

ZTE TECHNOLOGIES

FEB 2024 | VOL. 26 • NO. 1 • ISSUE 210

VIP Voice

Indosat: Empowering
Indonesia Through
Gotong Royong

Expert View

5G-Advanced:
Bridging to 6G

Special Topic 5G-Advanced



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FEB 2024 | VOL. 26 · NO. 1 · ISSUE 210

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Indosat: Empowering Indonesia Through Gotong Royong

Reporter: Liu Yang



Since the merger of Indosat Ooredoo and Hutchison 3 Indonesia in January 2022, the newly combined operator, known as Indosat Ooredoo Hutchison (Indosat or IOH) has demonstrated impressive performance. Vikram Sinha, a thought leader in telecom industry and President Director & CEO of Indosat, the second-largest mobile network operator in Indonesia, shares insights into telecom trends and key learnings from this merger. Vikram also delves into the company's commitment to empowering Indonesia and its journey towards becoming a TechCo. Throughout the interview, he emphasizes the significance of collaboration or "Gotong Royong" in Indonesia.

Vikram Sinha, President Director & CEO of Indosat

With rich experience in the telecom industry across different countries, what key changes have you observed in the sector?

Having been in the industry for two decades, I think COVID has been a silver lining for the industry. It made not only us but also policy makers and governments realize the importance of the whole industry when it comes to working, studying or even getting entertained from home. For me, that was a complete turning point.

What COVID has done is that customers are seeking a better experience rather than a cheap product. Data, which is our core connectivity, is not just a consumption. Even during times of inflation, our industry is least impacted because data is primary, helping both B2C and B2B customers do a lot of productive work at a fraction of the cost. For example, ride-hailing drivers in Indonesia who spend \$5 per month are my high ARPU customers, compared to the average customer spending \$2.5. That \$5 per month helps them earn \$500, making it a primary necessity rather than a mere consumption.

Similarly, if you look at SMEs, the moment when COVID happened, they realized that they had to go online and do business. The role of the telecom industry, along with partners like ZTE, has come to the forefront. The challenge is how to grow our core business while also building adjacent revenues. Telcos like us want to transition from being a pure Telco to being a TechCo. Indosat aspires to be an AI-native TechCo, and we see the importance of IoT and data in achieving this. Leveraging data with proper AI allows us to do a lot of things such as enhancing security for both our enterprise and B2C customers. We are getting more serious with these areas, and we want to do it with partners. We strongly believe that the next decade is all about collaboration to solve real problems. This is the infinite journey we are on.

Consolidation is also a big trend. As a newly combined operator, how do you plan to project the Indosat image in Indonesia?

I think this is a very good question. You are right because our business is CAPEX intensive. What was happening was that with governments and policymakers understanding the important role of the telecom industry, it was getting very important for the telecom industry to be more sustainable. Consolidation is a move towards sustainable growth and it benefits everyone.

Our case is a clear case study. When our merger happened on January 4th, 2022, I was asked a lot of questions by analysts and investors, and even rating agencies had put us on negative watch. I don't blame them because historically, most of the in-country mergers struggle in the first two years. We started the journey by saying that this merger is good for the country first, and good for our customers and our shareholders.

I'm happy to share with you that we are heading towards one of the most successful mergers and the numbers speak for themselves. Our market cap, which was \$2.3 billion when the merger happened, is over \$5 billion today. We now have 100 million customers, and we have seen the benefit for our customers.

My message to the industry is the role we play is very important. It is very important that we work closely with partners and government agencies on carving out a path in this digital era, where infrastructure is data.

What operations & management philosophy have you brought to Indosat?

The biggest learning I have had is about culture and people. When integrating two different sets of culture, you need to decide how to set a culture and ensure that you are



able to integrate people. Do whatever is needed if it is difficult, and do it in a fair, transparent and timely manner. Over the last 21 months, 80 percent of my time has been spent on culture and people. We always say that culture and people are soft aspects but they are the real hard aspects. Other things will follow if we get these right.

Another big learning was looking at the merger with a maximizing mindset—how we can make 1 plus 1 equal 11. Rather than focusing only from an optimized synergy value, which is my job to deliver, we galvanize the whole organization around the idea of maximizing. The second principle which greatly helped us was prioritizing customer experience over cost. Customers care more about how their experience improves rather than the merger itself. If we can deliver on that, they will support us.

Under your leadership, Indosat has achieved a robust financial performance. What is your strategy to navigate the fast-paced digital landscape?

We are moving from integration towards more of a transformation mindset. Now, we are looking at all those things from a transformation mindset—how we can leapfrog and set regional and global

benchmarks. Our center of focus is delivering marvelous experience, be it for employees, customers or even partners. We work very closely with partners like ZTE. We have close to 900+ vendors, shortlisting 22 as strategic partners. Our principle around working with partners and solving real problems is really something we are excited about.

Secondly, Indonesia's digital gross merchandise value (GMV) is more than \$80 billion today and will grow to \$110 billion by 2025. We have a role to play there, and that is where we believe we cannot do it alone. We need a partner ecosystem and that is the agenda we are driving.

In what ways does Indosat accelerate Indonesia's digital transformation?

Indosat, a 56-year-old brand, was the first company that connected Indonesia to the world. The brand is very strong. People in small cities and even in villages expect much more from Indosat. With our expanded scale of 100 million customers, we want to focus more on rural areas. There are close to 25 million first-time internet users coming from rural Indonesia. From an opportunity size point of view, it's like a new Australia getting born in rural Indonesia.

We are investing more to give a good network and connectivity, but we don't want

to stop there. Our purpose of empowering Indonesia starts with connecting, and then we want to be a part of their journey. For instance, in rural areas or cities, if they need micro lending, we help them through our partner. If they need other solutions for small and medium enterprises, we strive to provide plug-and-play options to help them earn \$10. If they earn \$10 through our support, for sure they will give us \$2. That is the approach we are taking.

Another big piece of digital Indonesia is skill development. Without skill development, there is a shortage of close to 10 million skilled digital talents. Through our CSR initiative, Indosat Ooredoo Hutchison Digital Camp, we have developed more than 250,000 digital talents. We believe that every dollar spent on technology needs to be backed up with money spent on skill development. Again, we can't do it alone. We keep encouraging all our partners to come in.

How does ZTE contribute to Indosat's digital transformation journey?

ZTE has been one of the fastest-growing partners in my ecosystem. When I arrived in Indonesia in 2019, they had some small piece. Their big entry came with IP. They were the first to deploy SRv6. We are very happy with their performance. They also help us on DWDM and transport. Most importantly, I see that ZTE now is more focused on customer experience because that is paramount for us. The most important thing is how we can deliver the best customer experience, and we cannot do it without our partners.

How are you doing in the aspect of the transition from Telco to TechCo?

In the first two years after the merger, our focus was on getting the integration right and enhancing the customer experience. Now, we feel that we have the skills and are in a good shape to move to the TechCo journey. Our

TechCo journey has five pillars.

The first pillar is the purpose of empowering Indonesia. Another significant aspect is the creation of an innovation stack. That innovation stack is not about conducting R&D but about working with like-minded partners to solve real problems. We have put aside some budgets on trying products and solutions that help solve real problems. Our approach with partners, known as "Gotong Royong" in Indonesia, is all about collaboration. We have our Indosat Marvelous Xperience Center in Jakarta, where ZTE is a key partner showcasing a lot of use cases. The whole principle is innovation and co-creation to solve real challenges. We are fast-tracking this culture, and we have seen some good results.

Moving forward, what are your priorities, and what can we look forward to in Indosat's future?

The top priority is to continue growing our core business. We believe that if we perform well in our core business, we can achieve much more in adjacent revenues. We want to record close to double-digit growth in our core business in both ToC and ToB. A key thing in 2024 will be more investments in the rural areas. With around \$800 million CAPEX deployed annually, we want to ensure that at least 55 percent of this investment goes to rural Indonesia.

The second priority involves adjacent revenue and the transition to TechCo. We have started a project called Meranti that focuses on three verticals: fintech, TechCo, and home broadband. We have set an ambitious target to increase the adjacent revenue, currently only 3 percent of our total revenue, to up to 20 percent. This year, we are doing around \$45 million, and we want to take it to \$1 billion by 2026. As we get into this infinite journey, the real focus will be on execution, and that is where we are building our capabilities. **ZTE TECHNOLOGIES**

5G-Advanced: Bridging to 6G

Wang Xinhui ZTE Vice President and Head of Standardization & Industry Relations

As the first release of 5G-Advanced, Release-18 has ushered in the 5G-Advanced era. The 3GPP standardization on physical layer design was finished in August 2023, and the ASN.1 will be frozen in June 2024, by which all specifications will be stable and ready for implementation.

Release-19, with the initial package approved in December 2023, has commenced exploration into 6G technology. Targeting completion by the end of 2025, it aims to serve as a bridge to 6G.

Release-18: Initiating 5G-Advanced Era

RAN Part

For RAN, 26 study items or work items have been completed in R18, with 3 of them enabling intelligence or efficiency, 9 supporting verticals, and 14 enhancing network coverage and capacity.

- **eSmall data transmission:** As a WI led by ZTE, in Rel-18, mobile terminated small data transmissions are supported with the completion of the MT-SDT WI. For DL, MT-SDT (i.e., DL-triggered small data) offers similar benefits as MO-SDT, such as reducing signaling overhead and UE power consumption by avoiding unnecessary transitions to RRC_CONNECTED and reducing latency by allowing fast transmission of small and infrequent

packets, e.g. for positioning.

- **Network controlled repeaters:** This work item, which is also led by ZTE, specifies the signaling and behavior for side control information (i.e., beam-forming, UL-DL TDD operation, and ON-OFF information), control plane signaling and procedures, and solutions for network-controlled repeater management.
- **Extended reality (XR):** XR Awareness, power saving enhancements and capacity enhancements have been specified in this work item. For XR awareness, one additional buffer size table, a new MAC CE for delay status report (DSR) of buffered data, and reporting of uplink assistance information (jitter range, burst arrival time, UL data burst periodicity) per QoS flow have been introduced to enhance uplink resource scheduling by NG-RAN. For power saving enhancements, the gNB may configure a DRX cycle expressed in rational numbers to match the periodicities of video frame rates. In addition, configured grants may be set without the need for the UE to monitor possible UL retransmissions, thus increasing power savings for the UE. For capacity enhancements, configured grant-based PUSCH transmissions are enhanced with support of multiple CG PUSCH transmission occasions within a single period of a CG configuration. Moreover, indications of unused CG PUSCH

With some study items and work items in Rel-18 and Rel-19, it is evident that some pre-research on 6G has been initiated in 5G-Advanced.

Wang Xinhui



occasion(s) of a CG configuration are provided, with uplink control information multiplexed in CG PUSCH transmissions of the CG configuration.

- **Network energy savings:** Network energy savings are key to 5G/NR success, aiming to reduce environmental impact (greenhouse gas emissions) and achieve operational cost savings. In the initial study conducted within RAN WGs, various techniques spanning time, frequency, spatial and power domains were investigated based on a network energy consumption model for base stations. Following that, the Rel-18 work item introduced several new features including CSI enhancements for adaptations in spatial and power domains, Cell DTX/DRX mechanism in time domain, SSB-less SCell operation for inter-band CA, mechanism to prevent legacy UEs camping and enhancements on CHO procedure, as well as inter-node beam activation and enhancements on paging.
- **NTN/NTN-IoT:** Rel-18 NR NTN work item specifies coverage enhancement, NR-NTN deployment in above 10 GHz bands, network-verified UE location, and NTN-TN and NTN-NTN mobility and service continuity enhancements. Rel-18 RAN work item further enhances the IoT-NTN in three major areas: performance (HARQ and GNSS enhancements), measurement and mobility

enhancements in both idle and connected modes, and enhancements in discontinuous coverage. It also complements the SA2 study on 5GC enhancements for satellite access Phase 2.

CN Part

For CN, 28 work items have been completed in R18, including 2 for intelligent network enablement, 11 for enhanced network services, 8 for vertical support, and 7 for enhanced network convergence and coverage.

- **Network slicing phase 3 & eNSAC:** These two work items are led by ZTE. In the network slicing phase 3, functional enhancements and deployment optimizations for 5GS network slicing are specified. Key features include support for slice service continuity, service area not matching TA boundary, temporary or periodic slice deployment, multiple network slice admission control (NSAC) service area, partial slices in the registration area, and improved network control of UE usage. Based on the GSMA-defined network slice template, the eNSAC work item enhances the existing NSAC procedure to control the number of UEs with at least one PDU session/PDN connection per network slice in the case of EPC interworking.

