



5G RedCap Case Studies

Smart Grid | Smart City | Smart Manufacturing

GSMA

Contents

Foreword

01 Part I Smart Grid

02 State Grid Shandong Advances 5G RedCap Large-scale Commercialization to Facilitate Building New Power Systems

05 State Grid Henan Promotes 5G RedCap Terminals

08 Tianjin Huadian Completed Commercial Verification of 5G RedCap Smart Power Plant

11 Part II Smart City

12 5G RedCap Environmental Monitoring by Shenzhen Nanshan District Ecological Bureau

15 Shenzhen's 5G RedCap + AI New Model for Waste Classification Supervision

18 5G RedCap Smart Parking by Zhengzhou Public Utility Investment Development Group

21 5G RedCap Smart Parking in Deyang of Sichuan Province

24 5G RedCap Unmanned Farm in Jiading of Shanghai

28 Part III Smart Manufacturing

29 5G RedCap and 5G-Advanced Private Network Integration Helps Baoshan Iron & Steel Go Digital

31 5G RedCap Empowers Safety Production at Yunnan Shenhua Aluminum

33 5G RedCap Empowers Safe and Efficient Production in the Chemical Industry

37 The Application of 5G RedCap at Midea's Kitchen Heating and Dishwasher Factory

39 Guangdong Brunp Recycling's Full-Chain Zero-Carbon Smart Factories Based on 5G Private Network and 5G RedCap

42 Park Security Management Based on 5G RedCap Visual Private Network

45 Summary

Foreword



Sihan Bo Chen
Head of Greater China
GSMA

In recent years, the swift advancement and extensive adoption of 5G technology have introduced a new round of transformation and prospects for the global telecom industry. In this context, 5G RedCap (Reduced Capability, abbreviated as RedCap) has emerged as a key component of 5G technology. Distinguished by its efficient spectrum utilization, low power consumption, and cost benefits, it has begun to shine since its debut in 2024 and is gradually playing a crucial role in a wide range of industries. In my role as Head of Greater China, GSMA, I am truly honored to witness and participate in this pivotal moment and see the important contributions of 5G RedCap to social and economic progress.

The 5G RedCap technology is designed to bridge the gap between conventional 5G and IoT, focusing on application scenarios that require moderate data rates, low power consumption, low costs, and native 5G features like network slicing. In addition to offering new solutions for smart grid, smart city, and smart manufacturing, it also shows great potentials in the consumer electronics domain, including wearable devices, smart home, and smart healthcare. By supporting a wider range of terminal devices and application scenarios, 5G RedCap is providing a powerful boost to digital transformation.

The smart grid sector reveals significant application prospects for 5G RedCap. Smart grid is a crucial direction in the development of modern grid systems, and by virtue of its low power consumption and high-efficiency connectivity, 5G RedCap offers essential support for smart grid construction. With the help of 5G RedCap technology, power companies can monitor and remotely control grid equipment in real time, promptly identifying and addressing faults to improve the reliability and operational efficiency of the grid. Moreover, 5G RedCap also supports the widespread use of smart meters, allowing users to monitor and manage their electricity usage in real time, thereby improving energy efficiency. Meanwhile, in distributed energy management, 5G RedCap can effectively support the access and management of distributed energy sources such as photovoltaic and wind power generation, optimize energy allocation, and promote the development of green energy.

The construction of smart cities is a key aspect of modern urban development, and 5G RedCap plays a pivotal role in this process. By linking diverse smart devices and sensors within the city, 5G RedCap enables real-time monitoring and management of transportation, environment, energy, and other areas. For instance, in traffic management, 5G RedCap can support smart traffic lights, Internet of Vehicles, and autonomous driving technology, thereby alleviating traffic congestion and improving travel efficiency. In terms of environmental monitoring, 5G RedCap can collect and analyze air quality, water quality, noise level and other environmental data in real time, helping governments and relevant departments take timely measures to improve urban environmental quality.

In the realm of smart manufacturing, the utilization of 5G RedCap is undoubtedly revolutionary. Efficiency improvement, cost control, and intelligent transformation present multiple challenges to the traditional manufacturing sector. The 5G RedCap technology, by providing stable and efficient connectivity, enables real-time data transmission and remote control of equipment in factories, thereby significantly improving production

efficiency and reducing downtime. Additionally, 5G RedCap can support large-scale machine-to-machine communication and IoT applications, further enhancing the automation level and intelligence of factories. This not only propels the transformation and upgrading of the manufacturing industry but also establishes a solid foundation for the realization of Industry 4.0.

GSMA Greater China has consistently played an active role in promoting and coordinating the application and development of 5G RedCap technology. Working closely with government bodies, enterprises, academic institutions, and other stakeholders, we strive to promote the formulation of 5G RedCap standards and the application of best practices. By hosting various workshops, technical seminars, and case study exhibitions, we bring the latest developments of 5G RedCap to the industry and share successful experiences and best practices to promote the widespread adoption of 5G RedCap technology. The "5G RedCap Case Studies" report, featuring 14 exemplary cases across the domains of smart grid, smart city, and smart manufacturing, explains the technical advantages and application value of 5G RedCap and envisions its application prospects and development direction.

In the near future, the consumer electronics sector will emerge as the stage for the full display of 5G RedCap technology and facilitate its large-scale expansion. As wearable devices, smart home appliances, smart healthcare solutions and other smart terminals become more prevalent, users are increasingly seeking network connectivity that is efficient, low-latency, low-power, cost-effective, and ubiquitous. With its technological edge, 5G RedCap can offer stable and efficient connectivity services for such devices, thereby enhancing user experience. As an illustration, smart devices such as speakers and door locks can be interconnected through 5G RedCap, making home life more convenient and intelligent. Furthermore, 5G RedCap can support various smart medical devices, such as wearable health monitors connecting to intelligent medication management systems and allow patients to manage their health independently to reduce healthcare costs.

As 5G RedCap technology advances and its application scenarios diversify, we are confident that 5G RedCap will drive further innovation and transformation across the economy and society. It represents not only a new milestone in technological advancement but also a fresh impetus for social progress. We are excited to see the broader adoption of 5G RedCap technology by enterprises and institutions, as they explore novel application models and create enhanced social and economic value.

I want to express my appreciation to all the teams and individuals who contributed to the compilation and release of the "5G RedCap Case Studies" report. Your hard work and dedication have made it possible to disseminate these real-world use cases, providing the industry with valuable knowledge and practical experience. I believe this report will offer crucial references and guidance for driving the development and application of 5G RedCap technology. GSMA is ready to join forces with our eco-partners to collectively write a new chapter in the era of 5G RedCap, making impactful contributions to a brighter and more intelligent future.

June 2024

01

Smart Grid

5G RedCap Case Studies



State Grid Shandong Advances 5G RedCap Large-scale Commercialization to Facilitate Building New Power Systems



State Grid Shandong's 5G RedCap success demonstrates the broad prospect of its application across the industry. The technology not only guarantees security isolation, reliability, and controllability, but significantly reduces terminal costs. With the deployment of 5G smart grids on a larger scale, a new power system can be seen earlier and the 5G technology can be deeply integrated with every industry, creating better benefits for society.

Wang Yong, Deputy Director of Digitalization Department, State Grid Shandong Electric Power Company

SOLUTION PARTNERS



OVERVIEW

In 2021, China Unicom and State Grid Shandong built China's first provincial 5G private network, with slices for production control and management information. The solution involved 37 sets of UPF in 16 cities and connected over 70,000 5G terminals. By deploying 5G applications across 12 scenarios, including power generation, transmission, transformation, distribution, and consumption, the solution significantly promoted the deep integration of 5G with power systems.

In 2023, China Unicom, together with State Grid Shandong and Huawei, launched the largest provincial-scale commercial deployment of 5G RedCap+ power in Shandong Province, facilitating easy 5G application.

While adhering to the principles of security zoning, dedicated networks, horizontal isolation, and vertical authentication, the project integrates 5G RedCap and 5G hard slicing to create terminal-network-business synergy.

On the terminal side, 5G RedCap modules and terminals such as distribution units, PV modules, and drones are applied, significantly reducing terminal costs. On the network side, 1% of RBs are reserved for hard slicing across the entire domain, the FlexE hard slicing technology is used for the transmission network, and a dedicated UPF is connected for production control, ensuring the stability and reliability of the private network. The largest 5G hard-slicing private network has been created in China. On the business side, applications such as distribution automation, PV regulation, and automated telemetry/teleprotection/telecontrol have been realized, achieving real-time monitoring and intelligent control at all stages, including generation, transmission, transformation, distribution, and consumption.



State Grid Shandong 5G RedCap Deployment in Distribution and Distributed PV Systems

CHALLENGES

Shandong has the largest installed capacity of new energy in China, housing a large number of PV power stations. Yet the widespread distribution and strong fluctuations of PV power generation pose new challenges to the safe operation of the power grid. State Grid aims to connect more power stations to the grid and realise flexible regulation. Shandong has a large power grid, with China's largest ultra-high-voltage AC/DC hybrid interconnected network and the highest number of ultra-high-voltage substations. The grid load has surpassed 100

million kilowatts. Therefore, emerging information and communication technologies are necessitated to improve the operational quality, efficiency, and safety of the power grid.

The 5G private network has tackled issues concerning terminal access and operational control in the power system, but several challenges remain in large-scale application. Firstly, the explosion in demand for power grid devices, power terminals, and new energy consumption necessitates a ubiquitous and all-encompassing wireless access network that is secure, trustworthy, efficiently accessible, flexible, and interactively real-time at the distribution terminals. The network can enable smart service access, carrying, and safe end-to-end autonomous control. Secondly, the sophisticated design of 5G terminal chips and modules has kept the R&D costs and terminal prices high, resulting in substantial network construction costs. Thirdly, manual site surveys are required for each deployment, with each person evaluating only four sites every day. The high costs and low efficiency have severely impacted business rollout. Moreover, key applications for power distribution and grid connection are widely distributed, demanding high network reliability. With the proliferation of 5G smartphones, networks will experience high latency and frequent jitter during busy times. Balancing network construction costs and network quality remains the primary concern for the large-scale commercial use of 5G private networks.

SOLUTION AND VALUE

1. Overall structure/solution

In this project, technologies such as edge computing, network slicing, cross-domain networking, 5G RedCap, and AI are leveraged to create an integrated terminal-network-business solution. With secure and trusted 5G access networks that enable wide area coverage, ubiquitous access, and unified management, the project has facilitated wide-area interconnection between terminals in the power system. Network slices for production control and management information have been created to meet the security isolation needs of different power services.

5G RedCap terminals are used. These terminals boast high capacity, low latency, accurate positioning, and high reliability when compared with traditional IoT communication technologies, and reduce costs by 50% and power consumption by 32% when compared with regular 5G terminals. China Unicom has pioneered the deployment of the country's first city-wide RedCap network in Jinan, with the installation of 3,220 5G RedCap terminals from brands like Yanfei and NARI.

A 5G hard-slicing virtual private network has been created, with 1% of RBs reserved for exclusive use by the power grid. This allows for almost unaffected latency of hard slices even in congestion scenarios, meeting requirements for reliable production control. By far, 650 hard slices have been activated, supporting over 300 distributed PV and distribution automation systems.

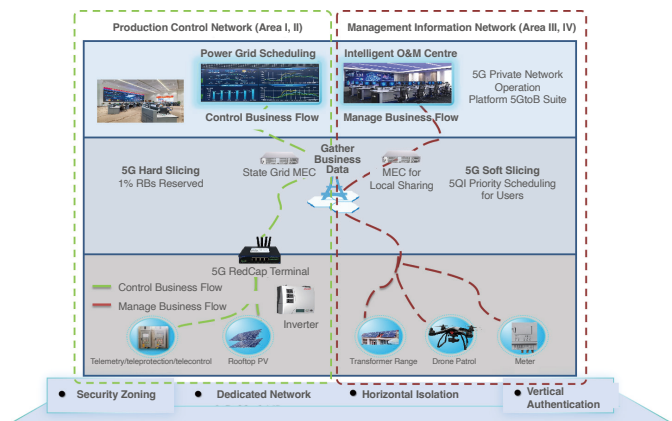
5G applications have been deployed across 12 scenarios including distribution automation, PV regulation, and automated telemetry/teleprotection/telecontrol. Besides, a management platform has been built for the 5G private network to realise network-wide monitoring, online business handling, and real-time terminal management, helping improve the quality and efficiency of the power system at all stages.

At the same time, an innovative 5GtoB site evaluation system has been put in place, reducing the workload of manual site surveys, increasing site online efficiency by 90%, and significantly shortening the business rollout cycle. A record of activating 2,000 sites in one week has been created.

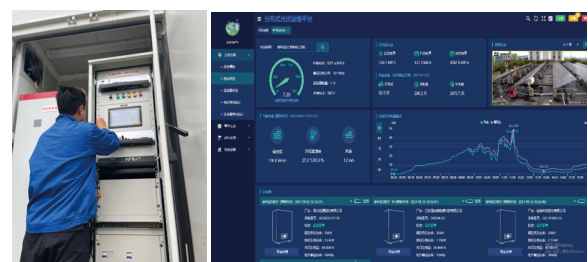
2. Application scenarios

● 5G PV systems

In the scenario, 5G RedCap terminals connect remote devices, AGC, AVC, inverters, as well as PV data collection and control equipment. The 5G hard-slicing technology is used to transmit station operation data to the centralized control center, helping PV stations realize operation analysis, intelligent power generation forecasting, and remote grid-connection control. As a result, it can increase power generation efficiency by 16%. Data from HD surveillance videos and environmental monitoring sensors at the stations can be transmitted to the centralized operation and maintenance platform via 5G soft slices of wide bandwidth, enabling unmanned inspection and intelligent video security. Therefore, grid-connected PV systems can operate safely and reliably.



State Grid Shandong 5G RedCap Networking



5G RedCap Supports Remote Intelligent Operation and Maintenance of Distributed PV Systems

● 5G distribution automation

Through built-in 5G RedCap modules, distributed distribution terminals are connected, collecting and computing position signals, voltage, and other data from switchgear in switch stations and distribution rooms. The data is accessed via dedicated slices to the production control area, achieving security isolation, reducing communication latency, and enabling millisecond-level fault section detection. This ensures the security isolation, stability, and reliability of distribution automation and precise load control. In this way, it can effectively tackle the challenges of the "last mile" costs and operation and maintenance of distribution terminals, improving the operation and management and power supply reliability of the distribution network.



④ Real-time Sensing of Distribution Network via 5G RedCap



④ Real-Time Power Consumption Data Collection via 5G RedCap

● 5G power consumption

5G networks boast high connectivity and 5G RedCap has performance and cost advantages. While combining them with smart meters and energy controllers, power operators can use real-time, accurate, two-way interactive smart metering technology and computing technology to achieve large-scale power use sensing. Embedding 5G RedCap into power use data concentrators and power controllers significantly reduces deployment costs. The power use data collected real-time can be sent to the main station for processing and analysis. This enables precise marketing, scheduling, and management of power load, meeting the needs of different groups for load control on the power side, grid side, and user side of the power system.

● 5G digital site evaluation system

Compared to traditional methods, the 5G digital site evaluation system delivers intelligent evaluation modules. A single task involves rapid and accurate evaluation of 2,000 sites in 2.5 person hours, saving 80% of labor and reducing the deployment cycle from 15 days to 1 day. This system enables parallel evaluation of multiple business types (such as distributed PV, smart power distribution transformer range, and second-level load control) and supports the differentiated capability evaluation of 5G RedCap terminals with one or multiple BWPs. It can automatically provide reasons for code number rejection and suggest cells open for slicing. The AI technology can simulate, model, and digitally and visually survey the network, automatically calculating sites. This can greatly shorten the rollout cycle of hard slices, reduce manual survey costs, and deliver mass RedCap terminals without surveys.

REFLECTION

This project has put in place the largest 5G RedCap + hard-slicing private network in China, with the installation of 3,220 5G RedCap terminals from brands like Yanfei and NARI. Terminal costs have been reduced by 50%, and energy consumption by 32%, saving network construction costs and optimizing the cost-effectiveness of the 5G private network.

The project not only guarantees security isolation and controllability, but significantly reduces construction costs. It demonstrates the feasibility of lightweight, low-cost 5G RedCap for large-scale commercial use in the power industry. The successful case injects new momentum into the 5G private network, accelerating the construction of smart grids and new power systems.

This case has broad prospects. State Grid Shandong plans large-scale deployment across the province, with an estimated of 300,000 5G connections by 2024, including 150,000 5G RedCap terminals. In China, there are over 1,000 power plants, 2.26 million kilometers of transmission lines, 300,000 distribution stations, and tens of billions of meters, suggesting demand for at least 40 million 5G terminals. By 2027, 50 million 5G RedCap units are expected in various power scenarios, reducing costs by approximately RMB 90 billion.

2024

300,000

5G connections

150,000

5G RedCap terminals

2027

50 million

5G RedCap units

90 billion

Reducing costs by approximately

State Grid Henan Promotes 5G RedCap Terminals



As a key 5G-Advanced technology, 5G RedCap can reduce energy consumption and costs at 5G terminals, significantly lowering the application costs of 5G in the power industry. State Grid Henan has pioneered testing and verifying the use of 5G RedCap in the power industry. State Grid Henan is very optimistic about the prospects of 5G RedCap in the power sector and will continue to create more demonstration projects to promote the large-scale application of 5G in the industry.

Dr. Li Yongjie, Operation & Inspection Director, Information and Communication Branch of State Grid Henan Electric Power Company

SOLUTION PARTNERS



OVERVIEW

The power grid is one of the largest and most complex 5G application scenarios. The high cost is the biggest obstacle to the application of the 5G technology in the power grid. As State Grid Henan launches 5G RedCap terminals extensively, positive progress is predictable in the development and large-scale application of lightweight chips and modules. As a result, the costs of 5G application in the power grid are significantly reduced and the construction of the 5G network accelerated.

The project plans a 5G virtual private network covering half of the province and the installation of 28,000 5G terminals from 2021 to 2024, with more than 50% being 5G RedCap ones. According to the 14th Five-Year Plan of State Grid Henan, Henan Province will put in place more than ten large-scale 5G applications, realizing the deep integration of 5G and the power grid.

