China 5G Vertical Use Cases Quarterly Report

Q4 2020

&

2020 Whole Package

Zemin Yang

CCSA

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Contents

Q4

1 Contributor List

- Editor

  CCSA (China Communications Standards Association) http://www.ccsa.org.cn/

- Others

  - ✓ 5GDNA (5G Deterministic Networking Alliance) https://www.5gdna.org/
  - ✓ 5GSA (5G Slicing Association) http://5gnsa.org/
  - ✓ 5GAIA (5G Applications Industry Alliance) http://www.5gaia.org/

2 Key Messages & Suggestions

- ✧ China 5G Vertical Industry in this quarter report includes Multimedia (updated based on Q3 report), Smart Factory (updated based on Q2 report), Mobile Health (updated based on Q2 report), Smart Grid (updated based on Q3 report), and 5G Slicing E2E Standard & Industry Progress and Research Requirements (updated based on Q3 report).
- ✧ In general, big progress have been made on terminals and slicing, and it is on the way to industry standards based on commercial cases
- ✧ Suggestions
  - ■ European partners could learn the experiences from China 5G vertical industry top use cases, and start commercial use with less difficulty.
  - ■ China and Europe corresponding partners could closely cooperate on the further requirements from the 5G vertical industry top use cases, not only on the technology research and standard enhancement, but also the industry bottlenecks.

3 General Information

In September 2020, the third "Bloom Cup" 5G application competition was held, representing the overall progress of China's 5G 2B industry exploration. A total of 4000+ projects were submitted for the competition, and 30 excellent cases were selected, including 10 first prizes and 20 second prizes. 5G 2B focuses on five directions: industrial IOT, medical IOT, multimedia, energy IOT, and intelligent transportation (including ports and metros). The mining industry has become a highly popular one. Among the top 30 projects, industrial IOT accounts for 43%, followed by medical IOT 20%, and multimedia, energy IOT, and intelligent transportation 10% respectively.

Industrial IOT is the key focus. Most projects involve machine vision and AI detection applications, which are the first batch of 5G application scenarios. The main requirements of the solution are that MEC meets data security assurance and

deterministic super uplink bandwidth, and new features such as 5G LAN of Release 16 are introduced. In terms of the industry ecosystem, industry convergence is accelerated, for example, the release of industry convergence white papers (such as steel and cement) and the establishment of joint laboratories / alliance.

The healthcare project accounts for 20%, second to industrial manufacturing, and is the focus of carriers. Telemedicine is the main service scenario, accounting for more than 54% of the total, and real-time remote consultation accounts for more than 57% of telemedicine. In terms of solutions, data transmission within campus networks and high bandwidth connection are the key content.

In the multimedia field, digital twin, 5G cloud XR, and MEC technologies are converged, with 5G high-precision capabilities to form industry solutions, such as 5G smart business.

The energy IOT field mainly includes the electric power and mining industries. Power distribution networks are the most valuable 5G scenarios in the electric power industry. Virtual industry private networks based on public network slicing have become the mainstream solutions. Quickly fill the weaknesses of industry terminals, including 5G industrial routers, 5G timing CPEs, and 5G cameras. The mining industry mainly focuses on AI video analysis and monitoring and automatic driving. Owners are willing to pay for the projects.

4 Use Cases Detail Information

4.1 5G Multimedia (updated based on Q3 report)

4.1.1 Top Use Cases - Smart Stadium (Continued)

The 5G+MEC smart stadium solution won the Excellent Innovative Product and Solution Award of China's Ultra HD Video Industry Alliance (CUVA) on November 2nd. It was the highest award in the UHD video field in China initiated by CUVA and serves as the industry trend vane, helps China's UHD video industry thrive.

The solution is planned to support key sporting events by the end of 2020 and establish industry commercial benchmarks. After the Chinese Super League start footballing events normally in 2021, the solution will be popularized and applied on a large scale, and will be extended to other sports events, shopping malls and supermarkets, exhibition halls, and tourist attractions.

4.1.2 Top Use Cases - Smart AR Advertisement Screen (Continued)

The AR advertising service based on 5G+MEC is attractive to airports, museums, and tourist attractions. It brings ultimate user experience and wins favors from multiple media groups and venue operators. The major industry breakpoint of project implementation is to find clear business operation entities, sort out the industry division of roles, and streamline supply and demand.

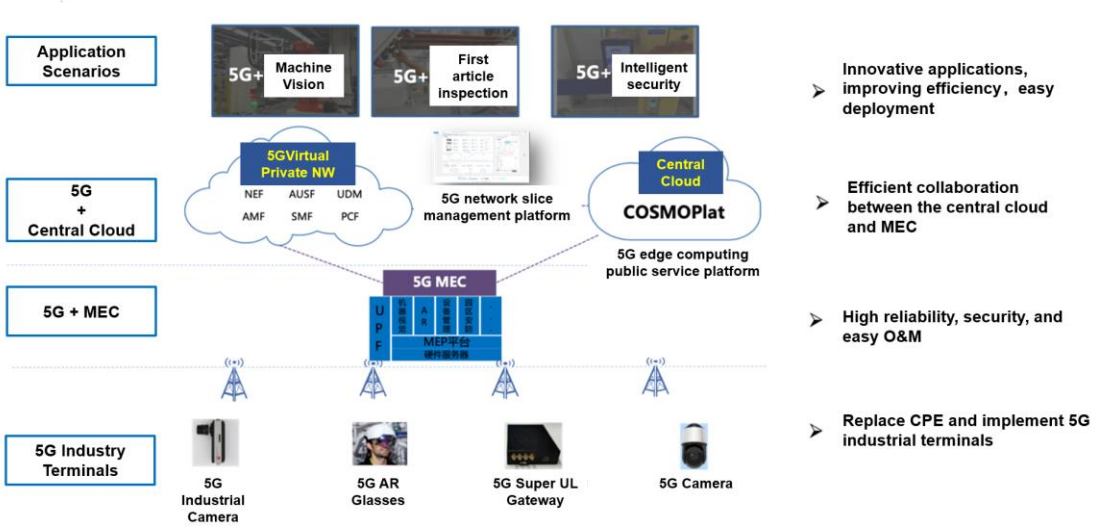
4.2 5G Smart Factory (updated based on Q2 Report, since Q3 report has no progress)

4.2.1 Top Use Cases – Haier Smart Factory (Continued)

- **Slicing Solution Progress**

Use 5G network slicing and MEC edge computing to build a 5G private network for smart industrial parks in the Haier China-German campus. 5G key technologies such as network slicing and edge computing could meet the campus's requirements for network determinism. The operation platform (MEC management platform and slice management platform) was deployed for visualized and manageable networks. Based on the convergence of COSMOPlat and 5G edge computing platforms, the solution was implemented to solve the pain points of traditional campus networks.

The Haier Industrial Park covers four slicing scenarios: smart manufacturing, smart home, smart logistics, and smart campus. It basically covers the network service requirements of multiple production phases, such as industrial manufacturing, smart logistics, and campus security. In September 2020, the Haier project successfully implemented slicing deployment and verification in service scenarios such as dressing mirrors, HD videos, machine vision, and intelligent large-screen refrigerators. The Haier project was the first to complete the E2E capability test and verification of 5G slicing subscription, rollout, and O&M, this is the first pilot deployment of 5G full-process slicing in industrial manufacturing scenarios in China, enabling 5G deterministic networks to support the industrial IOT.



