5G Evolution: European spectrum roadmap

April '22
Content

- Key opportunities and challenges
- The previous decade: Europe great spectrum policy leadership
- This decade: great opportunity to keep the European leadership
- 5G spectrum policy approaches globally
- Key issue for the new European spectrum roadmap
- Key takeaways
Key opportunity:
From IMT-2020 (5G) to IMT-2030 (6G):
Internet of everything to intelligent connection of everything

IMT-2020: 5G
100 Mbit/s any time, anywhere

5G-Advanced
Ongoing evolution

IMT-2030: 6G
Connected Intelligence

Spectrum: WRC-15, WRC-19

Spectrum: WRC-23

Spectrum: WRC-27
Key challenge: sustainability of investments

Digitization targets vs. European investment challenge

5G investment challenges in Europe

Ambitious political targets
All populated areas covered by 5G till 2030 (EU Commission)

BUT

Declining revenues in Europe vs. rising revenues in US
EU: -14% from 2012
US: +46% to 2018

Resulting in an EU 5G investment gap
€150bn (BCG)

Leading to lower 5G adoption in Europe

EU: 25%
North America: 45%
China, Japan and South Korea: 43%

REGULATION
More investment-friendly regulatory environment in the US – no access and price regulation for mobile in the US

FRAGMENTATION
Less fragmented market; 3 network operators for >300m people in US vs. >100 MNOs for >400m people in the EU
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The previous decade – great spectrum policy leadership

- Has set the framework of regulatory principles and strategic orientations on spectrum management as well as an initial set of spectrum-related actions on spectrum harmonisation and assignment for 4G.
- "Propose an ambitious EU RSPP in 2010 for decision by the EU Parliament and the Council that will create a coordinated and strategic spectrum policy at EU level in order increase the efficiency of radio spectrum management and maximise the benefits for consumers and industry."
- "On the basis of the EU RSPP, coordinate the technical and regulatory conditions applying to spectrum use and, where necessary, harmonise spectrum bands to create economies of scale in equipment markets and allow consumers to use the same equipment and avail themselves of the same services across the EU."
- "Implement the EU Spectrum Policy Programme, so as to ensure the coordinated allocation of the spectrum needed to meet the target of 100% coverage of 30 Mbps Internet by 2020, and the NGA Recommendation."

- "Every effort should be made to identify, based on the inventory established pursuant to Article 9, at least 1200 MHz of suitable spectrum by 2015. That figure includes spectrum already in use."
- "Member States shall make the bands covered by Decisions 2008/411/EC (3.4-3.8 GHz), 2008/477/EC (2.6-2.69 GHz), and 2009/766/EC (800-1100 MHz) available under terms and conditions described in those decisions, Subject to market demand, Member States shall carry out the authorisation process by 31 December 2012..."
- "Member States shall allow the transfer or leasing of rights of use of spectrum in the harmonised bands 790-862 MHz, 860-915 MHz, 925-960 MHz, 1710-1755 MHz, 1805-1880 MHz, 1900-1980 MHz, 2010-2025 MHz, 2110-2170 MHz, 2.6-2.69 GHz, and 3.4-3.8 GHz."
- "Contribute to the objectives of the Digital Agenda for Europe, promoting access to broadband at a speed of not less than 30 Mbps by 2020 for all Union citizens and making it possible for the Union to have the highest possible broadband speed and capacity."
- "WAS / RLAN" may outgrow their current allocations on an unlicensed basis. The need for and feasibility of extending the allocations of unlicensed spectrum for wireless access systems, including radio local area networks, at 2.4 GHz and 5 GHz, should be assessed in relation to the inventory of existing uses of and emerging needs for, spectrum, and depending on the use of spectrum for other purposes.
Spectrum assignments globally

~70 countries will release 5G spectrum by the end of 2022, while 100+ countries still needs to accelerate 5G spectrum allocation.

80-100 MHz @ 2.3, 2.6, 3.5, 4.9 GHz has become the main stream.

- 85% 5G new spectrum assignments at mid-bands
- ~80% 5G networks deployments rely on mid-bands

Mid band is the primary 5G spectrum. Europe has lead the trend.

Unclear plans for future mid-bands assignments in Europe.

*Source: GSA & Huawei
5G Deployment is Accelerating Globally

70+ countries have launched 5G service

- Live commercial 5G Networks
- Planned commercial 5G networks

700M+ 5G users
220+ 5G networks
2.2M 5G base stations
960 B$ 5G economy in 2030

Source: GSMA & Huawei

Mature E2E ecosystem supports the rapid development of 5G

1300+ 5G devices

~160 models of smartphones at below $300

5G CPE average price drop to $150

Source: GSA & Huawei

2020 2021 2022 2023

$350 $220 $150 $100

Source: GSMA & Huawei
Commercial Interest
ToH: 5G FWA boosts home broadband connections for unconnected households

Huge fixed BB connection gap remains in developing countries

HBB penetration rate in each region

- Northern America: 91%
- West Europe: 89%
- CEE & Nordic Europe: 82%
- Middle East: 55%
- Latin America: 47%
- Asia Pacifica: 35%
- Northern Africa: 18%
- Southern Africa: 1%

~800M homes unconnected

40%+ 5G operators have launched FWA services

- 83 5G FWA networks
- 3M+ 5G FWA users
- 3x~5x FWA ARPU @ Zain

SA Rain: Connected 200K homes rapidly with 5G FWA in 2 years

5G home package

- 25Mbps
- 50Mbps
- 100Mbps

HBB market share

- 5G FWA: 30%
Commercial interests
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6 GHz to support the EU policy objectives

**European Digital Compass cardinal point:**

“2) Secure, performant and sustainable digital infrastructures. By 2030, all EU households should have gigabit connectivity and all populated areas should be covered by 5G; the production of cutting-edge and sustainable semiconductors in Europe should be 20% of world production; 10,000 climate neutral highly secure edge nodes should be deployed in the EU; and Europe should have its first quantum computer; ...”

