



China Coal Group Dahaize Coal Mine 5G 700 MHz + 2.6 GHz Integrated Network Project



With the accelerated construction of smart coal mines in China, Dahaize Coal Mine adheres to the principles of safe production and high standards and strives to fulfill our responsibilities as a state-owned enterprise. We aim to become a benchmark for smart mines and a leader in the coal industry, and establish a reputable brand image of "smart company" for China Coal Group.

Zhu Wenliang

Party Secretary and Executive Director of China Coal Group Shaanxi Company

合作单位



Case Overview

Dahaize Coal Mine Project operated by China Coal Group Shaanxi Company is an auxiliary mine for coal chemical projects under China Coal Shaanxi Yulin Energy and Chemical Co., Ltd., a key pillar of the Inner Mongolia-Shaanxi 100-million-ton coal base built by China Coal Group, and one of the first batch of 71 demonstrative smart coal mines approved by the state. Located in western Yuyang District of Yulin City of Shaanxi Province, this project has a construction capacity of 15 million tons/year with a service life of 157.7 years. The total investment is estimated at RMB 12,979 million.

In July 2021, Dahaize Coal Mine completed the 5G 700 MHz + 2.6 GHz integrated network, becoming the first in the industry to realise VoNR high-definition videophone business. Currently, this project offers intelligent mining system, intelligent coal selection plant, intelligent auxiliary production system, and intelligent platform construction system to realise full-coverage 5G VoNR communications and cloud-network integration. It pioneers the construction of "control over one network" based on a new type of cloud-network architecture for coal mine.

Liu Daoyuan, Deputy General Manager of China Coal Technology Engineering Group Mine Intellectualisation Co., Ltd. said that in China's coal sector, the application of 5G technology has been plagued by

such issues as low coverage of conventional frequency bands and high costs. As one of the first batch of 71 smart demonstrative mines in China, Dahaize Coal Mine has innovatively adopted the 5G 700 MHz + 2.6 GHz integrated network to realise full coverage of 5G signals in the coal mine, both above-ground and underground. The overall network architecture and the transmission jitter and stability all outperform the traditional 5G single-frequency network. The better Quality of Service(QoS) for intelligent applications, such as 5G VoNR, mining, transportation, and "ventilation and safety". and lay a solid foundation for establishing intelligent application system clusters and promoting high-quality development of coal mines.



Industry Challenges

In March 2020, eight ministries including the National Development and Reform Commission of China jointly released the Guiding Opinions on Accelerating the Smart Development of Coal Mines, pointing out that "the smart development of coal mines provides a core technical support for high-quality development of the coal industry". The intelligent operation of fully-mechanized mining, exploration, transportation, ventilation, dressing by washing, safety protection, and management is of great importance to enhance coal mining safety and stabilise the supply of coal.

However, intelligent production in coal mines faces many challenges, including:



5G+ Smart Mining

High risks to personal safety and high accident rates

Safe production is a top priority in smart coal mining. Taking into consideration the key issues such as high concentration of gases, ashes and dusts, flooding and seepage hazards in underground mines as well as long working hours and heavy workloads for miners working underground, it is necessary to effectively reduce the number of miners working underground and cable deployment to achieve intelligent and safe production.

Incapacity of transmitting sufficient data

Working face visualization is a key condition to realise intelligent mine operation as Wi-Fi and 4G networks are incapable of supporting video-driven smart mining. Moreover, the traditional bearer network fails to realise business segregation, making it impossible to meet differentiated business requirements on video, controls, and communication.

Difficulty in business integration due to excessive production and management systems

Smart mining require a shift from a single-system approach towards coordination of multiple systems. As coal mine business runs a large selection of subsystems (more than 20 in the case of fully-mechanized working face) that operate separately from each other, It is difficult to realise business integration and operation and maintenance management.