- **XR & media services:** To better support XR and other media services in the 5G system, this work item enhances policy control and QoS mechanisms for characteristics like multi-modality flows and PDU set handling. It also supports 5GS information exposure for XR and other media services, and provides solutions to meet performance requirements for round-trip latency, jitter, UE power saving, and the trade-off between QoE and UE power saving.
- **System support for AI/ML-based services:** This work item aims to provide intelligent transmission support for AI/ML-based services at the application layer. This enables service providers to leverage 5GS as an intelligent platform to assist in their AI/ML operations at the application layer.

Release-19: Exploring 6G Technology

RAN Part

The initial Rel-19 package has included 16 study items and work items, with 8 being further enhancements of Rel-18 topics and 8 being new topics.

- **AI/ML for NG-RAN, air interface and mobility:** This study item led by ZTE aims to investigate new AI/ML based use cases, i.e., network slicing and CCO, within existing NG-RAN interfaces and architecture (including non-split and split architectures). This goal is to identify enhancements that can support AI/ML functionality. Moreover, the study involves further discussions on the Rel-18 leftovers, including mobility optimization for NR-DC, split architecture support for Rel-18 use cases, energy saving enhancements such as energy cost prediction, continuous MDT collection targeting the same UE across RRC states, and multi-hop UE trajectory across gNBs. The AI/ML for air interface and mobility in NR will also be specified in Rel-19.
- **Channel modelling enhancements for**

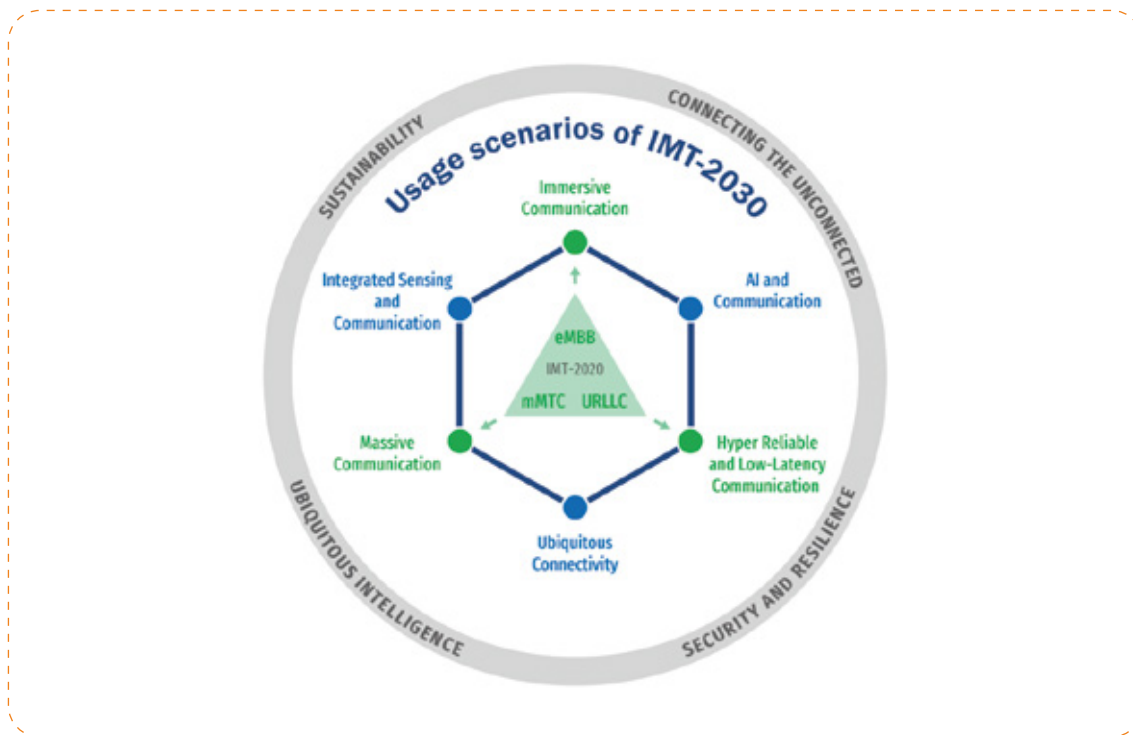
7-24GHz: This study item also led by ZTE aims to validate through measurements the channel model of TR38.901 within the 7-24 GHz frequency range. It will adapt and extend as necessary the channel model of TR38.901 for this frequency range, addressing key aspects for applicable scenarios such as near-field propagation (ensuring consistency between near-field and far-field) and spatial non-stationarity.

- **Ambient IoT:** This study targets a further assessment at RAN WG-level of ambient IoT, a new 3GPP IoT technology suitable for deployment in a 3GPP system. Ambient IoT relies on ultra-low complexity devices with ultra-low power consumption, specially designed for very-low-end IoT applications. The study will provide clear differentiation, addressing use cases and scenarios that cannot be fulfilled based on existing 3GPP LPWA IoT technology, such as NB-IoT, even when considering reduced peak Tx power.

CN Part

The initial Rel-19 package has included 15 study items, comprising 8 further enhancements of Rel-18 topics and 7 new topics.

- **UPF enhancement for exposure and SBA phase 2:** The study item led by ZTE aims to address R18 leftovers to enhance UPF capabilities for exposure and achieve better integration of UPF into 5GC SBA. The specific objectives include supporting selection of UPF for user plane functionalities, optimizing the procedures related to UPF data collection, e.g., direct/indirect subscription of UPF via control plane from application, and enhancing the interface between AF and 5GC to permit UPF handling of headers (e.g., detection of IP header, http header, etc), uplink and downlink, as well as reporting/notifications.
- **Architecture support of ambient power-enabled IoT:** This study item aims to



◀ Fig. 1. Usage scenarios of IMT-2030.

study the architecture support of ambient power-enabled IoT devices. The specific objectives include validating the device's ID, managing identification, subscription, registration and connection of ambient IoT devices, and supporting information transfer for ambient IoT services.

- **Energy efficiency and energy saving:** This study item aims to study architectural impacts and functional extensions required to facilitate efficient energy use and energy saving. The specific objectives include exposing information related to network energy, and implementing subscription and policy control to support energy efficiency and energy saving as service criteria.
- **Core network enhanced support for AI/ML:** This study item aims to study possible architectural and functional extensions for cross-domain AI/ML interworking and coordination (e.g., UE, RAN, core, applications) to address the overall AI/ML framework. It will investigate how to support collaborative AI/ML operations, involving 5GC/NWDAF and/or

AF for vertical federated learning (VFL), and how to support NWDAF-assisted policy control to prevent signaling storms.

IMT-2030 has defined six usage scenarios for 6G, including three extensions from traditional ones: hyper reliable and low-latency communication, massive communication, and immersive communication, and three new ones: AI and communication, integrated sensing and communication, and ubiquitous connectivity (Fig. 1).

With some study items and work items in Rel-18 and Rel-19, it is evident that some pre-research on 6G has been initiated in 5G-Advanced. For instance, NTN aims to provide ubiquitous connectivity, ambient IoT supports massive communication, AI/ML for NR-RAN explores AI and communication, and XR enhancement focuses on immersive communication. Consequently, it can be asserted that 5G-Advanced is establishing a bridge to 6G, facilitating the sustainable digitization and intelligence of the entire world. **ZTE TECHNOLOGIES**

ZTE Opens New Horizons of 5G-Advanced



Liu Shuang

Deputy General Manager of RAN Products, ZTE



Ni Yanzi

Solution Director of RAN Products, ZTE

The global 5G network is advancing steadily. By the end of September 2023, 300 operators in 114 countries and regions had launched commercial 5G networks based on 3GPP standards. 290 operators in 113 countries and territories had either launched or soft-launched 5G mobile services. As of Q3 2023, the total number of 5G base stations deployed worldwide had exceeded 4.81 million, with an addition of 330,000 in the quarter and a cumulative increase of 1.17 million for the year. This represents a year-on-year growth of 56.17% and a quarter-on-quarter growth of 7.3%. At the same time, driven by new technologies and business scenarios, the boundaries of wireless communication are continually expanding. 5G development is accelerating towards the new stage of 5G-Advanced, serving as the intermediate stage in the evolution towards 6G. 5G-Advanced is not only the cornerstone of 5G application development in the next decade but also the key to shaping the future digital society.

ZTE expands and evolves the technological capabilities of 5G-Advanced based on six major scenarios: seamless

10 Gbps+, Massive IoT, deterministic capability, integrated sensing and communication, ubiquitous connectivity, and universal intelligence (Fig. 1). It aims to deliver value in three key areas of 5G-Advanced: B2C (consumer-oriented) for a smart digital life, connecting virtual and real worlds; B2B (business-oriented) to build a smart digital industry, penetrating the production domain; B2X (society-oriented) to solidify a smart digital society, expanding the new economy of connected vehicles and low-altitude satellites. We will analyze the capabilities and value of 5G-Advanced based on these six scenarios, as well as introduce ZTE's accumulated expertise and practice in each scenario.

Seamless 10 Gbps+: Ubiquitous Wide Bandwidth, Enhanced Experience, and Scenario Expansion

The network is the foundation of all applications. Emerging business forms

5G-A



such as autostereoscopy, cloud computer, XR metaverse, ultra-high-definition live streaming, and 5G machine vision are driving the 5G experience from Gbps+ to 10 Gbps+. ZTE is the first in the industry to achieve a mid-frequency evolution from 64 TR to 128 TR, doubling the 5G network capacity. With FR2 products based on the industry's largest 1.6 GHz bandwidth, ZTE achieves a super capacity of 28 Gbps. Coupled with the industry's first dynamic reconfigurable intelligent surface (RIS) base station collaboration, it enhances base station coverage by more than 30%, supporting a ubiquitous, wide-bandwidth experience.

The seamless 10 Gbps+ network infrastructure has given birth to diverse 5G-Advanced application scenarios. In Shanghai, the "5G vehicle-ground system" featuring small cells on vehicle and 10 Gbps+ wireless backhaul has achieved the world's first launch with a backhaul capacity of up to 15 Gbps on the downlink and 2 Gbps on the uplink, providing passengers with

stable 5G connection and high-speed experience anytime, anywhere. The industry's first 5G-Advanced ship-ground backhaul system creates a 10 Gbps+ cruise ship, reaching a peak downlink speed of over 11 Gbps for a single terminal, and can simultaneously support hundreds of anchors for ultra-high-definition live streaming in Hangzhou. In the China Media Group's production and broadcasting technology exhibition area at the Hangzhou International Expo Center, the 5G-Advanced integrated computing network CampSite solution, with its simplified architecture and flexible deployment, achieved a measured uplink speed of over 2 Gbps, over 10 Gbps downlink speed, and a network transmission delay of less than 4 ms. This supports fast deployment of ultra-high-definition shallow compression, and virtual and real-time video production and broadcasting. The 5G-Advanced 10 Gbps+ network can also support dozens

of concurrent XR services, empowering new industries such as smart game viewing, cultural tourism, and gaming with immersive experiences, all without the need for backpacks.

Massive IoT: Seamless Connectivity Across High, Medium, and Low-Speed Scenarios

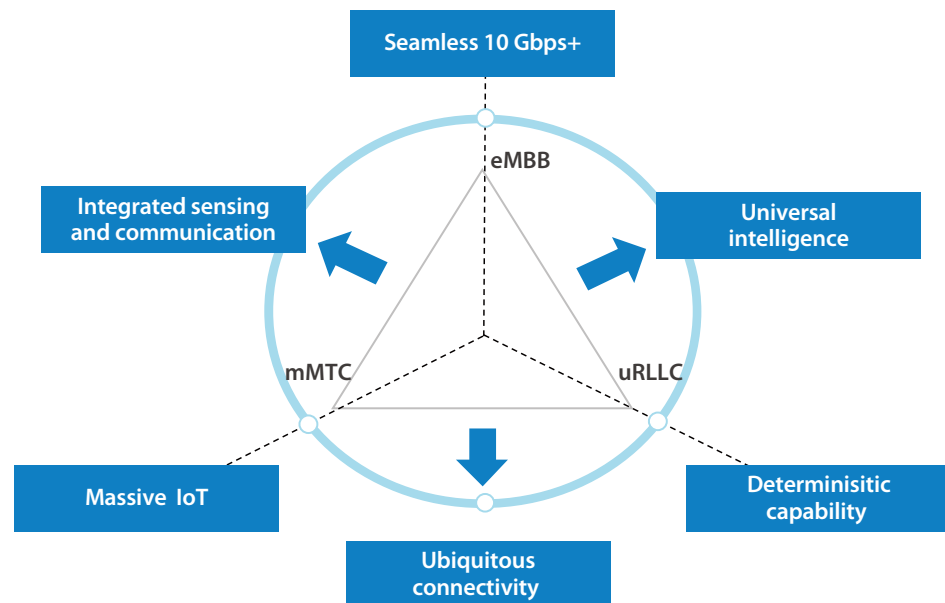
The Internet of things (IoT) demands seamless interconnection across various IoT technologies to meet industry-wide needs of digitization transformation. The industry has basically formed a coordinated development pattern for NB-IoT, 4G, and 5G networks. In the early stage, the high cost of 5G modules and terminals somewhat constrained the large-scale deployment of 5G applications. To address this challenge, 5G-Advanced introduces the lightweight 5G IoT reduced capability (RedCap), achieving cost and power reductions in terminals through capability trimming, thereby strengthening the IoT network foundation. ZTE has been committed to promoting the commercial deployment and accelerating the application of RedCap, collaborating

with operators to undertake extensive deployments.