2021-2024

28,000

Installation 5G terminals

>50%

5G RedCap

CHALLENGES

The new power systems today are increasingly characterized by the high proportion of renewable energy resources and power electronic equipment, with significant changes in power structure, grid form, and load characteristics. As grid control shifts from transmission and transformation to distribution and user side, higher requirements are posed for communication capabilities. Through operational control, grid operators can see, control, and use the power system efficiently.

To promote the large-scale application of 5G in the power sector, three issues should be addressed: business alignment, module pricing, and terminal management:



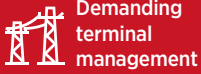
Difficult business alignment

The diverse variety of power services is more demanding for compatibility in communication units. The application in various power scenarios requires the consideration of network performance metrics such as latency and jitters, as well as multi-form customized terminals.



High module prices

The high prices of 5G chips and modules result in significant investments on large-scale 5G terminal applications. Embedded 5G communication modules and bins cannot be widely applied due to cost constraints.

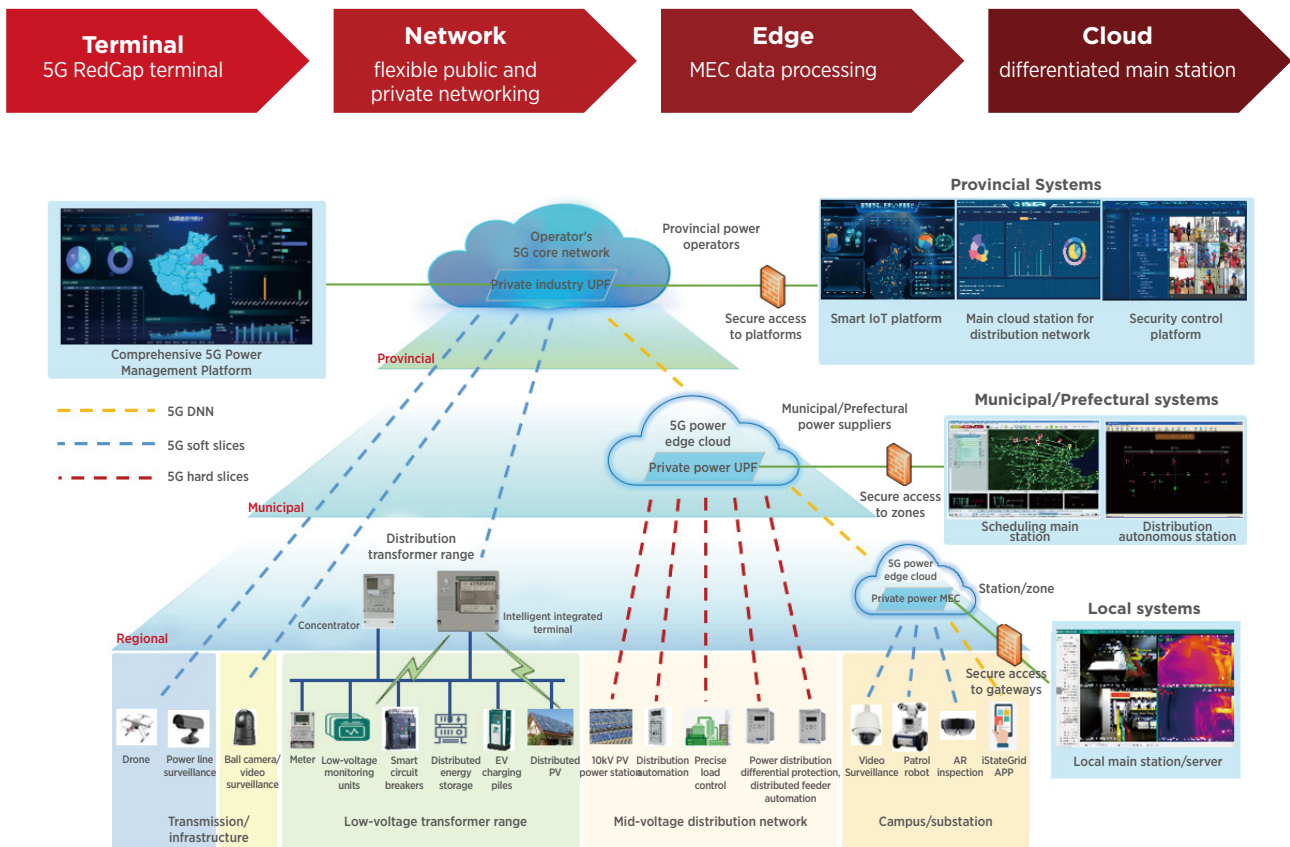


The massive connection of terminals demands higher management capabilities. 5G public networks have been widely used in the power industry and communication services are available for various power services. The growing addition of massive power terminals requires effective monitoring and management of 5G communication terminals to ensure safe and reliable operation.

A relatively small percentage of distribution systems at 35 kV and below are covered by optical fiber, and traditional optical fiber networks cannot meet the "ubiquitous and full coverage" requirements of the distribution networks. Over 90% of power outages happen on the last 5 km of the distribution systems. With an extended signal reach, 5G RedCap base stations allow for rapid deployment without any trenching and cable laying. Moreover, the use of slice isolation in 5G networks can enhance power management for safety, low latency, and massive connectivity.

SOLUTION AND VALUE

The project has creatively established a 5G power solution that involves "Terminal (5G RedCap terminal) - Network (flexible public and private networking) - Edge (MEC data processing) - Cloud (differentiated main station)". At the network layer, dedicated UPFs are deployed with the 5G slicing technology in the communication rooms of municipal power operators based on business needs to ensure safe and reliable power carrying. At the platform layer, a business terminal management platform is built for the unified management of 5G RedCap terminals within the province, ensuring the stable operation of power services. At the application layer, a replicable solution is developed, validated in pilot areas, and then promoted across the province.



5G Virtual Private Network Architecture

Intelligent terminals with 5G RedCap communication units are installed in smart power distribution transformer ranges (transformer range refers to the supply range or area of one transformer). Data like distribution status data, power environment data, etc., is collected and transmitted by monitoring devices to the intelligent integrated terminals and then uploaded to the IoT management platform via the 5G network. The business center and the IoT management platform combined can realize the configuration and management of edge and terminal devices and support

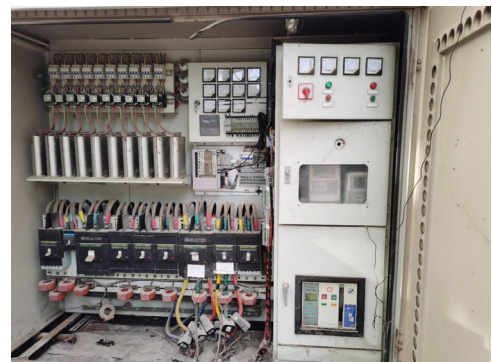
services such as intelligent fault diagnosis. The data center provides data services for the main station (the automated scheduling system) and uploads data to the distribution automation main station.



IoT Management Platform of State Grid Henan

By obtaining information from various types of sensors and acquisition terminals through 5G RedCap, the project achieves data interconnectivity, interoperability, and sharing, enabling multi-dimensional data integration and comprehensive analysis. This facilitates real-time perception of grid operation status, comprehensive energy management, rapid fault diagnosis, and transformer range line loss analysis and management.

Embedding 5G RedCap communication units in intelligent integrated terminals within transformer ranges ensures full coverage of local data interaction between integrated terminals and concentrators. The 5G RedCap integrated terminal can diagnose power outage faults at an accuracy rate of 98.4% and a completeness rate of 95.3%, 2.2% and 70% respectively higher than traditional power consumption data systems. It can effectively support quick repairs.



98.4%

Power outage faults at an accuracy rate

2.2%

Respectively higher than traditional power consumption data systems

95.3%

Power outage faults at a completeness rate

70%

Respectively higher than traditional power consumption data systems

REFLECTION

This project has significantly brought down terminal investment costs through the "lightweight" 5G RedCap technology. By building pilot 5G services throughout the stages of transmission, transformation, distribution, and consumption, State Grid Henan aims to establish a typical "5G + private network" that can be replicated in many scenarios.

5G RedCap terminals, which provide various value-added services, including network isolation, data localization, and secure encryption for smart distribution networks in diverse scenarios, can offer customized networking and differentiated wireless services for smart distribution networks.

Tianjin Huadian Completed Commercial Verification of 5G RedCap Smart Power Plant



Tianjin Unicom utilizes 5G RedCap to empower Tianjin Huadian in creating a 5G smart power plant. It features a dynamic perception of safety management, automatic early warning of safety risks, automatic closed-loop hazard inspection, and comprehensive control of high-risk operations, transitioning safety management from a reactive to a proactive model. As one of the first 5G application demonstrations among power generation enterprises in the Beijing-Tianjin-Hebei region, it plays a leading role in integrating new IoT technologies and new scenarios.

Chen Fengyan, Executive Senior Vice President, Tianjin Unicom Government and Enterprise BG

SOLUTION PARTNERS



OVERVIEW

China Unicom, in collaboration with the Huadian Tianjin branch, Huawei, and other industry partners, completed the nation's first end-to-end commercial verification of 5G RedCap in power generation at Tianjin Huadian Nanjiang Thermal Power Co., Ltd. The 5G smart power plant project co-developed by Tianjin Huadian, Tianjin Unicom, and Huawei promotes further deep integration of new 5G technologies with the power generation industry.

The project focuses on multiple safety production scenarios in the power plant, integrating 5G, big data, and IoT and utilizing 3D digital twins and AI visual analysis to build an intelligent safety risk control platform. It encompasses applications such as high-precision personnel positioning, access management, operation management, and video management, achieving visibility, awareness, and control over the entire plant. This enhances the production and operational efficiency of the enterprise and levels up the lean management further. The verification results indicate that 5G RedCap can support native 5G capabilities such as network slicing and low latency, meeting the safety control business requirements of power generation enterprises for safety, controllability, low latency, and reliability. This lays a foundation for the large-scale commercial use of 5G RedCap in power generation scenarios, a huge boost in building 5G+ smart power networks and accelerating the construction of new power generation systems.



RedCap Commercial Verification at Tianjin Huadian Nanjiang Thermal Power Plant

CHALLENGES

Traditional power plants are facing unprecedented industry challenges against the backdrop of modern industrial development. These challenges involve monitoring, risk warning, inspection, personnel management, and safety, which severely restrict the improvement of plant operational efficiency and sustainable development.

- 01 Monitoring challenges:** Traditional power plants have few monitoring methods, such as manual inspections and fixed camera monitoring. It is not only inefficient but also prone to blind spots. Additionally, the lack of an integrated data collection and analysis platform makes it difficult to support decision-making.
- 02 Insufficient risk warning:** Due to the lack of real-time data collection and intelligent analysis systems, traditional power plants find it challenging to timely identify and warn of potential safety hazards, thereby increasing production risks.

- 03 Inspection difficulties:** Inspections in power plants generally rely on manual labor, which is time-consuming and labor-intensive. It is also susceptible to human factors, leading to inaccurate inspection results.
- 04 Personnel management challenges:** Given the large workforce and varying skill levels of employees in power plants, significant inefficiencies exist in personnel management, reducing the overall operational efficiency of the plant.
- 05 Prominent safety issues:** Due to inadequate monitoring, warning, and inspection measures, the probability of safety incidents occurring during production operations in power plants is greatly increased, posing serious threats to employee safety and company property.

SOLUTION AND VALUE

1. Overall structure/solution

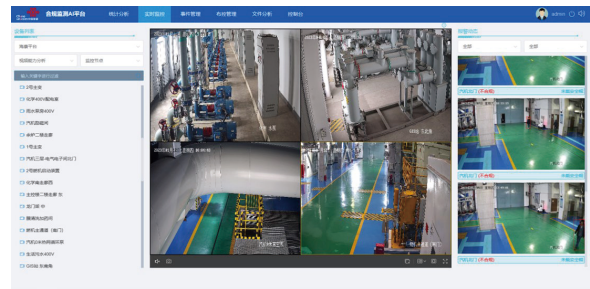
As a demonstration site for 5G smart power plants, Nanjiang Thermal Power has constructed a 5G hybrid private network and MEC edge cloud provided by Tianjin Unicom. The cloud hosts an intelligent power safety production risk control platform, which, combined with AI machine vision, inspection robots, smart helmets, UWB personnel integration positioning, and other typical 5G applications, provides key features such as graded safety risk control, safety hazard inspection and management, emergency management, team management, education and training, and two-ticket management.

In this commercial demonstration project, cameras embedded with 5G RedCap modules were installed in the plant's gas turbine room. These cameras transmit signals through the 5G network to the Unicom MEC edge cloud for data forwarding and AI computation. The video stream, with a frame rate of 50 and a resolution of 4K, is simultaneously transmitted back to the safety control platform. 5G and MEC private networks allow such functions as video access, real-time decoding, and AI computation. At the same time, various AI algorithms, including those for monitoring the absence of safety helmets and prolonged mobile phone usage, process the video and feedback results to the operator. Together, they enhance the plant's safety management capabilities and optimize the overall cost for 5G+ power applications.

2. Application Scenarios

● 5G RedCap + AI machine vision: comprehensive plant monitoring and early risk warning

5G RedCap-based multi-AI vision can detect compliance in personnel attire and work procedures and enable comprehensive intelligent monitoring and regulation of personnel, work, environment, and equipment on the production site. A total of 14 different smart power plant AI algorithms were deployed on MEC. Through the system access and upgrade of 160 routes and 145 cameras, it effectively prevents safety risks such as falls from heights and poisoning asphyxiation. The overall accident rate is significantly reduced, enabling traceability of sources, accountability, and the ability to identify patterns and trends.



📍 5G RedCap + AI Machine Vision Application

● 5G RedCap + Wheeled/Rail-Mounted Inspection Robots: Improving Inspection Quality and Reducing Accident Rates



📍 5G Wheeled Patrol Robot

By leveraging 5G RedCap and intelligent robot technology, robots can replace humans in inspection tasks. These inspection robots are equipped with HD cameras, infrared imaging devices, temperature and humidity detectors, and other collection and detection instruments. They can inspect equipment either automatically or via remote control, gathering information on equipment appearance and temperature anomalies. In light of the facts of the production area, 5G wheeled and rail-mounted robots are deployed in high-risk areas such as booster stations and 6kV distribution rooms. The inspection time per round is significantly reduced from 2.25 hours to 0.5 hours, saving 70% in labor costs and enhancing inspection quality by 60%. The risk of electric shock in high-risk areas is also eliminated.

The construction of the 5G robot inspection module adopts an integrated approach, in which data and anomaly analysis results collected by the robots are unified into the data platform. Based on big data modelling, intelligent reporting, and other application modules, data analysis functions are developed. Combined with the intelligent operation platform system, an intelligent closed-loop management of equipment defects is put in place.

- **5G RedCap + UWB high-precision personnel positioning: traceable, controllable, and manageable operations personnel**

By establishing a high-precision, to-scale 3D model of the power plant and utilizing 5G RedCap + UWB personnel positioning, precise positioning of all plant personnel during production is made possible. This is done through personnel positioning base stations covering key areas and positioning tags worn by on-site personnel, enabling monitoring of personnel movement trajectories across the entire production area and effective safety production control. A total of 280 5G indoor bases and UWB positioning base stations have been deployed. Together with video surveillance and authorized smart access control, as well as intelligent two-ticket systems, it enables real-time identification of operational personnel and area risks and intelligent warnings for violations. Dynamic risk real-time linkage reduces incidents such as falls from heights and electric shocks through centimeter-level positioning of personnel in the digital twin model.



① 5G Redcap +UWB High-Precision Personnel Positioning

Electronic fences allow safety control for areas that cannot be physically protected. When unauthorized personnel enter the electronic fence area, the system issues an alert and records the warning information.

Positioning is done in zero-dimensional, one-dimensional, and two-dimensional ways, depending on the precision requirements of different areas, with positioning accuracy requirements less than or equal to 30cm. It is linked with the plant video surveillance system for trigger alarms and video linkage viewing functions.

- **5G Redcap + intelligent safety helmet: Improving command accuracy and emergency response timeliness**



① 5G Redcap + Intelligent Safety Helmet

The 5G RedCap intelligent safety helmet system addresses issues in the safety production site operations, achieving an integrated approach to "perception, analysis, service, command, and monitoring." A new mode of intelligent, refined safety production management in the "Internet+" era is put in place. A total of 30 sets of 5G RedCap intelligent safety helmets featuring 14 functions in Tianjin Huadian Nanjiang and Nangang power plants greatly enhance the accuracy and timeliness of remote emergency command and on-site emergency response.

REFLECTION

This 5G RedCap commercial verification test integrated the existing network and core application scenarios of Tianjin Huadian Nanjiang Power Plant. With cutting-edge 5G RedCap terminals, the end-to-end verification demonstrated that RedCap can empower power production, laying the foundation for large-scale replication of 5G RedCap solutions in the power industry.

This milestone project not only showcased the immense potential of 5G RedCap in enhancing operational efficiency and safety but also underscored the importance of cross-industry collaboration in driving technological innovation and business upgrades. The close cooperation between China Unicom, China Huadian, and Huawei broke down industry barriers. By sharing and complementing each other in technology, resources, and experience, they inject strong momentum into the digital transformation of traditional factories. Additionally, the three partners are committed to promoting this successful case to other domestic and international power projects, driving broader industrial upgrades. They will also take an active part in policy and standard formulation, providing robust support for the digital and intelligent development of the entire power industry.

Following the success of the initial project, Tianjin Unicom, Huadian, and Huawei will continue to work together, exploring more applications of 5G RedCap in smart factories. This collaboration aims to foster a comprehensive 5G RedCap industry ecosystem, incubate more low-carbon, efficient power industry applications, and accelerate the 5G transformation of power enterprises for win-win industrial cooperation. Moreover, the successful validation of this 5G smart power plant project further proves the powerful potential of 5G technology in industry applications, offering valuable insights for the digital and intelligent upgrades of other sectors.