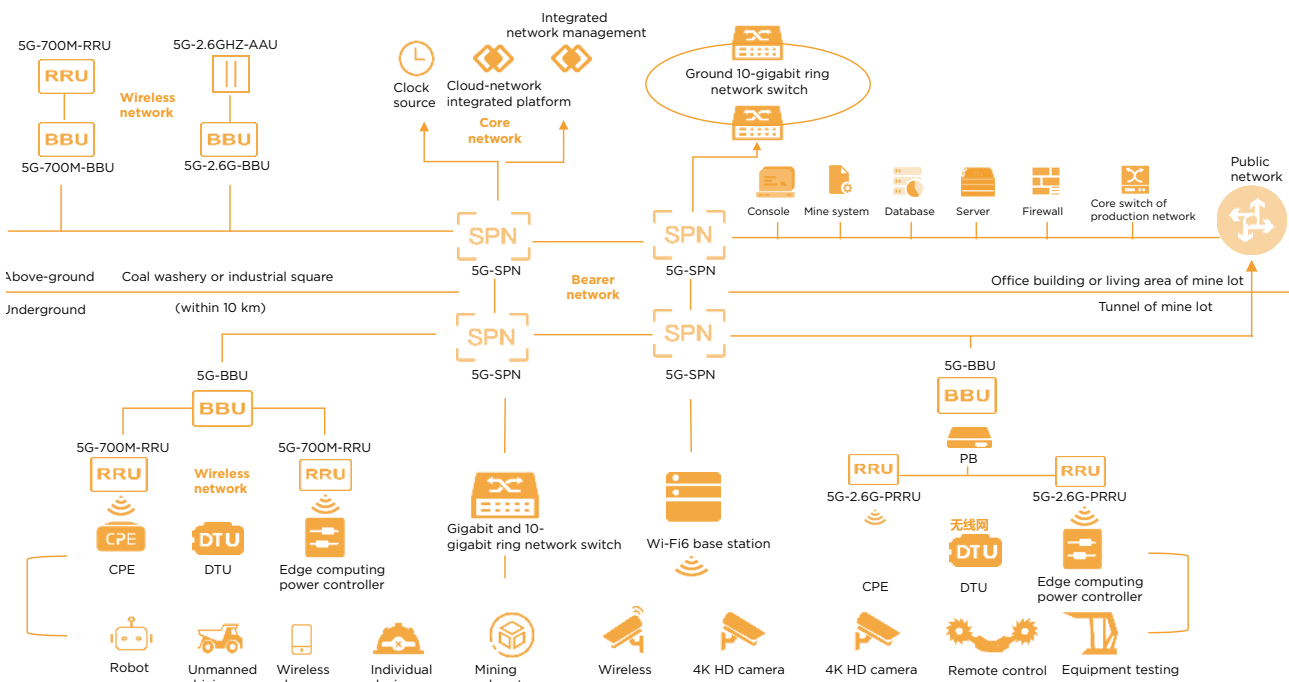
Low universality of "5G private network 1.0 version" and difficulty in large-scale application

As the current 5G private networks are typically of a single frequency, we face many challenges in large-scale application, including: higher construction cost of 5G network and difficulty in realising 5G full coverage in complex scenarios such as mining face, turning, uphill/downhill, undulation and blind side; data from underground industrial control ring network, video surveillance ring network, and safety monitoring ring network are independent from each other, which requires centralized bearing to enhance stability and operation and maintenance efficiency; and lowering MEC capacities alone cannot address the conflicts between overall digital transformation and fragmented requirements, which requires deep integration of 5G and key coal businesses driven by the new type of cloud-network architecture.

Solutions and Benefits

The application of a 5G cloud-network integration platform and the combined use of 700 MHz & 2.6 GHz frequency bands in Dahaize Coal Mine facilitate the development of the intelligent application system cluster for coal mines. In this plan, the 700 MHz base station (underground RRU) only accesses the core local private network (cloud-network integration platform) to offer 5G private network coverage. The 2.6 GHz frequency band base station (pRRU) uses MOCN to access the core local private network, and at the same time the operator's core public network to offer two types of 5G coverage, public and private.

5G 700 MHz and 2.6 GHz integrated network is the 2.0 version plan for the coal mine private network, where a new integration mode, an innovative base station with built-in safe features, and a new cloud-network architecture are used to promote the smart development of Dahaize Coal Mine, changing the "tough, tiring, and dirty" working condition of coal mines.



