Global update on spectrum for 4G & 5G

September 2020

@qualcomm_tech
Spectrum is critical for 5G success
Using all spectrum types and bands

**Licensed spectrum**
Exclusive use
Over 40 bands globally for LTE, remains the industry's top priority

**Shared spectrum**
New shared spectrum paradigms
Ex: 3.5 GHz USA, 3.7 GHz Germany

**Unlicensed spectrum**
Shared use
Ex: 5 GHz / 6 GHz / 60 GHz global

---

High bands above 24GHz (mmWave)
Mid bands 1GHz to 7GHz
Low bands below 1GHz
### Significant RF complexity with 5G

10,000+ early 5G band combinations

<table>
<thead>
<tr>
<th>Region</th>
<th>LTE bands</th>
<th>5G NR bands:</th>
<th>5G NR UL-MIMO:</th>
<th>LTE UL CA:</th>
<th>EN-DCA:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>71.29, 12.13, 14.5, 26.2, 25.4, 66.7, 30.41, 46.48</td>
<td>n71, n66, n2, n41, n5, n12, n25, n48, n78, n258, n260, 261</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+4/66, 25+41, 4+7, 7+30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+66+30, 2+4+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8+20, 20+28A, 1+3, 3+7, 7+3, 7+3+38, 3+32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+3+7, 1+3+7+3, 7+3+38, 3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+3+7+38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA: 8+20+n28A, 1+3+7+n75+n78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28A, 20, 8, 32, 1, 3, 7, 38, 46</td>
<td>n78, n28A, n8, n20, n38, n1, n3, n7, n75/76, n257, n258</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+4/66, 25+41, 4+7, 7+30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+66+30, 2+4+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8+20, 20+28A, 1+3, 3+7, 7+3, 7+3+38, 3+32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+3+7, 1+3+7+3, 7+3+38, 3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+3+7+38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA: 8+20+n28A, 1+3+7+n75+n78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Middle East / Africa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20, 8, 1, 3, 7, 38, 40, 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: no confirmed plans available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 1+3, 3+7+3, 7+3+38, 3+32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: 1+3, 3+7+7, 1+3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 7, 38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Latin America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28, 12.5, 26.8, 1, 2, 3, 4, 6, 7, 38, 41, 42, 46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: no confirmed plans available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 1+3, 3+7+7, 1+3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: 1+3, 3+7+7, 1+3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 4, 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>China (incl. Taiwan and Hong Kong)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5, 8, 1, 3, 7, 34, 39, 40, 41, 4, 12, 20, 38 roaming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: 41+1, 79, 1, 3, 78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 39+41, 3+41, 1+3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: w1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 7, 39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR UL-MIMO in SA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>India</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5, 8, 1, 3, 40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: no confirmed plans available</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 3+40, 1+3, 1+3+41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: 1+3+41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 40, 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28, 26, 8, 11, 19, 21, 1, 3, 41, 42, 46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: n77, n78, n79, n1, n3, n257</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 18+28A, 1+3, 1+21, 3+41+42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: 1+3+41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 40, 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR UL-MIMO in NSA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>South East Asia / Oceania</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28, 20, 5, 8, 1, 3, 7, 38, 40, 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5G NR bands: n78, n20, n40, n257, n258</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 2CA: 1+3, 3+7, 3+40, 3+41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 3CA: 1+3, 3+7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LTE 4x4 MIMO bands:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 3, 7, 38, 40, 41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN-DCA:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**South Korea**

- **LTE bands:** 5, 8, 1, 3, 7, 40, 46
- **5G NR bands:** n78, n257
- **LTE 2CA:** 1+3, 3+7, 1+3+40
- **LTE 3CA:** 1+3+7, 40
- **LTE 4x4 MIMO bands:** 1, 3, 7, 40
- **LTE UL CA:** EN-DCA: 3+7+n78

**India**

- **LTE bands:** 28, 12, 5, 26.8, 1, 2, 3, 4, 6, 7, 38, 41, 42, 46
- **5G NR bands:** no confirmed plans available
- **LTE 2CA:** 1+3, 3+7+7, 1+3+7
- **LTE 3CA:** 1+3, 3+7+7, 1+3+7
- **LTE 4x4 MIMO bands:** 1, 3, 4, 7
- **EN-DCA:**
Global Spectrum Status
## Global snapshot of allocated/targeted 5G spectrum

