ZTE Leading 5G Innovations

5G FORWARD
ZTE’s Vision & Capability
Topics:

1. 5G Status & Trends
2. 5G Frequency Bands and Applications
3. 2/3/4G to 5G Network Migration
4. Spectral Efficiency Technology
5. 5G Private Network
6. Leading 5G to Commercialization
Global 5G commercialization now in the fast track with huge potentials

### 5G in the fast track

- **Launched networks**
  - 2019: 61
  - 2020: 140
  - 2021: 200

- **Available phones**
  - 2019: 47
  - 2020: 335
  - 2021: 608

- **Penetration rate**
  - 2019: 0.2%
  - 2020: 7.7%
  - 2021: 97

- **Invested SA networks**
  - 2019: 27
  - 2020: 46
  - 2021: 97

### 5G’s huge potentials

- **5G traffic CAGR 63%**
  - Unit: million TB
  - Source: GlobalData

- **5G subscription CAGR 35%**
  - In billions
  - Source: GlobalData

### Driven by B2C & B2B

- **XR & gaming as key drivers**
  - 20x AR shipment 2025 vs. 2021
  - Source: IDC

### More industries to be transformed by 5G

- **B2B mobile market size CAGR 2021-2026**
  - 30.5%

- **Top 3 private networks (share in 2025)**
  - Manufacturing: 24.6%
  - Energy & Utility: 24.4%
  - Transport & Logistics: 13.6%
  - Source: Omdia
Different phases and challenges need prioritization and tailored solutions

**Initial development**
- Coverage: Hotspot only
- Penetration rate: >0%
- Service enhancements

**Scale development**
- Coverage: Urban
- Penetration rate: ~10%
- More new applications

**Massive-scale development**
- Coverage: Urban, suburban & rural
- Penetration rate: ~20% or higher
- More B2C & B2B applications

**Easy kickoff**

*Easy & fast 5G deployment is the top priority*

**Quality network**

*High-performance and efficient 5G network is critical to quality*

**All-round monetization**

*Monetization is the way to 5G value creation*
Phasing out 2G or 3G is not easy and 4G will continue to play a key role.

**Forecast on 3G, Connection & Traffic**

Source: Omdia, Feb. 2021

**2G and 3G network sunsets (2015–2025)**

Source: GSMA, Feb. 2021

**Mobile Connection Forecast & 4G**

Source: Omdia, Feb. 2021

**Mobile Traffic Forecast & 4G**

Source: Omdia, Feb. 2021
Challenges to tackle for materializing 5G

1. **Site solution & modernization**
   Migrate legacy network with both high capacity & simplicity

2. **5G architecture**
   Select the right 5G evolution path at the right time

3. **Spectrum & user experience**
   Ensure the best performance with the best efficiency

4. **Vertical industry**
   Materialize 5G with also industry applications

5. **Continuous optimization**
   Improve network operation efficiency and cost effectiveness
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## 5G Frequency Band

<table>
<thead>
<tr>
<th>5G Frequency Band</th>
<th>&lt;1 GHz</th>
<th>3 GHz</th>
<th>4 GHz</th>
<th>5 GHz</th>
<th>24 – 30 GHz</th>
<th>37 – 50 GHz</th>
<th>64 – 71 GHz</th>
<th>&gt;95 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 Mhz (US)</td>
<td>2.5 / 2.6 GHz</td>
<td>3.45</td>
<td>3.55</td>
<td>3.7</td>
<td>5.9–7.1 GHz</td>
<td>24.25–24.45 GHz</td>
<td>37–37.6 GHz</td>
<td>64–71 GHz</td>
</tr>
<tr>
<td>600 Mhz (Canada)</td>
<td>3.475–3.65 GHz</td>
<td>3.45</td>
<td>3.55</td>
<td>3.7</td>
<td>5.9–7.1 GHz</td>
<td>24.25–24.45 GHz</td>
<td>37–37.6 GHz</td>
<td>64–71 GHz</td>
</tr>
<tr>
<td>700 Mhz (France)</td>
<td>2.6 GHz</td>
<td>3.3–3.4 GHz</td>
<td>3.48</td>
<td>3.8 GHz</td>
<td>4.8–5 GHz</td>
<td>24.75–27.5 GHz</td>
<td>40.435 GHz</td>
<td></td>
</tr>
<tr>
<td>700 Mhz (UK)</td>
<td>2.6 GHz</td>
<td>3.42</td>
<td>3.7</td>
<td>5.9–7.1 GHz</td>
<td>25.7–26.5 GHz</td>
<td>26.5–26.9 GHz</td>
<td>37.5–38.7 GHz</td>
<td></td>
</tr>
<tr>
<td>700 Mhz (Japan)</td>
<td>2.6GHz</td>
<td>3.42</td>
<td>3.7</td>
<td>5.9–7.1 GHz</td>
<td>25.7–26.5 GHz</td>
<td>26.5–26.9 GHz</td>
<td>37.5–38.7 GHz</td>
<td></td>
</tr>
<tr>
<td>700 Mhz (India)</td>
<td>3.3–3.6 GHz</td>
<td>3.437 GHz</td>
<td>4.5–4.9 GHz</td>
<td>24.25–27.5 GHz</td>
<td>37.435 GHz</td>
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</tbody>
</table>