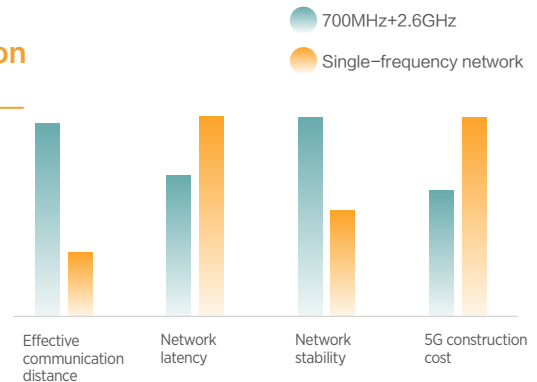
01 New networking mode that effectively reduces network construction cost and enables agile connection with the dispatching system

1 The first in China to adopt 700 MHz & 2.6 GHz integrated network for network coverage

When the edge uplink throughput of a single 5G 700 MHz base station exceeds 10M per user, the coverage reaches 1,600-1,800 meters; the latency is lowered by 35% and the stability performance is improved by 45% over the conventional 5G single-frequency network; and the 5G construction cost is reduced by more than 40%. Thus, small- and medium-sized coal mines can develop 5G + smart mines with acceptable investment, addressing the high cost and construction difficulty associated with 5G 1.0.

2 The first underground 5G VoNR, breaking the bottleneck of 5G network dispatching

Based on new networking, a seamless connection between the private network and the public one is realised. Miners in the underground are able to use mobile service of China Broadcasting Network Group to communicate via the private network with internal lines above-ground, and communication with subscribers of public network above-ground is also supported. Selective call, emergency call, full call, forced insertion and forced disassembly, among other functions, are supported via connection with the dispatching system. By using a single phone card, miners can work more efficiently and keep connection with loved ones outside of the coal mine, effectively addressing the issue in underground dispatching in the age of 5G 1.0.



02 The first 700 MHz Intrinsic safety base station in China, enhancing network safety

In complex underground conditions in coal mines, there is limited space for equipment installation. Based on the accumulated project experience, a 700 MHz base station with built-in safe features was jointly developed. This product uses native Electric Explosion Protection measures to enable safer features, so the safety of 5G network is intrinsically enhanced. Compared with common explosion protection equipment, it is smaller in size (80% smaller) and lighter in weight (3 kg/4 L, 90% lighter). No explosion proof box is deployed for underground projects, with no spark risks, lowering project cost by 60%. Super diffraction and anti-interference performance enables 5G full coverage at a single station on the mining face, totally eliminating the need of setting cable network on the mining face. Full coverage of 5G network underground at a low cost is realised and network construction cost is greatly reduced.

03 New-type cloud-network architecture that addresses conflicts between centralized management and agile innovation of business lines

The first to use "three-in-one" hard segregation sliced network based on cloud-network architecture in China

Centralized bearing of industrial control network, video surveillance network, and 5G bearing network enables flexible bandwidth adjustment based on needs. The minimum bandwidth can be sliced to 10M. One-stop bearing of underground networks reduces the investment by 60% and moves underground cable maintenance to the backend, which significantly saved manpower cost and enhance operational efficiency and safety.

The first to use "three-tiered resilient computing power architecture" in China

By empowering smart and unmanned coal mining, we promote deep integration of intelligent applications in coal mines. Cloud-network integrated architecture not only sustains 5G performance, but also provides backward compatibility with existing industrial ring networks of the mine. It also supports integration with wired and wireless networks such as WiFi6, IoT, and 4G. Furthermore, edge computing controller, CPE, DTU and other fog computing powers are used to empower 5G applications on the -edge and terminal. Issues such as difficulty in integrating with overall mine businesses, information silos, and inconsistent standards are solved.



04 Multiple applications on fragmented supply issue to promote deep integration of 5G and industry

1 Robot system cluster

Electromechanical chamber (central power distribution room and central pump house) and main haulageway are equipped with 15 sets of 5G mobile inspection robots to enable real-time backhaul of super HD video, audio, and infrared imaging data from on-site devices as well as early detection and pre-warning of device failures. Robots are equipped with multiple parameter sensors (CH4, O2, CO, temperature, and humidity), dual-spectrum PTZ camera (visible light 2 MP, infrared thermal imaging 640 x 512), pickup intercom, and two obstacle-avoidance lidars, and support 5G dual-frequency transmission. Inspection devices are built with 5G modules, which can communicate with the base station set in the chamber via the 5G wireless network. On the surface, a remote control station is in place to enable remote controls based on data transmitted to the surface via the 5G industrial network.