5G is being designed for diverse spectrum types/bands

<table>
<thead>
<tr>
<th>Region</th>
<th>&lt;1GHz</th>
<th>3GHz</th>
<th>4GHz</th>
<th>5GHz</th>
<th>24-30GHz</th>
<th>37-50GHz</th>
<th>64-71GHz</th>
<th>&gt;95GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>600MHz (2x35MHz) (2x3MHz) (B41/n41)</td>
<td>2.5/2.6GHz</td>
<td>3.1-3.45GHz</td>
<td>3.45-3.55GHz</td>
<td>3.7-4.9GHz</td>
<td>4.94GHz</td>
<td>5.9-7.1GHz</td>
<td>24.25-24.5GHz</td>
<td>24.75-25.25GHz</td>
</tr>
<tr>
<td>600MHz (2x35MHz)</td>
<td>3.475-3.65GHz</td>
<td>3.65-4.0GHz</td>
<td>26.5-27.5GHz</td>
<td>27.5-28.35GHz</td>
<td>37.37-37.6GHz</td>
<td>37.6-40GHz</td>
<td>57-64GHz</td>
<td>64-71GHz</td>
</tr>
<tr>
<td>700MHz (2x30 MHz)</td>
<td>3.4-3.8GHz</td>
<td>5.9-6.4GHz</td>
<td>24.5-27.5GHz</td>
<td>26GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz (2x30 MHz)</td>
<td>3.4-3.8GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz (2x30 MHz)</td>
<td>3.46-3.8GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz (2x30 MHz)</td>
<td>3.6-3.8GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz (2x30 MHz)</td>
<td>2.5/2.6GHz (B41/n41)</td>
<td>3.3-3.6GHz</td>
<td>4.8-5GHz</td>
<td>24.75-27.5GHz</td>
<td>40-43.5GHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700/800MHz</td>
<td>2.3-2.39GHz</td>
<td>3.4-3.42GHz</td>
<td>3.42-3.7GHz</td>
<td>4.0GHz</td>
<td>5.9-7.1GHz</td>
<td>25.7-26.5GHz</td>
<td>28.9GHz</td>
<td>28.9-29.5GHz</td>
</tr>
<tr>
<td>700MHz</td>
<td>3.6-4.1GHz</td>
<td>4.5-4.9GHz</td>
<td>26.6-27GHz</td>
<td>27-29.5GHz</td>
<td>39-43.5GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz</td>
<td>3.3-3.6GHz</td>
<td>24.25-27.5GHz</td>
<td>27.5-29.5GHz</td>
<td>37-43.5GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700MHz</td>
<td>3.4-3.7GHz</td>
<td>24.25-27.5GHz</td>
<td>39GHz</td>
<td>57-66GHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unlicensed Spectrum Bands in 3GPP

Standardized in 5G NR Release 16 – First global cellular standard with both license-assisted and standalone use of unlicensed spectrum

NR-U

<1 GHz
Low-bands (sub-1)

1-7 GHz
Mid-bands (sub-7)

24+ GHz
High-bands (mmWave)

Available now
Under study / review
The FCC is driving key spectrum initiatives to enable 5G
Across low-band, mid-band, and high-band including mmWave

**Low-band**
Broadcast incentive auction completed in March 2017

- Successfully auctioned a portion of the 600 MHz band that generated $19.8B in proceeds after assignment phase
- Includes 70 MHz (2 x 35 MHz) of licensed spectrum and 14 MHz for unlicensed use
- FCC allocated 2 x 3 MHz in 900 MHz for broadband, principally for utilities
- Spectrum availability timing aligns with 5G

**Mid-band**
CBRS¹, 3.4-3.5 GHz, 3.7-3.98 GHz, 4.94-4.99 GHz

- Opened 150 MHz in 3.5 GHz band with 3-tier sharing with incumbents, PAL², GAA³
- In Sep 2019, FCC approved initial GAA deployments and in Sep. 2020, FCC completed PAL auction
- In Mar 2020, FCC allocated 3.7-4.0 GHz. Auction scheduled for Dec. 2020
- NTIA and FCC are studying repurposing of 3.1-3.45 GHz for commercial use