Picture 1 - Haier 5G Private Network Solution with Terminal-MEC-Cloud Synergy

- **Progress Summary**

During the intelligent upgrade of the Haier industrial park, the COSMOPlat industrial platform integrates the differentiated and exclusive features of 5G deterministic networks to implement 5G-based Terminal-MEC-Cloud synergy applications, meeting industry users' requirements for algorithms to be migrated to the cloud while data are kept inside the factory, this solution effectively improves the efficiency, security, and labor costs of traditional factory operations and helps Haier implement the user experience-centric large-scale customization mode.

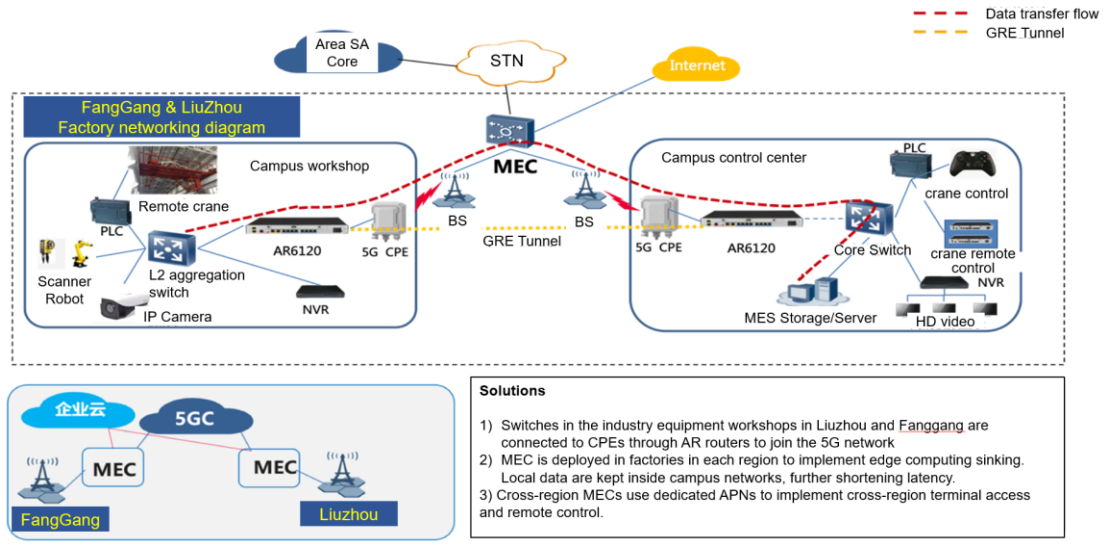
In addition, the upgraded industrial park also implements interconnection of all production elements and production processes, which is important for 5G industrial IOT applications in Haier interconnection factories. The project achievements can be converted into industrial IOT products or solutions that can be replicated and promoted, implement cross-industry and cross-domain enablement based on the COSMOPlat industrial IOT platform.

4.2.2 Top Use Cases – Smart Factory for Guangxi Liuzhou Iron and Steel Group Company Limited (NEW)

➢ Solutions

Based on the technical features of 5G deterministic networks with high bandwidth and low latency, the project customizes the "controller + 5G network + loader" solution to implement 5G HD video backhaul and remote accurate control.

Liugang Group uses the low-latency data transmission of 5G deterministic networks, industrial brain real-time analysis of big data, and machine vision servers and AI servers in the cloud to replace manual transfer rolls. Liugang Group gradually promotes the technology, reputation, and intelligence to other production lines.



Picture 2 - Solution Architecture of Cold Rolling Plant of Liugang Group

A set of 5G video backhaul control is deployed in Liuzhou, in order to support the remote control of the loader operation in FangGang Cold Rolling Plant, and the two places with distances of hundreds of kilometers. In addition, based on the remote control implementation in the two cities, Liugang Group tried to verify the feasibility of "Industrial Cloud Brain" and gradually cloudify production auxiliary data, device data, and related model computing algorithms.

In addition, the cost of machine vision servers is high and algorithm training is difficult. It is unrealistic for enterprises to develop AI algorithms such as machine vision. Liugang Group uses the 5G+cloud+AI mode to aggregate training and shaping cloud computing from multiple vendors to MEC, in addition, some applications of the same type and machine vision-based applications in Liuzhou and FangGang are gradually cloudified, greatly reducing the configuration threshold and quantity of local servers. Currently, matured cloud computing, such as QR code recognition, OCR recognition, facial recognition, NFC recognition, and capture location recognition, has been loaded to MEC.

- **Summary**

This project implement HD video backhaul and remote precise control, enables operators in the central control room of Liugang Group to operate the loader in FangGang Cold Rolling Plant in real time with multiple angles, reducing the manpower required for a single hoist by 60%, the loading and unloading efficiency is improved by 400%.

With the 5G+MEC application, the cold rolling plant has successfully resolved the pain points and difficulties that have plagued enterprises for many years. It once required three persons to complete a single lifting operation. Now, only one person can complete the operation by sitting in front of a computer. The 5G technology solves cabling problems and allows devices to be deployed anywhere, making applications more flexible and diversified scenarios.

4.3 5G Mobile Health (updated based on Q2 Report, since Q3 report has no progress)

4.3.1 Top Use Cases - Medical Alliance in Futian District, Shenzhen (Continued)

Medical device vendors provide various terminals with built-in 5G modules to meet 5G access requirements of Mobile ward round vehicles, mobile care vehicles, operating rooms, ICUs, bedside consultation vehicles for special patients, and remote video caravans. It includes:

Picture 3 – Medical Device Vendors Provide Various Terminals

4.3.2 Research Requirements and Industry standard (Continued)

On October 24, 2020, mobile vendors jointly released the 5G medical group standards with some hospitals, carriers, medical equipment vendors, and medical application vendors. Currently, 5G medical industry standard subject has been successfully initiated in the National Health Commission.

New standards are helping 5G deterministic networks enable the healthcare industry to move towards mobility, remote, and intelligent transformation, and facilitate the replication of 5G healthcare.

4.4 5G Smart Grid (updated based on Q3 report)

4.4.1 Top Use Cases - China Southern Power Grid (Continued)

- Technical PoC Update

China Southern Power Grid, mobile operators, and vendors jointly claimed the first prize in the 3rd 5G Application Contest of Blooming Cup in 2020. Based on this project, the three parties have sorted out the E2E 5G smart grid solution and started writing test solutions and test cases. The next step is to conduct live-network tests and verification.

- Standard Update

China Southern Power Grid plans to promote the 5G+ smart grid industry standard architecture in near term.

4.5 5G Smart Port (No update. Please check Q3 Report)

4.6 5G Slicing E2E Standard & Industry Progress, and Research Requirements (updated based on Q3 report, Progress in red)

Internationally, 5G RAN and CN network slicing standards are mainly researched in 3GPP, and transmission slicing standards are mainly researched in IETF. In China, the CCSA has established a special project team to solve the problem of independent deployment of each sub-domain and cross-domain interconnection manually. The progress of each standard organization is as follows.

4.6.1 3GPP

- ✧ SA2 (Architecture)

R15, the basic slice architecture functions are formulated, including architecture, identification and selection of a Network Slice, network slicing session management, network slicing for roaming, network slicing and Interworking with EPS, etc.

R16, the network slicing functions are enhanced, including interworking with EPS, network slice-specific authentication and authorization, slice-level SLA assurance, etc. R16 has been frozen in September 2019.

R17, the enhancements study of Network Slicing Phase 2 are proposed. The objective of this study is to identify the gaps in the current 5G system procedures defined in SA WG2 to support GST slicing parameters, and to study potential solutions that may address these gaps. The standardization will begin in 2021.