02

Smart City

5G RedCap Case Studies



5G RedCap Environmental Monitoring by Shenzhen Nanshan District Ecological Bureau



We will continue to promote the deep integration of 5G technology with ecological environment management, creating a more harmonious and liveable urban environment. This will allow residents to enjoy more blue skies, clear waters, and green mountains, setting a new benchmark for the construction of a beautiful China.

Zhang Xingzheng, Director, Shenzhen Nanshan District Ecological Bureau

SOLUTION PARTNERS



OVERVIEW

To set a benchmark for urban environmental management, the Shenzhen Nanshan District Government is building an ecological environment monitoring network that covers four major areas: environmental quality, carbon emissions, biodiversity, and environmental health. This project addresses three key issues: multiple monitoring elements, limited monitoring methods, and high public demand. Based on the 5G government private network, this project uses 5G RedCap to transmit various environmental information through video surveillance, data collection terminals, air micro-stations, and noise monitoring equipment, achieving 24-hour continuous intelligent precise tracing. This has contributed to 35% fewer frontline inspection personnel, a 7.7% increase in air quality, and a 30% reduction in noise complaints, thereby enhancing public happiness. This project represents the large-scale application of 5G RedCap in the government private network ecological field. The 5G RedCap modules significantly reduce the cost of using 5G networks, making large-scale replication feasible. The establishment of a real-time all-element monitoring system overcomes the limitations of fixed network resources in remote areas, achieving integrated management of mountains, waters, forests, fields, lakes, and grasslands.

CHALLENGES

Nanshan, as the top district among China's top 100 districts, hosts over 210 listed companies and is also China's first super-large city center district "Two Mountains" practice innovation base and a national ecological civilization construction demonstration zone. As a super-large city center district, Nanshan faces three major challenges in environmental management:



Multiple monitoring elements

Nanshan is one of the few urban areas that include all elements of "mountains, waters, forests, fields, lakes, and grasslands". It is on an international migratory bird route with two national nature reserves and 217 key protected wild animal species, making comprehensive monitoring difficult.

2
National nature reserves

4
Migratory bird routes

20.24 km²
Ecological redline area

43.5 km
Coastline

217
Key protected terrestrial wild animal species



Limited monitoring methods

Nanshan has many enterprises and heavy traffic, with peak traffic reaching 180,000 vehicles per hour. Real-time monitoring of traffic carbon emissions is currently a global gap.

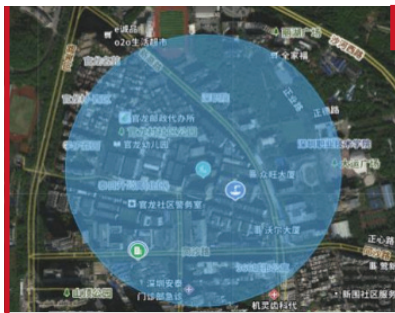
4
Power plants in an area of 187 square kilometers

Top 3
Shipbuilding and repair base ranking nationally for repair business volume

180,000
vehicles per hour
Traffic volume during peak times

140
million m²
Total building volume

8.48
tons per person
Per capita carbon emissions



High public demand

As the most densely populated district in China, Nanshan receives 16,000 noise complaints from construction activities annually, creating significant pressure on grassroots supervision.

20,000
people per km²
Highest population density

210
Highest density of listed companies

368
Construction sites

16,000
Construction noise complaints annually

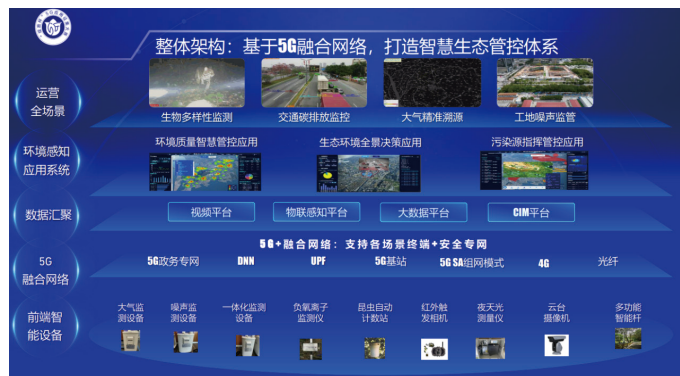
10
Enforcement officers on staff

The urban management and environmental monitoring of Nanshan are representative nationwide. Solving Nanshan's environmental management problems can provide references for similar scenarios in other parts of the country.

SOLUTION AND VALUE

1. Network planning

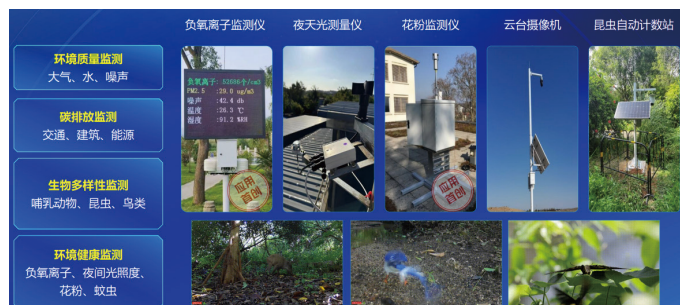
An end-to-end business architecture is designed using a 5G private network, integrating 5G RedCap technology. This ensures data security while fully connecting front-end hardware environment sensing devices. By combining CIM, BIM, meteorological data with advanced technologies such as AI and cloud computing, it achieves visualized supervision and intelligent decision-making, truly realizing comprehensive ecological management within the district.



Overall Network Architecture

2. All-element monitoring scenarios

Using the 5G government-enterprise private network and 5G RedCap smart terminals, a monitoring network is constructed that covers four major areas: environmental quality, carbon emissions, biodiversity, and environmental health. For example, in the protection of rare bird species, there is no wired network in ecological redline areas. The use of cloud camera technology with 5G RedCap solves this issue. Simultaneously, negative ion detectors and pollen detectors are connected to the 5G private network, marking their first application in the ecological field.



All-Element Monitoring Scenarios

3. Carbon emission monitoring scenario

The innovative application of 5G smart cameras, combined with traditional traffic pollution monitoring methods, fills the domestic gap in real-time traffic carbon monitoring. Utilizing the low latency of 5G RedCap, AI cameras and collectors are installed at key intersections to capture real-time road and vehicle information within the monitored area. This data is combined with smart traffic data to create a visible, dynamic, and precise traffic carbon map. This map provides a basis for urban policy-making, traffic planning, and travel information dissemination.



Carbon Emission Monitoring

4. Air pollution control scenario

High-density deployment of 5G+ air micro-stations allow for the timely collection of atmospheric data. By analyzing changes in wind speed, wind direction, and pollutant concentrations, and combining this with meteorological elements, the system can accurately predict and trace the sources of air pollution using the Gaussian model and wind rose charts.



Air Pollution Tracing

5. Noise pollution control scenario

Noise monitoring equipment is deployed to bring the target area under real-time control. When the monitored sound exceeds a set threshold, the system automatically verifies the on-site situation and checks for permits. If any anomalies are detected, the system triggers an automatic warning and remote shutdown, effectively safeguarding residents' environmental rights.



Noise Pollution Regulation

REFLECTION

The Nanshan District environmental management project, through all-element monitoring, carbon emission monitoring, air pollution control, and noise control scenarios, achieves 24-hour continuous intelligent precise tracing. This contributes to 35% fewer frontline inspection personnel, a 7.7% increase in air quality, and a 30% reduction in noise complaints, thus enhancing public happiness.



24-hour

Continuous intelligent precise tracing



35% ↓

Fewer frontline inspection personnel



7.7% ↑

Increase in air quality

The main innovations of this project include:

The application of 5G RedCap + government private network in the ecological field on a large scale significantly reduces the cost of 5G modules, equipment power consumption, and data charges, making large-scale replication feasible. The establishment of a real-time all-element monitoring system overcomes the limitations of fixed network resources in remote areas, achieving integrated management of mountains, waters, forests, fields, lakes, and grasslands. The construction of the nation's first real-time traffic carbon emission monitoring system and a localized traffic carbon emission factor database fills a domestic gap.

Aiming for "efficient, green, and sustainable" goals, urban environmental management has become standard in cities of all sizes in China. The Shenzhen Municipal Bureau of Ecology and Environment has established a special task force to leverage the practical experience of Nanshan District. By taking into account the scale and planning pace of carbon emission monitoring, air pollution control, and noise control needs in each district, the task force will continue to intensify project construction in other districts. This will promote positive collaboration among the government, network operators, and equipment manufacturers, opening new avenues for 5G applications in the ecological protection market and the domestic carbon market.

Shenzhen's 5G RedCap + AI New Model for Waste Classification Supervision



Promoting waste classification to achieve waste reduction, resource recovery, and harmless treatment is a key measure to resolve urban waste issues and reduce environmental pollution. As a mega-city, Shenzhen has innovated through 5G RedCap + AI three models of "new supervision for disposal, new scheduling for collection & transportation, and new evaluation for effectiveness" built on the sanitation full-cycle operation and management platform. This empowers the entire waste classification process with intelligent supervision and turns waste classification into a new low-carbon lifestyle trend.

Lin Longjian

Director of the Household Waste Treatment Supervision Centre, Urban Administration and Law Enforcement Bureau of Shenzhen Municipality

SOLUTION PARTNERS



OVERVIEW

This project establishes a new full-process supervision model for waste classification using 5G RedCap + AI, creating innovative scenarios for new supervision of disposal, new scheduling for collection & transportation, and new evaluation for effectiveness. It utilizes a 5G wide-area private network to solve the last-mile wired access issue, reducing construction costs by 60%. Additionally, it addresses the challenges of manual supervision with 5G RedCap + AI, cutting costs by 75%. Module costs come down by 50% thanks to 5G RedCap. This marks the industry's first scaled application of 5G RedCap in waste classification scenarios.

It utilizes a 5G wide-area private network to solve the last-mile wired access issue

60% ↓

Reducing construction costs

It addresses the challenges of manual supervision with 5G RedCap + AI

75% ↓

Cutting costs

Thanks to 5G RedCap

50% ↓

Module costs come down

CHALLENGES

Waste classification is a "key small issue" of concern to governments worldwide. However, implementing full-process supervision of waste classification faces three major challenges:

1

High manual supervision costs, short compliance time, inconsistent standards, lack of professionalism, and unsustainability;

2

Low efficiency in collection and transportation supervision, with difficulties in managing issues like mixing after classification, spillage, leakage, and inefficiencies in manual scheduling;

3

Difficulties in evaluating effectiveness, with scattered waste classification facilities making comprehensive assessment impossible and hindering problem rectification.

SOLUTION AND VALUE

Shenzhen has developed a new full-process supervision model for waste classification using 5G RedCap + AI. Based on a city-level 5G cloud network foundation and 5G RedCap smart terminals, it integrates capabilities in IoT sensing, AI, digital twin, big data, and video management. Featuring three innovative models of "new supervision for disposal, new scheduling for collection & transportation, and new evaluation for effectiveness," the new full-cycle sanitation operation and management platform significantly enhances the digital, intelligent, and refined management of household waste classification.

As of October 2023, over 10,000 disposal sites in Shenzhen have been covered by AI applications, with plans to scale up to 22,000 disposal sites, nearly 6,000 operational vehicles, and over 870 transfer stations citywide.



① Full-cycle Sanitation Operation and Management Platform in Shenzhen

5G RedCap + AI New Supervision for Disposal: 24/7 Intelligent Supervision and Precise Education

Traditional community waste classification relies on manual supervision, which yields inconsistent results. Equipping all 22,000 disposal sites in the city with manual supervision would require an annual investment of about RMB 600 million, which is unsustainable. Operational costs are reduced by 75% by constructing a new model of intelligent supervision at disposal sites, leveraging a 5G wide-area private network to solve last-mile access issues, and using 5G RedCap + AI cameras for 24/7 intelligent supervision. Areas with low participation, sorting, and accuracy rates can be pinpointed by analyzing residents' waste disposal behaviors through AI and big data, thereby education and enforcement can be more well-targeted to improve awareness and create a closed-loop process.



② 5G RedCap + AI New Supervision for Waste Disposal

5G RedCap + AI New Scheduling for Collection & Transportation: Full-Process Supervision and Intelligent Scheduling

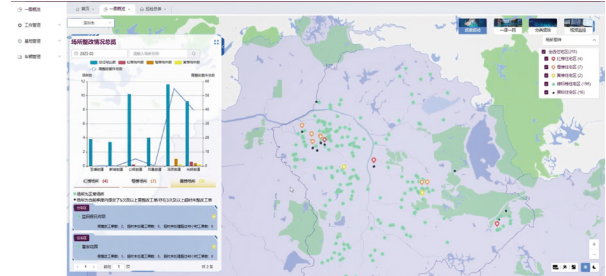
Issues like mixing after classification, spillage, leakage, and untimely collection severely affect residents' enthusiasm for waste classification and the city's environment. Relying solely on manual supervision, the efficiency of scheduling nearly 6,000 operational vehicles citywide is extremely low. With 5G RedCap + AI cameras and Beidou positioning, operational vehicles can be monitored for compliant operations, with spillage and leakage detected and addressed in real time. Additionally, by linking with overflow alerts at disposal sites, cloud AI can schedule vehicles as needed. This allows comprehensive, intelligent supervision to ensure daily waste collection and 100% harmless treatment.



③ 5G RedCap + AI New Scheduling for Waste Collection & Transportation

5G RedCap + AI New Evaluation for Effectiveness: Comprehensive Data Integration and Intelligent Automated Assessment

Traditional manual supervision and evaluation methods for waste management cannot timely or comprehensively cover all evaluation sites across the city. They are often subjective, affecting the fairness of assessments, and problem rectification requires on-site manual rechecks, which are both time-consuming and labor-intensive. By constructing a 5G wide-area private network, the project enables comprehensive data integration for the entire process, all sites, and all time periods. Utilizing end-to-end 5G automated identification and rectification procedures, along with a big data and AI evaluation capability center, the project quantifies evaluation indicators with consistent standards and ensures fairness and justice. The full-process AI closed-loop evaluation significantly reduces supervision costs.



5G RedCap + AI New Evaluation for Waste Classification Effectiveness

REFLECTION

The 5G application in this project features three major outcomes:

01 The city-level 5G RedCap wide-area private network cuts the network construction costs by 60%, while 5G RedCap lowers module costs by 50%, promoting the large-scale application of intelligent supervision facilities for waste classification;

60% ↓

Cuts the network construction costs

50% ↓

Lowers module costs

02 The three new supervision models empowered by 5G + AI significantly bring down supervision costs by 75%, increase residents' participation in waste classification to 99%, and ensure 100% harmless treatment of waste;

75% ↓

Down supervision costs

99% ↑

Increase residents' participation in waste classification to

100%

Harmless treatment of waste

03 The full-cycle, full-process closed-loop waste supervision boosts the recycling of recyclables, hazardous waste, and food waste, while the volume of other wastes comes down. The city's household waste recycling rate and resource utilization rate reached 48.8% and 87.7%, respectively, ranking among the highest in China.

48.8%

Household waste recycling rate

87.7%

Resource utilization rate

The new waste classification supervision model developed in this project has been adopted and promoted in cities such as Guangzhou and Dongguan. Next, it can be replicated in more cities, connecting the upstream and downstream industry chains, and opening up a trillion-RMB blue ocean market for waste classification.

5G RedCap Smart Parking by Zhengzhou Public Utility Investment Development Group



Technologies such as 5G RedCap, big data, and AI are fuelling the digital transformation of traditional enterprises. Zhengzhou Public Utility Investment Development Group's innovative practice of 5G RedCap smart parking has been strong proof that 5G RedCap lowers costs and increases efficiency in city-level smart parking scenarios. It has been the largest 5G RedCap smart parking project nationwide. Committed to public service and smart guidance, the Group aspires to offer car owners a new experience of convenience and benefit. By building a high-standard, intelligent static traffic industry ecosystem, the Group fosters new productivity and drives high-quality economic development in Zhengzhou.

Zhao Shaowei, Secretary of the Party Committee and Chairman of Zhengzhou Public Utility Investment Development Group

SOLUTION PARTNERS



OVERVIEW

Roadside parking in urban areas is already part of smart city services. As urbanization accelerates, parking issues pose increasing challenges for city governance and municipal management. Zhengzhou has a permanent population of over 12.8 million and more than 5 million motor vehicles, ranking among the top six in China. Traditional manual parking fee collection is costly, and wired monitoring requires long construction periods and high expenses for trenching and laying cables. Regulating roadside parking has become a major problem for municipal management.

Zhengzhou Public Utility Investment Development Group, in collaboration with Zhengzhou Mobile, Huawei, and camera manufacturers, has deployed monitoring cameras for 80,000 new roadside parking spaces. Using the new 5G RedCap broadband IoT technology and wireless DTU return, they have established a smart parking service system that avoids trenching and laying cables, enabling quick delivery and launch. This large-scale application scenario is highly replicable. By leveraging a coordinated full-stack AI smart parking solution, they continuously reduce delivery costs and enhance the city's image of seamless management, creating a city-level 5G RedCap visual connection demonstration project.

CHALLENGES

Municipal roadside parking operations face several pain points that urgently require wireless deployment and full-stack AI solutions to address high construction costs and long cycles:

High labor costs

Traditional solutions require staff for detection, with each person overseeing 80 parking spaces. Managing 80,000 spaces requires 1,000 people, along with backend personnel to verify order accuracy, resulting in high annual labor costs and low operational efficiency.

High construction costs

Traditional geomagnetic + PDA solutions require regular maintenance and high labor costs for construction. Wired video monitoring involves trenching and laying cables for both power and data, leading to high costs and long construction periods in terms of compensation and construction.

Revenue loss

Wired network deployments face potential network disconnections in extreme situations, making recovery difficult and lengthy. This would cause order billing failures and revenue loss.

SOLUTION AND VALUE

This project created a large-scale 5G RedCap visual connection application, utilizing the high capacity of 5G networks, the advantages of decoupling software and hardware with full-stack AI algorithms, and low terminal costs. Continuous innovation on the network and platform reduces construction and delivery costs, providing an industry-leading advantage.

The full-stack solution plan is based on the "three unifications" of management, monitoring, and operation and maintenance, integrating video platforms, cloud infrastructure, transmission networks, and terminals.