**High-band**
FCC has completed 3 mmWave auctions, including most recently the largest auction in history

- In 2016, FCC allocated 10.85 GHz in multiple mmWave bands⁴, 70% of newly opened spectrum is shared or unlicensed
- In Nov 2017, FCC adopted second order allocating 24.25-24.45, 24.75-25.25 GHz, and 47.2-48.2 GHz
- In Jun 2018, FCC proposed making 25.25-27.5 and 42-42.5 GHz for flexible wireless use
- FCC has held auctions in 28 & 24 GHz bands
- In Mar 2020, FCC has completed the auction for upper 37, 39, & 47 GHz bands
- FCC is considering rules for 70/80/90 GHz, and FCC has opened spectrum above 95 GHz

---

1 Citizen Broadband Radio Services; 2 Priority Access Licenses to be auctioned; 3 General Authorized Access; 4 FCC ruling FCC 16-89 on 7/14/2016 allocated 3.25 GHz of licensed spectrum and 7.6 GHz of shared/unlicensed spectrum.
Low-band: 600 MHz LTE initially deployed in areas already clear of TV stations – now will be used for 5G

Meeting 5G timeline
Completed auction in March 2017; process of clearing the spectrum & repacking TV stations to end in 39 months. Process is on track.

Greater capacity and wider coverage
Low-band spectrum is optimized for long-range macro deployments - optimal for connecting the wide-area IoT and more

Broad industry support
Qualcomm Technologies Inc. is working closely with operators & OEMs to enable early launches, incorporating our industry-leading modem, transceiver, and RFFE
Mid-band: CBRS introduces a 3-tiered shared spectrum

FCC optimized rules in Oct 2018, allowed initial GAA deployments in Sept 2019, and PAL auction completed in August 2020

- **Tier 1**
  - **Incumbents**
    - Navy radar
    - FSS RX²
    - WISP³

- **Tier 2**
  - **Priority Access Licenses (PAL)**

- **Tier 3**
  - **General Authorized Access (GAA)**

- Incumbents are protected from interference from PAL and GAA
- PAL has priority over GAA, licensed via auction, 10 MHz blocks, up to 7 licenses
- GAA can use any spectrum not used, yields to PAL and incumbents

---

1 Wireless ISP transitioning from incumbent to PAL/GAA after 5 years; 2 Fixed satellite service - receiving only; 3) Citizen Broadband Radio Service (CBRS)
6 GHz brings new unlicensed bandwidth for Wi-Fi and 5G

Standardized for 5G NR-U in the United States

2.4 GHz
580 MHz of unlicensed bandwidth

5 GHz

AFC = Automated frequency control, DFS = Dynamic Frequency Selection, LPI = Low power indoor

2.4 GHz
83.5 MHz

5 GHz
DFS = 100 MHz
DFS = 255 MHz
DFS = 125 MHz

6 GHz
1200 MHz of unlicensed bandwidth

AFC Standard power
LPI = 500 MHz
LPI = 100 MHz
LPI = 350 MHz
LPI = 250 MHz

Outdoor + Indoor
Outdoor + Indoor
Indoor
Outdoor + Indoor
Indoor

UNII-1
UNII-2A
UNII-2C
UNII-3
UNII-5
UNII-6
UNII-7
UNII-8

1200 MHz
A massive amount of new unlicensed spectrum is now available in the U.S. for Wi-Fi 6E and 5G
High-band: FCC rapidly bringing mmWave spectrum to market

**FCC opened total of 10.85 GHz as part of the Spectrum Frontiers Ruling**
- Licensed: 27.5-28.35 GHz (2x425 MHz); 37.6-38.6 GHz (5x200 MHz); 38.6-40 GHz (7x200 MHz)
- Shared/unlicensed: 37-37.6 GHz (3x200 MHz); 64-71 GHz that expands the existing 60 GHz band

**FCC announced first wave of mmWave auctions**
- November 2018: 24 GHz and 28 GHz
- 2H2019: 37 GHz, 39 GHz, and 47 GHz

**FCC proposed making mmWave spectrum for flexible deployment**
- 25.25-27.5 GHz and 42-42.5 GHz

**FCC adopted second order allocating additional mmWave spectrum**
- 24.25-24.45 GHz, 24.75-25.25 GHz, and 47.2-48.2 GHz

**FCC announced procedures for the largest mmWave auction**
- Auction started on Dec. 10th, 2019
- Included 37.6-38.6 GHz and 47.2-48.2 GHz across the US and some licenses for 38.6-40 GHz

**FCC completed the largest mmWave auction**
- Successfully completed actions of 37 GHz, 39 GHz, and 47 GHz
European Commission driving a Gigabit Society