**N78 will be the Prime Band for Initial 5G Deployments**

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Sources: 5G Observatory, Qualcomm
5G Technology Laid Foundation for New Business

<table>
<thead>
<tr>
<th>Year</th>
<th>R15 NSA</th>
<th>R15 SA</th>
<th>R15 Late Drop</th>
<th>R16: NR Enhancement</th>
<th>R17: NR Enhancement</th>
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</thead>
<tbody>
<tr>
<td>2018</td>
<td>Option 3</td>
<td>• Option 2 &amp; 5</td>
<td>• Option 4 &amp; 7</td>
<td>All Options</td>
<td>All Options</td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td>• eMBB/uRLLC</td>
<td>• eMBB/uRLLC</td>
<td>• uRLLC</td>
<td>• Tera Hz</td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td>• SBA</td>
<td>• Option 4 &amp; 7</td>
<td>• mMTC</td>
<td>• Accessing satellite</td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td>• Network Slicing</td>
<td></td>
<td>• 5G V2X</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td>• VoNR</td>
<td></td>
<td>• FMC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 4/5G interoperability</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>• 5G MEC</td>
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</tbody>
</table>

Technologies:
- DC(dual-connectivity)
- 5G QoS Enhancement
- SBA
- Network Slicing
- VoNR
- 4/5G interoperability
- 5G MEC
- Option 4 & 7
- uRLLC
- mMTC
- 5G V2X
- FMC
- Tera Hz
- Accessing satellite
Frequency Bands for the Network Layers

Coverage layer:
- Low band --- Below 3 GHz bands like 600 MHz and 700 MHz
- FDD legacy band are recommended for widely coverage.
- eg. 700/800/900/MHz can be used for ULRRC/IOT service;
  1800/2100/2600 can be used for eMBB service

Capacity layer:
- Mid-band --- Mid 3GHz to 6 GHz bands for higher bandwidth
- Wide bandwidth that can provide ultra high capacity for the system.
- eg. N78 band is used for eMBB service

Hot spot layer:
- High band --- mmWave, FR2
- Lays a big role in 5G NR system due to much higher bandwidth
- eg. 26GHz currently is mainly planned for eMBB service
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A Future-oriented 4G is the Answer to a Better 4G & 5G Co-evolution

- **Suggestion**
  - LTE network should be modernized to meet the requirements of the ever increasing data traffic and various new services, ensuring a long-term success;
  - Along with it, the LTE network should be consolidated as ready for 5G and ready for better 4G & 5G co-evolution;
<table>
<thead>
<tr>
<th>ZTE Solution overview</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Architecture</strong></td>
</tr>
<tr>
<td>SA &amp; NSA &amp; SA/NSA hybrid all supported with great flexibility</td>
</tr>
<tr>
<td>NSA SA</td>
</tr>
<tr>
<td>Massive commercial deployment &amp; migration experience</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
ZTE SA+NSA Dual-mode Architecture

NSA Option3X: 5G quick introduce

NSA+SA: Facilitate smooth evolution

SA Option2: Enjoy all 5G Services

A Quick Roll-out Option
- eMBB as the main focus
- No 5GC required
- Maximized branding effect
- Lower initial investment

ZTE provides flexible architecture and evolution paths to operators.