Video platform

Utilizing full-stack AI algorithms and public cloud resources, the vehicle trajectory tracking algorithm addresses the issue of obstructed urban street points, compensating for the disadvantages of traditional high-level monitoring, improving comprehensive recognition accuracy, reducing monitoring actions for vehicle parking in/out, and enhancing parking data accuracy.

Cloud infrastructure

Full-stack cloud services for elastic expansion are adopted, together with AI capabilities that can be timely and continuously iterated.

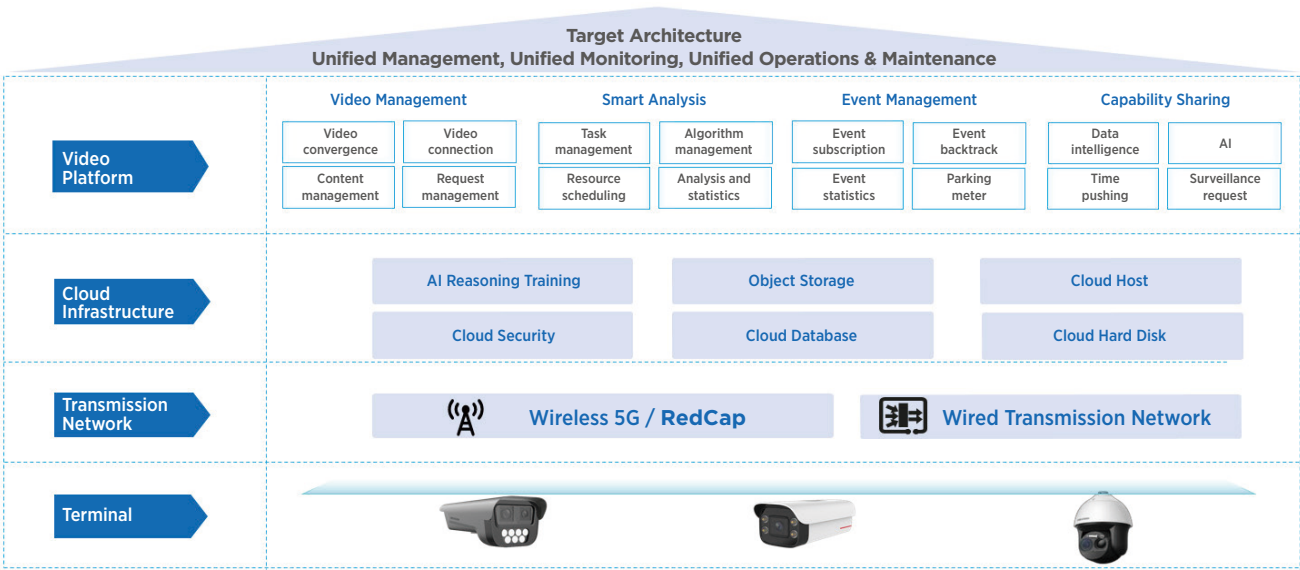
Transmission network

Massive 5G RedCap visual connection terminals can be easily managed by leveraging Zhengzhou Mobile's existing 700MHz wide area coverage and 2.6GHz capacity, along with wireless network transmission anytime and anywhere.

Terminal

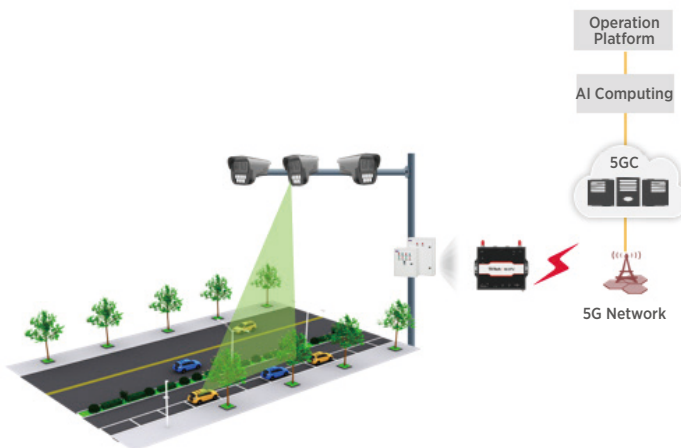
5G RedCap lightweight connection services enable terminal-network-cloud-platform collaborative AI capabilities. The video platform provides AI inference capabilities for camera terminals, allowing algorithm software and hardware decoupling for camera terminals. This reduces terminal-side investment and avoids trenching and laying cables for weak electricity, which shortens construction cycles.

The "three unifications" of management, monitoring, and operation and maintenance



① 5G RedCap-Powered Full-Stack Solution Plan for Smart Parking Management

AI intelligent computing combines with the end-to-end network to form a full-stack solution where terminals, networks, and services are mutually adapted, enhancing the overall solution's competitiveness. Compared to traditional wired networks, the overall cost is reduced by over 10%, the delivery cycle is shortened by 50%, and order accuracy improves from 90-95% to over 97%, providing experience for large-scale replication across the country.



① 5G RedCap-Powered Smart Parking Management Sites and Topology

REFLECTION

This project combines 5G RedCap with city-level visual network monitoring applications, perfectly addressing the inconvenience of urban trenching and cabling construction and meeting the rigid demand for rapid project delivery. By leveraging visual network services, the project solves challenges in municipal parking management and enables the early operation and launch of roadside parking monitoring services, allowing early benefits for car owners. Zhengzhou Municipality has begun to shape a new image of a smart city on top of this project.

Expanding 5G RedCap visual network points for newly built parking spaces to meet new demand, replicating the scenario on a larger scale within the province, and enhancing the modernization and intelligent service levels of parking management.

Follow-up plans

Introducing commercial collaboration projects to accelerate the scaling up of native 5G RedCap cameras and drive the continuous maturation of the ecosystem industry.

5G RedCap Smart Parking in Deyang of Sichuan Province



In the wave of digital transformation, we have partnered with Deyang Energy Group to promote the deep application of 5G technology in smart city construction in line with the development principles of "innovation, coordination, green, openness, and sharing." We have created a smart parking project powered by 5G RedCap. This innovative practice not only optimizes urban traffic management but also explores new models for smart city construction. We will continue to deepen the application of 5G technology in the smart city, driving low-carbon growth with the digital economy, supporting low-carbon living with digital governance, and propelling low-carbon transformation with digital innovation, all in an effort to promote high-quality development.

Zhang Wei, Deputy General Manager of Deyang Branch, China Mobile Group Sichuan Co., Ltd.

SOLUTION PARTNERS



OVERVIEW

Smart parking has become an important measure to solve urban parking issues as the construction of smart cities has advanced in recent years. Smart parking utilizes information and communication technology to support the detection, management, and service of urban parking resources. With strong support from national and local governments, it is expected that smart parking projects will soar, with the industry scale anticipated to reach trillions of RMB.

Stable and reliable network communication is crucial to smart parking systems. Considering the widespread distribution of urban parking lots and the need for smart upgrades to many existing parking lots, ubiquitous and flexible 5G wireless networks have become a new choice for smart parking network communication. The high capacity, wide connectivity, and high performance of 5G can fully enable smart parking applications. 5G RedCap, a new technology in the 5G IoT domain, will aid the large-scale development of 5G+ smart parking applications with its low-cost, high-performance advantages.

China Mobile, in collaboration with ZTE and other partners, has created a 5G RedCap-based smart parking lot in Deyang, Sichuan. As a pilot project, it initially provides 5G RedCap smart parking management services for over 100 parking spaces, offering more efficient and convenient parking services for car owners. Through 5G RedCap technology, various devices within the parking lot, such as data collection devices (e.g., vehicle detectors), smart control devices (e.g., automatic gates), and information display devices (e.g., electronic screens), can seamlessly connect to a remote management platform. This integrated management approach improves the operational efficiency of the parking lot with lower labor costs. Unmanned and refined management of parking resources, together with optimized allocation of parking resources, enhances the utilization efficiency of urban traffic resources and promotes the development of urban digital governance.

CHALLENGES

Difficulties in deploying wired equipment when constructing or upgrading smart parking lots

When constructing or upgrading smart parking lots, it is necessary to introduce a large number of data collection or smart control devices. Connecting these devices via wired networks requires laying fiber optic cables and other infrastructure, which is expensive and requires coordination among property management, telecom departments, and constructors.

High network performance requirements for multi-device connectivity

In smart parking lots, most devices need to be connected for remote management and control, which demands high network capacity and reliability. For example, HD cameras may be deployed at intervals of a few meters to detect parking spaces. Considering the concurrent use of cameras, the network must support significant uplink capacity.

User experience sensitive to latency

In parking management systems, the management cloud platform needs to receive signals from sensors or video surveillance in real time to ensure that parking control systems such as gates can accurately and quickly perform billing and guidance functions. Lower network latency is required to ensure that parking control systems can respond swiftly to environmental changes, improving operational efficiency and user experience. In the future evolution of vehicle-to-everything (V2X) communication, the communication between vehicles and parking lots will require extremely low latency to ensure that vehicles can timely receive information on available parking spaces and navigation instructions.

Cost sensitivity in large-scale deployment of smart parking applications

The smartification of parking lots is driven by both policy and demand and will be introduced into urban management. Cost is, therefore, also an important factor to consider.

SOLUTION AND VALUE

This project, based on 5G networks, connects parking lot devices such as parking space detection cameras, parking guidance screens, LED fare display screens, and gates to the parking management cloud platform through 5G RedCap terminals and CPE. Leveraging the large capacity and slicing features of 5G RedCap, the project features real-time monitoring of vehicle entry and exit information, quick response, and precise billing. This provides a seamless parking experience for car owners and offers real-time data analysis and decision support for urban road management.



Overall Architecture Diagram of 5G RedCap Smart Parking

Real-time Parking Space Detection

The smart parking lot is equipped with multiple HD cameras to achieve real-time parking space detection and other services. The HD cameras require high uplink bandwidth for real-time video feedback. When several HD cameras transmit simultaneously, it demands high uplink capacity. Using HD cameras equipped with RedCap modules for wireless transmission can fully utilize the wide bandwidth of 5G through multi-BWP technology, offering over ten times the uplink capacity compared to 4G networks. Additionally, using a multi-frequency network (700MHz + 2.6GHz + 4.9GHz) and flexible frame structure configurations like "1D3U" can further enhance uplink capacity. These RedCap features fully meet the uplink bandwidth needs of smart parking lots.

Efficient Parking Guidance

Smart parking lots typically deploy parking guidance screens at several key points to guide changes in parking resources, requiring real-time and rapid responses to resource changes, and thus, high requirements for network latency and reliability. The parking guidance screens can be connected to the 5G network through 5G RedCap industrial CPE. 5G RedCap inherits the low latency and high reliability of 5G, fully meeting the communication requirements of smart parking-related devices.

Accurate and Secure Billing

Billing is also a crucial service in smart parking lots. Usually, a billing system consisting of HD cameras, billing terminals, and fare display screens is deployed at the gate. All devices in the billing system can connect to the 5G network through 5G RedCap CPE. Since financial transactions are involved, the billing system has high requirements for network security. 5G RedCap can inherit the slicing feature of 5G, achieving secure isolation of different services, thereby ensuring accurate and secure billing processes.

Value of 5G RedCap

As a new 5G IoT technology, 5G RedCap can upgrade smart parking lot device networking based on existing 5G networks, offering cost-effective and efficient solutions compared to wired deployments. Addressing the network needs of smart parking lots, 5G RedCap can inherit the large capacity, low latency, high reliability, and slicing features of 5G, providing a high-performance network that meets the requirements. Moreover, the low cost and low power consumption advantages of 5G RedCap terminals compared to 5G eMBB terminals will accelerate the large-scale promotion and application of smart parking lots.

REFLECTION

The development of smart cities in China has gone through four stages: exploration and practice, regulation and adjustment, strategic breakthrough, and comprehensive development. Currently, the achievements of smart city construction are gradually extending to districts and rural areas. From 2016 to 2022, the market scale of China's smart parking industry maintained a compound annual growth rate of about 19%, growing from RMB 6.2 billion in 2012 to RMB 20 billion in 2022. The investment scale of smart parking projects in third-, fourth-, and fifth-tier cities accounts for nearly 70% of the national total. The introduction of RedCap also offers a promising opportunity to expand smart parking projects. This project provides a demonstration of 5G RedCap application in smart city-related fields. Next, the results of this project will be exploited in exploring and practicing more smart parking-related applications. At the same time, the successful experience of this project will be promoted and applied in other cities, aiding in the digital and intelligent transformation of cities.

5G RedCap Unmanned Farm in Jiading of Shanghai



This project introduces the "5G Private Network + 5G RedCap Terminal" business model within the unmanned farm industry for the first time, promoting a solution that is both affordable and practical. It successfully addresses the issue of remote control over unmanned agricultural machinery. Not only did it win the only "Most Commercially Valuable Award" at the 6th Blooming Cup Shanghai Region, but it also received recognition from the Jiading Agricultural Committee.

Gao Hao, Head of Shanghai Waigang Agricultural Development Co., Ltd.

SOLUTION PARTNERS



OVERVIEW

The Jiading District Waigang Unmanned Farm Project in Shanghai, jointly developed by China Telecom, Shanghai Waigang Agricultural Machinery Service Cooperative, Shanghai Zuoan Xinhui Electronic Technology Co., Ltd., and ComNav Technology, involves the transformation of 40 pieces of agricultural machinery, including tractors, rice transplanters, plant protection drones, and harvesters. It boasts a perception and monitoring system based on 5G RedCap and video AI. The 20MHz bandwidth of 5G RedCap ensures the simultaneous transmission of 2-4 high-definition videos, allowing real-time transmission of high-definition video during the operation of agricultural machinery to the control room. This setup meets the requirements for high stability and low latency in operations. Farm operators can remotely control the start/stop, throttle, and brakes of the machinery from the control room, ensuring high-quality farming operations and meeting the essential need for safe production.

The ploughing, planting, and harvesting of 1,600 acres of rice fields are made unmanned, demonstrating the rapid and stable data transmission capabilities of 5G RedCap combined with a customized 5G network. Through scientific planning and high-precision seeding of the rice fields, land use efficiency improved by 2.3% compared to manual farming. Rice yield per unit area and production efficiency were up by 2% and 30%, respectively, while labor costs decreased by 53%. This has notably enhanced the farm's economic benefits and set a typical example for the large-scale construction of smart agriculture.

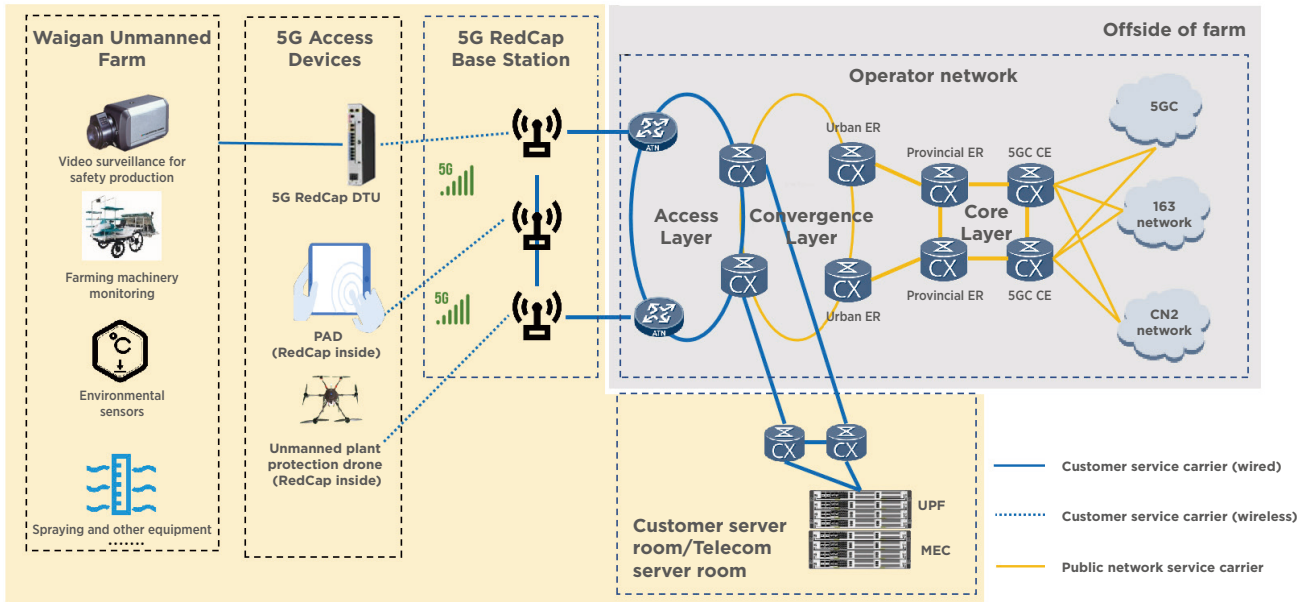
CHALLENGES

With economic development and urbanization, rural populations are increasingly migrating to cities, leading to a continuous decline in agricultural workers. Manual labor in agricultural production is becoming more expensive and scarcer. Leveraging technological advancements to transition to unmanned agricultural production can compensate for the shortage of manual labor and ensure stable and sustainable agricultural production. Unmanned agricultural machinery is a key exploratory practice in unmanned farms. The Waigang Unmanned Farm is Shanghai's first experimental base of its kind and a benchmark in the East China region and even nationwide. The ploughing, planting, management, and harvesting operations on 4,000 acres of rice fields have been made unmanned, initially forming an industry chain centered around the farm. However, in actual operation, agricultural production based on "Wi-Fi + bridge" still faces challenges such as unsatisfactory planting effects, the need for manual assistance, and poor remote-control performance. Conventional 5G technology can solve these issues. As the development and manufacturing of 5G equipment and technology are still in their early stages, the construction costs of 5G networks and the prices of 5G modules remain extremely high. Combined with the vast and diverse geographical conditions of farmland, it complicates the construction of 5G networks covering farmland, increasing the difficulty and cost of applying 5G technology to unmanned farms. Finding a solution that combines the advantages of 5G with economic feasibility is essential for the expansion of unmanned farms.