- ✧ SA5 (Telecom Management)

R15 released at the end of 2018, including basic concepts, roles, management requirements of network slicing, lifecycle management of network slicing, hierarchical and service-oriented architecture, resource model, configuration management, fault management and performance management, etc.

R16, network slicing management were enhanced, including service discovery of cross-vendor management, support tenant concept, slicing management capability exposure and E2E key performance indicator enhancement for network slicing. In addition, charge of network slicing (2B) was defined.

Now, R17 research is in progress. This research focuses on how to provide consistent and assured communication services across operators, define operators' network resource models and ensure slice SLAs for industry network slicing. The standardization will begin in 2021.

- ✧ SA3 (Security)

3GPP SA3 mainly researches standards related to mobile network security. In 3GPP R16, the major research contents of network slicing include: (1) network Slice-Specific Authentication and Authorization, re-authentication and re-authorization, authorization revocation. (2) Privacy of a network slicing, including privacy protection of a network slicing at air interface and protection solutions for network slice privacy not known by third-party slice authentication and authorization servers. (3) Privacy of user IDs used for network slice authentication and authorization; (4) Network slicing management security. Now, R16 has been released.SA3 is currently discussing whether a study is needed in R17 for the security of enhanced slicing.

4.6.2 IETF

IETF mainly focus on research on IETF network slice standardization. The standardization research mainly includes: (1) Research on the IETF network slice architecture, including the VPN+ architecture, IETF network slice definition, upper-layer architecture and cross domain network slice mapping. (2) Research the network slicing management plane, focusing on the IETF network slice northbound interface model. (3) Research on the control plane of IETF network slice, focusing on the extension of control plane protocols of IETF network slice. (4) Research on the data plane of IETF network slice.

Currently, the architecture is gradually stable and it is expected that the data plane standardization of slicing will become stable by end of 2020. The other projects are still being defined. But the detailed work plan has not been determined. The key industry members hope the control plane protocol extension can be stable by 2021.

4.6.3 CCSA

In order to resolve cross domain network slicing specifications, CCSA established a special project team in December 2019. At the first meeting of the project team, some standards were proposed, including the generic requirements of 5G E2E network slicing, E2E network slicing interworking requirements based on SPN/IP transport network and technical specification for 5G network slicing SLA. In July 2020, the second series of standards were proposed, including TN-NSSMF (Network Slice Subnet Management Function) functional and interface requirements. In September 2020, the three industry standards of the generic requirements of 5G E2E network slicing and E2E network slicing interworking requirements based on SPN/IP transport network were stable. These three industry standards will guide the E2E 5G network slicing construction. In the future, the other 5G slicing industry standards will be studied, such as 5G network slicing SLA, transport slice management, etc.

4.6.4 5GSA (NEW)

In March 2020, 5GSA (5G Slicing Association) members, including Huawei, China Mobile Research Institute, Tencent, China Electric Power Research Institute, and Digital Kingdom, jointly released the “Network Slicing Hierarchy White Paper”, which is based on vertical industry requirements, current network slicing standard definitions, and industry implementation capabilities, five capability levels of E2E 5G network slicing are defined: L0 public network slice, L1 public network VIP slice, L2 industry network slice, L3 industry network VIP slice, and L4 industry network special slice. The release of the white paper provides technical guidance for commercial use of network slicing, helps the industry to have a clearer understanding of network slicing capabilities in the early stage of commercial use, and builds a bridge between technology and business.

In the second half of 2020, five new members, including China Telecom, China Unicom, Sports media, AsiaInfo, and Gree, officially joined the 5GSA Slicing Alliance. The alliance members were further expanded and the voice of the slicing industry was further strengthened.

In November 2020, Huawei, China Mobile Research Institute, China Unicom, China Telecom Research Institute, China Electricity Research Institute, Tencent Game, Sports media, Gree, Digital Kingdom, AsiaInfo, and many 5G SA Members jointly released the “5G Network Slicing Industry Self-Management White Paper”, which summarizes the four-layer overall architecture of the network slicing management plane, includes the slice capability exposure platform, communication service management function (CSMF), network slice management function (NSMF), and network slice subnet management function (NSSMF). The key capabilities of these functions can be used as a reference for carriers' network construction and deployment.

China 5G Vertical Use Cases Quarterly Report

Q3 2020

Zemin Yang

CCSA

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Q3

1 Contributor List

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- Others

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2 Key Messages & Suggestions

- ✧ China 5G Vertical Industry in this quarter report includes Multimedia (updated based on Q2 report), Smart Grid (updated based on Q2 report), Smart Port (New), and 5G Slicing E2E Standard Progress & Research Requirements (New).
- ✧ Smart Grid is already commercial. Multimedia is pre-commercial. Much more POCs have been deployed in China.
- ✧ Suggestions
  - ■ European partners could learn the experiences from China 5G vertical industry top use cases, and start commercial use with less difficulty.
  - ■ China and Europe corresponding partners could closely cooperate on the further requirements from the 5G vertical industry top use cases, not only on the technology research and standard enhancement, but also the industry bottlenecks.

3 Detail Information

3.1 5G Multimedia (updated based on Q2 report)

3.1.1 Top Use Cases - Smart Stadium (Continued)

China Sports Media (CSM), China Mobile and telecom vendors have jointly built a 5G smart stadium solution at the Jinan in Shandong Province.

The project is divided into two phases. The 1st stage is "editing & communication", mainly used for sports competitions and commercial show for CSM. The 2nd stage is now pre-commercial, to cooperate with stadium operators to digitize stadiums and enable "Internet + sports" and "Internet + stadiums". The Q2 quarterly report explained the first phase. This quarterly report illustrates the progress of the second phase.

CSM, Shandong Mobile, Migu, Shandong Luneng Taishan Football Club, and telecom vendors worked together to achieve the first MEC-based 5G smart stadium show at Jinan Luneng Training Base on June 4, 2020.

➢ The pre-commercial solution is mature

- Multi-camera live broadcast with ultra-low latency

In the actual event, the 4 camera signals from different positions are encoded (single-channel uplink coding rate is 15Mbps), and they are respectively transmitted to the MEC through uplink of the 5G network. Transcoding is performed by the MEC (single-channel transcoding rate is 10Mbps), and distributed to 5G terminals through the 5G network. Mobile users can independently select multi-camera signals, switching to watch the content of the event. The end-to-end delay of all multi-camera signals is required to be less than 1s. Synchronous transmission among multi-cameras is maintained. The live broadcast signal and multi-camera switching require smooth and no frame freezing, and the visual quality was evaluated by subjective evaluation to achieve excellent on-site experience.

- 180°VR / 360°VR

In the actual event, the multi-camera signals of the two specifications of 180° and 360° VR are encoded (180° single-camera uplink coding rate 15Mbps, 360° single-lens uplink coding rate 5Mbps), respectively uplink to MEC through the 5G network. The 180°VR signal is processed by the MEC for distortion correction, virtual background fusion and transcoding (single channel transcoding rate 10Mbps), and is distributed to 5G terminals through the 5G network downlink. The 360°VR have 4 lens, and each lens signal is independently transmitted through uplink to the MEC. The MEC performs synchronous alignment, multi-lens splicing, FOV (Field of View) optimization and transcoding (single channel transcoding rate 10Mbps), then distribute to 5G terminals through the 5G network. The mobile user can independently select the multi-camera signals to switch the viewing angle. The VR live signal requires no visible defects in splicing quality, no visible distortion of the 180° foreground signal, and smooth signal without frame freezing.