Final Roll-out Option
- 5GC is required
- eMBB/URLLC/mMTC
- Relaxed coupling between 4G & 5G
- SA UEs ready in 2020
UniSite NEO: Simplest 4G modernization & 5G evolution

Enhancement, Extension, Efficiency

- **40%** Max. RRU rental saving plus new 5G in 700MHz & 3.5GHz
- **35%** Power Saving with latest products and technologies
- **25%** CAPEX saving in power supply & battery

**Pioneer for Evolution**
- New 5G AAUs of lightest, energy-saving and excellent performance
- Industry's Leading Integration, 7 Units for 3-sector & 7-band
- Hardware ready for DSS on FDD bands
- All radio units are ready for 5G
- **4*4 MIMO** ready for 1.8GHz, 2.1GHz & 2.6GHz
- All in one BBU, Most Powerful BBU for all RATs

UniSite NEO: Industry’s leading integration
UniSite NEO: 4G Modernization with Extreme Efficiency

High Integration
- 2TR, 4TR ➔ 6TR, 12TR

Ultra broadband
- Series UBRs with PIMC

High Output Power
- 2*180W, 4*180W, 6*120W

Low Power Consumption
- 40% reduction for next generation

**4TR Enhancement** for RAN Sharing & Large Traffic

- 700M + 900MHz
  - 1.8G + 2.1GHz
    - 4 x 160 W
    - Suitable for RAN sharing
    - 35L / 35kg
  - 1.8G + 2.1G + 2.6GHz
    - 4 x 180 W
    - Output power sharing
    - 35L / 37kg

- 700M + 850MHz
  - 1.8G + 2.1GHz
    - 4 x 160 W
    - Suitable for RAN sharing
    - 35L / 35kg

**2TR Extension** for Multiple scenarios

- 800MHz + 900MHz
  - 2*120 W
    - Coverage boosting
    - 18L / 20kg

- 700MHz + 800MHz + 900MHz
  - 2 x 180 W
    - PIMC enhancement
    - 29.7L / 28kg

**12TR & 6TR Breakthrough** for Extreme Efficiency

- 700MHz + 800MHz + 900MHz
  - 6 x 120 W
    - 2TR per band
    - 37L / 39kg

- 1.8GHz + 2.1GHz
  - 12 x 80 W
    - 4TR per band
    - 45L / 45kg

- 3 radios into 1 for three sectors

Industry leading UBR series, provides flexible choices with 4G modernization and 5G evolution.
UniSite NEO: New generation AAU to carry 5G capacity

200M BW@n78
- AAU weight up to 30%
- Power consumption 40% down
- Crane free deployment

400M BW@n78
- AAU weight up to 30%+
- Power efficiency up to 45%
- Multi-operator RAN sharing
- Fragmented spectrum utilization

5G AAU New Generation
- 320W power output
- 192 antenna elements
- Lower weight and volume
- Higher energy efficiency

A+P for full-bands
- Innovative interleaved solution for lower CAPEX & OPEX

Active Part
- Fully decoupled with passive antenna
- Flexible 200M/400MHz@n78, 32TR/64TR config.
- 320W High output power & green energy saving

Passive part
- Integrated interleaved solution with Transparent antenna for high antenna gain and high reliability
- 12 ports (4L+8H) for 700M-2600MHz full bands
- Independent or integration use for phased construction
Ubiquitous Deployment 4 “U”

Urban Requirements
- Large capacity
- Continuous Coverage
- Vertical Beamforming

Suburb/rural Requirements
- Low capacity
- Wide Coverage
- Priority to meet coverage requirement

Urban Requirements
- 32TR AAU
- 4TR pad RRU
- 64/32TR AAU

Suburb/rural Requirements
- 4TR Pico
- 2TR Pico
- 4TR iMacro
- 4TR Micro

Deep Coverage
Wide Coverage

Uni-site NEO
UBR
Unify
Ubiquitous
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SuperDSS (Tri-RAT Dynamic Spectrum Sharing) facilitates sub3G smooth evolution.

- User loyalty enhancement
  - Avoiding user churn during 2G/3G sunset
  - Both static and dynamic SuperDSS can be supported

- User experience improvement
  - 2G/3G voice service experience guarantee
  - 4G/5G user throughput improved

- Lean networking O&M
  - 5G evolution oriented networking design, one time deployment is the final network status
  - Improving network potential

- Smooth Evolution
  - When UMTS shutdown, SuperDSS can flexibly evolve to DSS or NR without extra configuration

U/L/NR coordinated scheduling enables triple RAT dynamic spectrum sharing.