SOLUTION AND VALUE

1. Network planning

5G Customized Network Architecture For RedCap Unmanned Farm



④ 5G RedCap Network Architecture for Unmanned Farms

2. 5G RedCap Application 1: Remote Control of Unmanned Harvesters



④ Remote Control of Unmanned Harvesters



④ 5G RedCap DTU



④ Unmanned Harvester Equipped with 5G RedCap DTU



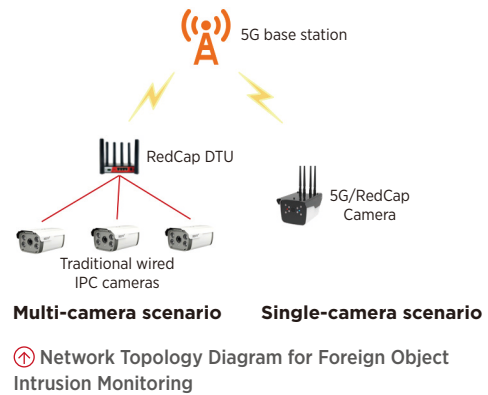
④ Control Room Interface for Remote Control of Agricultural Machinery

Pain Point	Proximal control of unmanned harvesters is highly dangerous, and few farmers need to undertake a large workload.
Solution	Each agricultural machinery is equipped with two HD cameras and four switches. Video and control data are networked through CTWing IoT's 5G RedCap Gateway (Model CTW-GW-01), enabling remote start/stop, rear suspension lifting/lowering, throttle, and brake operations.
Outcomes	<p>01 One farmer can now control three machineries instead of one only, significantly reducing labor costs.</p> <p>02 Farmers can remotely control machinery, reducing safety issues caused by unmanned harvester malfunctions.</p>

3. 5G RedCap Application 2: foreign object intrusion monitoring based on HD video surveillance

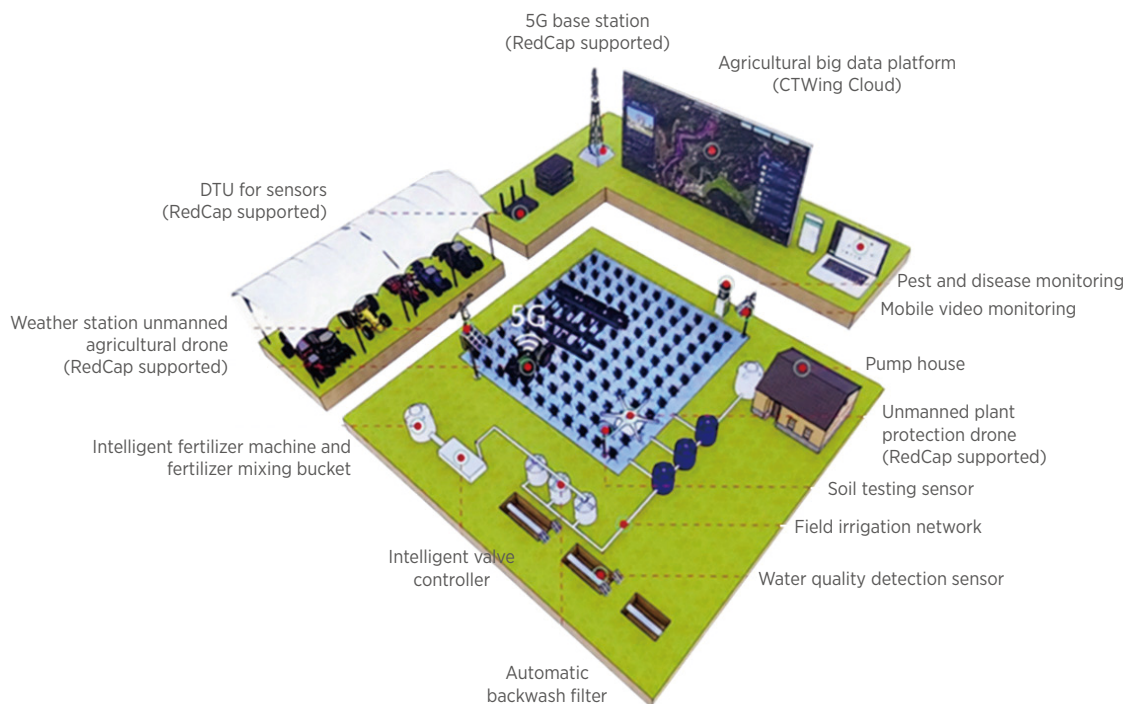


⌚ Intrusion Monitoring for Unmanned Agricultural Machinery



Pain Point	Farms are frequently invaded and damaged by people picking rice ears, birds, and small animals, and it is challenging to drive them away promptly.
Solution	HD cameras powered by 5G RedCap are deployed across the farm. These cameras, combined with AI video recognition, can promptly detect intruding objects. An audible alarm system helps to drive away intruders, ensuring a timely response.
Outcomes	<ul style="list-style-type: none"> 01 5G RedCap cameras deployed across the farm ensure seamless monitoring without blind spots, eliminating the need for cable deployment and saving construction costs. 02 Intruding objects are detected and driven away promptly, securing proper crop yield.

4. 5G RedCap Application 3: All-scenario applications for smart farms



⌚ All-Scenario 5G RedCap Application Diagram for Smart Farms

5. Project Innovations and Problems Solved

Fit with the development trends to solve future labor shortages and high labour costs in farming.

Agricultural production remains a top priority as China puts 1.8 billion mu of arable land under control. In Shanghai, a major city in China, agricultural production is under pressure from urbanization, industrialization, and urban construction, leading to a decline in the agricultural workforce. The Shanghai government is committed to promoting agricultural modernization and improving production efficiency and quality through technological innovation and application. The unmanned farm is an irresistible trend as agricultural technologies develop.

Embracing innovative technologies for new application scenarios.

Breakthroughs in technologies like 5G make unmanned agriculture a possibility. The high speed, low latency, extensive connectivity, and wide coverage of 5G enable efficient and stable data collection, transmission, monitoring, and interaction. While maintaining 5G performance advantages, 5G RedCap is more streamlined; Beidou navigation provides precise positioning with a straight-line walking accuracy of up to 2.5 cm for unmanned agricultural machinery; AI-enabled cameras ensure effective obstacle avoidance during machinery operation; and the cumulative application of these innovative technologies accelerates the deployment of unmanned agricultural production scenarios.

Lower cost in farm construction and operation.

Compared to 5G eMBB, 5G RedCap devices are cheaper and more energy efficient, therefore lasting longer. They feature low latency, high reliability, and superb security, with peak uplink and downlink rates sufficient for various industry needs. The device costs under RMB 1,000 and monthly data costs as low as RMB 50 per card. The application of 5G RedCap significantly reduces the costs of network construction and operation for farms, offering high feasibility and replication value.

REFLECTION

This project has fully validated the rapid and stable data transmission capabilities of agricultural data under the combination of 5G RedCap technology and customized 5G networks. It has achieved unmanned ploughing, planting, and harvesting over 1,600 acres of rice fields. Through scientific planning and high-precision sowing, land use efficiency increased by 2.3% compared to manual farming, rice yield per unit area rose by 2%, production efficiency improved by 30%, and labor costs decreased by 53%, significantly enhancing the economic benefits of the farm and creating a model for smart agriculture with high replication value.

Through long-term planning and phased implementation, we will build unmanned farms that are smart, visualized, command-able, and dispatchable in all aspects and levels.

2.3% ↑

Land use efficiency increased

2% ↑

Rice yield per unit area rose

30% ↑

Production efficiency improved

53% ↓

Labor costs decreased

- 01 Through intelligent modification of agricultural machinery and the construction of a comprehensive management system for agricultural machinery, the entire process of farming will be transformed from mechanization to unmanned intelligence, ensuring all operational information is visible, dispatchable, monitorable, and alert able.
- 02 Satellite, meteorological, drone, and pest monitoring systems will be combined to create an integrated aerial-ground perception and monitoring system. This involves using satellite remote sensing for crop growth monitoring, precise drone positioning and field patrols, and comprehensive pest and disease monitoring to enhance patrol efficiency, enabling one farmer to oversee thousands of acres.
- 03 An integrated smart irrigation system will be put in place, which can automatically control irrigation based on environmental parameters like soil moisture, temperature, EC value, and air temperature and humidity. Smart rice cultivation prescription management will be developed, and modern rice production will be reshaped through agricultural big data, remote sensing diagnostics for crop growth, precise decision-making for rice cultivation, and intelligent operations in paddy fields.

03

Smart Manufacturing

5G RedCap Case Studies



5G RedCap and 5G-Advanced Private Network Integration Helps Baoshan Iron & Steel Go Digital



A new control architecture based on 5G+RedCap has been successfully applied to the spray printing equipment at the entrance of the thick plate shearing line. After being integrated into the existing four-level control architecture, it replaced traditional controllers in the steel plate number spray printing control process. That way it allows a rapid response to on-site process flows, enhancing the efficiency of the thick plate shearing line unit.

Wang Quansheng, Senior Chief Researcher, Central Research Institute of Baoshan Iron & Steel Co., Ltd.

**SOLUTION
PARTNERS**



OVERVIEW

Baoshan Iron & Steel Co., Ltd., or Baosteel, is one of the world's most competitive steel enterprises and the largest, most modernized steel conglomerate in China. It ranks second globally in crude steel production and first in automotive sheet and silicon steel production, offering the most comprehensive range of carbon steel products worldwide. In line with national policies promoting smart manufacturing in the steel industry and industry development trends, Baosteel keeps pushing its 5G smart factory project. Utilizing the deterministic network capabilities of 5G RedCap and 5G-Advanced private networks, Baosteel levels up its intelligence by upgrading applications such as new control architectures, video surveillance, data collection, and energy management.

RedCap, a lightweight 5G technology, significantly reduces terminal costs while inheriting the native 5G capabilities such as high capacity, low latency, high reliability, and network slicing. 5G RedCap has already been applied to production control to help build new control architectures. Wireless connectivity between PLC controllers and distributed IO via 5G RedCap CPE meets the ultra-reliable and ultra-low latency network requirements. Assistance in production processes such as campus security and production monitoring addresses the critical needs for safe production.

CHALLENGES

Under traditional industrial structures, Baosteel faces numerous issues: Production Intensity and Hazardous Environments: Steel production involves high intensity work often conducted in harsh environments with high temperatures, dust, hazardous gases, and noise, posing many potential safety risks to both workers and properties. These conditions necessitate the reduction or elimination of personnel in critical positions to ensure safety. At the same time, traditional industrial control solutions can no longer support business agility. The existing diverse and numerous PLCs used across Baosteel's production lines lead to high wiring costs and complex maintenance processes. Hardware-software integrated controllers commonly used in key steps struggle to adapt to the evolving cloud-edge smart manufacturing systems, particularly in meeting the requirements for personalized, precise adjustments for specific steel grades in online control. Although 5G applications in the steel industry have developed for years, and Baosteel has implemented several early-stage 5G applications with China Telecom and Huawei, further exploration of RedCap and 5G-Advanced private network integration is required to meet extreme demands for low latency, low power consumption, large-scale connections, and low costs in certain scenarios.

SOLUTION AND VALUE

5G-Advanced is empowering deep industrial digital transformation. RedCap technology can be applied to wireless sensors, video surveillance, and core production processes, aiding Baosteel in cost reduction, efficiency improvement, and accelerating its digital transformation.

1. 5G RedCap + 5G-Advanced New Control Architecture

A new control architecture is established by using 5G RedCap CPE combined with 5G-Advanced private network innovations. This involves the industry's first full core network deployment, supplemented by 5G LAN, dual transmission, deterministic network, and uRLLC technologies. Through 5G RedCap CPE, real-time interaction between control programs and underlying IO devices is realized, enabling collaborative control of multiple processes. Software-hardware decoupling, autonomous control, and cost-efficiency become a reality.



⌚ Thick Plate Shearing Line Entrance Printer Powered by 5G New Control Architecture

2. 5G RedCap + Video Surveillance

5G RedCap HD cameras deployed in key areas and high-temperature environments within the steel plant enable 24/7 real-time monitoring of the entire plant's production operations. This ensures seamless surveillance, smooth video streams, and clear images, and meets various business needs such as pre-emptive defense, real-time visibility, centralized command, and post-event traceability and evidence collection.

5G RedCap cameras in key areas of the campus and electronic fences for intrusion detection, loitering detection, and line-crossing detection fully replace manual patrolling and physical isolation measures. This enhances the accuracy and efficiency of perimeter defense while reducing its costs.



3. 5G RedCap + AI Predictive Maintenance

The steel industry's production processes (such as steelmaking, hot rolling, and cold rolling) involve a vast amount of large motor equipment, and once these continuous production operations commence, they cannot be interrupted. Numerous pieces of equipment are involved at each stage. If equipment anomalies are not promptly detected, leading to unscheduled downtime, the entire production process may come to a halt. This can result in reduced output, increased maintenance costs, shortened equipment lifespan, stockpiling issues, and even potential casualties. Therefore, real-time monitoring of key equipment status and predictive maintenance is crucial to enhance equipment utilization, ensure production stability, and reduce maintenance costs. By incorporating 5G RedCap instruments or 5G RedCap industrial gateways, it is possible to collect and upload real-time data on the status of key equipment, enabling real-time monitoring. Equipment status information under different operating conditions can be compared and analyzed in a timely manner, providing analytical insights and maintenance operation suggestions. This helps to prevent critical equipment failures and downtime. Through AI big data analysis, future potential conditions of the equipment can be predicted, scoring the health status of the equipment, and providing relevant warnings and recommendations for replacement and repair.

REFLECTION

The new control architecture system based on 5G and 5G video surveillance adopted by steel enterprises can effectively reduce the cost of control architecture and labor in the steel industry (please supplement with quantitative data). The application of RedCap can significantly reduce the cost of procuring 5G terminals, thereby achieving cost reduction and efficiency improvement. This innovation not only effectively addresses bottlenecks in the production process but also brings additional revenue growth points for enterprises, demonstrating the robust momentum of the steel industry's digital transformation journey.

While reducing terminal costs, 5G RedCap technology retains the native capabilities of 5G, meeting the needs of mid-to-high-speed IoT scenarios. Promoting the application of 5G RedCap in the steel industry can effectively reduce the cost of digital transformation in the steel industry, accelerate the large-scale replication of 5G applications, and deepen the integration of 5G with the industry. Continual optimization and refinement of related scenario applications on the production site are ongoing. Future plans include exploration in the following scenarios:

Intelligent inspection and robotic inspection: With the help of RedCap technology, steel enterprises can achieve intelligent inspection and robotic inspection. Robots equipped with sensors and cameras can conduct automated inspections of production lines and equipment, improving inspection efficiency and accuracy.

Logistics and warehousing management: The logistics and warehousing segments of steel enterprises are also potential application scenarios for RedCap technology. Through 5G RedCap technology, real-time tracking and management of materials and products can be done, which optimizes logistics and warehousing processes, improves logistics efficiency, and reduces inventory costs, such as with 5G RedCap AGVs.

Scrap steel grading: 5G RedCap cameras can be used to capture multi-angle images of scrap steel to establish a data foundation. A 5G + cloud + AI solution can be used to transmit multi-angle scrap steel images in real-time to an edge-side central control room for large-screen display and edge computing inference. This increases the recycling rate of scrap steel, fueling low-carbon green transformation.

5G RedCap Empowers Safety Production at Yunnan Shenhua Aluminum



Since its establishment, Yunnan Shenhua has focused on building a top-tier green hydroelectric aluminum smart factory nationwide. Since 2020, in partnership with China Mobile and ZTE, we have embarked on the construction of 5G+ smart factories. Utilizing a premium 5G park private network, we have established a visual "command brain" to underpin various innovative application incubations through the digital industrial infrastructure platform, thereby empowering intelligent production systems. With the advent of 5G RedCap, we have witnessed more possibilities for 5G. In terms of improving quality and security, reducing costs and increasing efficiency for enterprises, its low-cost, high-performance advantages will help us explore more 5G applications and push the scale of 5G applications to new heights.

Zhang Wenzhang, Chairman of Yunnan Shenhua Aluminum Industry Co., Ltd.

**SOLUTION
PARTNERS**



OVERVIEW

Yunnan Shenhua Aluminum Industry Co., Ltd. is a subsidiary of Shenhua Group, which ranks as the sixth largest aluminum electrolysis producer in China. The non-ferrous metal smelting industry is a typical process industry, characterized by a wide variety of equipment, complicated processes, and harsh operating environments. The current automation level in metallurgical enterprises varies, and the overall production organization lacks flexibility. In the age of smart manufacturing, Yunnan Shenhua is also contemplating how to enhance resource utilization, achieve precise management, and promote intelligent production transformation and development.

In June 2020, Yunnan Shenhua, China Mobile, and ZTE officially formed a strategic partnership to collaboratively develop a top-tier green hydropower aluminum smart factory in China. After extensive research and discussions, the high-performance 5G network has been confirmed as an advanced network for connecting machines, materials, people, and information systems. This network can help achieve comprehensive sensing, dynamic transmission, and real-time analysis of industrial data, ultimately leading to the digital transformation of manufacturing. As of now, Yunnan Shenhua's 5G smart factory has started to produce tangible results.

Since its debut, 5G RedCap, a newly introduced 5G IoT technology, has garnered significant attention for its advantageous features of low cost, low power consumption, and high performance. The intelligent safety helmet based on 5G RedCap technology can connect to 5G networks, and provide real-time, high-quality safety protection for workers. Additionally, it can offer enterprises more precise personnel and process control information, thereby aiding in the refined management and scheduling of resources. In this project, the introduction of the 5G RedCap smart safety helmet in the Yunnan Shenhua 5G smart factory smoothly integrates into the existing 5G smart production system. This not only enhances safety measures for frontline workers but also accelerates Yunnan Shenhua's digital transformation journey.