Deterministic Capability: Empowering 5G Penetration into Core Production Areas with Bounded Latency

The digitization transformation of vertical industries empowered by 5G has achieved significant results, entering a critical period of large-scale replication in the application management domain. The next step involves further development and penetration into the core production domain. Deterministic capability is the primary challenge, and ZTE addresses this by providing extreme determinism with a low latency of 4 ms at 99.999% reliability and μ s-level ultra-low jitter. It also offers gigabit-per-second or higher uplink capacity. ZTE achieves the integration of communication and computing through the base station computing engine NodeEngine and communication-computing-in-one UniEngine, thereby creating a full-stack 5G industrial field network solution. This enables flexible deployment of cloud-based

Fig. 1. Expanding the capabilities of 5G-Advanced based on six major scenarios.



programmable logic controllers (PLC) and other production-line-level applications, supporting the deep integration of 5G into core industrial production processes. Currently, the deterministic capability of 5G has been verified in various scenarios, such as steelmaking, manufacturing, empowering the transformation and upgrading of intelligent production.

Integrated Sensing and Communication: Paving the Way for New business Opportunities

5G-Advanced breaks communication boundaries, enhancing sensing capabilities with a single station sensing range exceeding 1 km and sensing accuracy reaching sub-meter level. Based on the integrated capabilities of communication, sensing, and computing power, 5G-Advanced empowers new digital social economies, such as vehicle-road coordination and low-altitude services.

ZTE continues to lead in communication and sensing integration trials and exploration in various scenarios. It has achieved several industry firsts: the first to achieve communication and sensing integration of a single AAU, and the first integrated sensing and communication (ISAC) networking test, verifying the sensing capability from single-site to multi-site networking. In the V2X scenario, ZTE completed the industry's first 5G-based communication-sensing-computing-in-one V2X architecture trial in Zhuhai. This trial successfully enabled real-time warnings for blind spots through the entire Uu interface. Moreover, it created the industry's first 5G ultra-stable network in Suzhou, supporting the construction of a 5G vehicle-road-cloud integrated autonomous driving technology experience route. In the low-altitude scenario, ZTE completed the industry's first trial of a "5G based communication-sensing-computing-control integration" low-altitude unmanned aerial

vehicle route in Shenzhen. It also realized the application trial of low-altitude unmanned aerial vehicle management based on the communication and sensing integrated AAU in the Hangzhou Asian Games Village.

Ubiquitous Connectivity: Converging Satellite and Terrestrial Networks for True Connectivity Everywhere

Ubiquitous connectivity, a key goal of 5G-Advanced, is realized through non-terrestrial network (NTN), an innovative satellite communication technology. By leveraging satellite coverage, NTN integrates with mobile communication standards for connectivity across air, space, sea, and land. This allows smartphones and IoT devices to directly connect to satellites, supporting applications such as emergency communication and wide-area IoT, and ushering in the era of "consumer-grade" satellite communication.

ZTE, in collaboration with industry partners, has conducted successful technical trials and commercial applications. These include the first domestic field trial of 5G NTN mobile phones connecting directly to satellites, the first domestic laboratory trial of NR-NTN low-orbit satellite broadband services, and the first 5G NTN test in marine areas. Real-time service trials in marine and uninhabited island scenarios, covering aspects like water quality monitoring, temperature and humidity monitoring, and emergency rescue, have been completed. These achievements have laid a solid foundation for the commercialization of 5G NTN.

Universal Intelligence: Comprehensive Smart Solutions Enhancing Quality, Efficiency, and Innovation Integration

Universal intelligence has become a vital core capability in the new stage of



5G-Advanced. It supports autonomous network (improving O&M efficiency), promotes green development (intelligent energy savings), and facilitates business intelligence operations (stimulating B2C traffic and ensuring B2B determinism). ZTE realizes intrinsic intelligence in wireless networks within a single domain through an end-to-end intelligent architecture encompassing the physical network layer, intelligent service layer, and scenario application layer. This provides operators and partners with support for cross-domain closed-loop, collaboration, and orchestration. By combining intent-driven, foundation models, digital twins, and other advanced technologies, ZTE achieves intelligent management and empowerment throughout the entire lifecycle and all-scenario services of wireless networks.

ZTE continues to advance its commitment to intelligence by pioneering the DeepEdge solution. This innovative solution, utilizing intrinsic intelligence in base stations, enables precise identification and differentiated assurance for over 16,000 service types. This dual enhancement significantly improves

user perception and cell traffic. ZTE has also successfully implemented the industry's first high-speed rail precise planning innovation solution based on digital twins in Tianjin, supporting more accurate visual network planning through higher-precision twinning modeling, and facilitating engineering optimization in the planning stage. At the 2023 World Internet Conference Wuzhen Summit, ZTE employed an AI foundation model assurance assistant for on-site assurance, achieving a 5-fold efficiency improvement compared to traditional methods.

As a key stage in the evolution from 5G to 6G, 5G-Advanced will build upon current 5G achievements. Focused on six major scenarios including seamless 10 Gbps+, massive IoT, deterministic capability, integrated sensing and communication, ubiquitous connectivity and universal intelligence, 5G-Advanced will continually enhance capabilities, explore new business opportunities, and expand its scope. These six scenarios will also seamlessly transition to the subsequent 6G network, laying a solid foundation and conducting innovative experiments for the evolution to 6G. [ZTE TECHNOLOGIES](#)

Revolutionizing Immersive Virtual Reality Expeditions with mmWave Technology

The extended reality (XR) industry stands as one of the seven key industries for the development of the digital economy, given its potential to lead us into the future meta-universe. With the widespread commercial use of 5G, XR businesses have reached a crucial point. According to Statista's forecast, XR market revenue is projected to reach USD 250 billion by 2028, with the B2C segment expected to reach USD 52 billion by 2027. Additionally, by 2026, the combined shipment of head-mounted display devices in both augmented reality (AR) and virtual reality (VR) categories is forecasted to more than triple, exceeding 35 million sets.

So far, "Horizon of Khufu" has emerged as a popular VR expedition, guiding viewers through a captivating journey spanning 4,500 years of global history and showcasing the true commercial potential of the VR industry. Launched in Shanghai for three months, this project has already generated over 10 million RMB in revenue, signaling the significant impact that VR expedition applications can have on large-scale commercial use.

However, there are noteworthy challenges associated with the current backpack solution. It weighs over 5 kg and the fan outlet gets heated, causing discomfort during prolonged use. This discomfort poses a barrier to the participation of the elderly and children. Additionally, the Wi-Fi has weak wireless capability, limited coverage,

and fails to meet the demands of large spaces. As a result, the concurrent user capacity is hindered, leading to inefficiencies in commercial operations.

Addressing VR Expedition Challenges with 5G mmWave X-Edge Solution

Instead of using a backpack, the solution involves cloud rendering and accessing a millimeter-wave mobile network. This not only eliminates the interference caused by multiple Wi-Fi connections but also improves mobility, allowing the elderly and children to be free from the weight of a backpack. ZTE's ultra-large-bandwidth millimeter wave device can support the industry's largest 1.6 GHz bandwidth and a single-cell peak data rate of 28 Gbps, effectively meeting the requirements for large-capacity concurrent users in a VR theater mode with a spacious environment. This wireless network solution offers a zero-to-one approach, establishing a robust business model for this service.

In particular, the intelligent identification function on the base station side accurately identifies XR services, ensuring a differentiated service experience. Intelligent scheduling reduces delay and jitter in XR services, while capacity enhancement guarantees a smooth user experience in large-capacity scenarios. Additionally, ZTE has established the industry's



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first end-to-end XR evaluation system based on digital twins, providing intelligent multi-target optimization results for network planning and optimization. The XR rendering based on computing power at base stations minimizes latency, and the terminal energy-saving solution mitigates heat generated in XR devices, improving user comfort during wear.

Intelligent Identification: Base Station-Level Service Identification Database

The XR industry is undergoing significant growth and development, with a robust demand for XR applications across various sectors. However, the wide range of services and diverse features pose challenges in standardizing requirements for mobile networks. ZTE has a unique advantage in the industry with base station-level deep packet inspection (DPI) capabilities, enabling the

identification of 16,000 types of services (apps) and offering targeted guarantees for different XR services.

Intelligent Scheduling: Self-Learning Features of XR to Improve Efficiency

Once different XR data flows are identified, ensuring the reliability of each specific XR service becomes crucial. An intelligent scheduling policy can help to reduce waiting delays in XR services. The XR video source coding algorithm follows a quasi-periodic rule, for example, transmitting one frame of data packet every 8.33 ms for a 120 fps video. The next-generation base station (gNodeB) automatically learns the periodic features of different XR data flows and matches them with efficient scheduling policies, effectively reducing delay and jitter in XR services.

Multi-User Anti-Congestion Scheme: User Experience Fully Guaranteed in Large-Capacity Scenarios

Video data packets typically consist of I frames and P frames. An I frame encompasses all the image information, making it considerably larger than a P frame, which only contains supplementary information. In high-capacity scenarios where I frames are indispensable, simultaneous requests for XR service from multiple users can lead to I frame collisions and immediate congestion at the base station. This, in turn, results in delayed XR services and a subpar user experience. To address this issue, the X-Edge solution employs an anti-congestion policy, strategically staggering service traffic periods to prevent congestion. The outcomes indicate a significant reduction in collision probability, specifically by a factor of 10, translating to a 10-fold decrease in the probability of video stalling.

XR Evaluation System: Accelerating Industry Chain Growth

Built upon a differentiated guarantee for XR services, ZTE has established an end-to-end XR evaluation system. Leveraging digital twins, it

has not only enhanced evaluation efficiency and accuracy but also expedited the development of the entire XR industry chain. The evaluation system covers media quality, interactive quality, and display quality. Key evaluation factors include the realism of VR audio, video, and freedom of movement, user susceptibility to dizziness, as well as the occurrence of issues like screen distortion and video stuttering during playback. Moreover, ZTE has pioneered the incorporation of digital twin technology in the industry by establishing a digital twin simulation platform. This platform serves as the industry's first XR experience evaluation system integrating digital twin technology. The twin platform efficiently collects and processes data, analyzes service features, and iteratively optimizes evaluation algorithms, contributing to a significant enhancement in the accuracy of the evaluation system.

Cloud Rendering and Computing Power Base Station: Creating Ultimate User Experience

The current processing capability of terminals falls short of the demands for complete immersion, and the existing network architecture fails to meet the low-latency requirements essential for robust interactive XR services. A standout feature of the X-Edge solution lies in the pioneering introduction of an industry-exclusive cloud rendering and computing power base station. This innovation facilitates precise identification of XR services, ensuring the prioritized scheduling of these services. Notably, the rendering function is shifted from the terminal to the base station, resulting in a reduction in both power consumption and terminal complexity. This strategic offloading enhances the overall efficiency and performance of XR services.

Efficient XR Terminals: Enhanced Battery Performance

The XR terminal's energy-saving feature has a triple impact: enhancing battery life, alleviating terminal heating issues, and

delivering a more comfortable user-wearing experience. For instance, consider a video frame rate of 60 fps, where the XR service transmits one frame of data packets at a 16.7 ms interval. In conventional solutions, the connected-mode discontinuous reception (C-DRX) period is typically an integer (e.g., 6/8/10/20/30), which doesn't precisely align with the XR service cycle. As data volume increases, this misalignment grows, resulting in noticeable jitter.

The X-Edge solution introduces adaptive adjustments to wake-up signals by the gNodeB based on identified period characteristics. This dynamic matching ensures that the C-DRX period aligns seamlessly with the XR service period. Simulations indicate a noteworthy 20% reduction in power consumption as a result of this intelligent adaptation, underlining the efficiency gains provided by the X-Edge solution.