UMTS BW changes on demand 4.6M~9M

3G+4G/5G DSS

3G/4G/5G SuperDSS
FAST – the 5G coverage and capacity booster

FAST: Fusion Assisting Super TDD

FAST leverages 3GPP-standard carrier aggregation to enhance 5G coverage & capacity

Abundant CA capabilities
- 700M + 3.7G
- 700M + 2.6G
- 2.1G + 3.5G
- 2.1G + 3.7G
- 700M + 2.1G + 3.7G
- ...

Capacity (both UL & DL)
DL & UL benefited from traditional CA. UL also benefited from TDM CA.

Coverage
Mid-low band coordination to extend UL coverage.

Latency
With flexible coordination, uplink freq-time resources is increased to reduce latency.

Inter-cell CA & inter-site CA supported

ZTE

FAST can benefit from both Rel-15 and Rel-16 with increased number of features

19Q2 20Q2 21Q2

UL CA included in Rel-15 late drop
UL CA strengthened in Rel-16 with Uplink Tx Switching for CA
UE available & FAST commercial use

UL TDM CA (Rel-16)
Simplest beam design achieves stable H and flexible V collaborative coverage

SSB 1+X simplifies 5G network planning & improves performance
- Reduce 5G planning complexity by leveraging 4G planning data
- No change of beam planning required when migrate from NSA to SA
- Both coverage and capacity for high-rise buildings can be enhanced
- Decoupling horizontal and vertical beams
- Simplest beam design, for both H&V coverage
- Intelligent network planning tool for 1+X efficient deployment

### Enhanced Horizontal Wide Beam

**Intelligent Planning SSB Staggering in Time Domains**

<table>
<thead>
<tr>
<th>Serving cell</th>
<th>Neighbor cell 1</th>
<th>Neighbor cell 2</th>
<th>Neighbor cell 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>+6dB</td>
<td>+6dB</td>
<td>+6dB</td>
<td>+6dB</td>
</tr>
</tbody>
</table>

SSB staggering in time domain and service puncturing to control interference.

### Flexible Vertical Beams

**Intelligent planning of X beam weight**

<table>
<thead>
<tr>
<th>Building floor</th>
<th>&lt;8 F</th>
<th>8-16F</th>
<th>16-24F</th>
<th>24-32F, &gt;32F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vertical beams</td>
<td>X=0</td>
<td>X=1</td>
<td>X=2</td>
<td>X=3</td>
</tr>
</tbody>
</table>

Similar horizontal coverage between 1+X and horizontal multi-beams.
Flexible deep coverage solutions fit for diversified scenarios

- **Business street**
  - Crowd people in hotspot areas
  - Difficult site acquisition for macro BTS

- **Scenic spot**

- **Shopping mall**
  - High value area and indoor high traffic requirement

- **Transportation hub**
  - High capacity and superior experience with indoor digitalization

- **High Buildings**
  - Poor coverage in high floors
  - EMF concerns

- **Residential area**

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**Accurate Scenario Analysis & Matching**

- **Outdoor hotspots**
  - Pad RRU
  - iMacro

- **Deep indoor**
  - QCell

- **Outside-in**
  - AAPC, 1+X SSB
  - Fast and flexible indoor coverage with low cost

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PowerPilot - Greener network for a more sustainable digital future

**Basic functions** facilitates energy saving
- Channel shutdown
- Carrier shutdown
- Symbol shutdown
- High efficiency PA
- Leading algorithm
- New material

**AI empowers** precise energy saving
- Threshold self-optimization
- Period self-adjustment
- Cell-based strategy delivery
- Traffic load prediction
- Machine learning based traffic prediction
- KPI based roll-back self-optimization
- 5-6 pp energy saving efficiency improvement
- One-click import, 90% man-power reduction

**Service pilot** drives further energy saving
- Suitable User Selection
- Consequent User Direction
- Network/band Selection
- Suitable User Selection
- Traffic load prediction
- KPI baseline online iteration
- Period self-adjustment
- Traffic-aware spectrum utilization and energy efficiency identification
- Service-aware based user redistribution
- Up to **twice as much** energy saving as previous solutions

**30+ networks, 900,000+ sites**

**AIS @ Thailand**
- 25% energy reduction for TDD LTE/NR dual-mode

**DIGI @ Malaysia**
- over 70,000 4G cells
- intelligent energy saving

**Airtel @ India**
- twice energy saving
- comparing to traditional solution
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Global 5G Private Network Development

The German telecoms regulator, BNetzA, reserved 100MHz of spectrum in the 3700MHz-3800MHz band to private companies. According to the regulator, 33 companies have bought 5G private licenses so far including Bosch, BMW, BASF, Lufthansa, Siemens and Volkswagen.

