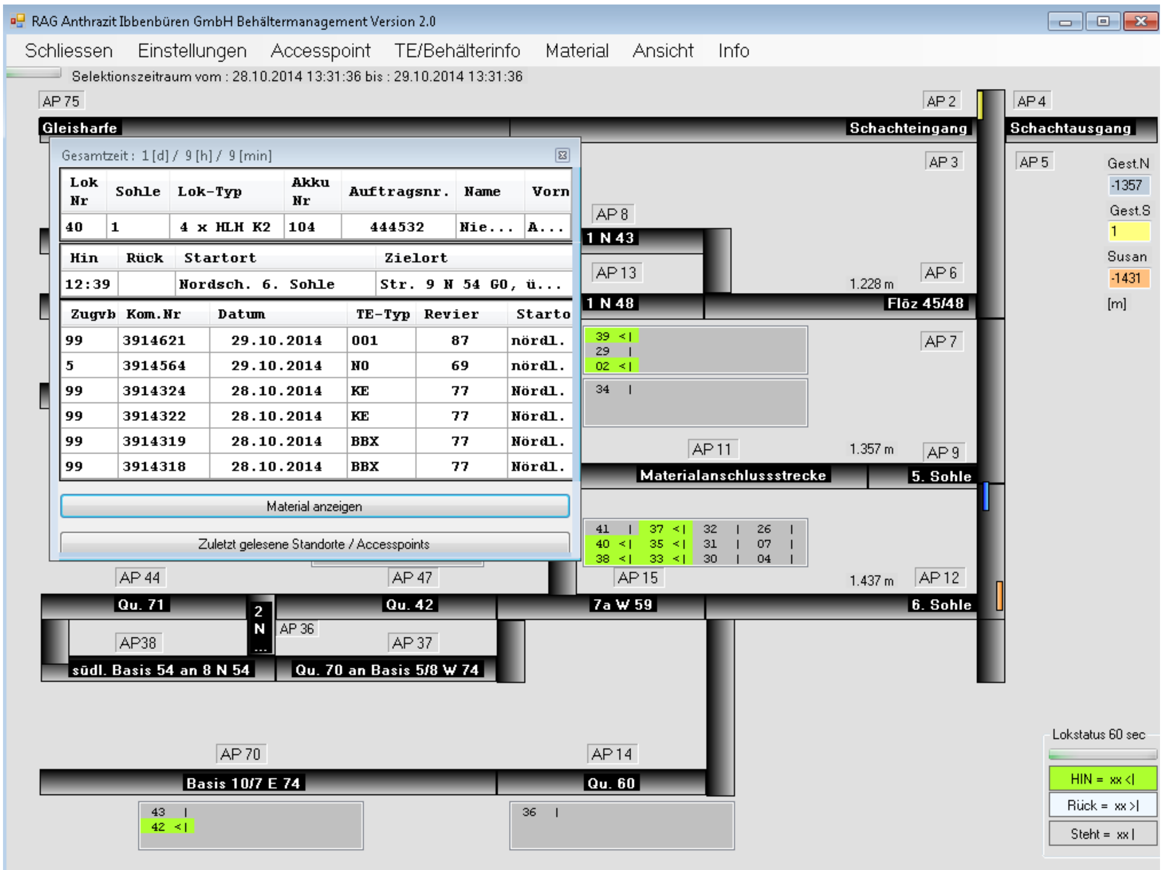

Figure 10: Current loco information with transport units

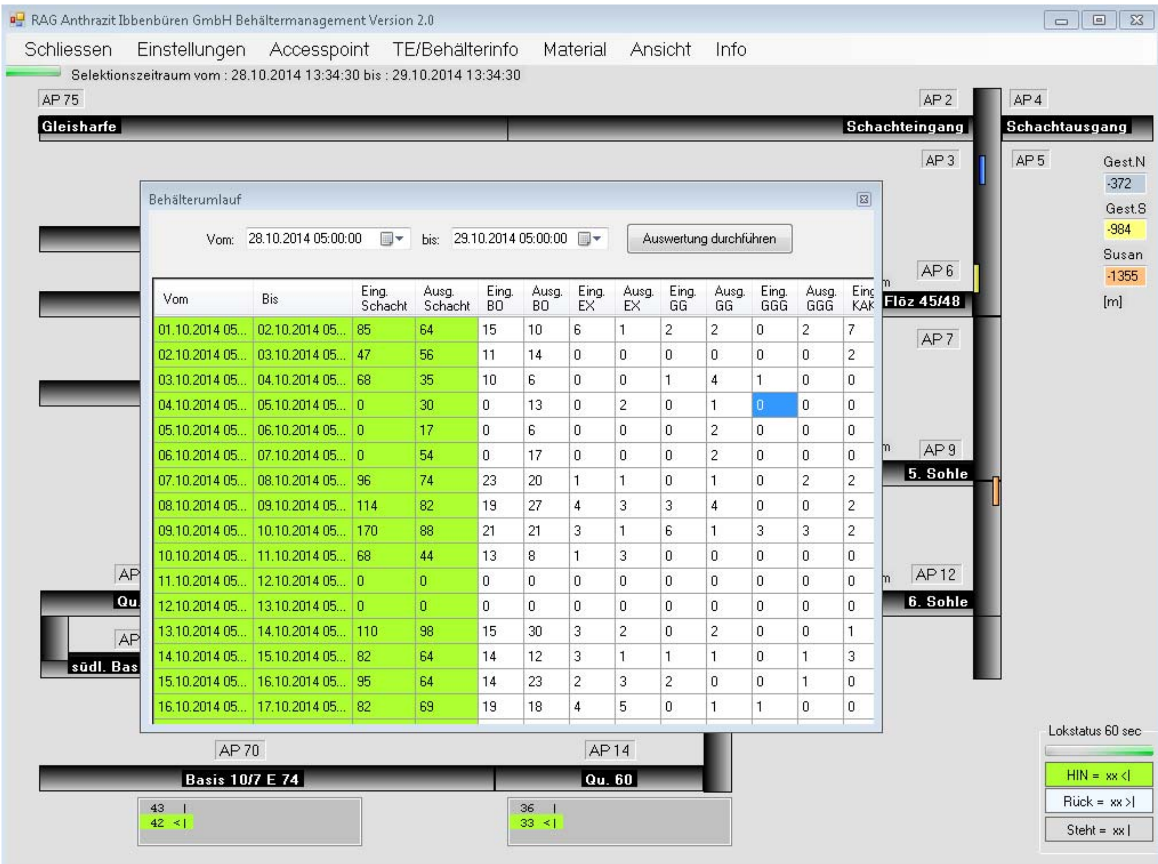

Figure 11: Container cycle shaft entrance / exit

Task 2.3 - Personnel communication and information (RAG-A, MT)