Unlocking Vast VR Expedition Experiences with mmWave Technology

Through groundbreaking innovations and the support of 5G mmWave technology, VR large-space expedition applications have effectively addressed operational efficiency challenges. The seamless integration of advanced technologies has not only optimized performance but has also ushered in a new era of immersive experiences on a grand scale. These applications, evolving continuously, are set to redefine the virtual reality landscape, offering users an unparalleled cinematic journey within expansive virtual environments.

Looking ahead, the market for VR large-space expedition applications is experiencing remarkable growth, surpassing a size of 10 billion yuan. This growth underscores the increasing popularity and commercial viability of these applications. With their ability to provide captivating and realistic experiences, VR large-space expedition applications are poised to lead the way in the widespread commercial utilization of VR services. **ZTE TECHNOLOGIES**

ZTE Dynamic RIS: Towards Cost-Efficient and Sustainable 5G-Advanced and Beyond



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Challenges Facing 5G-Advanced and Beyond

As 5G commercialization gains momentum, active exploration of 5G-Advanced and 6G communication systems is underway. Nevertheless, the industry faces challenges on this evolutionary journey. Traditional network deployment proves inadequate for seamless coverage due to the assumption of an uncontrollable wireless environment, and the construction cost and energy consumption remain notably high. The advent of 5G-Advanced and future communication systems introduces new and demanding services, such as high-speed, low-latency applications (e.g., mixed reality, holographic rendering, sensing, and wireless medical services), creating a notable contradiction between service capacity requirements and limited spectrum resources.

While 5G continues to dominate headlines, the telecom industry is already focusing on technological advancements beyond the 5G era. Reconfigurable intelligent surface (RIS) has emerged as a robust contender for 5G-Advanced

and 6G mobile networks, gaining global attention from academia and industry stakeholders.

RIS: A Novel Form of Antennas for Next-Generation Networks

RIS stands out as a cutting-edge and promising technology, poised for commercial success in 5G-Advanced and 6G. This innovation offers enhanced performance, cost-effectiveness, easy deployment, and low-carbon networks, playing a pivotal role in the cost-efficient and sustainable evolution of 5G-Advanced and beyond. The fundamental principle of RIS lies in creating an intelligent and adaptable environment through digital programming, manipulating the electromagnetic properties of metamaterials for unparalleled flexibility.

In contrast to conventional materials following Snell's Law, which dictates that the angles of reflection and incidence signals remain equal and unalterable, RIS leverages electromagnetic (EM) metamaterials to precisely control the direction, width, and quantity of EM waves, facilitating accurate reflection or penetration.

ZTE Leading RIS Application in 5G Networks for Ecosystem Growth

ZTE has long been committed to R&D and commercial trials in the field of RIS. Leveraging advanced algorithms, a diverse range of product offerings and extensive partnerships, ZTE continues to drive the development of the RIS ecosystem.

Diverse Portfolio

ZTE has launched a diverse RIS product portfolio including reflective RIS and refractive RIS, tailored to



different use cases and environments.

Reflective RIS is primarily used for on-demand signal reflection in base stations. When obstacles between the base station and the user affect signal quality and user experience, reflective RIS can be deployed to reflect the signal to the user's location, thereby enhancing the signal there. This technology can be strategically placed in accessible areas like poles, billboards and walls, offering cost-effective deployment options.

At the June 2023 Shanghai exhibition, ZTE unveiled its second-generation dynamic reflective RIS, named D-RIS 2.0. This device boasts an 80% reduction in power consumption compared to its predecessor, thanks to advancements in new materials and architecture. It also supports IP65 for outdoor long-term deployment, offering waterproof and dustproof capabilities.

Refractive RIS is primarily applied to glass surfaces, such as windows in buildings or carriage windows, to achieve outdoor coverage indoors or enhance coverage in high-speed train carriages. To avoid impacting indoor brightness, refractive RIS is typically designed in a transparent form and is therefore also referred to as transparent RIS.

Advanced Algorithm

In the early stages of RIS research, the typical approach was static RIS. However, the performance of static RIS is severely constrained due to the inability to dynamically adjust the antenna beam direction in response to changes in the environment and terminal positions. ZTE has developed D-RIS to address this challenge. D-RIS uses dynamic beamforming to automatically track devices in real-time as they move within the coverage area, connecting them to the strongest available link. This greatly expands the base station's coverage and ensures an optimal user experience. To reduce the processing complexity of RIS and maintain its cost and power consumption at extremely low levels, ZTE's D-RIS relies on the channel estimation capability of base stations. The base station guides the D-RIS through a beam sweeping process to determine the user's location. As users engage in services, the base station signals the D-RIS through an in-band air interface to adopt the optimal beam direction towards the user.

Additionally, this implementation preserves the interface protocols between base stations and terminals, allowing 5G commercial terminals to access the network through RIS without modifications. This enables operators to deploy RIS in their 5G networks well before its widespread introduction in 6G.

ZTE Leads Commercial RIS Trials in the Fields

ZTE leads multiple commercial RIS trials, demonstrating that D-RIS can address operators' growing coverage and performance needs while reducing their CAPEX and OPEX.

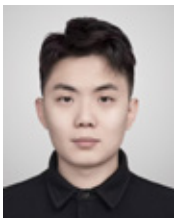
In September 2023, the 19th Asian Games were held in Hangzhou, China. During the event, China Telecom and ZTE showcased cutting-edge 5G-Advanced technologies and implemented several smart projects. Notably, D-RIS emerged as a key technology, delivering cost-effective and energy-efficient features. It played a significant role in ensuring ubiquitous 5G-Advanced coverage across sports venues and the Asian Games Village.

In the vicinity of the Hangzhou Asian Games venues, numerous high-rise buildings posed challenges to indoor 5G signal coverage due to non-line-of-sight (NLOS) conditions. To overcome this, RIS was rapidly deployed to expand the coverage of base station within living areas, shops and parking garages. This cost-effective and eco-friendly solution ensures comprehensive indoor coverage, delivering consistently high data rates for users.

In sports venues, the demand for network capacity surged, particularly with the introduction of HD 8K sports broadcasts. 5G-Advanced technology facilitated seamless HD streaming of Asian Games events, providing continuous high-speed services for multiple devices. Despite ample bandwidth from high-frequency bands, coverage challenges existed. The combination of AAU with RIS at the Hangzhou Asian Games achieved full coverage within the competition venues, substantially reducing deployment costs and speeding up the deployment process.

It is imperative to embrace RIS to sustain high-capacity performance in as many indoor and outdoor venues as possible. Imagine enjoying streaming videos or making calls over a 1 Gbps connection from a millimeter-wave outdoor base station, then seamlessly moving indoors without any disruption—this is the true power of RIS. **ZTE TECHNOLOGIES**

ZTE's Integrated Sensing and Communication Solution Helps Low-altitude Economy Take Off



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Introduction to Low-altitude Economy

Low-altitude airspace typically refers to the airspace within 1,000 meters from the ground, and it may extend to 3,000 meters based on different regional characteristics and actual needs. Low-altitude airspace has gradually transformed from a natural resource into an economic resource. In the past, although low-altitude airspace was accessible, human entry was infrequent due to many restrictions, and conventional methods to mark, measure, and plan physical space were not applicable. With the rapid development of sensing, communication, positioning, digital and intelligence technologies, low-altitude airspace can now be fully digitized into computable airspace. Under the framework of computable airspace, intelligent machines can quickly process complex data, making large-scale low-altitude activities possible, thereby creating huge low-altitude economic value.

The development and expansion of low-altitude airspace has not only significantly reduced the ground traffic pressure, but also created a new industrial space with broader applications and prospects. The low-altitude economy, driven by urban air transportation, drone distribution and logistics, urban drone applications, and consumer and industrial drone applications, has witnessed rapid growth, and is poised to foster a variety of innovative applications on a scale comparable to, or even exceeding, that of the traditional transport

industry. This will redefine the paradigm of work and life, creating a new low-altitude industry ecosystem that includes low-altitude manufacturing, low-altitude operation, low-altitude protection and comprehensive services.

Bolstered by the market and policies, China's low-altitude economy has developed rapidly. Notably, China secures a leading position in the global civilian drone market, accounting for 70% of the global market. The low-altitude economy is predicted to contribute 3–5 trillion yuan to China's economy by 2025. It is becoming a new economic growth opportunity for both China and the world.

ZTE's Integrated Sensing and Communication Solution

Despite its broad prospects, the low-altitude economy faces the challenge of insufficient support capabilities in low-altitude communication, sensing, navigation, making effective control and flight services difficult.

For low-altitude communications, given the enhanced intelligence of low-altitude aircraft, there is a need for higher bandwidth communication to support a wider range of flight data.

For low-altitude sensing, the signal quality of satellite navigation (such as Beidou Satellite and GPS) is unstable due to the obstruction of buildings in urban environments. Traditional ground radar has high deployment costs and lacks the networking capability. Communication base stations or other auxiliary facilities are needed to improve the accuracy of perception and positioning.

For low-altitude navigation, high-frequency and high-density low-altitude activities require a more digital and refined aircraft navigation mode. This requires not only the support of communication facilities, but also the exploration and use of new technical means, such as computer vision, for positioning and navigation.

5G-Advanced will continue to enhance network performance in terms of coverage, capacity, and user experience. More importantly, it will enhance the business value of 5G networks. ZTE's integrated sensing and communication (ISAC) solution extends the business scope of the 5G network from communication into sensing. As one of the important innovative technologies for monetizing the 5G network, it enables the 5G base station to serve as the digital infrastructure of the low-altitude economy, providing capabilities such as real-time broadband communications, precise sensing, positioning and sensing data calculation.

- First, ZTE achieves network coverage in low-altitude areas by using technologies such as large-scale antenna arrays. Leveraging the networking characteristics of base stations, ZTE provides high-speed and reliable communication networks with stable, continuous, seamless coverage for low-altitude areas.
- Second, ZTE leads the industry with the implementation of the monostatic sensing mode AAU. Compared with the bistatic sensing mode, monostatic sensing mode is more flexible and convenient for base station networking. The introduction of ISAC enables 5G base stations to detect the position, speed, trajectory of low-altitude drones, thereby enabling the 5G network to provide capabilities such as positioning, navigation, and trajectory tracking alongside low-altitude communications.
- Moreover, the computing power provided by the industry's unique NodeEngine computing power base station can realize sensing data calculation, encompassing sensing calculation, target recognition, trajectory prediction, monitoring control and video processing. Through capability openness, sensory data can be shared with a low-altitude management platform.

Ultimately, the communication, navigation, sensing (CNS) requirements of low-altitude applications can be met.

ZTE's Efforts in Verifying Integrated Sensing and Communication

ZTE has been actively exploring and applying ISAC.

- In May 2023, ZTE completed the industry's first 5G "integrated sensing, computation, control and communication" low-altitude drone route verification in Shenzhen with the industry's first monostatic mode ISAC AAU prototype. The system can detect drones with an area as small as 0.01 square meters, and achieve a sub-meter sensing accuracy, a sensing distance of more than 1 km, and a detection accuracy of more than 99%.
- In September 2023, in order to facilitate low-altitude security inspection during the 19th Asian Games held in Hangzhou, ZTE carried out the application verification of a single ISAC AAU device to achieve low-altitude drone control in the Asian Games Village. The AAU can sense the flight trajectory of a drone in real time and alert when the drone approaches a warning area, thereby greatly ensuring the low-altitude safety of the Asian Games.
- In October 2023, ZTE completed the industry's first 5G-A ISAC networking verification test, marking a transition from single-point technical verification to multi-station regional networking applications. This represents a critical step in exploring low-altitude security assurance and expanding the capacity of communicating networks.

Moving forward, ZTE will continue to work with industry partners to explore the potential capabilities of "communication+perception+N technology", conduct system experiments, build end-to-end capabilities, and enhance the integration of multiple 5G-A technologies and the maturity of related industry chains, creating unlimited possibilities for social development and industry upgrading. **ZTE TECHNOLOGIES**

5G RedCap Poised to Boost 5G Applications



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Since the launch of 5G in 2018, 5G applications have been deployed at significant scale. However, as the development of 5G applications continues, certain scenarios have emerged where the current capabilities of 5G such as extreme high speed exceed the actual demands, leading to higher costs for 5G terminals and posing challenges for large-scale deployment of 5G applications.