In France, frequencies in the 2600 TDD MHz band (band #38, 2570-2620 MHz) have been offered to metropolitan businesses by the regulator ARCEP. The airport operator, ADP Group and its subsidiary Hub One, Air France, The major French electricity company EDF, The mobility company TransDev have been granted some bandwidth for years.

In the Netherlands, spectrum at 3400-3450 MHz and 3750-3800 MHz is intended to be made available for local use. Nevertheless, the 3500 MHz auction is planned for 2022 as the band is currently used for satellite communications.

Sweden’s 5G auction of the 2.3 and 3.5 GHz bands will reserve 80MHz of frequencies between 3720MHz and 3800MHz for local and regional licenses.

In the UK, OFCOM will dedicate the 3.8-4.2 GHz band for local deployments, requiring national operators to hand over unused licensed spectrum to enterprises. The lower 26 GHz band will be reserved for private and shared access as well.

Other countries outside Europe including the US, Japan, Australia and China are also moving forward with their plans to identify and allocate spectrum for localized.

> The dedicated 5G spectrum for private network is the most important accelerator for the private network development.
Spectrum for 5G Private Network

- Industrial 5G. For the industry of tomorrow > siemens.com/industrial-5g

- 5G Private Network Main Spectrum: 1) N78/3.5GHz; 2) mmWave/26G/28G; 3) 2.6GHz (France); 4) 4.9GHz (Jap)
Three Modes of 5G Private Network:

- **Outsourced private network** — the manufacturer requests a proposal for a managed private network based on its connectivity requirements. The service provider is responsible for the network build and is subject to exacting service levels. It might also help develop digital services or platforms to fully realize the benefits of private 5G network capabilities.

- **Semi-private network via network slicing** — a mobile network operator uses network slicing to create a semi-private 5G network for the manufacturer. There’s flexibility in tuning the technical capabilities of the product to meet connectivity needs.

- **Self-managed private network** — the manufacturer keeps complete control of the network build and digital capabilities. They can tune the network specifications and performance to exact requirements.

Features of 5G Private Network depend on: 1) **Capex/Opex**; 2) **Network Control** and 3) **Architecture Complexity**

Selection of Modes: 1) Is there dedicated spectrum? 2) Have the Capability for network design and operation? 3) Have the ability to translate application demands into technical specifications.
5G Private Network is Ready for Vertical Industry

- **5G Dedicated Spectrum for Private Network**
- **3GPP Release 16 for Industry**
- **Large Investment Expectation**
- **Multiple participator in Eco-system**

**Industry 5G!**

5G Private/Campus Network is Warming up for Entering the Fast Lane.
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ZTE – a Leading 5G Supplier

500+ Industrial Partners

90+ Operators Collaboration

Rollout in 350+ Cities in China & 60+ Cities Overseas
The Major Contributor in 5G Standardization

- **2500+** 3GPP 5G SEP
- **5000+** 5G Patents
- **7000+** 5G Proposals
- **200+** 5G Standard Experts
- **Leader** of Multiple WI in 3GPP
- **2** 3GPP WG Vice Chairman (1 new in Aug 2019)

**5G Technology Innovation in All Aspects**

- LDPC
- Mini Slot
- Massive MIMO
- Beam Management
- Channel Modeling @mmWave
- FB-OFDM
- Unified Frame Structure
- Network Slicing
Modernization

• Unit-site, simplified site solution
• Flexible spectrum utilization
• Highly efficient O&M

New Business

• Flexible architecture
• New vertical application
• New business

Leading 5G Technologies with Innovations

Standard Contributor

• 3GPP 5G SEP TOP3
• Leading Work Items of key technologies in 3GPP

Key Chipset

• In-house designed high-performance 5G chips
• Reduce power consumption of key products

Massive MIMO

• High performance M-MIMO towards commercial scenarios definition
• Varies of enhanced features for M-MIMO with over 5 years experience
Thank you