Figure 12: TS4 Intranet

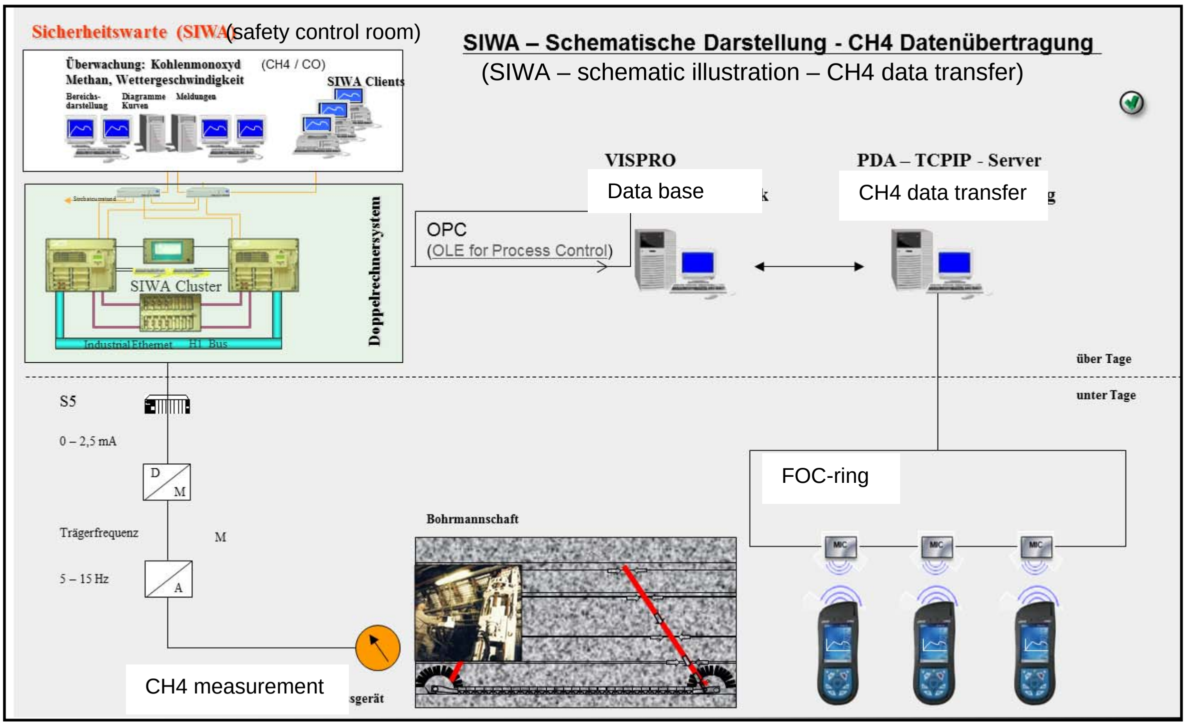

Figure 13: CH₄ data transfer of the safety control room (SIWA)

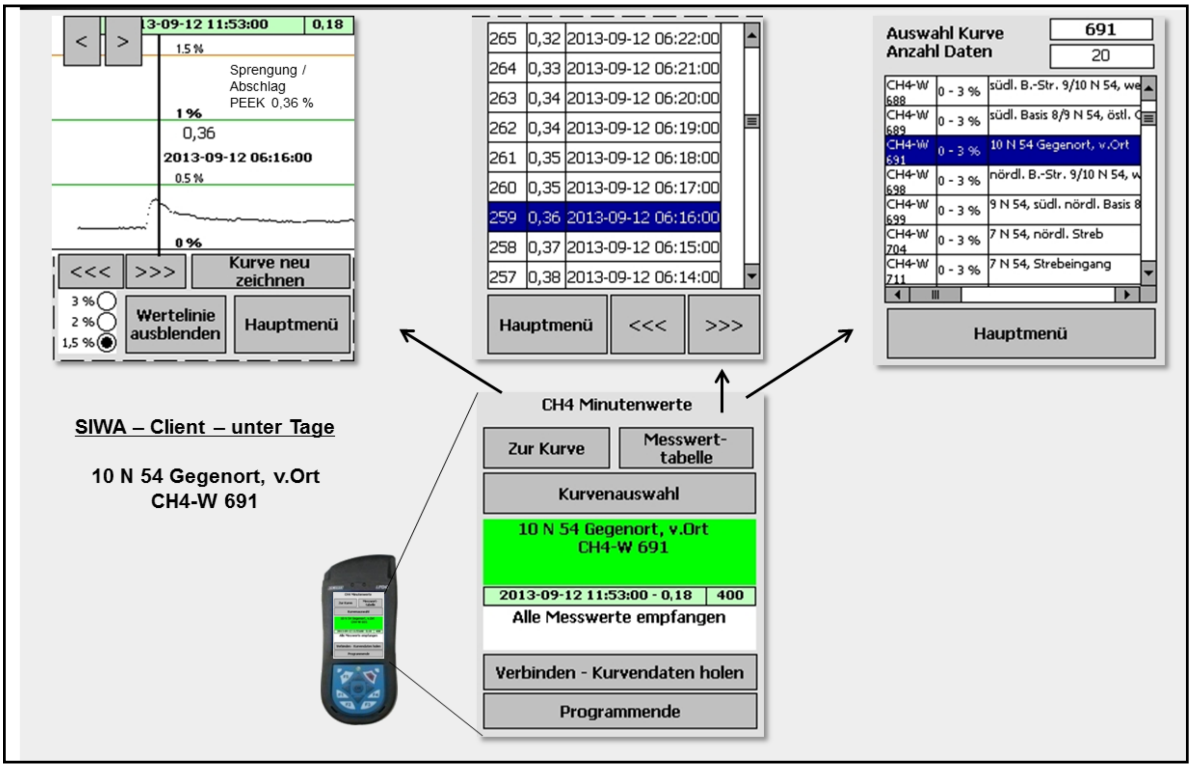

Figure 14: PDA – display of CH4 course

Task 2.4 - Conveyor belt skew detection (RAG-A, MT)