Deploying 5G across Europe by 2020 with pre-commercial trials starting in 2018

- Early trials in 2017, pre-commercial trials from 2018
- Full commercial 5G services (one major city per country) in 2020
- All urban areas and major terrestrial transport paths with 5G coverage by 2025

Pioneer spectrum bands for 5G (low: 700 MHz, mid: 3.4-3.8 GHz, high: 24.25-27.5 GHz)
- EC Mandate to CEPT focusing on 3.5 GHz and 26 GHz pioneering bands – completed in 2018
- Additional EC Mandate to CEPT on extended L band (1427 - 1518 MHz) – completed in 2018
- CEPT harmonization of the 26 GHz band ahead of WRC-19 – completed in June 2018
- EC working on binding decision for EU Member States – completed in Q1 2019
- 5G commercial services to use both 3.4-3.8 GHz and 26 GHz in Europe – targeting 2020

Full set of 5G spectrum bands and implementation measures
- EC mandate to CEPT on the development of harmonized technical conditions suitable for 5G in the 900 MHz, 1.8 GHz, 2.6 GHz, and the paired terrestrial 2 GHz frequency bands – completed in 1H 2019
- RSPG\(^2\) working on how to defragment 3.4-3.8 GHz band and on the impact of the future use of 5G in areas other than MBB\(^3\)

---

5G spectrum status dashboard in Europe
Commercial targets focusing on 3.4-3.8 GHz and/or 26 GHz
5G spectrum auctions in Europe – 3.4 to 3.8 GHz band

Awarded or ongoing auction
- Spectrum awarded in 14 European countries: Austria, Belgium, Czech Republic, Finland, Italy, Norway, Slovakia, Switzerland, Ireland, Spain, Germany, Hungary, Latvia, and UK
- Auction in Poland to re-start in Q4’20, Portugal in Q4’20, France in Q4’20

Expected to be awarded in 2020
- Additional 11 countries expected to award spectrum in 2020: Bulgaria, Croatia, Denmark, Greece, Lithuania, Luxembourg, Poland, Romania, Serbia, Slovenia, Sweden, Ukraine

Expected to be awarded after 2020

Auctions impacted by COVID-19 - restart in Q4 2020

Second round of auctions impacted by COVID-19
- UK delayed minimum 6 months – MNO legal challenge
5G spectrum auctions in Europe – 26 GHz band

- **Auctioned or to be awarded on market demand**
  - Italy, Finland and Russia have awarded 26 GHz
  - UK has made available based on market demand and indoor only, 24.5 - 26.5 GHz - The whole 26 GHz band expected in 2021

- **Expected to be awarded in 2020**
  - Germany, Greece, and Denmark are expected to award the band in 2020

- **Under public consultation to get market demand**
  - The Netherlands, Estonia, Slovenia, Croatia, Czech republic
  - consulting on proposals to make available the band in 2021

- **Trials – 3 years license**
5G spectrum status in China, South Korea, and Japan

China

• MIIT officially allocated 700MHz (703-733/758-788MHz), 3.3-3.6 GHz & 4.8-5.0 GHz as 5G bands; in addition, 2.6 GHz (Band n41) has been allowed for both 4G & 5G deployments
• Chinese government approved 5G technology R&D trial frequencies usage in 24.75-27.5 GHz & 37-42.5 GHz mmWave ranges in Jul’17
• Chinese government supported global IMT identification in 5925-7125MHz, 24.75-27.5GHz, 40.5-43.5GHz and 66-71GHz frequency ranges in WRC19

South Korea

• MSIT has successfully completed 5G spectrum auction in June 2018 for both sub-7 and mmWave, including 3.42-3.7 GHz and 26.5-28.9 GHz
• The world first commercial 5G smartphone for sub-7 was launched in Apr’19. mmWave was commercially launched for smart factory in Jul’20
• Achieved over 7.9 million 5G subscribers as of Jul’20
• MSIT plans to allocate additional 5G spectrum in 2022-2023

Japan

• In Apr’19, MIC assigned new 5G spectrum, 3.6-4.2 GHz, 4.4-4.9 GHz and 27-29.5 GHz, to four operators
• All existing 4G spectrum bands, 700 MHz, 850 MHz, 900 MHz, 1.5 GHz, 1.8 GHz, 2.1 GHz (FDD), 2.5 GHz and 3.5 GHz (TDD) are available for 5G NR deployment
• Technical rules for private network bands in 2575-2595 GHz (NSA anchor) and 28.2-28.3 GHz have also been regulated. Additional private network bands in 1.9 GHz (NSA anchor), 4.6-4.9 GHz and 28.3-29.1 GHz will be regulated in Q4’20
• Technical rules for additional licensed spectrum (4.9-5 GHz, 26.6-27 GHz, 39.5-43.5 GHz) will be studied by 2021
• As per WRC-19 outcome, 7025-7125 MHz study will also be conducted
5G spectrum status in Oceania, South East Asia, and India