- Wonderful short video

In the actual event, the multi-camera signals are transmitted to the remote production center for short video editing and production, and packaged as a video clip with video title and description information. The encoding standards include H.264, mp4, 4M code rate encoding. The remote production center uploads short videos to MEC through the public network, and the MEC distributes them to 5G terminals through the 5G network. The short video playback delay requires that it can be watched on the terminals within 2 minutes after the event occurs. The quality is evaluated by subjective evaluation, and the video has no visible flaws and frame

freezing. The short video title and description information can be normal present in the corresponding position.

- Real-time event data

Real-time event data is provided by the platform of Yingdong Power Event Data (GDM), and CSM Remote Big Data Center provides real-time data analysis and production. 5G terminals at the game site accesses the game platform interface through the app, and presents real-time game data in the form of automatic data capture. The terminals experience requires that the data presentation delay is less than 10s. The app obtains the dynamic information of the event data at a refresh rate of 1s. The presentation of the event data is consistent with the actual game content, and the event information is displayed in an accurate chronological order.

Picture 1 - Real-Time Super Audience Experience

	Number of Cam	Number of View	Camera	Video specifications	Estimated Upstream Bandwidth	Actual Downlink Bandwidth	Estimated downstream bandwidth	Actual downstream bandwidth
Multi-cabinet plane live broadcast (fixed slot)	4	4	Broadcast TV SDI HD Camera Output 1080p	1080P 25FPS	15M*4	10M*4	10Mbps	10Mbps
Ultra-wide-angle 180° VR live broadcast	1	1	4K stream output of the ultra wide-angle fisheye lens	4K 25FPS	30M	15M	15Mbps	15Mbps
360° VR live broadcast	1	4	4-channel 4K output of a 4-camera 360-degree VR camera	4K 25FPS	15M*4	3M*4	15Mbps	15Mbps
Total	6	9			150Mbps	67Mbps	10Mbps~15Mbps	10Mbps~15Mbps
About 120 minutes of broadcast					135GB	60.3GB	9GB~13.5GB	9GB~13.5GB

Table1 - E2E traffic measurement

Picture 2 - Test on the switch delay of multiple cameras: ~290ms

➢ The value chain of the pre-commercial solution is clear

The 5G smart stadium solution realizes the key capabilities of MEC's multi-stream real-time splicing, high-definition low-code and precise streaming, and can provide live users with a real-time super live viewing experience of less than 1 second (multi-camera viewing, VR viewing, Wonderful short videos and real-time event big data), to provide event organizers with agile production and broadcasting service capabilities that replace broadcast trucks, and enable intelligent services in stadiums. The 5G smart stadium solution can save event organizers more than 40% of operating costs such as OB (Outside broadcasting) vans and stadium wiring, and the revenue per event is expected to increase 20%. The 5G network operators can lease 5G super uplink dedicated lines and 5G edge computing services, which bring more than extra 30% revenue.

5G smart stadium applications have been widely disseminated in stadium live broadcasting related industries, and aroused positive responses. CSM has successively received feedback and cooperation requirements from customers in various industries. In addition to sports event organizers and sports industry bases, there are also other industries such as Beijing International Service Trade Fair and Taihe Music in the field of digital music. Now, the solution still needs further exploration and innovation in the product offering, and the clarification of the responsibility interfaces among CSM, the 5G network operators, and industry customers.

3.1.2 Top Use Cases - Smart AR Advertisement Screen (NEW)

Outdoor advertising, which introduces 5G and AR technology and connects with consumers' paths, has once again attracted the attention and favor of advertisers. According to the analysis of iResearch, the compound annual growth rate of the outdoor advertising market in the past four years was 18.2%, reaching 6.5 billion US dollars. With the commercialization of 5G, outdoor AR is bound to further accelerate the industrial upgrading of traditional advertising, and it is expected to bring at least $500 million in space for 5G connection services each year.

In December 2019, telecom vendors, China Mobile Guangdong Shenzhen Branch and Blaz Information demonstrated the “5G+AR” education, cultural and travel application for the first time at Shenzhen Airport. The cooperation lasts till today.

At present, most outdoor advertising screens are SD/HD TV screens, and 2D advertisements are transmitted unidirectionally, and the communication efficiency and advertising conversion rate are not high. Its deployment and operation are mostly carried out through manual on-site operations, and a small amount of wired broadband or Wi-Fi access is used for cloud transformation. It faces challenges such as complicated wiring, long cycles, unstable Wi-Fi connections, and a long cloud-based AR interaction delay. In contrast, the smart AR advertising screen based on 5G connection fully embodies the new industrial development trend, merging advertising, education/culture/tourism, and entertainment together. It not only has richer content and more accurate delivery, but also effectively improves the efficiency of operation and maintenance.

The low latency of the 5G network (less than 20ms) ensures the user experience of AR applications. The precise positioning capability of 5G networks enables AR applications to be accurately delivered according to the users’ location. 5G networks make it possible for outdoor advertising screens to transform from the traditional offline mode of all-in-one machines to the online mode of "Agile deployment and operation based on MEC". This solution is expected to be applied first in airports, shopping malls, tourist attractions and hotels.

Mr. Zhu Wenzhen, founder and chairman of Blaz Information, said that the 5G MEC solution provides AR applications with large bandwidth, low latency, flexible deployment of connection and computing services, which greatly reduces the deployment threshold of AR terminals and AR experiences are guaranteed. According to authoritative reports, the complete rate of users watching advertisements through AR/VR reaches more than 80%, which greatly improves the interactive effect of advertisements and can help increase 30% revenue of the outdoor advertisements.

Picture 3 - Smart AR Advertisement Screen

3.2 5G Smart Factory (No update. Please check Q2 Report)

3.3 5G Mobile Health (No update. Please check Q2 Report)

3.4 5G Smart Grid (updated based on Q2 report)

3.4.1 Top Use Cases - China Southern Power Grid (Continued)

- Technical PoC Update

In August 2020, the miniature 5G timing CPE developed by China Southern Power Grid, China Mobile, and telecom vendors was put into commercial use on the live network in Shenzhen. Joint commissioning with the distribution network differential protection device was successful. The timing precision, channel delay, and line differential current met expectations. The CPE supports the 5G network timing function and has built-in power security chips developed by China Southern Power Grid. It is the industry's first 5G timing CPE that complies with security standards in the electric power industry, marking a solid step in the maturity of the “5G + smart grid” industry ecosystem, breakpoints in the 5G power industry are being quickly filled.

- Business Model Update

China Southern Power Grid is conducting group-level business model negotiation with the three major carriers. It is expected to sign a mid- and long-term unified framework contract in Q4 2020.

3.4.2 Top Use Cases – SGCC Qingdao Supply Company (NEW)

Since August 2019, as the member of the 5GDNA (5G Deterministic Network Industry Alliance), China Telecom, State Grid Shandong Power Company Qingdao Power Supply Company, and telecom vendors have worked with upstream and downstream partners of the industry chain, relying on the three-party joint innovation lab, China's largest 5G smart grid experiment network with diverse scenarios and a complete ecosystem has been successfully built in Qingdao. The following achievements have been made.

- ✧ The largest scale in China

  Since October 2019, the first phase of the project has deployed the largest 5G smart grid experiment network with 29 5G sites and 2 MECs, in four demonstration areas, including Qingdao Ancient Town Entrance, Jinjialing, International Sailing Centre, and Qingdao Power Supply Company Dispatch Building.

- ✧ The first commercial contract in China

  At the end of June 2020, Qingdao Telecom and State Grid Qingdao Power Company successfully signed the industry's first “5G + smart grid” commercial contract, marking the official transition from application demonstration to commercial implementation. The entire business contract is based on the 5G Network as a Service (NaaS) model. Operators provide a package solution of 5G VPN for the grid of the electric power industry. .