CHALLENGES

The electrolytic aluminum industry is known for its intricate processes, long workflow, and harsh operational conditions. A large number of frontline workers need to operate in harsh working environments for long periods, where the safety helmet serves as the fundamental and indispensable protective gear. However, ordinary safety helmets are plagued by the following issues:

Single purpose, with only basic protection

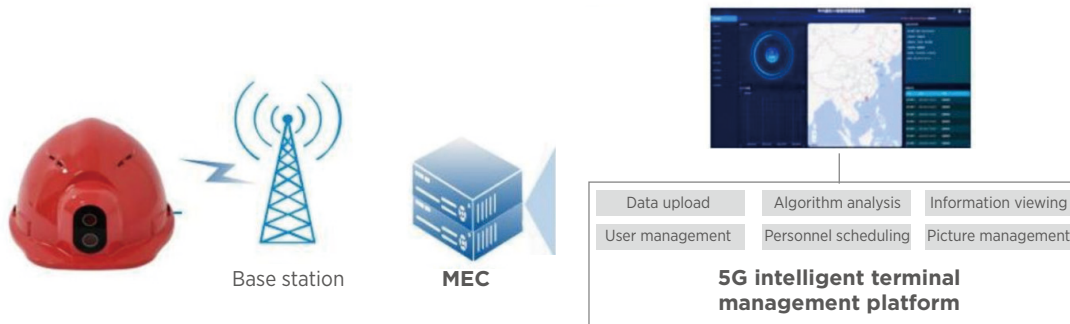
Ordinary safety helmets can only provide basic physical protection and are classified as passive protective gear. When dealing with intricate and constantly changing work environments, safety helmets are unable to adapt actively to these changes. Moreover, there is no interaction between safety helmets and their wearers, leading to a limited reflection of the workers' physical condition.

Unable to support intelligent management

Ordinary safety helmets are not equipped with information collection modules and communication functions. From an enterprise perspective, the inability to gain real-time insight into personnel operations and perform precise resource scheduling and management is a drawback.

SOLUTION AND VALUE

The holistic solution relies on the ZTE Digital Nebula Platform and 5G RedCap safety helmets. Equipped with HD cameras and environmental sensors, these helmets can connect to remote management platforms via 5G networks, enabling real-time communication and safety management. For frontline workers, functions such as vital signs monitoring, video calls, and environmental anomaly detection provided by the safety helmet allow for simultaneous environment monitoring while ensuring worker safety, completely freeing up their hands and facilitating safe, standardized, and convenient operations. For enterprises, networked safety helmets can offer real-time feedback on personnel status and production environment conditions and empower the digital transformation and upgrading and refined operations of enterprises, so as to achieve personnel online monitoring, intelligent scheduling, and meticulous management.



Architecture Diagram of Safety Production Solution Enabled by 5G RedCap Safety Helmet



Security inspection

Built on 5G networks, 5G RedCap safety helmets can transmit live video surveillance footage in real-time as workers move, complementing fixed security monitoring to efficiently complete comprehensive plant security inspections. 5G RedCap can adopt 5G-related features, making full use of the wide bandwidth provided by 5G. By configuring multiple BWP (Bandwidth Parts) and employing functionalities such as adaptive addition and deletion of BWP overlays, it achieves real-time adaptation of uplink capacity to meet actual capacity requirements, thereby supporting security inspection tasks for multiple workers within the factory premises.



Monitoring of complex operating environments

Using 5G networks, sensors attached to the safety helmet can transmit real-time data to the management platform, facilitating monitoring of complex work environments. 5G RedCap can incorporate 5G uRLLC-related features, such as uplink grant-free transmission, to decrease air interface latency, allowing for swift response and handling of emergency situations. 5G RedCap can support low latency of less than 20ms, and fully meet data collection needs.



High-definition video call

Based on 5G networks, workers can use the safety helmet to communicate with each other and with the management platform via high-definition video calls, enabling real-time transmission of shared work information. This scenario can be supported by adding VoNR functionality to 5G RedCap.

Value of 5G RedCap:

As a wearable device, safety helmets have high requirements for size, weight, and battery life. Furthermore, safety helmet-related operations necessitate high standards from mobile networks. Compared to 4G, 5G RedCap can inherit 5G features such as network slicing, high uplink, low latency, and high reliability, providing high-performance assurance for safety helmet-related operations. Compared to 5G, the low power consumption and cost advantages of 5G RedCap terminals are expected to drive the growth of 5G applications.

REFLECTION

After a trial run in the electrolysis workshop, the project is set to expand the implementation of 5G RedCap safety helmets in Yunnan Shenhua's foundry and pneumatic workshop this year, to promote the upgrade of safety production. This project has showcased how RedCap can be applied in smart factory settings. We will continue to explore and implement such technologies extensively and accumulate expertise for the intelligent development of the non-ferrous metal smelting sector. These efforts aim to facilitate the digital transformation of the non-ferrous metal smelting industry while pooling resources through technological strength to boost the development of the digital economy in the southwestern.

5G RedCap Empowers Safe and Efficient Production in the Chemical Industry



The shift from wired to wireless connectivity will be a dominant trend in the digital transformation of chemical manufacturing and operations. The arrival of 5G RedCap is well-timed, with benefits of low latency, high reliability, extensive connectivity, and low cost. Wanhua Fujian, driven by the digital requirements for production safety, has forged a new benchmark in the chemical industry with its project on 5G RedCap wireless video AI and DCS production data flexibility, originating from real-world scenarios.

Nie Cunliang, General Manager of Wanhua Chemical (Fujian)

**SOLUTION
PARTNERS**



OVERVIEW

Wanhua Chemical is a chemical new materials company with global footprint, and has ten major production bases and factories at home and abroad, including Yantai (headquarters) and Fuzhou Fuqing. Situated in Fuqing City, Fuzhou, Wanhua Chemical (Fujian) Base covers a total area of 11,000 mu and is considered a benchmark enterprise in the petrochemical industry of Fujian Province. In 2022, Fujian Telecom teamed up with Huawei and other partners to initiate the phased rollout of a 5G custom network at WanHua Chemical in Fujian. The network adopts the proximity service model: By sinking the UPF to the edge, data remains within the park. It features a coordinated explosion-proof private network scheme with macro and micro sites; in non-explosion-proof areas, macro sites with 64T64R equipment cover 80% of the area, while in explosion-proof areas, explosion-proof small sites (pRRU) with 4T4R provide supplementary coverage for the remaining 20%. Using a dual-frequency network with 3.5G and 800M, the 800M frequency is employed in the complex environment of the unit area to meet the specific needs of high-density, low-bandwidth instrument access in the chemical industrial park.

Wanhua Chemical (Fujian) takes a phased rollout approach with its native 5G RedCap case, beginning with trial commercial use in the existing plant area (West Zone). After establishing a baseline plan, it is replicated and expanded to the new plant area (East Zone). The first phase (West Zone) launches with 120 routes of native 5G RedCap cameras and over 400 routes of instruments, while the second phase (new East Zone) introduces more than 3,000 routes of native 5G RedCap cameras and over 5,000 routes of instruments.



The first phase (West Zone)

120

Native 5G RedCap cameras

400+

Instruments

the second phase (new East Zone)

3000+

Native 5G RedCap cameras

5000+

Instruments

By embedding 5G RedCap modules into cameras, instruments, and other terminals, Fujian Telecom, in partnership with Huawei, Dahua, Zhejiang SUPCON, and TD Tech, has replaced the original CPE and relay gateways. This results in a more lightweight 5G solution, offering lower power consumption and cost for terminals, while preserving the native features of 5G. This project is now in the large-scale trial commercial use

stage, involving the terminal upgrade of 120 routes of cameras and over 400 routes of instruments to 5G RedCap in the existing plant area (West Zone). After mass deployment, key technologies such as bandwidth management will be employed to optimize the network and ensure user experience, and a 5G RedCap local visual networking industry baseline will be established.

This case represents the world's first 5G RedCap chemical industrial park. This project leverages large-scale 5G RedCap technology to replace wired networks in the high-value, harsh environment of the chemical industrial park, leading to considerable savings in manpower, time, and cost. Process safety prediction efficiency has improved by 70%, violations have decreased by 78%, and management costs have dropped by 80%. Notably, the 5G RedCap instrument marks the first deep integration of 5G into the control domain of the chemical industry. With flexible data collection capabilities, it sets a precedent for employing 5G RedCap in the chemical industry. In this case, the extensive application of 5G RedCap is complemented by the development of a 5G RedCap baseline tailored to the chemical industry, grounded in an understanding of industry needs. This lays a robust groundwork for replicating and disseminating 5G RedCap across more than 30,000 large-scale chemical enterprises in China.

70%

Process safety prediction efficiency has improved

78%

Violations have decreased

80%

Management costs have dropped

CHALLENGES

The chemical industry, as a key sector of China's economy, contributes more than 12% to the nation's GDP. A well-developed digital workflow will facilitate a holistic upgrade in enterprise production and operations. This advancement entails enhancing product quality, optimizing production efficiency, and realizing profit growth. Moreover, it fosters the smart management of the entire industry value chain, empowering the overall positive development of the chemical industry. As 5G, AI, cloud and other information and communication technologies rapidly evolve, digital upgrading has become the necessary path for the chemical industry's high-quality development.

However, based on recent experience, there are three major challenges to the digital upgrade of the chemical industry.

The high frequency of safety incidents in the chemical industry and the need for high safety standards

The reasons for the frequent occurrence of safety incidents are multifaceted, including non-standard operational behaviors (unauthorized entry, hot work, excavation, work at heights, lifting operations, etc.); unsafe conditions of materials (abnormal parameters of pressure vessels, exceeding liquid levels in storage tanks, decreased water seal liquid levels, etc.); and unstable environmental factors (monitoring of toxic and hazardous gases, storage of flammable and explosive materials, etc.).

The complexity of production processes and the multitude of equipment and instruments

The chemical industry features intricate process technologies and involves extensive use of cables, bridges, conduits, and connectors. Additionally, there are numerous sets of pumps and rotating equipment. Each unit area comprises tens of thousands of data collection points, totaling over 10,000 channels of sensor data including vibration, flow rate, pressure, temperature, etc., presenting substantial difficulties in operation and maintenance management.

Various networks in chemical production, with complex architectures

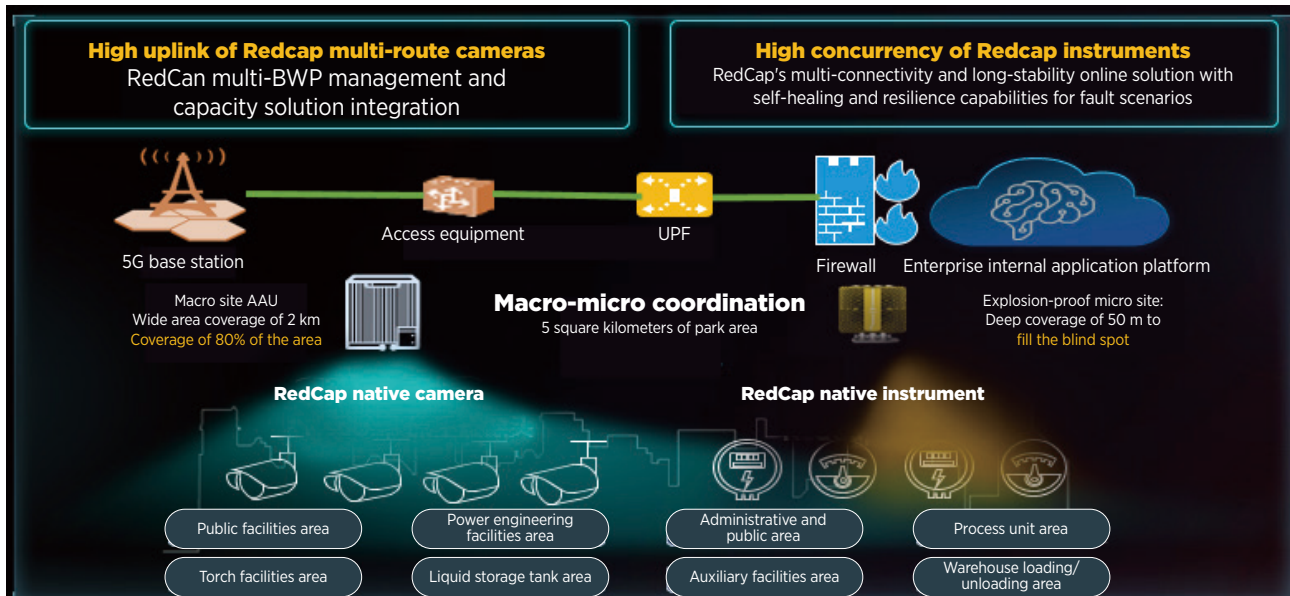
For example, the industrial control network, the video network, and the office network are independent of each other. Specifically, the industrial control network adopts wired copper cable, which poses challenges in deployment and operation maintenance. The video network faces difficulties in cable excavation and burial, resulting in high switch and operational costs. Meanwhile, the office network cannot utilize Wi-Fi for inspection within the unit area and relies on 4G network transmission of data outside the park, with limited capacity.

Wanhua Chemical is a global player in the chemical new materials industry, and Wanhua Chemical (Fujian) is a leading company in the petrochemical sector of Fujian Province. These entities also grapple with the same pain points brought about by the three major challenges in the digital upgrade of the chemical industry.

SOLUTION AND VALUE

The project adopts the proximity service model. The network solution uses the UPF sinking scheme for deployment, which ensures that data remains within the park for data security while significantly reducing data transmission latency. By employing a coordinated deployment strategy involving both macro and micro sites, macro sites provide overarching signal coverage across the chemical industrial park. Targeting areas with high signal interference within the production unit area, explosion-proof micro sites are strategically placed to enhance signal

coverage in blind spots. This coordinated deployment approach achieves comprehensive and seamless coverage of communication signals within the chemical industrial park, meeting various communication needs across the park. With a dual-frequency network configuration of 3.5G and 800M, 3.5G base stations provide signal coverage to address the wide bandwidth requirements in this context. For scenarios involving 5G+HART instruments that are primarily distributed within production unit areas and demand extensive signal coverage despite smaller data transmission volumes, communication is facilitated via the 800M frequency band. The construction cost prevents competition for bandwidth resources among different services and guarantees stable data collection and transmission.



Architecture Diagram of 5G RedCap Solution

Scenario 1: Large-scale implementation of 5G RedCap video surveillance

Usage scenarios for 5G RedCap cameras include personnel checkpoint monitoring and logistics warehouse areas, among other business applications. Each route averages 2Mbps (1 pole supports 3 routes, with Dahua 5G RedCap built-in cameras), providing real-time transmission back to the NVR platform.

At present, within the Wanhua Chemical (Fujian) Base premises, multiple monitoring functions are achieved using 5G RedCap cameras, including

Off-duty monitoring	real-time alarm and display of relevant point-of-view videos when off-duty incidents are detected in key areas;
Lane occupation detection	real-time platform alerts upon detecting unauthorized lane occupation in designated no-parking zones on specified roads;
Personnel congregation monitoring	real-time early warnings for personnel congregation behaviors identified within defined key areas;
Personnel identification	detection of outsiders using cameras through saved facial data of registered personnel in the park.



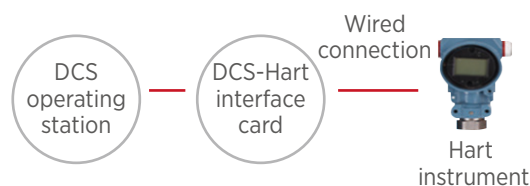
5G RedCap Video Surveillance

Scenario 2: Large-scale implementation of 5G RedCap instruments

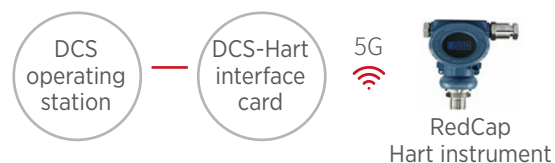
The internal wiring configuration within chemical factories is intricate, involving a complex network of cables, cable trays, conduits, connectors, and network device deployments. With tens of thousands of instruments in place, the wiring expenses are substantial. Each unit area involves tens of thousands of data collection points, totaling over 10,000 channels of data sensors for vibration, flow, pressure, temperature, and more. The 5G RedCap module can be embedded within Zhejiang University SUPCON's instruments to harness its ability to provide extensive connectivity and flexibility. This integration streamlines management and operation, resulting in a more lightweight production network.

With a multitude of meters in the factory premises, including tens of thousands of chemical meters, the current setup relies on wired transmission. In the newly built plant area, wireless connectivity is established using 5G, leveraging its flexible wireless characteristics to save on copper cabling and maintenance expenses. Polling occurs at a second-level interval, enabling remote parameter control. This project signifies the initial foray of 5G technology into chemical production processes. It not only streamlines the industrial control network, but also enables the consolidation of 5G into a unified network.

Existing model



5G RedCap model



This project represents the first large-scale commercial application of 5G RedCap in the chemical industry, and features multidimensional innovation in solutions and application scenarios, thereby driving the implementation of 5G in the chemical industry.

- 01** For the first time in China, the pioneering use of a multi-BWP capacity solution with 5G RedCap enabled the connection of over 20 cameras within a single cell, ensuring seamless real-time video streaming without buffering. By developing methodologies for site PCI, camera positioning, and BWP activation count, the deployment of over 100 cameras in West Zone was achieved, while simultaneously providing support for the future deployment of 3000+ cameras in the second phase of East Zone.
- 02** For the first time in China, a differentiated assurance solution was implemented using 5G RedCap and eMBB, where individual QCI settings were applied to 5G RedCap cameras to ensure a steady guaranteed bitrate of 3-4Mbps. Under scenarios of near, mid, far distribution of camera services in a ratio of 3:4:3 and during busy periods with over 100 background users, the guaranteed bitrate from cameras supported the service experience.
- 03** The first-ever 5G RedCap BWP capacity network standards were formulated for the chemical industry, where the baseline for uplink capacity at the cell level considered the distribution of BWP positions, IoT interference for business uplink (uplink of 10dB/20dB), and typical user distribution, to support the subsequent scaling of camera deployments.
- 04** The first networking solution tailored to the chemical industry was formulated, utilizing the 3.5G and 800M frequency bands together to address the high capacity of cameras and dense terminal access of DCS instruments.
- 05** For the first time in the chemical industry, the native Hart instruments with 5G RedCap were introduced. The 5G solution employs native instruments with embedded 5G RedCap modules, replacing the long-distance and complex wired transmission from DCS (Distributed Control System) cabinets to field instruments with 5G wireless transmission. The 5G solution requires overcoming the challenge of converting the standard Hart protocol transmitted in the chemical industry, using frequency-shift keying (FSK) signals, into IP packets and then further converting them into the Hart protocol required by DCS systems, while ensuring data stability. In the chemical industry, this project marks the first successful resolution of the industry's challenge in adapting between the Hart protocol and IP packet protocol, resulting in substantial cost reductions for instrument installation and wiring, and improved operational efficiency.