Australia
- 3.4-3.7 GHz allocated and 5G has been commercially deployed
- 3.7 - 4.2 GHz under consultation for 5G, FS, FSS deployment
- 26 GHz: spectrum allocation for 5G scheduled for March 2021
- 26/28 GHz: apparatus licenses for local 5G + FWA to start 1Q21

New Zealand
- 3.5 GHz: 3400-3590 MHz and 3590 - 3800 MHz access until 2022, longer term access to be provided prior to 2022
- mmWave 26/28 GHz under consideration

Hong Kong
- 3.3, 3.5, 4.8 GHz: 5G Spectrum allocated
- 26/28 GHz: 3 operators awarded 400 MHz each, with 400 MHz reserved for local licensing
- 5G commercially deployed from April 2020
- Additional 4.9 GHz spectrum under consideration

Taiwan
- 3.3, 3.5 GHz: 5G spectrum allocated
- 27.9 - 29.5 GHz: 5G spectrum allocated (27.0 - 27.9 GHz held for future allocation)
- 5G commercially deployed from July 2020
- 4.9 GHz spectrum planned for localized networks

Singapore
- 3.5 GHz: 5G spectrum allocated for 2 networks
- 800 MHz of mmWave allocated to 4 operators
- 5G deployed

Malaysia
- Government plan to allocate 3.5 GHz and 26/28 GHz spectrum in 3Q20 deferred to 1H21
- Operators have conducted 5G trials

Thailand
- 2.5 GHz TDD spectrum allocated for 2 networks
- 26 GHz spectrum allocated to 4 operators
- 28 GHz spectrum being considered
- 5G commercially deployed

Indonesia
- All operators conducted 5G trials in 28 GHz
- Government plans to conduct trial in 3.5 GHz
- Government announced that it will consult on 5G policy and sub 6 GHz, 26 GHz and finalize policy in 2020.

Philippines
- 3.5 GHz band assigned
- 5G deployed commercially in Manila
- mmWave spectrum under consideration by Government

Vietnam
- Government has announced timeframe for planned commercialization in 2020
- 3.8 GHz and 4.8 GHz bands are under consultation
- 26/28 GHz in ongoing consultation process
- 5G trials underway by all 3 mobile network operators

India
- High Level Forum submitted 5G recommendation in Aug’18
- 617-698 MHz in planning; 698-803 MHz auction in Q4’20
- 3.3-3.6 GHz and 24.25-27.5 GHz auction expected in Q3’21
- 24.25-27.5 GHz, 27.5-29.5 GHz preferred mmWave bands – two years free for trials; also looking at 37-43.5 GHz
Brazil has auction of C-band & 26 GHz planned for March 2020.

Peru has C-Band auction planned for 2020.

Uruguay has very small fixed wireless deployment.

Colombia and Chile have consultations underway.