- ✧ Abundant use-cases deployment

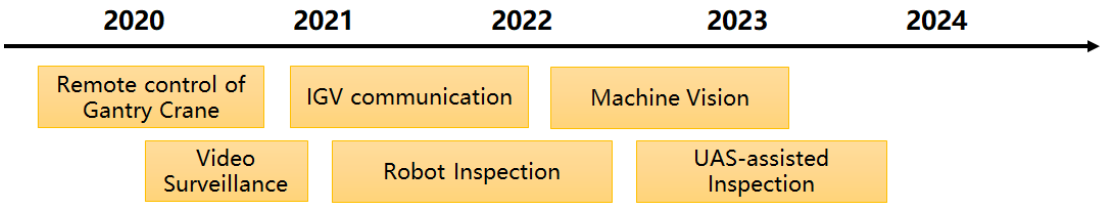
  Phase 1 focuses on five application scenarios: intelligent distributed feeder automation, 5G distributed differential protection, distribution network situational awareness, 5G 4K UHD security surveillance for transmission lines, and intelligent peak clipping and filling. More scenarios will be launched in the future.

- ✧ Comprehensive ecosystem

  Based on the 5G applications joint innovation lab and external lab network, the project team continuously promotes breakpoints in the 5G terminal devices of the electrical power industry. Currently, telecom vendors have successfully incubated three types of 5G power industry terminals (5G industrial routers, 5G intelligent integrated terminals, and 5G power security surveillance cameras) with built-in 5G chips, and is cooperating with Dajiang on 5G power inspection drones.

3.5 5G Smart Port (NEW)

3.5.1 General Plan



Picture 4 – 5G Smart Port General Plan

Ports are hubs for transporting cargo between container ships and vehicles. Seaborne trade contributes to two thirds of all global trade. There are more than 800 seaports in the world, among which 7 of top 10 ports are in China, ranking No. 1 in the world. It is estimated that by 2025, the 5G communications service space in global ports will reach US$2.4 billion annually. It could be US$700 million in China.

Picture 5 – Smart Port

The transformation of remote control of gantry cranes at ports is urgently needed. As a key service of port operation, the remote control has strict requirements on communication and control networks. Industry-oriented, dedicated, differentiated, and user-defined 5G networks open up new choices for ports.

1. Workers remotely control gantry cranes based on multiple-channel video images backhauled to the control center. The networks are required to provide high uplink bandwidth (35 Mbit/s for a single Rubber Tyred Gantry - RTG crane) and stable low latency.
2. Gantry crane operation data is the key for ports. Network isolation and data local procession is basic requirement.
3. The port communication and control network currently has problems such as slow commissioning and provisioning and an untraceable network running status. A DIY network is required to respond to rapidly changing service requirements and make network monitoring more convenient.

To sum up, the primary scenario for 5G applications in smart port is remote control. Other scenarios include IGV (Intelligent Guided Vehicle) communication, video surveillance, and robot / UAS (Unmanned Aerial System) -assisted inspection. Operators need to use new deployment and service architectures when deploying networks to meet port owners' strict requirements. The Cloud Native-based 5G mobile networks are deployed for the dedicated resources allocation and control signals with customized SLAs. MEC is also deployed by operators at the network edge to fit PLC stability requirements of control signal latency. These deployments will make remote control of RTG cranes ready for commercialization and help the owners of ports process data locally.

3.5.2 Top Use Cases – Ningbo Port

China Mobile, ZPMC (Shanghai Zhenhua Heavy Industries Company), Ningbo Port and telecom vendors, reconstructed the communication network of gantry cranes using 5G SA Network Slicing and MEC at the Meishan Island international container terminal in Ningbo Port. 5G-based remote control of gantry cranes is realized at Ningbo Port with guaranteed SLAs.

This is the first “5G + smart port” project empowered by 5G SA Network Slicing and MEC technologies.

Ningbo Port is one of the world's largest port with an annual cargo throughput of over 1 billion tons for 10 consecutive years. It has more than 550 gantry cranes responsible for transshipping 70% of goods in the port. Work conditions for the workers driving gantry cranes are poor. Port enterprises urgently need to transform traditional ports that rely heavily on manual operations to automatic ports to improve workplace conditions and efficiency.

Zhejiang Mobile, together with telecom vendors and other partners, builds the “5G + smart port” solution using the 5G SA Network Slicing and MEC. This solution overcomes technical difficulties, such as ultra-low latency and highly reliable data transmission, and has successfully completed the reconstruction of gantry cranes in Ningbo Port. For 5G remote control of RTG cranes, the MEC deployment reduced the average control signal latency from 28 ms to 10 ms.

Telecom vendors has applied the solution to the overseas market and verified the feasibility of “5G + MEC-based” remote control of RTG cranes at the Laem Chabang Port in Thailand

After the reconstruction into automation, one worker can remotely monitor multiple RTG cranes at the same time. This greatly improves the working environment for employees, reduces the labor cost, and resolves recruitment difficulties. ZPMC once tried to use Wi-Fi and 4G to build port communications infrastructure. However, these solutions could not meet the requirements of large bandwidth, low latency, wide coverage, and mobility. 5G networks satisfy all the requirements.

3.5.3 Research Requirements

The 5G technology should be used to reconstruct the port information systems, including horizontal transportation, vertical transportation, and ship entry and exit system, to achieve smart transformation.

The next step research scenarios include multi-channel onsite video backhaul, automatic port tally, and self-driving of container trucks in closed areas.

3.6 5G Slicing E2E Standard Progress & Research Requirements (NEW)

Internationally, 5G RAN and CN network slicing standards are mainly researched in 3GPP, and transmission slicing standards are mainly researched in IETF. In China, the CCSA has established a special project team to solve the problem of independent deployment of each sub-domain and cross-domain interconnection manually. The progress of each standard organization is as follows.

3.6.1 3GPP

- ✧ SA2 (Architecture)

R15, the basic slice architecture functions are formulated, including architecture, identification and selection of a Network Slice, network slicing session management, network slicing for roaming, network slicing and Interworking with EPS, etc.

R16, the network slicing functions are enhanced, including interworking with EPS, network slice-specific authentication and authorization, slice-level SLA assurance, etc. R16 has been frozen in September 2019.

R17, the enhancements study of Network Slicing Phase 2 are proposed. The objective of this study is to identify the gaps in the current 5G system procedures defined in SA WG2 to support GST slicing parameters, and to study potential solutions that may address these gaps.

- ✧ SA5 (Telecom Management)

R15 released at the end of 2018, including basic concepts, roles, management requirements of network slicing, lifecycle management of network slicing, hierarchical and service-oriented architecture, resource model, configuration management, fault management and performance management, etc.

R16, network slicing management were enhanced, including service discovery

of cross-vendor management, support tenant concept, slicing management capability exposure and E2E key performance indicator enhancement for network slicing. In addition, charge of network slicing (2B) was defined.

Now, R17 research has been initiated. This research focuses on how to provide consistent and assured communication services across operators, define operators' network resource models and ensure slice SLAs for industry network slicing.

✧ SA3 (Security)

3GPP SA3 mainly researches standards related to mobile network security. In 3GPP R16, the major research contents of network slicing include: (1) network Slice-Specific Authentication and Authorization, re-authentication and re-authorization, authorization revocation. (2) Privacy of a network slicing, including privacy protection of a network slicing at air interface and protection solutions for network slice privacy not known by third-party slice authentication and authorization servers. (3) Privacy of user IDs used for network slice authentication and authorization; (4) Network slicing management security. Now, R16 has been released. SA3 begins to discuss whether to initiate a research on slicing security enhancement in R17.