The introduction of 5G reduced capability (RedCap), also referred to as NR Light, in 3GPP Release 17, came at the right time, achieving a trade-off of cost and performance. 5G RedCap obtains the advantages of low cost and low power consumption by reducing terminal complexity while inheriting unique characteristics from 5G such as high capacity, low latency and network slicing, enabling mid- and high-speed IoT scenarios and promoting the large-scale deployment of 5G applications. In the upcoming 3GPP Release 18, RedCap will further reduce the terminal capability. This version, called 5G eRedCap, can be described as the 5G equivalent of 4G Cat.1 and Cat. 1bis, extending the application boundary of 5G RedCap.

Currently, three addressable 5G RedCap use cases are proposed in 3GPP Release 17. These include industrial wireless sensors, video surveillance, and wearables, which can be widely used across multiple vertical industries such as smart manufacturing, smart power grid, and smart city. The application of 5G RedCap is poised to accelerate the digital transformation within these industries.

5G RedCap has broad prospects due to its cost-effective advantage. The deployment of 5G RedCap will start to take shape in the coming years with China expected to lead the initial commercial deployment, followed by a phased global rollout.

According to Counterpoint Research, 5G RedCap modules will constitute 18% of total cellular IoT module shipments by 2030, indicating the significant market potential. In the long term, 5G RedCap provides an evolution path for existing mid-tier 4G connections.

ZTE “Basic + Enhanced + X” RedCap Solution

To address the application scenarios of 5G RedCap, ZTE has launched the “Basic + Enhanced + X” 5G RedCap Solution to facilitate the smooth rollout of RedCap across different stages and various scenarios, enabling 5G RedCap to go from being “usable” to being “useful”.

- The basic 5G RedCap features ensure that RedCap terminals can smoothly access the existing 5G networks. When these terminals access the 5G network as a new type of 5G terminal, access control, user identification and a flexible bandwidth part (BWP) strategy are required. ZTE supports all these basic features to guarantee efficient connectivity of 5G RedCap terminals to the existing 5G network.
- The enhanced RedCap features aim to maximize the usage ratio of network resources. When integrated into the existing 5G network, the compatibility with both the existing network and terminals needs to be considered for 5G RedCap. ZTE supports the 5G RedCap enhancements in terms of capacity, coverage, and power saving. In terms of capacity, ZTE provides functions such as BWP Adaptive Adding and Deleting and Non-aligned Space Division Pairing to maximize spectrum efficiency and improve the user experience in large-capacity scenarios such as multi-channel concurrent high-definition video surveillance. In terms of coverage, recognizing that 5G RedCap with reduced

capabilities has limited UL coverage compared to existing eMBB terminals, ZTE supports multiple uplink coverage enhancement functions such as Joint Channel Estimation to improve the uplink coverage capability of RedCap terminals and ensure that the edge rate of 5G RedCap meets the service demand. For power saving, considering the service characteristics of some 5G RedCap application scenarios, such as multiple small-packet data transmissions from wearable devices, ZTE supports the small packet transmission (SDT) feature, which reduces signaling overhead and extends the battery standby time of terminals.

- RedCap + X enables 5G RedCap to provide extreme performance guarantee for targeted applications, ensuring the fulfillment of service requirements. ZTE supports the customization of application-oriented RedCap network capabilities to meet the diverse needs of different vertical industries. For instance, RedCap + Slicing is provided to ensure isolation between control services and management services, which is mandatory for the power grid scenario. RedCap + High Precision Time Synchronization can also be supported for the control services in the power grid. RedCap + NodeEngine provides base station-based edge computing power for the campus, applicable in AI-based video surveillance scenarios. RedCap + uRLLC enables the implementation of remote control in smart factory while RedCap + VoNR facilitates high-definition video calls for wearables.

ZTE Achievements in 5G RedCap Verification and Application

Since the freeze of 3GPP Release 17 in 2022, which specifies 5G RedCap, ZTE has actively participated in promoting the commercial use of 5G RedCap with industry partners, encompassing completing research and verification of 5G RedCap technology, accelerating the maturity of the industry chain, and deploying multiple industry pilots.

In collaboration with four Chinese operators, ZTE has completed 5G RedCap verification at all the 5G frequency bands and using multiple bandwidths. Diverse networking scenarios, including RAN Sharing and DSS, have been verified. From lab technical

verification to performance tests in commercial 5G networks, the feasibility of RedCap in existing commercial 5G networks has been proved through full-scenario verification, laying the foundation for its commercial deployment. In Thailand, ZTE, in collaboration with AIS, accomplished the first collaborative validation of 5G RedCap at 2.6 GHz in Southeast Asia. The test outcomes consistently achieved theoretical peak values for single-user throughput. In addition, RedCap + NodeEngine was verified, showcasing the capability to provide users with an end-to-end low latency of about 10 ms.

As for real industry scenarios, ZTE, with the industrial partner Brunp Recycling Co., Ltd. Cycle, has completed RedCap verification in a smart manufacturing factory, proving that RedCap terminals, with reduced cost and reduced power consumption, can meet the application criteria of typical services in the manufacturing scenario. ZTE has also completed RedCap pilots in the power grid and security industries, including the verification of power distribution automation services in the smart grid and high-definition video surveillance in the campus security scenario, demonstrating RedCap's applicability in various vertical industries.

To accelerate the maturity of 5G RedCap ecosystem, ZTE has completed interconnection verification between the 5G network and the 5G RedCap terminal side. Partners included mainstream chipset vendors like Qualcomm, MTK, UniSOC and mainstream module vendors such as QUECTEL and China Mobile IoT. The verification tests were conducted using commercial 5G networks and pre-commercial chipsets and modules. This has proved the compatibility between existing 5G networks and RedCap terminals, advancing the maturity of the RedCap industry chain.

As a highly cost-effective IoT solution, 5G RedCap provides a superior choice for mass-scale IoT growth and holds the potential to become the basic technology for digital transformation. ZTE is committed to promoting the commercial deployment and application of RedCap. Moving forward, ZTE will continue to collaborate with industry partners to drive 5G RedCap innovation, explore additional applications, and offer more convenient and efficient communication experiences. **ZTE TECHNOLOGIES**

ZTE 5G NTN: Bridging Global Connectivity Divide



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Introduction

In the surging tide of the information age, the development of integrated global communication networks encompassing sea, sky, and land has become a key driving force in societal progress. Despite significant advancements in terrestrial network expansion, vast oceans and remote lands still face the reality of lacking network coverage, leaving a considerable proportion of the globe in an information isolation. Leveraging its profound technical expertise and insight into the era's trends, ZTE has introduced the 5G non-terrestrial network (NTN) solution based on 3GPP standards. This article delves into ZTE 5G NTN concept, implementation, and prospects, illuminating how it sets a new direction for the future development of integrated satellite-terrestrial communication networks.

Satellite Communication: Meeting Urgent Demands for Comprehensive Coverage

Addressing the challenge of facilitating effective communication and emergency responses in areas without terrestrial network coverage is a significant hurdle facing the global communications industry. Satellite communication has emerged as a key solution to this challenge. The widespread deployment of satellite communication is gradually revealing its indispensable strategic role in the communications sector (Fig. 1). Leading companies are leveraging satellite communication as a breakthrough, exploring diverse technological pathways. SpaceX's Starlink program has deployed over 5,000 satellites in orbit, with a user base exceeding two

million; the emerging force, AST SpaceMobile, is closely collaborating with numerous global operators to co-develop future strategies.

However, current satellite communication methods have their limitations. Traditional satellite telephony offers stable signals and strong environmental adaptability but requires bulky, cumbersome terminals. Moreover, satellite broadband services, represented by Starlink, have made technical advancements, yet their terminal equipment and service fees remain relatively high, hindering widespread adoption.

ZTE 5G NTN: Achieving Universal Connectivity Through Space, Air, and Land Integration

ZTE has proposed a unique, 3GPP-compliant 5G NTN solution. This approach opens up communication channels for remote areas, providing not only convenience and efficiency in communication for users but also paving new avenues for economic growth within the industry.

In its initial phase, the solution leverages mature geostationary satellites. These high-orbit satellites effectively cover vast areas, thereby significantly reducing the number of satellites required. This approach not only conserves resources but also contributes to global environmental protection. The solution aligns with 3GPP standards, ensuring minimal resource utilization for emergency communication and IoT services. This marks a multifunctional and forward-looking milestone in telecommunications development.

As networks evolve to the next step, especially with low earth orbit (LEO) satellites, the renewable network architecture will support satellite uplink

capabilities for base stations. This enables existing network terminals to connect directly to satellites without the need for modifications. The significant economies of scale brought about by existing terminals and their satellite links will rapidly reduce the cost of satellite connections, showcasing the potential for large-scale commercial applications.

- **Universal benefits, diverse integration:**

Compared to other satellite communication methods, the 5G NTN solution, grounded in the 3GPP standard, offers distinct advantages in terms of terminal ubiquity, industry integration, and service versatility. This places it at the forefront of satellite-terrestrial integration technology. Currently, 5G NTN excels in IoT-NTN short messaging and IoT services, and in the future, it will support NR-NTN voice and broadband data services for existing mobile phones.

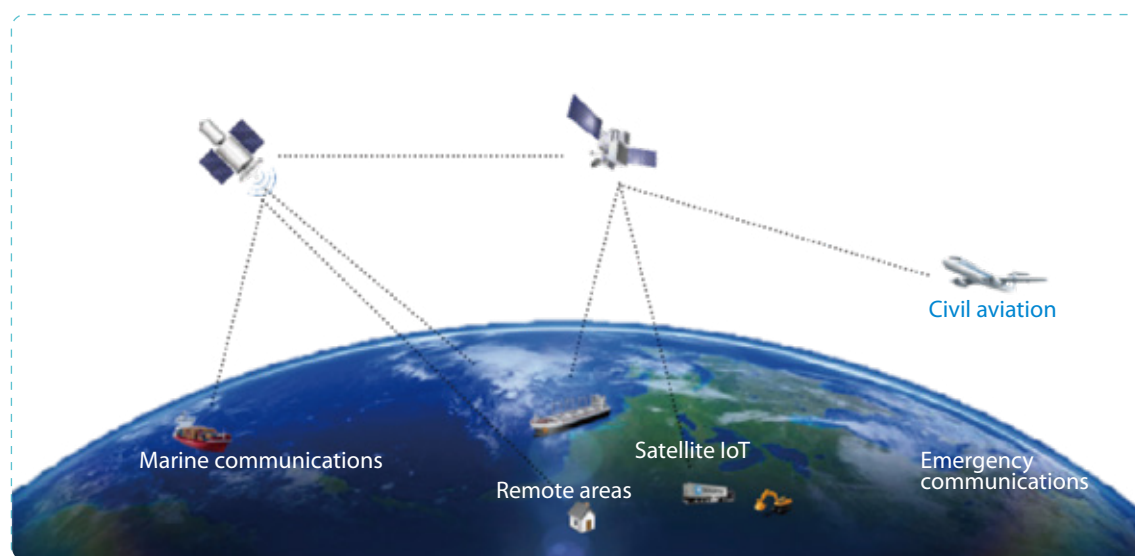
- **Customer priority, enhanced experience:** At the core of ZTE 5G NTN solution is a dedication to enhancing user experience. The technology transforms ordinary smartphones into advanced communication devices capable of connecting via satellite, enabling individuals in the most remote areas to access reliable network services. For industry users, the solution ensures robust, reliable, and cost-effective communication—essential for efficient operations in maritime, logistics, and

emergency scenarios.

- **Secure and reliable, exceptional trust:** In the realm of global telecommunications, security and reliability are paramount. ZTE 5G NTN solution is built on advanced encryption and robust communication protocols, ensuring secure communication across all channels. The system's resilience and reliability are engineered to ensure consistent performance, even under challenging environmental conditions. This reliability is crucial for addressing critical communication needs, especially in scenarios involving natural disasters, remote explorations, and maritime emergencies.

Rapid Technological Advancements in ZTE 5G NTN

After the R17 NTN standard was frozen in June 2022, ZTE has initiated a series of technical experiments and commercial applications worldwide. In May 2023, ZTE, in partnership with China Telecom and VIVO, completed the first 5G NTN direct-to-cell field trial in China. This trial utilized domestically developed communication satellites and ground mobile communication systems, with ZTE's 5G base stations featuring NTN capabilities. It overcame crucial technical challenges such as frequency and time synchronization in geostationary orbit satellite communications, verifying the



◀ Fig 1. Satellite communication is a valuable complement to terrestrial networks.



practicality and reliability of 5G NTN technology and solidifying the foundation for the commercial application of direct-to-satellite smartphone technology.

In September 2023, ZTE's collaboration with China Mobile marked another significant achievement with the successful completion of the first domestic operator-led NR-NTN low-earth-orbit satellite broadband service laboratory trial. This success not only showcased technological prowess but also hinted at the expansive future applications of 5G NR-NTN technology.