REFLECTION

Using native 5G RedCap visual networking and Hart instruments, this project has established a smart 5G RedCap chemical industrial park, enhancing the management efficiency and economic benefits of Wanhua Chemical (Fujian): Compared to traditional wired cameras, native 5G RedCap visual networking eliminates the need for trenching and cable burial, saving significant installation and maintenance costs. Combined with AI platforms, it enables intelligent security and real-time supervision of hazardous operations within the park. Additionally, native 5G RedCap Hart instruments facilitate highly flexible production, which not only saves substantial costs associated with copper cabling and maintenance, but also allows remote parameter control to achieve polling intervals in seconds. Through the large-scale application of 5G RedCap, Wanhua Chemical (Fujian) has achieved a 70% improvement in process safety prediction efficiency, a 78% reduction in violation behavior, and an 80% decrease in management costs.

Currently, the deployment plan for RedCap cameras at Wanhua Chemical (Fujian) Base includes the first phase (West Zone) with the installation of 120 routes of native RedCap cameras and over 400 routes of instruments. This phase involves addressing a series of issues such as BWP capacity assessment, stable baseline for business standards, latency, I-frame collision, concurrency, etc., to establish the RedCap visual networking baseline solution. In the second phase (newly constructed East Zone), relying on the industry baseline established in the first phase, a custom network combining macro and micro sites is planned for construction, with the deployment of over 3,000 routes of native RedCap cameras and over 5,000 routes of instruments. Drawing on the baseline and experience of the Wanhua Chemical (Fujian) case, replication at various major bases of Wanhua Chemical Group is feasible. Meanwhile, it also lays a solid foundation for the replication and promotion of RedCap in large chemical enterprises represented by the oil, gas, coal and chemical industries.

Based on the case of Wanhua Chemical (Fujian), it's evident that the streamlined 5G RedCap makes the last milestone of industrial digitization easier and more accessible. By accelerating the fusion of next-generation information technology with advanced manufacturing, it achieves true "smart manufacturing" and propels the rapid development of China's new productive forces. This case is important and representative, with advanced and demonstrative implications.

The Application of 5G RedCap at Midea's Kitchen Heating and Dishwasher Factory



In addition to core functionalities, such as slicing, low latency, 5G Lan, and MEC, found in traditional 5G terminals, 5G RedCap terminals stand out due to their low cost, low power consumption, and compact size, bringing significant benefits to various production processes in the manufacturing industry.

Ni Xiaobing, General Manager of Water Dispenser Factory, Midea Group

**SOLUTION
PARTNERS**



OVERVIEW

In partnership with Midea Group, Guangdong Unicom has completed the technical validation of the nation's first fully connected factory for commercial 5G RedCap DTU terminals at Midea's kitchen heating and dishwasher factory in Foshan. For the data collection scenarios of the MES system at Midea's kitchen heating and dishwasher factory, data collection and transmission are carried out through 5G RedCap DTU. This verifies the network performance, speed, and compatibility of the 5G RedCap DTU terminal for the business scenario, fully demonstrating the feasibility of 5G RedCap applications in fully connected factories.

CHALLENGES

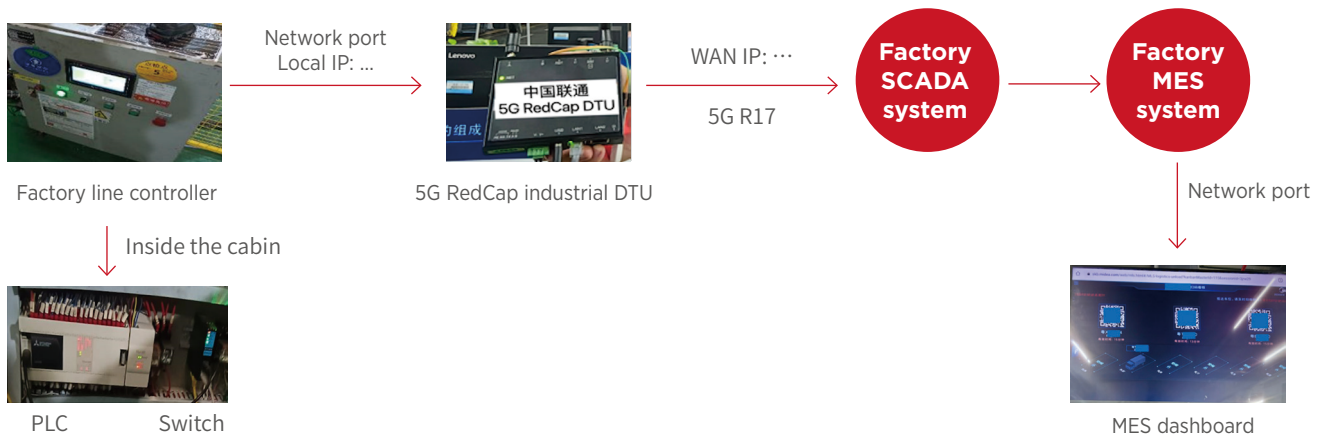
Among the four key scenarios and 11 production phases in industrial manufacturing, at least eight phases, such as industrial data collection and power distribution automation, are suitable for 5G RedCap terminal products. However, these industrial scenarios demand high network latency standards, with core production phases requiring data transmission latency to be stable at 20ms or less. Additionally, there is a high-cost requirement for terminals, and industrial-grade terminal costs are generally controlled under RMB 500.

SOLUTION AND VALUE

1. Overall structure/solution

5G RedCap, defined by the 3GPP R17 protocol standard for mid-to-high-speed IoT, is a lightweight 5G technology. Compared to 5G NR technology, 5G RedCap reduces terminal costs by simplifying antenna numbers and transmission bandwidth. It also decreases UE wake-up time through paging optimization and measurement relaxation, and by optimizing business scenarios, it reduces UE listening duration, thus lowering terminal power consumption and enhancing energy efficiency. Hence, the 5G RedCap solution not only maintains the excellent native 5G features such as large capacity, low latency, high reliability, and network slicing but also boasts lower power consumption, reduced cost, and decreased complexity, achieving a balance between cost and performance.

Guangdong Unicom and Midea Group collaborated to formulate a technical verification scheme and conducted field testing and validation for 5G+AGV scheduling, 5G+MES online integration, and 5G+SCADA online integration within a commercial 5G network setting. Using 5G RedCap



DTU connected to MES devices, product assembly stations, finished product scanning for stock-in, and other information are transmitted back to the workshop production dashboard, enhancing production efficiency, and achieving visual control over production processes. The primary focus of testing and validating 5G RedCap terminals involves key indicators including connection and residency within cells, peak uplink and downlink speeds, throughput, coverage capacity, and user latency. This test fully verifies that 5G RedCap can completely meet the application requirements of fully connected factories such as MES online connection and AGV scheduling.

2. Application Scenarios

- 01 Intelligent operation and maintenance of equipment: Through 5G RedCap technology, industrial manufacturing enterprises can achieve remote monitoring and maintenance of manufacturing equipment. Leveraging the low-latency characteristics of 5G networks, real-time collection of equipment operation data enables fault warning and predictive maintenance, thereby reducing equipment failure rates and downtime.
- 02 Safety production management: In terms of safety production management, 5G RedCap technology can support real-time monitoring of safety hazards in the production environment. For instance, sensors are installed to monitor safety risks such as toxic gas leaks and machine overheating. Relevant personnel can be promptly notified to take appropriate measures.
- 03 Material management: 5G RedCap technology can be utilized to optimize material management processes. By installing 5G RedCap terminals on materials, real-time tracking and inventory management of materials can be achieved, thus improving material circulation efficiency, and reducing inventory costs.
- 04 Smart logistics AGV: In the field of smart logistics, automated guided vehicles (AGVs) can efficiently schedule and plan routes using 5G RedCap technology. AGVs communicate with the central control system via the 5G network to achieve precise navigation and allocation of transportation tasks.

These application scenarios showcase the potential of 5G RedCap technology in the industrial manufacturing sector. Leveraging the characteristics of 5G networks such as high security, low latency, and high reliability, 5G RedCap can empower industrial manufacturing enterprises to achieve intelligent and automated transformation and upgrade.

REFLECTION

Based on this collaboration, we can draw the following conclusions: With the flexible and reliable 5G connectivity provided by 5G RedCap, coupled with the cloud-based control of PLC/SCADA systems, factories can achieve flexible production. Integration with internal logistics systems such as AGVs has reduced labor costs by 90% and increased manufacturing efficiency by 80%. In the inspection phase, leveraging the high uplink capacity and slicing capabilities of 5G RedCap, machine vision AI quality pre-inspection is implemented to achieve unified standards across multiple production lines and sharing of platform computing power. End-to-end latency is less than 25ms, resulting in a 30% increase in inspection efficiency and a 78% reduction in incoming materials defective rates. In warehousing, 5G RedCap terminals support sub-meter level fusion positioning, allowing for precise matching of material storage locations and inventory visualization. Container loading efficiency has increased by 55%. In maintenance, a plethora of 5G RedCap terminals is utilized for quality inspection, predictive maintenance, remote control, intelligent patrols, warehousing logistics, and safety monitoring in fully connected factories. By supporting 5G LAN for minimal L2 networking and autonomous terminal IP address allocation, operation and maintenance costs have been reduced by 30%.

In the future, Guangdong Unicom will collaborate with Midea's fully connected factories to complete a cooperative program involving over 100,000 5G RedCap terminals, jointly creating a new development pattern of carbon peaking and carbon neutrality in the manufacturing industry. 1) Technological innovation enhances humanistic care, as evidenced by a 100% reduction in the number of high-risk job positions for employees, a 35% increase in job satisfaction for logistics personnel, and a 30% improvement in customer satisfaction with customization experience. 2) Green strategies lead the way to carbon peaking and carbon neutrality, by reducing paper use and lowering energy consumption. 3) Industrial integration promotes a "dual circulation" development pattern. The industrial integration model of Guangdong enterprises is encouraged to be replicated worldwide, penetrating both upstream and downstream ecological industrial chains.

Guangdong Brunp Recycling's Full-Chain Zero-Carbon Smart Factories Based on 5G Private Network and 5G RedCap



As a leading player in domestic battery directional recycling, Guangdong Brunp Recycling employs China Mobile's kite-like 5G private network to establish a secure and reliable industrial intranet, providing crucial support to strategic national industries. In the future, we will continue to delve into more 5G integration application scenarios, utilizing a variety of 5G-Advanced technologies, including 5G RedCap, to set benchmarks for energy-efficient manufacturing. We will persistently lead Guangdong Brunp Recycling's nine global all-chain zero-carbon factories towards a greener, lower-carbon, and more environmentally friendly path.

He Xiaopeng, CIO of Guangdong Brunp Recycling Technology Co., Ltd.

SOLUTION PARTNERS



OVERVIEW

Guangdong Brunp Recycling has previously set up a China Mobile 5G private slice network. To decrease latency and ensure the security of manufacturing data, the "kite-like" UPF sinking scheme is adopted. By introducing 5G RedCap technology, the complexity of 5G modules has been significantly reduced, leading to a decrease of over 50% in the procurement cost of gateways containing 5G modules for Guangdong Brunp Recycling. In addition to reduced costs, 5G RedCap effectively inherits attributes such as low latency of 5G. Moreover, it overlays independent slices under the 5G exclusive mode, resulting in end-to-end latency as low as 10-15ms. This facilitates precise control of equipment such as material deployment and accurate predictive maintenance of production line faults. Owing to this, Brunp Recycling has obtained international SGS certification for zero-carbon smart factories, leading the world in quality control processes (with only 1 impurity per ton of product, equivalent to 50ppb/T of a single hair strand).



5G Private Network Platform of Guangdong Brunp Recycling

CHALLENGES

New energy batteries are a strategic sector for the nation. Currently, there are three key challenges in the manufacturing of new energy batteries:

Quality management requirements

The production and manufacturing of battery materials in the industry have high-quality control requirements. The environment is characterized by high temperatures (1000°C) and strong oxidizing properties (pure oxygen), demanding strict maintenance of equipment and facilities, control of process temperatures and energy consumption. There are multiple data collection and control points (e.g., the factory kiln for lithium battery anode materials has 70 temperature zones and 420 rods), with high frequency and reliability requirements.

Energy-saving and emission-reduction requirements:

Guangdong Brunn Recycling has established six major bases in Foshan, Guangdong; Changsha, Hunan; Yichang, Hubei; Pingnan, Fujian; and Fuding, Fujian, as well as in Indonesia, to create nine zero-carbon factories. Guangdong Brunn Recycling's nine global zero-carbon factories cover all key processes in the upstream and downstream of the recycling industry chain. They establish a "full-chain zero-carbon" model covering the entire battery recycling industry chain. In aspects such as manufacturing, logistics transportation, and park management, energy-saving and emission reduction measures need to be implemented through digital and intelligent means.

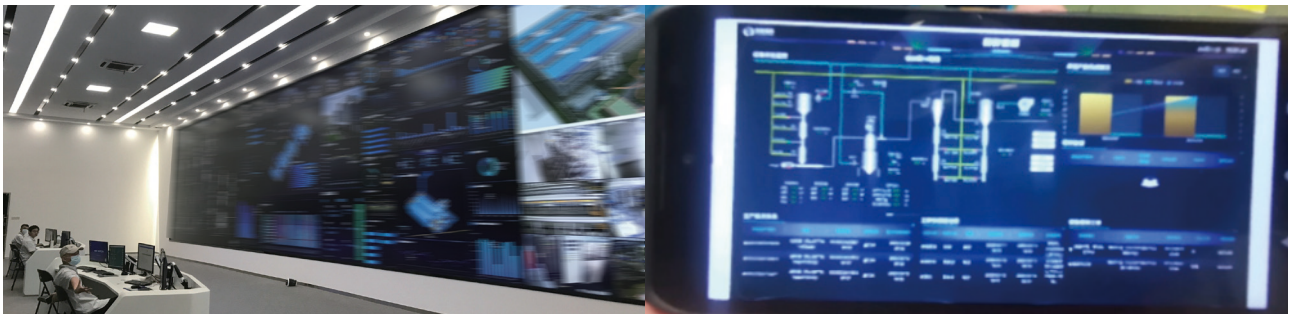
Cost reduction and efficiency improvement requirements:

During the large-scale deployment of 5G applications, there are typical pain points such as high costs of 5G modules, high terminal power consumption, and insufficient concurrent capacity, as well as challenges such as high coverage and latency requirements, and difficulty in adaptation. These issues impose certain limitations on the large-scale deployment of collection points.

SOLUTION AND VALUE

1. 5G Redcap technology empowers precise control of process deployment

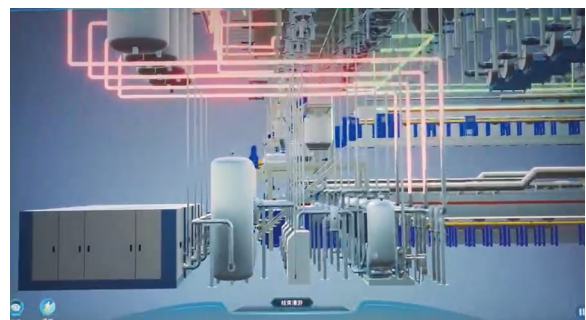
In Guangdong Brunn Recycling's factories, the latency requirement for material deployment to production is controlled within 20ms. Based on 5G RedCap technology, the industrial PDA inherits the low-latency attribute of 5G slicing. With the additional support of independent slicing under China Mobile's exclusive mode, it achieves precise control over remote material deployment. It also digitizes the management of raw materials such as nickel, cobalt, and manganese, with impurities per ton being less than one strand of hair. The process has reached a world-leading level.



① 5G RedCap + precision process control application

2. 5G RedCap empowers comprehensive energy management and control

On every hundred-meter line, there are over 100 heating rods. The control of temperature difference must have an error rate of no more than 0.005% at a temperature of 1200°C, hence the requirements for effective real-time data collection are extremely high. Empowered by the high reliability and low latency characteristics of 5G RedCap, the temperature sensor data from the heating rods, after being collected and summarized by the 5G RedCap data collection gateway, is transmitted to the factory temperature control server. A "kite-like" private network ensures uninterrupted network connectivity. As a result, the overall equipment effectiveness (OEE) of the 814 interconnected devices increases by 12.37% to reach 91.02%. Additionally, the comprehensive energy consumption per unit product decreases by 20.79%, and the product qualification rate improves to 97.54%.



① 5G + Comprehensive Energy Management and Control

3. 5G RedCap empowers predictive maintenance of equipment

AI models for quality inspection can analyze real-time equipment data and faults, predict failures, identify issues early, prevent potential risks, and proactively formulate equipment maintenance plans. The data related to the heating rods is collected and aggregated by the 5G RedCap data collection gateway for precise AI prediction, achieving a maximum allowable limit of only 50ppb (parts per billion) of impurities per ton.



5G RedCap+ Energy Control and Predictive Maintenance of Equipment

REFLECTION

The design of the 5G full-chain zero-carbon smart factory starts with the core business of Guangdong Brunp Recycling. Following the principle of practicality, production elements are divided into several key production environments such as lean production, process improvement, product development, technological innovation, and equipment management. Based on the 5G private network, it comprehensively deepens the digital construction of enterprises. Aimed at reducing costs, improving efficiency, and boosting enterprise resource synergy, the design focuses on solving the issue of information silos to facilitate the interconnected digital development of enterprises.