3.6.2 IETF

IETF mainly focus on research on transport network slicing standardization. The standardization research mainly includes: (1) Research on the transport network slicing architecture, including the VPN+ architecture, transport network slicing definition, upper-layer architecture and cross-domain transport network slicing mapping. (2) Research the network slicing management plane, focusing on the transport network slicing northbound interface model. (3) Research on the control plane of transport network slicing, focusing on the extension of control plane protocols of transport network slicing. (4) Research on the data plane of transport network slicing.

Currently, the architecture is gradually stable. The other projects are still being defined. But the detailed work plan has not been determined. The key industry members hope that the data plane standardization of slicing can be clarified by the end of 2020 and the control plane protocol extension can be basically completed by 2021.

3.6.3 CCSA

In order to resolve cross domain network slicing specifications, CCSA established a special project team in December 2019. At the first meeting of the project team, some standards were proposed, including the generic requirements of 5G E2E Network Slicing, E2E Network Slicing Interworking Requirements based on SPN / IP transport network. Now the first series of standards are relatively stable. In

July 2020, the second series of standards were proposed, including TN-NSSMF (Network Slice Subnet Management Function) Functional and Interface Requirements. These new series of standards will further study the transport network slicing standardization.

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(First Release)

Zemin Yang

CCSA

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Q2

1. Contributor List

- Editor

  CCSA (China Communications Standards Association) http://www.ccsa.org.cn/

- Others

  - ✓ 5GDNA (5G Deterministic Networking Alliance) https://www.5gdna.org/
  - ✓ 5GSA (5G Slicing Association) http://5gnsa.org/
  - ✓ 5GAIA (5G Applications Industry Alliance) http://www.5gaia.org/

2. Key Messages & Suggestions

- ✧ China 5G Vertical Industry in this quarter report includes Multimedia, Smart Factory, Mobile Health, and Smart Grid.
- ✧ POC of the initial phases have been finished for all these 5G vertical industries in China. The value and value chain are clear, and the use cases are being put into commercial use right now.
- ✧ While, the new vertical terminals, further convergence of 5G and vertical industries, and E2E enhancement, would be the key for next step scale commercialization.
- ✧ Suggestions
  - ■ European partners could learn the experiences from China 5G vertical industry top use cases, and start commercial use with less difficulty.
  - ■ China and Europe corresponding partners could closely cooperate on the further requirements from the 5G vertical industry top use cases, not only on the technology research and standard enhancement, but also the industry bottlenecks.

3. Detailed Information

3.1 5G Multimedia

3.1.1 General Plan

Table 1 - 5G Multimedia General Plan

3.1.2 Top Use Cases – Smart Stadium

China Sports Media, telecom carriers, and telecom vendors are working together to build a 5G smart stadium in Olympic Sports Center in Jinan, Shandong Province.

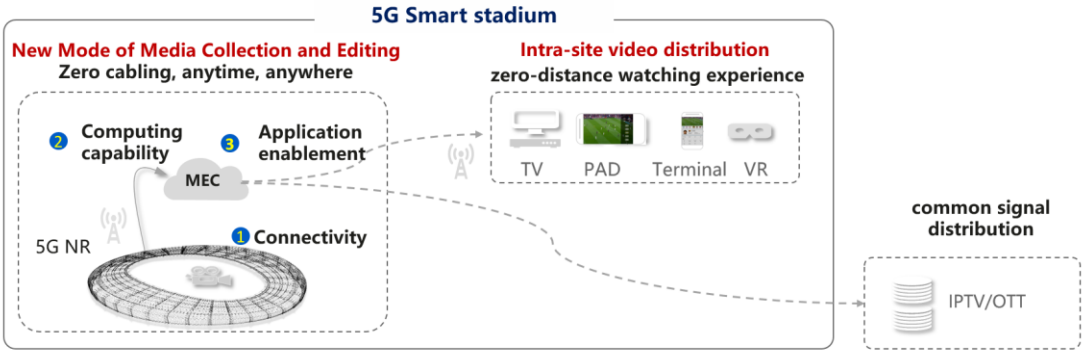
Picture 1 - 5G Smart Stadium Overview

The project is divided into two stages. The 1st stage is "editing & communication", mainly used for sports competitions and commercial show for China Sports Media. The 2nd stage is to cooperate with stadium operators to digitize stadiums and enable "Internet + sports" and "Internet + stadiums".

Now it is in the first phase, solution development and lab tests have been completed based on the 5G SA network.

Lab test - The broadcast-level production system consists of one group of 4K video servers, six groups of HD codecs, one group of 4K codecs, and video switching and monitoring devices. Adjust the video encoding bit rate to 10 Mbit/s, 15 Mbit/s, 25 Mbit/s, 30 Mbit/s, 50 Mbit/s, and 80 Mbit/s step by step. After the video is decoded, the video of the monitor is fluent without mosaics, the image details can be completely restored, the average RTT delay is within 10ms, and the packet loss rate is close to 0%. In the lab environment, multimedia services are provided, such as 4K ultra-HD and multi-channel high-definition (HD) stand-alone signals, and the 5G core network supports an end-to-end delay of 10 ms in addition to the fixed encoding and decoding delay. The relative delay of multi-position synchronization is within one frame, which can meet the requirements of remote production and even the requirements of remote reverse control and monitoring.

The outdoor solution has been deployed, and would be available soon in the first half of this year.



Picture 2 - 5G Smart Stadium Solution

Application of 5G capabilities

- ✓ Uplink capability based on slices - The uplink data rate of 17* 4K cameras reaches 1 Gbit/s.
- ✓ MEC based editing - Non-linear editing, VR stitching, multi-view production, short video production, AR game watching, and AR navigation.
- ✓ MEC based targeted streaming - Considering copyrights, the super venue service is open only to paid users. The maximum downlink data rate is 100 Gbit/s.
- ✓ Other capabilities - Positioning, frame synchronization technology, and UHD encoding and decoding.

3.1.3 Research Requirements

(1) Build a 5G+UHD/VR video production and communication platform based on MEC to enrich video content. (2) Supports source aggregation, signal scheduling, transcoding, content playback control, and playback distribution of ultra-large UHD/VR streams with 5G systems. (3) Supports UHD/VR video encoding formats such as H.265/HEVC and AVS2.0, HDR technologies, and immersive audio. (4) Implements 5G network transmission of UHD/VR video streams, optimizes Internet protocols such as SRT, and supports revision of related industry standards. (5) Large-scale application of 5G+UHD/VR videos. The smart stadium is a transformation of media production from traditional SDI/HDMI wired transmission to IP-based 5G wireless transmission. Currently, mainstream professional cameras cannot directly output IP streams or use 5G for transmission. They need to connect to 5G backpacks (encoders and 5G transmission modules). There is still much room for improvement in terms of integration and convenience.