Also, in September 2023, ZTE and China Telecom finished a maritime scenario trial of 5G NTN technology, achieving successful interaction and data transmission via on-orbit geostationary satellite in sea and uninhabited island scenarios. The trial, which involved real-time business verification in multiple terminals and scenarios like ocean water quality monitoring and emergency rescue on uninhabited islands, demonstrated the effectiveness and reliability of 5G NTN in complex environments.

In November, in collaboration with China Unicom, ZTE completed the first laboratory trial of 3GPP NR NTN low-earth-orbit satellite voice and video calls, laying the foundation for the deployment of integrated satellite-terrestrial network applications. This series of verifications and experiments is not only a testament to technological innovation but also reinforces ZTE's leadership in the global 5G NTN sphere. As these technologies continue to mature

and find applications, communication of the future will be boundless, and information exchange more fluid. ZTE is leading this wave of innovation and transformation.

Real Impact and Future Prospects

The practical impact of ZTE 5G NTN solution is demonstrated through its successful deployments in a variety of scenarios. By providing stable and high-quality connectivity, ZTE is helping to break down barriers that have hindered the progress of remote regions. Moreover, as economies of scale materialize, the cost of satellite connections is expected to decline further, expanding the commercial prospects and market potential for 5G NTN technology. This represents a pivotal direction for the future of the telecom industry and its evolution towards 6G.

ZTE, positioned at the forefront of this transformation, is driving innovation to achieve more seamless, rapid, and universal connectivity. The company's commitment to research in this field underscores its determination to maintain a leading position in the telecom industry, ensuring that its solutions remain at the cutting edge. As 5G NTN is increasingly adopted and implemented, it is reasonable to anticipate a world where information exchange flows more freely, and every corner of the planet enjoys access to equal and efficient communication services. **ZTE TECHNOLOGIES**

Next-Generation Radios: Unprecedented Capacity, Simplified Site Deployment and Superior Energy Efficiency

ZTE is dedicated to continuously innovating its AAU/RRU solutions for wireless networks, with a focus on addressing key challenges such as the growing demand for large capacity and optimal user experience, crowded tower space, and a high carbon footprint. ZTE AAU/RRU series is well-suited for any CSPs modernizing 4G networks and rolling out 5G networks, with careful consideration of the best TCO.

Industry's First Single Sub-6 GHz 5G Cell Achieves Peak Throughput of 10 Gbps+

Over the past four years, since the advent of 5G networks, the number of 5G users has surpassed 1.2 billion. Both total mobile internet traffic and monthly average user traffic (DOU) have doubled. Various video applications continue to evolve, introducing services like 4K/8K resolution, VR/AR, and glasses-free 3D. Existing service upgrades and new services impose higher demands on network capabilities. According to GlobalData's predictions, global network traffic is expected to increase 3.5 times by 2026 compared to 2022. The emergence of new high-traffic services will intensify the demand for network throughput, thereby amplifying the need for capacity enhancement.

The introduction of ultra-large-scale MIMO, with increased channels and

antenna elements in higher sub-6 GHz frequencies, is a key research area in evolving wireless technologies for 5G-Advanced and 6G, recognized by standardization organizations and enterprises. Integrated sensing and communication (ISAC) also represents a significant innovation for 5G-Advanced and 6G. The industry anticipates incorporating higher frequency bands like 4.9 GHz in sub-6 GHz for improved sensing accuracy with more transceivers.

- **Coverage enhancement:** The new AAU (Fig. 1) has doubled transceivers and antenna elements, which enhance beamforming capabilities and significantly improve cell capacity and coverage. The 128TR AAU boasts 798 antenna elements, providing a coverage gain of over 5 dB compared to the conventional 64TR AAU with a maximum of 192 antenna elements. Notably, the vertical scan angle has expanded from 12 to 24 degrees, ensuring sufficient vertical coverage, especially for high-rise buildings in densely populated urban areas.
- **Capacity increase:** The new AAU achieves 32 downlink streams and 24 uplink streams, doubling spectral efficiency compared to 64TR without relying on protocols or increasing uplink/downlink DMRS overhead. This results in a doubling of cell peak data rate and up to a 40% enhancement in user throughputs.



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- **Standard evolution:** In 3GPP Release 18, supporting up to 24 DMRS ports for both uplink and downlink is achievable without additional DMRS overhead. Release 19, specific to 128TR, introduces support for 128 port CSI-RS. This enhancement improves channel state information estimation and utilization, facilitating better beamforming and overall network optimization.

We have successfully tested the first 128TR massive MIMO AAU at 4.9 GHz in collaboration with China Mobile. The results demonstrate that on a 100 MHz single carrier, the downlink peak data rate of the cell is 10.3 Gbps, twice the current 5G network's maximum spectrum efficiency. The uplink peak data rate is 2.8 Gbps, 2.4 times the existing 5G network's maximum spectrum efficiency.

During the festival of lights event in China (Nov. 21–30), the 128TR AAU outperformed 64TR sites, boosting downlink and uplink

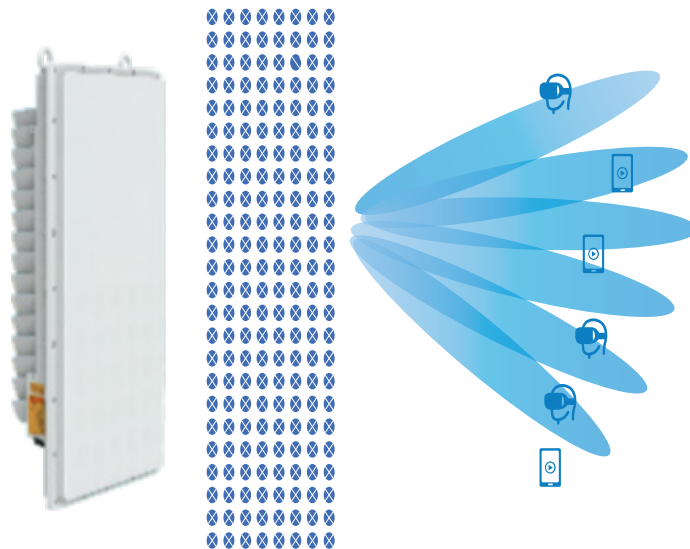
rates by 70% and improving spectrum efficiency by over 40%. It excelled in emergency support at large-scale concerts with 800+ connected users, and its power-saving scheme reduced consumption to watt-levels, ensuring considerable energy savings for base stations.

ZTE's UBR Series for Site Simplicity and Energy Efficiency

In response to the needs of both developed and developing markets, ZTE offers a comprehensive ultra-broadband radio (UBR) series based on the new-generation platform, providing simplified and energy-efficient solutions to CSPs. These solutions aim to optimize TCO through simplified site deployment and significant energy savings.

- **Simplified site deployment:** ZTE's UBR series streamlines tower sites with unique features. It includes the industry's only

Fig. 1. The 128TR AAU.



three-sector-in-one UBRs, providing high output power in a single unit. This series reduces the number of radios per base station from fifteen to just two with the introduction of 6TR and 12TR UBRs, resulting in significant cost savings of up to 60% on rental expenses. ZTE also offers a unique FDD-TDD-integrated 5G UBR for seamless multi-RAT integration, enhancing overall efficiency.

- **Significant energy savings:** ZTE's UBR series brings substantial energy savings with high-efficiency technologies. The unique RF pooling solution optimizes power amplifier utilization, resulting in up to 40% energy savings. The RRU hibernation function and AI-based traffic prediction further contribute to additional power reduction. With a significant reduction in power consumption, ZTE's UBR series helps operators minimize costs and build a sustainable and efficient network infrastructure.

ZTE supports its industry leading UBR series through three key technologies.

- **Unique Super-N power amplifier architecture:** ZTE employs an innovative Super-N architecture with a multi-level optimal adjustment system, enhancing efficiency and reducing power consumption at multiple levels for improved output performance. This results in an 8–10 percentage point increase in power amplifier efficiency compared to the previous generation, leading to a 15–20% reduction in total power consumption.
- **Advanced algorithm:** ZTE develops a successful cognitive radio digital pre-distortion (CR-DPD) algorithm, reducing power fallback for efficient and linear power amplifier operation. This innovation leads to lower power consumption and improved performance.
- **Unique RF pooling solutions:** Leveraging the UBR series, ZTE develops unique RF

pooling solutions dynamically adjusting output power among sectors to increase revenue, save energy, and ensure an optimal user experience. Effectively managing increased traffic, these solutions convert it into substantial revenue without negatively impacting performance or coverage. With a 15–20% boost in busy sectors, subscribers enjoy an enhanced experience, and operators achieve increased power efficiency.

In recent projects, over 50,000 new-generation ZTE's UBRs have been successfully deployed in more than 20 countries worldwide. Addressing crowded conditions in existing tower and pole installations, these deployments increase output power and capacity in the FDD sub-3 GHz range, improving performance while significantly reducing energy consumption. For instance, in one operator's case, where there is a growing demand for multi-technology multi-band service and traffic, tower load efficiency and space optimization are vital. In high-traffic hotspot areas, the operator introduces the unique tri-band UBR with the industry's highest output power, reducing site footprint by two-thirds and power consumption by 50%. This leads to significant savings in tower space and rental expenses. With UBR replacement and AI features, the total power efficiency (GB/KWh) improves by up to 21.6%.

Conclusion

ZTE AAU/UBR series addresses the major needs of mobile operators in different regions. It plays an increasingly important role for the vast majority of CSPs, as UBR facilitates super cost-effective 4G modernization and enhances 5G coverage with increased cost-effectiveness. This not only addresses the most pressing current demands but also provides better solutions for future business growth. [ZTE TECHNOLOGIES](#)

Ultra-Reliable 5G Network for High-Level Autonomous Driving



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With the proliferation of intelligent vehicles on urban roads and the emergence of automated applications such as unmanned delivery and street sweeping, autonomous driving is gradually transitioning from a mere concept to a remarkable reality. As a crucial pillar of economic development, the transportation industry is actively seeking transformation by seamlessly integrating vehicle, road, network, and cloud intelligence to empower smarter cities. Autonomous driving is no longer merely the job of individual vehicles.

High-level autonomous driving refers to a mode where machines autonomously undertake most driving tasks, truly liberating drivers' hands, eyes, and feet while bringing unparalleled convenience into our lives. However, this also imposes higher demands on automation precision.

The advancement of vehicle intelligence is currently impeded by the lack of synergy with artificial intelligence in other domains. High-level autonomous driving vehicles require an extensive array of on-board cameras, radars, and computing chips, which can be quite costly. In terms of safety, the limited field of view and perception distance of on-board sensors may result in blind spots and delayed awareness. In addition, single-vehicle decision-making lacks efficient coordination between vehicles and road systems, leading to inaccurate predictions in complex scenarios. In consequence, single-vehicle intelligence has remained stagnant at L2 for an extended period with

significant challenges for advancement.

With the advancement of 5G technology, the industry envisions harnessing the potential of this cutting-edge technology to enhance both quality and efficiency in autonomous driving solutions, propelling continuous improvements in autonomous driving through 5G+ vehicle-road-cloud integration.

ZTE has introduced the industry's first ultra-reliable 5G network guarantee solution for autonomous driving (Fig. 1), dedicated to providing low-latency and trustworthy service connections for autonomous vehicles. The solution incorporates two major highlights: ultra-reliable 5G transmission and ultra-reliable computing service.

Ultra-Reliable 5G Transmission

5G naturally boasts numerous advantages over the conventional PC5 vehicle-road transmission system. The latter is limited to a mere 20 MHz bandwidth, posing challenges in terms of future evolution and commercialization capability. In addition to 5G's inherent large bandwidth and low latency, ZTE has also employed various network guarantee techniques to further ensure transmission reliability.