Studies under way for both C-Band & mmWave spectrum in key countries.
<table>
<thead>
<tr>
<th>Country</th>
<th>Spectrum Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>• 3.5 GHz CBRS, exclusive &amp; shared licenses, deployments in 2H19</td>
</tr>
<tr>
<td></td>
<td>• 37 - 37.6 GHz shared spectrum/local licenses, under evaluation</td>
</tr>
<tr>
<td>Germany</td>
<td>• 3.7 - 3.8 GHz</td>
</tr>
<tr>
<td></td>
<td>• 24.25 - 27.5 GHz, local licenses, expected Q4 2020</td>
</tr>
<tr>
<td></td>
<td>• Local licenses. Assignment complete; available 2H 2019</td>
</tr>
<tr>
<td>U.K.</td>
<td>• 3.8 - 4.2 GHz</td>
</tr>
<tr>
<td></td>
<td>• 24.25 - 26.5 GHz, local licenses, applications open since end of 2019</td>
</tr>
<tr>
<td></td>
<td>• Local licenses (50 meters square); regulator database; decision formalized; applications invited from end 2019</td>
</tr>
<tr>
<td>Sweden</td>
<td>• 3.72 - 3.8 GHz, in consultations</td>
</tr>
<tr>
<td>Finland</td>
<td>• Sub-licensing of 3.4 - 3.8 GHz</td>
</tr>
<tr>
<td></td>
<td>• Local permission via operator lease; assignment complete</td>
</tr>
<tr>
<td>Netherlands</td>
<td>• 3.5 GHz for local industrial use; 3.7 - 3.8 GHz (in consultations); 2.3 - 2.4 GHz (licensed shared access online booking system)</td>
</tr>
<tr>
<td></td>
<td>• 3.5 GHz for local industrial use; however users may need to move to 3.7 - 3.8 GHz, if allocated; 2.3 GHz approved for PMSE</td>
</tr>
<tr>
<td>France</td>
<td>• 2.6 GHz, regulator database &amp; approval. Up to 40 MHz approved for Professional Mobile Radio</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>• 3.4 - 3.44 GHz for private networks</td>
</tr>
<tr>
<td>Brazil</td>
<td>• 3.7 - 3.8 GHz, under consideration</td>
</tr>
<tr>
<td></td>
<td>• 27.5 - 27.9 GHz, allocation completed</td>
</tr>
<tr>
<td>Chile</td>
<td>• 3.75 - 3.8 GHz, allocation completed at end of 2019</td>
</tr>
<tr>
<td>Australia</td>
<td>• 24.25 - 27.5 GHz and 27.5 - 29.5 GHz for local licensing in 1Q21</td>
</tr>
<tr>
<td></td>
<td>• 3.7 - 4.2 GHz under consultation for local licensing</td>
</tr>
<tr>
<td>New Zealand</td>
<td>• Licenses in 2575 - 2620 MHz may be assigned for localized use</td>
</tr>
<tr>
<td>Malaysia</td>
<td>• 26.5 - 28.1 GHz will be assigned for the deployment of local/private networks</td>
</tr>
<tr>
<td>Singapore</td>
<td>• Each operator has acquired 800 MHz of 26/28 GHz spectrum to deploy local networks</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>• 24.25 - 28.35 (400 MHz) available for local licenses</td>
</tr>
<tr>
<td>Japan</td>
<td>• Phase 1: 2,575 - 2,595 MHz (NSA anchor) and 28.2 - 28.3 GHz; local licenses, legislated in December 2019</td>
</tr>
<tr>
<td></td>
<td>• Phase 2: 1888.5 - 1916.6 MHz (NSA anchor), 4.6 - 4.9 GHz (4.6 - 4.8 GHz indoor only, 4.8 - 4.9 GHz outdoor possible) &amp; 28.3 - 29.1 GHz (150 MHz outdoor use; total 250 MHz range 28.2 - 28.45 MHz); local license. Legislation in 4Q20. Uplink heavy TDD config. using semi-sync is allowed in sub-6 &amp; 28 GHz</td>
</tr>
</tbody>
</table>
Global 4G LTE spectrum landscape
Over 1,000 band combinations now supported for LTE

- **U.S. / Canada**
  - 600/700/850 MHz (FDD)
  - 1700/1900 MHz (FDD)
  - 2300/2600 MHz (FDD/TDD)
  - 2500 MHz (TDD)

- **Europe**
  - 450/800/900 MHz (FDD)
  - 1800/2100 MHz (FDD)
  - 2600 MHz (FDD/TDD)

- **Latin America**
  - 700 MHz (FDD)
  - 1700/1800/1900 MHz (FDD)
  - 2600 MHz (FDD/TDD)

- **MENA**
  - 800/1800 MHz (FDD)
  - 2300 MHz (TDD)
  - 2600 MHz (FDD/TDD)

- **India**
  - 850/1800 MHz (FDD)
  - 2300 MHz (TDD)

- **South Korea**
  - 850/900 MHz (FDD)
  - 1800/2100/2600 MHz (FDD)

- **Japan**
  - 700/850/900 MHz (FDD)
  - 1500/1800/2100 MHz (FDD)
  - 2500/3500 MHz (TDD)

- **SE Asia**
  - 700/850/900 MHz (FDD)
  - 1800/2100/2600 MHz (FDD)
  - 2300 MHz (TDD)

- **Australia**
  - 700/850/900 MHz (FDD)
  - 1800/2100/2600 MHz (FDD)
  - 2300 MHz (TDD)
Thank you!

Follow us on: f  
For more information, visit us at: 
www.qualcomm.com & www.qualcomm.com/blog