3.2 5G Smart Factory

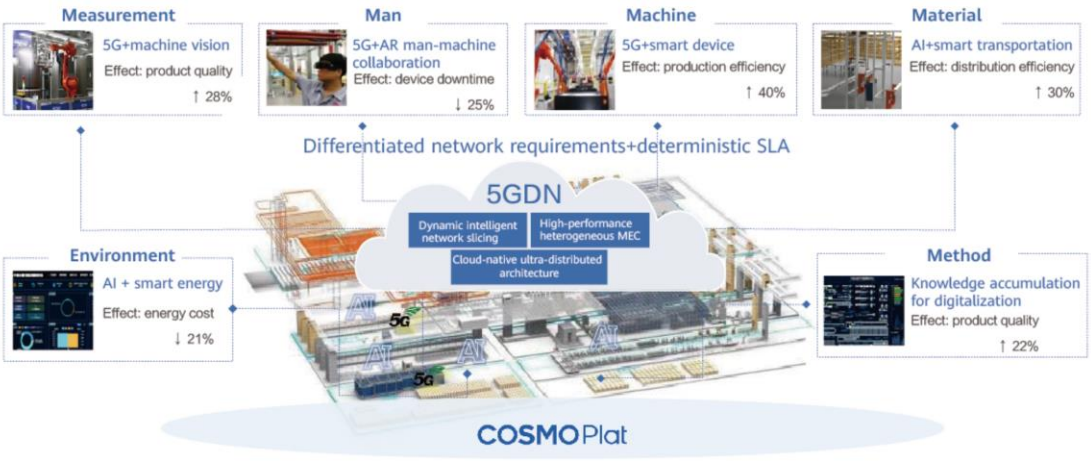
3.2.1 General Plan

2020	2021	2022	2023	2024	2025
Industrial Wireless Camera	Remote Monitoring		Remote assistance Collaborative Design		Cloud-Based Robot
Intelligent Warehousing / Logistics		Remote Maintenance		Remote Automation Control	

Table 2 - 5G Smart Factory General Plan

3.2.2 Top Use Cases – Haier Smart Factory

In July 2019, Haier, together with telecom carriers and telecom vendors, officially released the world's first 5G smart factory at the “Industrial Internet Ecosystem Innovation Forum” of the World Industrial Internet Industry Conference in Qingdao. The solution include 5G deterministic network, the cloud native ultra-distributed architecture, dynamic intelligent network slicing, and the key technologies of super-performance heterogeneous MEC. The solution could provide “differentiated + deterministic” network service capabilities, build intelligent, complex and multi-scenarios manufacturing systems, such as 5GDN + intelligent devices, 5GDN + machine vision, and 5GDN + AR man-machine collaboration. And the solution could implement full-process information self-sensing, full-element event self-decision, and full-cycle scenario self-iteration.



Picture 3 – Haier 5G Smart Factory

Based on the intelligent upgrade of 5G deterministic networks, the Haier industrial park explores more scenario-based IoT smart products, smart portfolio solutions, and 5G+AI technology applications through data-based simulation modeling verification, efficient production collaboration, and precise quality control.

Algorithms are migrated to the cloud, and data is secured within the factory. This effectively improves the efficiency, security, and labor costs of traditional factories, meeting the requirements of smart operations. The product quality is improved by 28%, the number of device downtime faults is reduced by 25%, the production efficiency is improved by 40%, and the investment cost is reduced by 30%.

In addition, the factory implementation details need to be considered for the 5G

commercial scenarios. For example, in machine vision, the range of industrial camera pixels and uplink bandwidth varies greatly based on the factory's requirements on identification, detection, measurement, and positioning. For low-precision defect detection and bar code identification (such as two-dimensional code, one-dimensional code, and OCR characters), a camera with 30–200 megapixels can be used. However, for high-precision positioning, measurement, and detection, for example, sub-millimeter-level positioning and detection of very small particles are required, the 1500+ megapixels cameras need to be enabled, which has higher requirements on the 5G uplink bandwidth. Therefore, during commercial deployment in factories, you need to determine whether to use lossy or lossless compression and the deployment solution based on network performance, visual application scenarios, and production cycle.

3.2.3 Research Requirements

(1) In an enterprise or campus, deploy the virtual enterprise private network with 5G base stations and the MEC platform. (2) Deploy 5G terminal modules in industrial terminals or equipment. (3) Make full use of existing platform resources or build a collaborative manufacturing operating system cloud platform to interwork with mainstream industrial platforms. Implement the usages, monitoring, and management of a large number of terminals based on 5G network. (4) Implements industrial applications in specific scenarios and supports the revision of industry standards such as 5G + AGV and 5G + machine vision.

3.3 5G Mobile Health

3.3.1 General Plan

Table 3 – 5G Mobile Health General Plan

3.3.2 Top Use Cases - Medical Alliance in Futian District, Shenzhen

In 2019, medical application companies worked with telecom carriers, telecom vendors, and device partners to help hospitals provide 5G telemedicine services for patients, including remote audio & video consultation and remote image diagnosis. Through the 5G deterministic network, experts and doctors in the central hospital help

the doctors in the clinics provide better medical services for patients. The following table lists the capabilities of the 5G deterministic network for telemedicine.

5G Network （with MEC）Capabilities	Medical Application Scenarios	Network Requirements
Connectivity	4K Video	Data rate uplink >20Mbps E2E latency 50~100ms
	PACS Image Data	Data rate >5Mbps E2E latency 50~100ms
Computation	AI-assisted diagnosis	AI Computing capability
	3D image reconstruction	E2E latency <1s
Security/Isolation	Remote consultation	Data in hospital

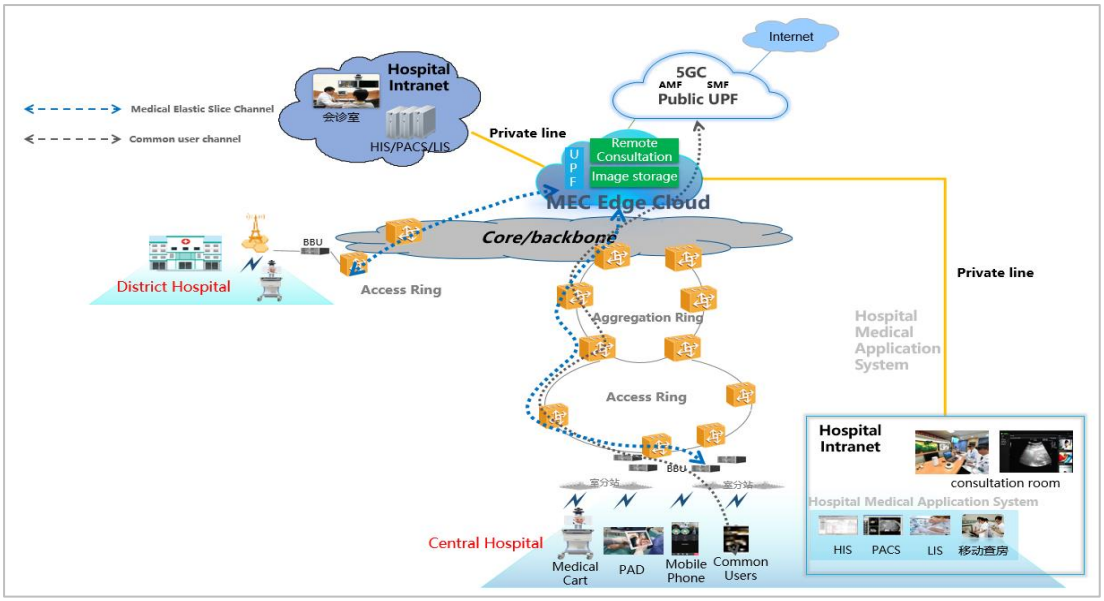
Table 4 – 5G deterministic network Capabilities for telemedicine

Telecom carriers deployed 5G private networks for the medical alliance in Futian District, Shenzhen, and deploy third-party PACS systems, AI-assisted diagnosis, and video systems based on the MEC platform. MEC and Slicing are as follows,

	Domain	Project Name	Construction Content
1	MEC	5G MEC Gateway	The MEC private network gateway (dedicated UPF) provides medical service identification and local traffic breakout for hospitals, community health centers, ambulances, and medical examination vehicles. In this way, services are locally closed, and data is kept inside the hospitals, meeting the requirements for medical service security and latency.
2		MEC Edge Cloud	Telemedicine applications are deployed on the edge cloud to meet the requirements of high-performance agile and elastic computing. It supports fast and flexible deployment of innovative services of the medical alliance, and reduce service latency by moving computing to the edge. It also ensures data security and implement cross-hospital interconnection and data sharing, in addition, firewalls are deployed to ensure network security in one hospital. Converged deployment with the 5G MEC gateway and connected to the local equipment room of the hospital/community health center through private lines.