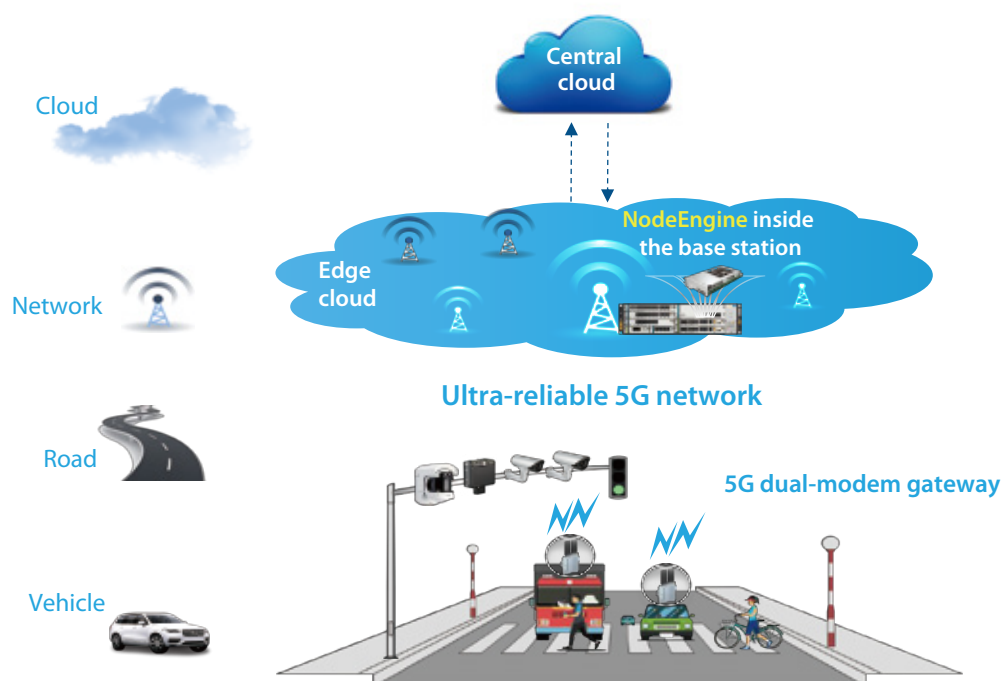
Firstly, the 5G dual-modem gateway enables dual-link transmission and selective reception, effectively mitigating potential delays caused by single-link package loss that could compromise both driving safety and efficiency in

autonomous vehicles. Additionally, to ensure the independent transmission of both links, two distinct frequency points are adopted, thereby minimizing interference and maximizing the bandwidth resources of V2X services. For instance, a 100M private V2X network can be virtually created on the existing 100M public network, restricting public network users from accessing the private V2X network, thus enhancing transmission reliability. Moreover, through intelligent pre-scheduling, required service resources and periodicity can be accurately identified, allowing the network side to proactively provide dynamic resource reservations for terminals, thereby reducing service latency. Overall, ZTE's solution achieves a low latency of 20 ms and a high reliability of 99.99%, demonstrating industry leading performance for driving safety.

Ultra-Reliable Computing Service

In traditional methods, data is

transmitted through one node but processed and computed at the other location, such as a central cloud or regional computing center. This results in prolonged transmission delays and increased investment. ZTE has innovatively merged 5G network and computing capability by simply inserting a computing board, NodeEngine, into 5G base stations. This allows service data to be processed locally in real time, rather than being transmitted over long distances, thereby accelerating decision-making processes. NodeEngine boasts plug-and-play functionality, delivering exceptional performance and ample capacity to enable real-time processing and sending of roadside perception data. This deployment method eliminates the need for new machine rooms, leveraging existing base station resources to reduce the deployment costs and the deployment time. Moreover, computing power can be shared across base stations to form an edge cloud, ensuring uninterrupted service delivery. It is estimated that a single base



◀ Fig. 1. Ultra-reliable 5G network guarantee solution for autonomous driving.

station modification will enable all base stations at 16 crossroads within one square kilometer to provide V2X services.

Paving the Way for Future Applications

With this groundbreaking, ultra-reliable network guarantee as the cornerstone, combined with cutting edge high-precision roadside perception and a digital-twin cloud control platform, autonomous vehicles will gain access to comprehensive and reliable V2X information. Lidars, 4D imaging radars, high-definition cameras, and other sensors are equipped on the traffic light stand for real-time, beyond-line-of-sight perception. The cloud control platform is a massive data source that can provide perceptual data for autonomous driving companies to facilitate better vehicle perception, prediction and planning. It is estimated that if every crossroad in Suzhou is connected to the platform, 198 PB of data will be generated per day, equivalent to the daily amount of data collected by 290,000 autonomous

vehicles using on-board sensors. Automobile companies can also purchase this data to develop and deliver their own driver assistance services, thereby enhancing their core competitiveness. Moreover, the platform can serve as an overall monitoring center that inspects conditions of vehicles and roadside equipment, enabling the government to enhance road efficiency through trend prediction and congestion optimization.

Currently, the ultra-reliable 5G network guarantee has been trialed in the pilot intelligent road area spanning 162 kilometers, where L2 vehicles can achieve L4 autonomous driving services solely through roadside sensing and reliable 5G transmission, without the need for onboard sensors. Three Robobus lines have also been commercialized on the 5G intelligent road. The self-driving bus is empowered and operated with real-time roadside perception data and is remotely monitored by the cloud control platform. There is no bus driver behind the steering wheel of the L4 Robobus, only a safety supervisor who awaits nearby in case of any unforeseen emergencies. Additionally, over 1,000 self-driving vehicles from more than 20 automobile companies are connected to the system for real time supervision, both in the technology park and on the intelligent road. These vehicles include RoboBus, RoboTaxi, automated delivery, sweeper, patrol, sightseeing shuttle, truck, and retail cart.

With more than 3.1 million 5G base stations in China, a solid foundation has been established for the future rollout and large-scale commercialization of the integrated 5G vehicle-road-cloud system. Looking ahead, the ultra-reliable network is poised to enhance the autonomous driving capabilities of diverse automated applications, ultimately bringing an improved and more intelligent urban lifestyle to people. **ZTE TECHNOLOGIES**





5G-Advanced Powered Smart Metro: Empowering Passenger Services and Metro O&M

In a city, ensuring residents a high-quality living experience and a convenient, healthy living environment is crucial. The development of urban transportation plays a key role. Metro commuting offers an efficient and low-carbon choice amid escalating traffic congestion. The metro lines in Shanghai are approximately 936.17 km, with an average daily capacity of about 13 million passengers, ranking first in the world. The average commuting time on Shanghai metro is over 40 minutes, and passengers need stable and reliable Internet connections for social and entertainment. However, 5G network coverage on metro is less than 20%, and the actual network demand of passengers has been suppressed. In such a densely populated situation, translating passenger traffic into value creation is not only a critical challenge, but also a valuable opportunity to enhance the urban economy.

ZTE and China Telecom unveil a groundbreaking 5G-Advanced powered smart metro solution for Shanghai Metro Line 4. Since April 2023, the 34-kilometer Line 4 has

been commercially deployed with this solution, handling 0.98 million daily passengers. ZTE introduces an industry-first 5G indoor solution with BBU + pRRU two-level architecture inside metro carriages. Additionally, 5G-Advanced AAUs are deployed in tunnels, achieving “high-speed backhaul” with up to 15 Gbps downlink and 2 Gbps uplink. This ensures extremely large bandwidth and high transmission capacity, providing passengers with a seamless and reliable 5G network for an enjoyable journey.

For metro operation, ensuring tunnel security is crucial. Previously, manual checks took three hours daily to eliminate potential risks and hazards in tunnel. Millimeter-wave technology’s high backhaul capacity enables real-time transmission of operating information from platforms and carriages to the metro control system. Pattern recognition and object detection can replace over 80% of daily manual checks for platforms, pantographs (electricity transfer from catenary to locomotive), and railways. This solution brings significant benefits to users, mobile operators, and metro operations.



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Reducing Limitations on Mobile Network Infrastructure

In China, most metro systems were built with a distance of about 1 meter from tunnels to train carriages. However, a minimum of 1.2 meters is needed for installing new cables, considering isolation and security requirements. Insufficient power is another factor. To support 5G service and new signal sources (5G RRUs), the power supply needs to increase from 60 kW to at least 100 kW. The cable-based solution faces obstacles, with network signals significantly weakened inside the metro due to signal attenuation from dense metal carriages and the Doppler Effect caused by the train's rapid movement.

The 5G-Advanced powered smart metro solution innovatively relocates network equipment deployment from tunnels to metro carriages, effectively addressing China Telecom's space limitations and signal attenuation challenges caused by dense metal carriages.

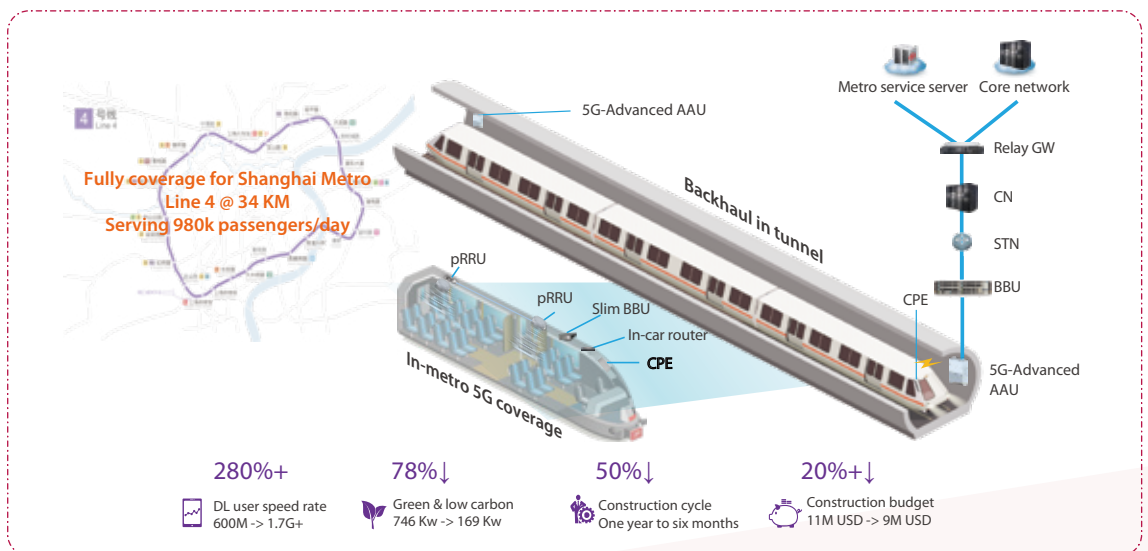
Creating More Value for Mobile Operators

5G-Advanced powered smart metro is the most cutting-edge solution for

specialized 5G network coverage. With a quadrupled average downlink speed, equivalent to upgrading from 480p to 1080p video quality, it achieves a 15 Gbps high-speed backhaul through the millimeter-wave technology. This technology supports approximately 75 channels of 8K HD camera live-streams simultaneously. Metro mobile users, on average, consume three times more payload. This unique solution allows for deployment across over 190 metro models, providing mobile operators with increased collaboration opportunities with various industrial partners. The achievement is attributed to its unique architecture and innovative products (Fig. 1).

- **Easier deployment:** The unique BBU + pRRU two-level architecture significantly simplifies metro network deployment. Specifically, slim BBU and Qcell (pRRU) are used for in-metro coverage, while 5G-Advanced AAUs deployed in tunnels serve as high-speed backhaul, receiving data from CPEs at both ends of the train simultaneously. Construction time has been reduced from one year to six months.
- **Innovative products:** The slim BBU, half the size of typical BBU and the industry's

Fig. 1. 5G-Advanced powered smart metro solution.



only in-metro BBU, is the smallest in its field. It perfectly fits metro carriages, supporting up to 12×100 MHz Massive MIMO cells while weighing only half as much as a typical BBU. Despite its compact size to accommodate limited metro space, the slim BBU is powerful enough to ensure stable and seamless 5G coverage. Moreover, the 5G-Advanced AAU supports a 1.6 GHz bandwidth and can reach peak rates of up to 28 Gbps when used with NR-DC, making it the largest backhaul option.

- **Lower investment and greener operation:** For Metro Line 4 alone, the number of 5G network devices deployed has been reduced from 640 to 192, saving approximately \$2.1 million. The energy consumption of the 5G network has decreased from 746 Kw to 169 Kw, representing a remarkable 78% reduction. This results in an annual savings of 3.7 million kWh, enough to power a community of 5,000 people for a year.

Empowering Smart Metro Operation

This 5G-Advanced powered smart metro solution based on 3GPP 5G standards offers high security, ultra-low latency (<5 ms), high bandwidth, and excellent reliability. Providing complete visibility and situational awareness of the entire metro line, it also integrates communication and perception, identifying objects as small as 20×20×20 (cm³). This enhances overall security and reliability for completely driverless driving.

Inspecting trains, rails and tunnels involves risks, such as gaps of up to 100 meters on both platform and non-platform tracks, with water accumulation. All inspections must be completed within a three-hour window at midnight. Machine vision and AI pattern recognition can cut down human inspections by 80%, enhancing employee safety, improving

operating efficiency by 30%, and reducing night working by 50%.