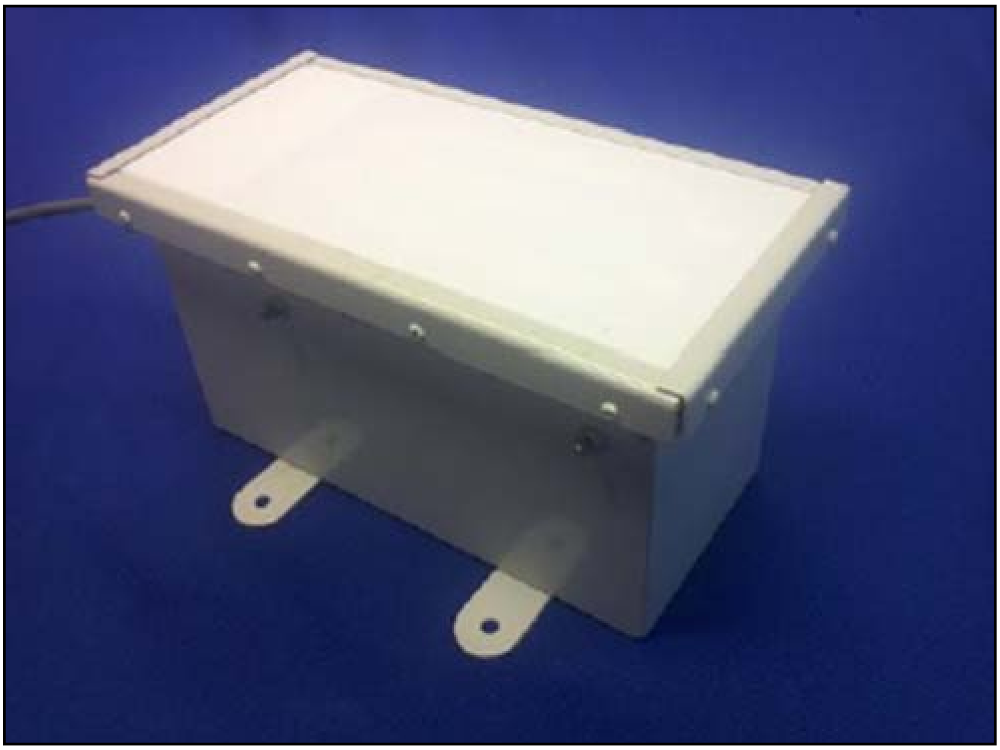

Figure 15: Prototype conveyor belt skew sensor of company MineTronics

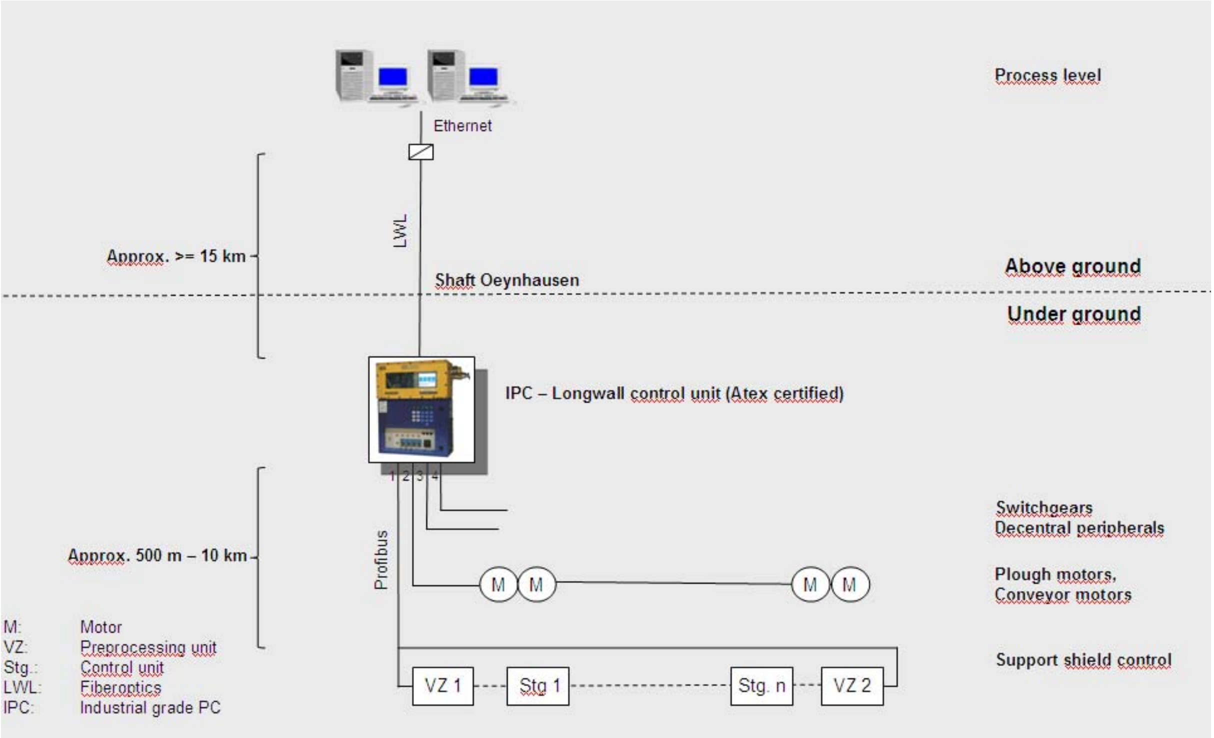

Bild 16: IPC – control underground – longwall installations so far

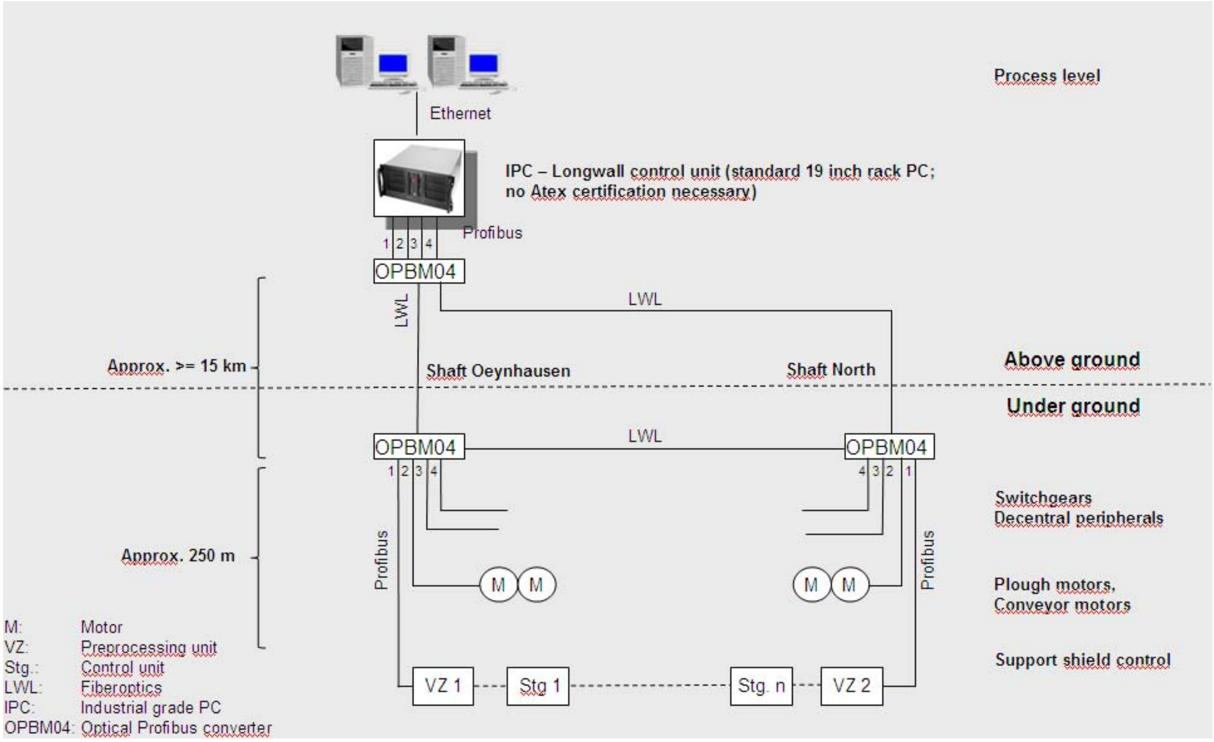

Bild 17: Longwall control on surface – production area 'Beustfeld'

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Tools for central network device operation and remote maintenance were developed by the technology providers. New and existing, wired and wireless components and systems were integrated. Hardware, interfaces, software and firmware were developed, field tested and deployed at the mines (inclusive belt skew sensor prototype). Further activities related to improving, bug fixing and information display on further computers.

The activities at the mines included concept design, equipment procurement, installation, testing, demonstrative operation of network and applications (e.g. personnel information and communication, material logistics, etc.), optimisations, extensions like visualisation and integration of further components and software. Experiences were gained and information for the performance assessment was generated and provided.

Key performance indicators (KPI) for all five mines and an assessment methodology were agreed. The data to be collected from the operations were specified and after receipt analysed by the scientific partners. KPI's were calculated for both cases, without and with the new ICT for process optimisation. Information for assessment of additional criteria like safety, health and environment were collected and assessed as well.

As dissemination activities, three OPTI-MINE Industry Forum events were conducted, many publications at conferences and in a professional magazine were made, a study and a handbook produced and a website (www.opti-mine.de) was set up.

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