3	Slicing	5G Slicing Services	The 5G network slicing provides E2E slicing capabilities covering the wireless, transport, and core networks. It separates medical services from public services at the network layer to ensure service SLA.

Table 5 – 5G deterministic network MEC and Slicing for telemedicine



Picture 4 – 5G Private Medical Network

5G private medical network has 3 values. (1) Streamline the pre-operation, in-operation, and post-operation processes to improve doctors' efficiency by 20%. (2) Video and medical image data is directly transmitted and processed among hospitals. The latency is reduced without frame freezing. The response time of 3D image reconstruction is reduced from 3 seconds to 1 second. (3) All data is stored in the hospital MEC to guarantee the security.

3.3.3 Research Requirements

(1) Currently, medical terminals access the 5G network by connecting to external 5G CPEs. The specifications and plan of medical terminals with built-in 5G modules need to be studied. (2) The new standard is being drafted for the convergence of the communications industry and the medical industry, helping the 5G deterministic network enable the transformation of the medical industry to mobile, remote, and intelligent.

3.4 5G Smart Grid

3.4.1 General Plan

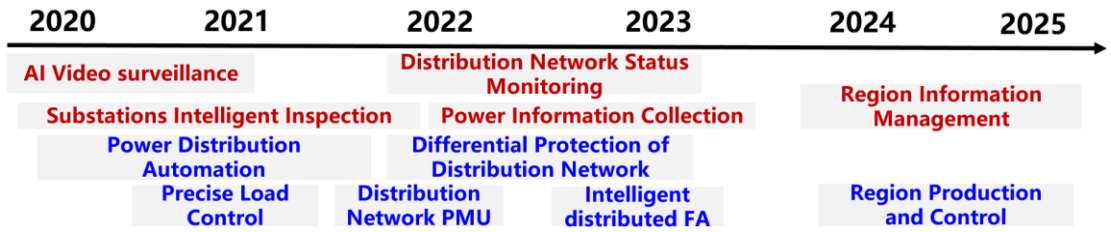


Table 6 – 5G Smart Grid General Plan

3.4.2 Top Use Cases - China Southern Power Grid

The power grid system mainly comprises five parts: generation, transmission, transformation, distribution, and consumption throughout delivery of electric power. The backbone power communication network is responsible for power generation, transmission, and transformation which has been fully covered with the optical private network in China. The terminal access network is responsible for power distribution and consumption with features of wide-area coverage and ubiquitous access. The deployment of traditional optical private networks for the terminal access network is costly and time-consuming, and is unsuitable for special terrains such as bridges and elevated roads. Thus cannot cater for wide-area ubiquitous access and there are still some considerable coverage blind spots that affect services. In addition, mobility scenarios, such as substation robot inspection and UAV-assisted inspection of power lines, place high demands on wireless networks. To address all these issues, a ubiquitous, flexible, economical, and reliable wireless network is urgently required.

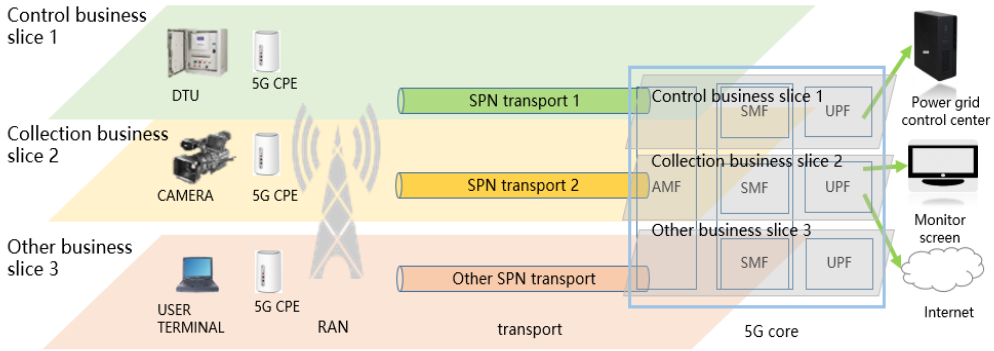
Based on the network slicing technology, 5GDN can virtualize a wireless private network to implement higher security isolation and customized resource allocation. Based on the technologies such as 5G MEC and 5G TSN, 5GDN can realize lower latency and more deterministic connections. Thus 5GDN can effectively supplements the existing electric power communication private network to solve bottleneck and challenges facing wireless communication services such as intelligent power distribution and inspection.

Let's take the differential protection for power distribution as an example. 5GDN's differentiated network capabilities can achieve ultra-low latency, ultra-high precision synchronous timing, and high reliability. The dedicated network for the 5GDN can meet the strict security isolation requirements of the virtual private network of the electric power industry. In addition to this, the self-service network capability can be exposed through northbound APIs to allow electric power customers to autonomously perform O&M and management within the specified scope, such as the network slicing KPI visualization and intra-slice user management. Therefore, the 5GDN based differential protection solution for power distribution can provide more efficient and flexible access solutions with high security and isolation in the electric power industry. Compared with

traditional optical fibers, it can effectively reduce deployment costs and greatly improve service provisioning efficiency.

Since 2018, China Southern Power Grid, telecom carriers, and telecom vendors have started strategic cooperation on 5G + smart grids. The joint team have comprehensively promoted 5G + smart grid application research in terms of top-level design, international standards, key technologies, live network pilot, terminal modules, and service operation, and have made significant breakthroughs in both technical and business aspects, and achieved multiple No. 1s in the world.

In June 2019, China Southern Power Grid Shenzhen Power Supply Bureau, telecom carriers and telecom vendors completed the industry's first commercial-oriented 5G power slice field test in Shenzhen. In this project, they completed the industry's first 5G differential protection test for power distribution, as well as a slice isolation test for the 5G CN and TN network. Besides that, the industry's first 5G B2B network slicing management platform also be built.



Picture 5 – 5G Smart Grid Slicing Solution

3.4.3 Research Requirements

5G technology research is carried out throughout the entire process of generation, transmission, transformation, distribution, and consumption. It involves not only internal power grids, but also external organizations such as telecom carriers, equipment vendors, and standards organizations. It also involves the establishment of the standard system, management models, and business models. It is a complex and systematic project.

(1) Technical standards and industry support - 5G vertical standards have not been completed, and telecom carriers do not have the complete 5G vertical service networks. The verification of typical services covering the entire power grid has not been completed, and the large-scale commercial use of customized 5G communication terminals needs time. The market scale and industry chain need to be further expanded. (2) Adaptation between technologies and services - There is no systematic architecture design that deeply integrates smart grids and 5G networks for large-scale applications. Some key 5G technologies that support power grid service applications need to be

researched. The security isolation of 5G network slices to carry power grid services in different areas needs to be verified, the intelligent control and reliability assurance capabilities of power grid services and 5G slicing resources need to be improved. The 5G business model between telecom carriers and grids still need to be improved. The E2E SA network slicing process is not matured for the actual service operation. (3) Terminal heterogeneity and telecom carrier system differences - Due to terminal heterogeneity and telecom carrier system differences, 5G power applications must be verified by multiple telecom carriers before being scale commercialization.