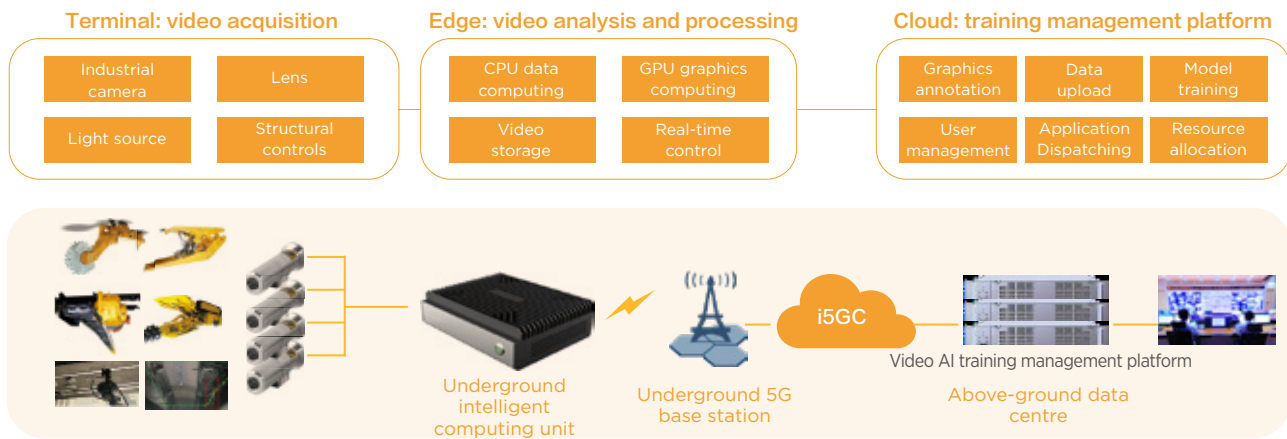


over the fully-mechanized mining face, abnormality detection on the main transport belt, personnel behavior monitoring, regional access management, intelligent control of air doors, electronic seal, hoist head and tail rope detection, AI identification of coal selection plant, and underground intelligent traffic control, among other AI-assisted functions.

2 5G + underground video AI analysis

The overall design of the underground video AI plan is based on cloud-edge-terminal coordination. The terminal side collects videos and upload to the edge side, and receive control commands from the edge side. The edge side conducts video analysis and reasoning. Then, it reports the analytical results to the cloud management platform, and sends control commands to the terminal side (such as control access and control belt). The cloud side performs algorithm training with training and management functions, delivers trained models to the edge side, and manages and dispatches intelligent computing units on the edge side. This deployment mainly realises intelligent supervision

Based on the 700 MHz & 2.6 GHz integrated network, multiple applications including the 5G + drone for coal mines, unmanned driving, automated transport, remote industrial control, unmanned mining, precise personnel positioning, and robot system cluster have been realised. Currently, the project has reduced manpower from 4 shearer drivers, 6 hydraulic support workers, and 5 clearance staff to one remote control personnel and one safety inspector. The establishment of 5G robot cluster with 15 robots has contributed to 12 intelligent inspection and collection subsystems and 20 unmanned positions, reducing 90 personnel while cutting coal cost by RMB 12 per ton and labour cost by RMB 20 million per year.



Solutions and Benefits

With the joint efforts from China Coal Group Shaanxi Company, China Coal Technology Engineering Group Mine Intellectualisation Co., Ltd. ZTE Corporation, China Broadcasting Network Group, China Mobile, and China Coal Information Technology (Beijing) Co., Ltd., the 700 MHz & 2.6 GHz integrated network has been successfully developed. Under the condition of an uplink edge speed of 10 Mbps, the integrated network is capable of realising enhanced coverage and effect of 5G network when tunnels use 700 MHz, with effective actually-measured coverage of 1,600-1,800 meters, which is 4-6 times that of conventional base stations. Overall, the solution has reduced the production cost,

creating economic benefits and practical value for the mining sector. This project marks the first successful application of 700 MHz & 2.6 GHz integrated network technologies in China's coal industry.

We will continue to develop 5G virtual interaction application, robot cluster, unmanned driving, intelligent wearables, intelligent inspection, shearer, and intelligent tunneling machine for China Coal Dahanzi Coal Mine, further promote the integration of new 5G infrastructure and Industry 4.0, and provide key support for comprehensive reform and digital transformation in coal mines.