Based on the digital operation and stringent process control objectives of Guangdong Brunp Recycling, the project has set up a "kite-like" private network that ensures uninterrupted connectivity, creating over 10 5G AI application scenarios for key aspects of new energy manufacturing. In response to the park's massive data collection needs, the 5G RedCap lightweight technology effectively controls the cost of 5G industrial terminals and further reduces energy consumption. Through multi-level linkage of energy monitoring and evaluation, and product traceability management, critical process parameter recording achieves a collection rate of 99.99%, and the accuracy of critical process parameter execution reaches 99.99%. 5G-enabled intelligent equipment monitoring, intelligent assessment, and standardized production can prevent mistakes and incorrect operations, eliminating operator errors by 99.99%. The operation guidance stage of the formula can achieve a 99.99% reduction in operational variances.

Through multi-level linkage of energy monitoring and evaluation, and product traceability management

5G-enabled intelligent equipment monitoring, intelligent assessment, and standardized production can prevent mistakes and incorrect operations



Guangdong Brunp Recycling has planned 11 production bases globally. In the future, based on the needs of digital factories, international development of the enterprise, and leading global technologies, the company plans to deploy 5G private networks in its global production bases to further expand the implementation of 5G RedCap applications and kite-like private networks. With the advancement of the Internet of Things and cloud computing, information technology will be further integrated with industrial sectors. Functions such as intelligent control of industrial equipment and integrated system scheduling will gradually become a reality. Digital and intelligent production will bring enormous social benefits.

Park Security Management Based on 5G RedCap Visual Private Network



The 5G RedCap Visual Private Network is a new 5G private network connectivity service jointly created by China Unicom, Huawei, Dahua, and other industry giants, leveraging forward-thinking and outstanding technical expertise. By offering lower costs, decreased power consumption, faster speeds, more stable performance, and higher service quality, it redefines the industry standard for 5G private network services and provides an innovative video solution for industry customers. The 5G RedCap Visual Private Network aims to enhance the digital and intelligent progress of the visual networking industry with better cost efficiency, thereby creating greater value for our partners and customers.

Pan Haifeng, Executive Vice President of the Zhejiang Branch of the Government and Enterprise Customer Business Division, China Unicom Group

**SOLUTION
PARTNERS**

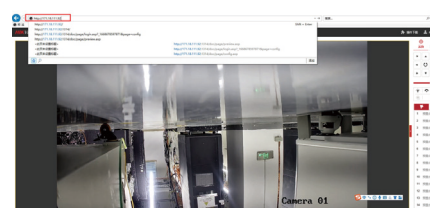


OVERVIEW

In 2023, Zhejiang Unicom, Huawei, Dahua, and other organizations jointly developed the "Park Security Management Demonstration Project Based on 5G RedCap Visual Private Network" at the Zhejiang Unicom Park in Binjiang, Hangzhou. Building on the capabilities of China Unicom's 5G RedCap network, the project deployed Dahua's 5G RedCap cameras embedded with Unicom's Yanfei 5G RedCap modules for the first time, on the basis of the Zhejiang Unicom Park Management Platform. The integration of 5G private networks, MEC edge cloud, and China Unicom cloud platform helps achieve cloud-network-edge-end collaborative innovation. This jointly verifies multiple key indicators of the 5G RedCap private network, enabling various control businesses such as seamless access control for park entrances, visitor management, fire monitoring, border control, and prevention of object throwing. With a focus on 5G RedCap+ video interaction, combining real-time feedback capabilities for park traffic and intrusion behavior, we have constructed a 5G RedCap Visual Private Network, a 5G+ park management platform, and various application scenarios to reshape park management processes. Proactive monitoring can address safety incidents and low passage efficiency due to delayed response and achieve intelligent and efficient park management. The 5G RedCap Visual Private Network has also enriched the ecosystem of the security and surveillance industry. By creating low-cost 5G video solutions, it provides a fresh boost for the further promotion of 5G video private networks.



📍 Pilot Demonstration of the 5G RedCap Visual Private Network



📍 Video Surveillance of the 5G RedCap Visual Private Network

CHALLENGES

Video private network is designed for scenarios such as security surveillance and access control linkage, serving as an effective means of monitoring illegal intrusions and issuing timely alerts for dangerous events. The current pain points are as follows:

1. High costs and low efficiency of wired surveillance restrict flexible deployment of security monitoring.

Wired surveillance systems demand a significant amount of physical wiring, leading to heightened initial installation costs and time, and potentially compromising the aesthetic integrity of the structure. Once wired surveillance cameras are installed, their positions cannot be easily changed. The addition of new monitoring points may require extra wiring efforts, and practical execution may face numerous obstacles, such as wall structure limitations and congestion in existing wiring. This constrains the system's flexibility, posing challenges for temporary monitoring requirements or situations where frequent adjustments to the monitoring perspective are needed. Moreover, as the system expands in scale, the complexity of managing and maintaining these lines also grows.

2. The efficiency of surveillance is diminished by Wi-Fi monitoring signal coverage, bandwidth constraints, and security issues.

Despite addressing wiring concerns, the stability and coverage range of Wi-Fi signals pose ongoing challenges for Wi-Fi monitoring systems. It is not easy to maintain a stable Wi-Fi connection in large facilities or environments with multiple sources of interference. Conventional Wi-Fi monitoring systems might be unable to cope with the high bandwidth requirements of multiple high-definition video streams, restricting the number of cameras and the quality of video. Without proper safeguards, a Wi-Fi network may be susceptible to hacking attacks or data breaches. While wired networks are relatively more secure, they still face the risk of physical interception or sabotage. Particularly in intricate industrial settings, electromagnetic interference and signal attenuation can compromise the performance of wired and Wi-Fi surveillance systems.

3. Traditional wired and Wi-Fi surveillance systems struggle to meet the requirements of new technologies and emerging business models.

Traditional surveillance systems undergo technological updates at a slower pace, while Wi-Fi surveillance systems demand regular firmware updates, vulnerability fixes, or feature enhancements, leading to elevated maintenance expenses. The application of AI, large models, big data, and similar technologies, alongside heightened security demands, raises significant requirements for network mobility, real-time responsiveness, and high-speed transmission. The 5G RedCap video private network is designed to meet different mobility, AI-enabled collaboration demands, and high-security scenarios with network isolation through cloud-edge collaboration.

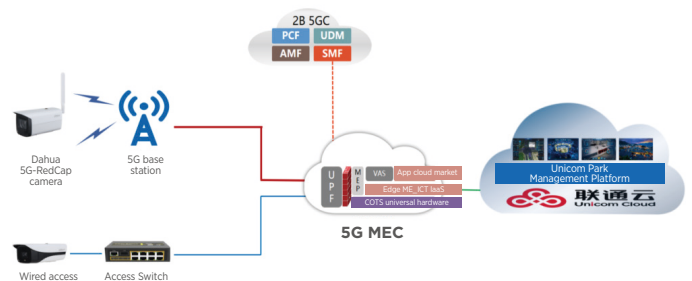
SOLUTION AND VALUE

1. Overall structure/solution

The advent of 5G RedCap technology has facilitated the development of video services by offering capabilities such as low cost, high speed, dedicated private network, and multi-system interaction, addressing challenges of remote monitoring locations, inconvenient wiring, high construction costs, and insufficient business interaction in park management settings. Focusing on 5G RedCap+ video interaction technology, this project incorporates AI analysis, network slicing, and other technologies to interconnect multiple videos of park entrance control, fire monitoring, and border control. The use of 5G RedCap cameras, access control, park management platform, employee app, and other tools enables capabilities like park entry access, clocking in and out, fire control, intrusion detection, etc. This facilitates information sharing and collaborative interaction, leading to reduced response time and improved park management efficiency.

(1) System architecture

The 5G RedCap Visual Private Network, developed and operated by China Unicom in collaboration with Huawei and Dahua, is a private network project in Hangzhou aimed at reducing the deployment costs of visual networks through 5G RedCap cameras in scenarios such as park security, smart manufacturing, cultural tourism live broadcasting, and intelligent roads. Based on cloud-edge collaboration, fixed-mobile integration of private lines and private networks, it meets the requirements of visual networking services for terminal cell residency, network latency, jitter, bandwidth, etc. This achieves functions such as visualizing security data in parks, flexible deployment of tourism live broadcasting, and coordinated road information perception.



Architecture of the 5G RedCap Visual Private Network

(2) Network

Through key technologies such as network slicing and edge computing, a 5G RedCap park-level video private network is built to offer continuous full-domain coverage, medium to high speed, low latency, broad connectivity, customization, and reliable security. This network links multiple layers of network connections from "access control/surveillance cameras - park intelligent management platform - employee devices".

(3) Technical solution

1. 5G RedCap+ intelligent park management platform

Including 5G RedCap cameras, access control, and the 5G RedCap park management platform. The real-time sharing of camera video and access control information with the park management platform ensures more efficient security monitoring operations within the park. This allows for smoother connection inside and outside the park and enhances the park's overall management service capabilities. Employees and visitors are provided with more convenient and efficient services, and the park's security measures and early warning capabilities are strengthened.

2. 5G RedCap camera transformation

By retrofitting the cameras with 5G RedCap technology, enabling compatibility with 5G RedCap modules, and conducting tests on camera terminal hardware and networks, the cameras can meet the demands of 4K video streaming and various AI application scenarios, thus reducing the cost of 5G cameras and increasing 5G utilization.

2. Application scenarios

(1) Park security

The 5G RedCap Visual Private Network, developed and operated by China Unicom in collaboration with Huawei and Dahua, is a private network project in Hangzhou aimed at reducing the deployment costs of visual networks through 5G RedCap cameras in scenarios such as park security, smart manufacturing, cultural tourism live broadcasting, and intelligent roads. Based on cloud-edge collaboration, fixed-mobile integration of private lines and private networks, it meets the requirements of visual networking services for terminal cell residency, network latency, jitter, bandwidth, etc. This achieves functions such as visualizing security data in parks, flexible deployment of tourism live broadcasting, and coordinated road information perception.

Park security management is achieved based on the 5G RedCap Visual Private Network + Park Management Platform, using real-time synchronization of multi-dimensional perception data from videos, real-time superimposition of point video data, and full-domain security visualization. It includes the following capabilities:

(1) Video surveillance system: 5G RedCap HD cameras are deployed to monitor key areas of the park in real time. Video data is recorded and stored for future retrieval and analysis.

(2) Access control system: Identity authentication devices such as employee card swiping, fingerprint recognition, or facial recognition are used to regulate personnel entry and exit permissions in specific areas, ensuring that only authorized individuals can access sensitive zones.

(3) Intrusion alarm system: Equipment such as infrared motion sensors and vibration detectors are employed to detect unauthorized intrusion attempts and immediate alarms are issued upon detection of anomalies.

(4) Vehicle management system: License plate recognition technology is used to manage vehicles entering and exiting the park, which not only improves traffic flow efficiency but also prevents unauthorized vehicles from entering.

(5) Visitor management system: Visitors' identities are registered and verified before temporary passes are issued. Their movements are tracked during their visit to ensure they remain within designated areas.



(6) Electronic patrol system: Patrol points are set, along with patrol batons or mobile applications, to ensure security personnel conduct patrols on time and along designated routes, effectively preventing security risks.

(7) Emergency alarm and response system: In emergency situations such as fire, earthquake, etc., the system can quickly trigger alarms and notify relevant personnel to evacuate and respond promptly through broadcasts, text messages, etc.

(8) Environmental monitoring system: Temperature, humidity, smoke, and other environmental parameters within the park area are monitored to implement appropriate measures upon detection of anomalies.

(9) Public broadcast system: It is used to disseminate daily notices, emergency messages, etc., ensuring that information can be quickly conveyed to everyone within the park.

(10) Data center and monitoring center: Serving as the "brain" of the park's security system, it is responsible for receiving, processing, analyzing various information, and generating reports for management decision-making.

(11) Intelligent analysis and early warning system: Artificial intelligence technology is used to intelligently analyze surveillance footage, automatically identify abnormal behavior, and issue warnings, thereby enhancing security capabilities.

(12) Mobile application and remote management: Through a mobile application, management personnel can access the security system anytime and anywhere, view real-time video, receive alarm notifications, and perform remote scheduling.

REFLECTION

The 5G RedCap visual networking system tackles issues of high terminal costs and difficult deployment in wired environments and enhances economic benefits. The cost per device is decreased by 20%, terminal power consumption is lowered by 60%, and installation time is reduced to just a few minutes. The 5G RedCap Visual Private Network system, enabled by cloud-edge coordination, has enhanced deployment efficiency and improved application effectiveness. Unidirectional latency drops to 15ms, application judgment time is reduced to seconds, and alarm accuracy is increased by 10%.

Takeaways:

1) Cloud-edge coordination-based visual networking services powered by 5G RedCap are proposed to assist government and enterprise customers in upgrading their security systems wirelessly.

2) The case provides reference and inspiration for the implementation of multiple scenarios such as park security, smart manufacturing,

cultural tourism live broadcasting, and intelligent roads, meeting customers' needs for mobility, environmental sustainability, and low carbon emissions.

3) The development of security products delves deeper into the realm of 5G, thereby shaping a new trajectory for 5G development across the security industry.

Follow-up plans:

1) Promotion of 5G RedCap Visual Private Networks in segmented areas, including scenarios such as waste sorting, environmental monitoring, and public safety.

2) Promotion in scenarios such as urban road surveillance, community blind spot coverage, and scenic area blind spot coverage by leveraging the extensive network coverage and ease of deployment advantages of 5G RedCap cameras.

Summary

The mass commercialization of 5G technology heralds the beginning of the Internet of Everything era, significantly accelerating the digital transformation of numerous industries and injecting robust momentum into the high-quality growth of the mobile IoT sector. According to data from the Ministry of Industry and Information Technology of China, by the end of 2023, China had achieved 1.845 billion mobile IoT connections. Outpacing major global economies, China is the first to reach the milestone where "the number of IoT devices exceeds the population". Forecasts indicate that by 2030, global mobile IoT connections will total 5.3 billion, with an annual compound growth rate exceeding 20%.

5G RedCap is a "lightweight" 5G technology that, while meeting business needs and performance requirements, trims bandwidth, the number of antennas, and modulation order, and lowers terminal complexity and power consumption to reduce the cost of 5G terminals. 5G eMBB technology leads the trend with its high speed and efficiency, while NB-IoT technology dominates low-speed scenarios. The emergence of 5G RedCap fills the gap in mid-to-high-speed and medium-speed connection fields. In conjunction with 5G eMBB, LTE, and NB-IoT technologies, it has developed an all-encompassing mobile IoT technology framework that addresses low, medium, and high-speed needs, ensuring the coordinated operation of 4G and 5G.

- High-speed scenarios (>100Mbps) rely on 5G eMBB support;
- Medium and high speed scenarios (10-100Mbps) are jointly supported by LTE Cat4 and 5G RedCap;
- Medium-speed scenarios (100kbps-10Mbps) currently rely on 4G Cat1, and will be served by enhanced RedCap (eRedCap) in the future as the 3GPP R18 standard defined;
- Low-speed scenarios (<100kbps) are supported by NB-IoT and other low-power wide-connectivity technologies.

3GPP began formulating the 5G RedCap in R17 standard from 2019 on and completed it in 2022, addressing aspects such as reduced terminal complexity, residency and access control, mobility, terminal identification, BWP configuration, and low power consumption. Since 2021, 3GPP has launched research on R18 eRedCap technology, scheduled to conclude by June 2024, aiming to further lower terminal complexity and power consumption by reducing service bandwidth and peak rates.

Key features of 5G RedCap technology include:

- **Efficient spectrum utilization:** By optimizing spectrum resource management, it offers efficient connectivity services within the confines of limited spectrum resources, ensuring robust performance even in spectrum-constrained environments.
- **Low power consumption:** Compared to traditional 5G technology, 5G RedCap significantly lowers power consumption, making it particularly suitable for terminal devices powered by low-capacity batteries, such as wearable devices and IoT sensors.
- **Low cost:** One of the design intentions is to reduce the cost of

terminal equipment and promote large-scale deployment and widespread adoption. The economic benefits of 5G RedCap are evident in various application scenarios due to simplified terminal device hardware designs and reduced network deployment costs.

- **Catering to diverse application scenarios:** 5G RedCap supports a broad spectrum of applications including smart grid, smart city, smart manufacturing, and consumer electronics.

The primary application scenarios of 5G RedCap currently include video surveillance, data collection, and remote control. Thanks to its low power consumption and efficient connectivity, it emerges as the perfect option for video surveillance systems, offering significant extension of device battery life without compromising image quality. In the data collection domain, such as environmental monitoring and industrial sensor networks, 5G RedCap technology enables real-time and precise low-cost data transmission, demonstrating advantages even in power-sensitive situations. Regarding remote control, the low latency feature of 5G RedCap ensures the efficiency and reliability of industrial automation and remote operation, improving production efficiency and operational safety without substantial cost increases.

Currently, leading chip manufacturers have rolled out 5G RedCap products, and nine chip manufacturers have released relevant products, four of which have started mass production. Moreover, nine module manufacturers have unveiled over 20 varieties of modules with various packaging types, comprising industrial DTUs, video surveillance IPCs, CPEs, dongles, and more than 50 terminal products are available on the market.

The year of 2024 marks the inaugural year of commercialization for 5G RedCap. This "5G RedCap Case Studies" report demonstrates the broad utilization and significant potentials of 5G RedCap technology in areas such as smart grid, smart city, and smart manufacturing. Through detailed data and case studies, it offers insights into how 5G RedCap plays a pivotal role in various contexts and outlines its future development.

The consumer electronics field is essential for the extensive deployment of 5G RedCap, covering wearable devices, smart home, medical and health equipment, and beyond. Notably, 5G RedCap features 10 Mbps-level audio and video transmission and 100 ms-level latency interaction, while satisfying the lightweight and low-energy requirements of multimodal edge-cloud collaborative wearable AI devices. This advancement is poised to shift wearable AI devices from relying on smartphone tethering to standalone cellular network connectivity.

In brief, 5G RedCap technology is gaining significance in diverse industries due to its distinctive strengths. Through detailed case analysis and data presentation, the "5G RedCap Case Studies" report provides readers with a comprehensive understanding of this technology. We believe that as technology advances and application scenarios grow, 5G RedCap will bring more innovation and transformation to the digital transformation and development of the economy and society.

GSMA

**1 Angel Lane
London
EC4R 3AB
United Kingdom**

**Tel: +44 (0)20 7356 0600
Fax: +44 (0)20 7356 0601**