Unprecedented Metro Experience Enhancement

The 5G-Advanced powered smart metro solution offers passengers an unparalleled gigabit experience, ensuring an enjoyable journey. Each metro has a network capacity of up to 15 Gbps, sufficient for 1800 people to watch HD video streams or play cloud games simultaneously without any Internet slowdown. The peak rate within the metro has tripled, reaching 2.1 Gbps from 600 Mbps, meeting passengers' daily social and entertainment needs.

The mobile network infrastructure enhances user experience for various services. In Shanghai, the METRO app (available on both IOS and Android) provides real-time information on carriage arrival time and crowding levels, enabling passengers to plan optimal travel routes. After passengers disembark, the sub-meter-accuracy positioning guides passengers to the optimal route via the METRO app when GPS is unavailable, whether changing trains or exiting the station.

After the commercial launch on Line 4, deployment on Line 9 is underway, with plans for expansion to additional metro lines in Shanghai. The 5G-Advanced powered smart metro solution is applicable to at least 70 metro lines in medium- and large-sized cities like Beijing, Tsingtao, and Hangzhou in China, and aims to extend its reach globally.

Digitalization construction forms the foundation of a smart metro, focusing on safety, performance, comfort and reducing operational costs to support long-term, sustainable urban growth. ZTE is committed to advancing 5G-Advanced innovation in this digital economy era through collaboration with more industrial partners to create a brighter future. [ZTE TECHNOLOGIES](#)



China Telecom Builds Smart City in Hangzhou with 5G-Advanced Technology



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Hangzhou, known as the ‘Capital of Internet’ in China, is a city at the forefront of innovation. During the 19th Asian Games, China Telecom and ZTE actively explored innovative 5G-Advanced (5G-A) technology and applied it to secure major events and support innovative business endeavors across various fields. With a focus on delivering an exceptional event experience while enhancing urban infrastructure, they have successfully established a smart city in Hangzhou powered by the 5G-A technology.

Offering More Immersive Viewing Experience

Empowering Immersive Experience with a 25 Gbps Network

China Telecom and ZTE collaborated to create ultra-large 1.6 GHz bandwidth 5G-A equipment, which has been deployed in Xiaoshan, Qiantang River, and other hotspot areas in Hangzhou. The peak

downlink rate reached 25 Gbps, and the peak uplink rate reached 17 Gbps. When deployed in large sports venues, a single base station can support dozens of 8K cameras for real-time live broadcasts. The 5G-A network can also support more than 60 XR business concurrent connections, combined with bullet time and other technologies to achieve an immersive experience for game watching.

Providing Seamless 5G-A Network Coverage with Dynamic RIS Technology

China Telecom has customized dynamic reconfigurable intelligent metasurface (RIS), successfully implementing applications in the Asian Games Village. This achievement has enabled high-speed network coverage in challenging areas such as underground garages and shops. The measured data indicates a significant improvement compared to scenarios without RIS, with a six-fold increase in the downlink rate and a twenty-fold increase in the uplink rate. Furthermore, the reflection beam of dynamic

RIS can seamlessly move along with users.

In addition to the Asian Games Village, the Binjiang Gymnasium has also implemented dynamic RIS deployment, facilitating 8K UHD live broadcasting services. Moreover, along the 10 km footpath by the Qiantang River, real-time testing and display of sports data become achievable through beam tracking based on dynamic RIS technology, thereby contributing to the advancement of sports development.

Promoting Intelligence Growth Across Diverse Scenarios

Industry's First 5G Smallcell in Ship and 5G-A Backhaul System for Qiantang River Cruises

As one of the prominent water tourism routes in Hangzhou, the Qiantang River serves as a significant destination for online anchors. However, signal reflection on the river and substantial attenuation caused by ships make traditional networks inadequate to meet the demands of multiple anchors. In collaboration with ZTE, China Telecom has successfully deployed cutting-edge 1.6 GHz ultra-large 5G-A equipment on the Qiantang River. This deployment enables a single terminal downlink peak exceeding 11 Gbps, facilitating numerous anchors in conducting high-definition live broadcasts. Additionally, an innovative 5G smallcell and 5G-A backhaul system have been implemented on cruise ships, significantly

enhancing user experience by more than tenfold.

5G-A Nomadic Base Station Facilitates New Business of China Media Group

China Telecom and China Media Group (CMG) have collaborated to implement a new lightweight business for new media based on 5G-A. Leveraging ZTE's 5G-A private network and nomadic base stations, they can achieve stable transmission of uplink 2G+ ultra-large capacity and 4k live broadcasts with a shallow compression ratio of 1:8. By incorporating real-time chroma keying in live broadcasting, low-latency virtual interaction within the same frame can be experienced. This technology has been successfully applied to numerous CMG new media programs.

RedCap and ISAC Enable Low-Cost Ground and Air Inspections

China Telecom and ZTE have implemented the reduced capability (RedCap) technology in Hangzhou Smart E Valley. Leveraging the advantages of RedCap's high capacity and low latency, real-time ground image acquisition and transmission can be achieved, enabling cost-effective campus inspections.

Intelligent solutions are also being applied in the low-altitude domain. China



Telecom introduced ZTE's integrated sensing and communication (ISAC) technology, ensuring low-altitude security during the Asian Games. By utilizing this technology, a low-altitude security line is established at the entrance of the Asian Games Village. The 5G-A base station facilitates the detection of object positions and heights within a 1 km range, achieving sub-meter level accuracy.

Industry's First 5G NTN Application in Sea Scenario Enables Real-Time Monitoring and Transmission of Water Quality Data

China Telecom and ZTE have successfully conducted the industry's first 5G non-terrestrial network (NTN) application verification in sea scenarios. In these sea and uninhabited island scenarios, seamless on-orbit interaction and efficient business data transmission can be achieved, enabling real-time business verification across multiple terminals and diverse situations. This encompasses sea water quality monitoring, uninhabited island temperature and humidity monitoring, as well as uninhabited island emergency distress management, yielding favorable outcomes.

Optimizing Network Operational Efficiency

Establishing a Comprehensive Control System Based on Digital Twin

In the face of the vast scale of networks, achieving rapid response and coordination is of great importance. Therefore, China Telecom collaborates with ZTE and other industry partners to contribute to the "Tianmu" control system. By leveraging the digital twin technology, they can realize a 3D venue rotation effect for provincial sports events while establishing a robust "central brain" for safeguarding. This central brain empowers real-time control

over large-scale communication networks, private networks, and critical services, facilitating efficient command execution and accurate decision-making.

Cluster DFS Offers Effective Solutions for Uplink Capacity

China Telecom and ZTE has implemented the Cluster dynamic frame sharing (DFS) technology. By predicting traffic distribution characteristics, the frame structure is dynamically adjusted within base station clusters, enabling the network in Asian Games venues to effectively cater to dynamic fluctuations in services. The data from Binjiang Gymnasium demonstrates that Cluster DFS enhances venue upstream capacity by over 60%, ensuring bandwidth for various upstream services including live streaming.

Intelligent Respiration Network Ensures Seamless Internet Access for A Multitude of Individuals

To address network congestion issues in high-concurrency scenarios, China Telecom and ZTE have introduced the industry's first intelligent respiration network solution. This innovative approach leverages time and frequency-based traffic distribution trends to enable power shrinkage within the network through power sharing, thereby facilitating flexible coverage adjustments. By efficiently allocating limited network resources, it effectively caters to the requirements of multi-terminal high-concurrency services while ensuring an optimal user experience.

The collaboration between China Telecom and ZTE is driving progress and innovation, empowering the transformation of Hangzhou with cutting-edge technologies. Through the deployment of 5G-A innovations, they inject boundless vitality and enthusiasm into Hangzhou, ultimately establishing it as a smart city. [ZTE TECHNOLOGIES](#)



CMG Achieves UHD Shallow Compression Coding and Real-Time Production with 5G-A CampSite

Ultra-low latency and ultra-large bandwidth are crucial for the new media industry's real-time production of ultra-high definition (UHD) shallow compression video services. Wired transmission is conventionally used but proves inconvenient due to cost, network construction, and event response challenges. At the Hangzhou International Expo Center, China Telecom and ZTE introduced a 5G-A CampSite, establishing a wireless UHD shallow compression coding and real-time production system for China Media Group (CMG). This system can provide virtual co-hosting video service applications with ultra-low latency and ultra-large bandwidth based on JPEG-XS shallow compression. The service demonstration at the expo center received high praise from China Telecom and CMG leaders, showcasing ZTE's robust technical capabilities and agile market responsiveness.

The 5G-A CampSite uses millimeter-wave

frequencies with large bandwidth and low latency characteristics for the air interface technology to upload and download video data. It utilizes ZTE's innovative NodeEngine, the industry's first base station with built-in computing engine, to identify and distribute video data. The data is then offloaded separately to CMG and China Telecom's local data networks, ensuring seamless connectivity between their exhibition booths. A local video server merges and composites real-time videos, transmitting them back to on-site screens through the CampSite's air interface. This achieves the continuity and display of the entire broadcast, allowing hosts from different booths to appear on the same screen and interact. Additionally, real-time video merging avoids the use of traditional green background solutions, enhancing versatility in various environments for practical live broadcasting. The NodeEngine, as the built-in computing engine, adopts a direct offloading solution



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within the base station, eliminating the need for detours to UPF in traditional private network services. This significantly reduces the transmission path, simplifies the network structure, decreases transmission latency, and ensures network reliability.

The NodeEngine computing engine deployed this time not only supports video data identification and distribution but also incorporates a simplified core network function known as 5GCCP. This deployment liberates the production and broadcasting network at the Hangzhou International Expo Center from the cumbersome process of remotely connecting to the core network required by conventional private networks, preventing business interruptions caused by link failures. Moreover, while NodeEngine identifies business types, it can also analyze the QoS requirements through its intelligent algorithm. By deploying various scheduling strategies, it ensures optimal business QoS performance, greatly simplifying operational challenges related to card management and network maintenance that may arise during the video production and

broadcasting process.

The 5G-A network capabilities, characterized by large capacity, high reliability and low latency, serve as the core driving force behind CMG's UHD shallow compression coding and real-time production technology. This meets the requirements of 4K video 1:8 (8K video 1:32) shallow compression large uplink services and virtual co-hosting services. The system operates smoothly and reliably for a long time with no packet loss, meeting the higher requirements of video shallow compression production and broadcasting compared to traditional deep compression. It requires ultra-large uplink bandwidth (4K@50P 1:8, 1.1G), ultra-low latency (end-to-end 100 ms), and transmission stability (no packet loss during transmission). The successful demonstration offers insights and reference for the future evolution of wireless production and broadcasting studios, providing valuable scenario validation for the industry.

During the demonstration, the camera achieved end-to-end business transmission through the encoding and decoding box





Millimeter-wave macro RF unit



Millimeter-wave MiCell RF unit

connected to customer premises equipment (CPE). Leveraging world-leading 5G-A commercial terminals, the CPE supports ultra-large bandwidth transmission modes, meeting the transmission requirements of nearly 1.1 Gbps for UHD shallow compression video uplink. Additionally, 5G-A also provides downlink channels for real-time demonstrations of low-latency virtual co-hosting videos.

As the core equipment for the demonstration, the 5G-A CampSite, a minimalist and mobile coverage solution jointly launched by China Telecom and ZTE, comprises a small cart, an equipment cabinet, and the radio frequency (RF) part. It serves to establish network coverage for temporary needs. The showcased live video transmission and processing, a common business application, jointly demonstrated by CMG and China Telecom, caters to real-time, mobile, high-bandwidth, and low-latency scenarios in new media. The demonstration utilizes a millimeter-wave solution with an 800 MHz bandwidth for RF. The CMG booth, equipped with the A9825 macro base station, achieves an uplink measurement exceeding 2 Gbps and a network RTT latency of less than 4 ms, showcasing superb

performance.

In the China Telecom booth, the MiCell indoor distributed RF unit demonstrates flexible capabilities of RF equipment in diverse scenarios. Utilizing industry-leading distributed architecture and intermediate frequency pooling technology, MiCell is compact, lightweight, and versatile for deployment on poles, walls, and ceilings. Supporting both horizontal and vertical installation, it caters to various indoor scenarios. Moreover, MiCell employs multi-array antenna technology, allowing flexible beam coverage through software configuration, enhancing coverage capabilities.

The 5G-A CampSite at the Hangzhou International Expo Center significantly highlights 5G-A network capabilities in advancing new media technology. It showcases robust network capabilities and reliable 5G-A application solutions, delivering an excellent UHD experience. ZTE, in collaboration with China Telecom and CMG, will further promote the development of video services using 5G-A technologies, offering enhanced business experiences to audiences in the future. [ZTE TECHNOLOGIES](#)

To enable connectivity and trust everywhere