The important efforts in R&D should be supported with the development of an ambitious and forward looking European spectrum roadmap for the evolution of 5G.

The European partnership on **Smart Networks and Services (SNS)**

Joint Undertaking co-led by industry and the Commission with close involvement of Member States, sets the strategic **R&I roadmap for Europe**. The initiative builds on an EU contribution of €900 million over the next 7 years to be matched by the private sector with the same amount. The aim is to enable European players to build the R&I capacities for 6G systems and develop lead markets for 5G infrastructure as a basis for the digital and green transformation.
This decade – great opportunity to keep leadership

Best practices to incentivize investments
• Promote adequate reserve prices
• Enable payment of award fees in instalments

Reduce the cost of deploying VHCN and ensuring timely and investment-friendly access to 5G radio spectrum.

EC Rec. (EU) 2020/1307

“Common Union toolbox for connectivity” (Connectivity Special Group) (Sep 20)

RSPG draft Opinion “2030 Digital Compass: the European way for the Digital Decade” (Feb 21)

2030 Policy Programme “Path to the Digital Decade” (Decision of the EU Parliament and Council) (Q3 22)

RSPP (Rel. 16) ?

Connectivity targets:
• All EU households have Gigabit connectivity
• All populated areas are covered by 5G

Very limited reference to spectrum

Next steps:
• Best practices to incentivize investments
• Review national spectrum plans on a regular basis

Promote the infrastructure sharing with financial incentives

• Financial aid as complement to incentivize investments
• Structure of recurrent spectrum fees to incentivize rollout

Combining coverage obligations with financial incentives

• Enable payment of award fees in instalments

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Europe strategy for UHF

- In Europe, DTT consumption is constantly decreasing while MNOs need both DL and UL additional spectrum in lower bands:
  - DL capacity in rural areas to meet demand for delivering AV data & coverage obligations;
  - Enhanced UL connectivity, not least to achieve balanced coverage when using higher bands for DL

- Most promising use cases in low bands are among mMTC and eMBB types of services requiring wide and deep coverage while certain URLLC services could be also efficiently implemented.

- The alternative DTT/IMT co-existence scenario would require severe power and geographical restrictions on IMT, both within countries and along the borders with neighboring countries, and would thus lead to a low spectrum efficiency.
5G relies on mid-band spectrum to realise its full potential

- In 2030, 5G is expected to generate $960 billion in GDP on a global basis;
- Mid-band spectrum will drive an increase of more than $610 billion in global GDP in 2030, producing almost 65% of the overall socio-economic value generated by 5G;
- However, up to 40% of the expected benefits of mid-band 5G could be lost if no additional mid-band spectrum is assigned to mobile services;
- To realise the potential benefits, countries must fulfil mid-band needs in harmonised ranges including 3.5 GHz, 4.8 GHz, and 6 GHz to deliver economies of scale and lower broadband costs.
Need for additional mid-bands spectrum

The GSMA recommends governments and regulators to:

- Plan to make 2 GHz of mid-band spectrum available in the 2025-2030 time frame. This is the average value needed to guarantee the IMT2020 requirements for 5G;
- Carefully consider 5G spectrum demands when 5G usage will be reaching its peak, and advanced use cases will carry additional needs;
- Base spectrum decisions on real-world factors including population density and extent of fibre rollout, and;
- Support harmonised mid-band 5G spectrum (e.g., within the 3.5 GHz, 4.8 GHz and 6 GHz ranges) and facilitate technology upgrades in existing bands.

1) 36 studied cities
2) Population density
3) Available spectrum
4) Inter-site distance
5) 5G technology, massive MIMO upgrades
6) High bands, indoor small cells and Wi-Fi offload
7) End users’ activity factor
Additional mid-band spectrum and network densification

- MNOs’ sustainable business needs to minimize the cost per transmitted bit since revenues are flat / slightly growing.
- While network densification plays an important role, there is clearly an upper limit to it.
- Two main scenarios for MNOs’ networks coverage expansion in medium/long term:

<table>
<thead>
<tr>
<th>A. Add new radios (to existing macro sites) using new mid-band spectrum, in combination with small cells densification</th>
<th>Balance between macro and small cells coverage minimizing cost/transmitted bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Enhance coverage through small cells densification only</td>
<td>Extreme densification</td>
</tr>
<tr>
<td>• Unsustainable radio network deployment costs (x4.1 in Paris, source Coleago)</td>
<td></td>
</tr>
<tr>
<td>• Increases overall power consumption (x2.2 in Paris, source Coleago)</td>
<td></td>
</tr>
<tr>
<td>• May not even be feasible due to interference or site availability.</td>
<td></td>
</tr>
</tbody>
</table>

“Densification in the urban areas in Europe is a myth, small cells are not economically viable. That is the reality, if small cells were viable we would have deployed them by now instead of investing in 3.5 GHz spectrum. We are seeing a significant growth in traffic rate, nearly doubling every year when you count fixed and mobile. That growth can be accelerated by other applications such as AR/VR and metaverse. We think the 3.5 GHz will be congested before the end of the decade.”

Source: Santiago Tenorio, Fellow and Network Architecture Director – Vodafone at the 6 GHz 5G/IMT Spectrum Forum (March ’22)

Spectrum policy is important to minimize the cost/transmitted bit.
For sustainable deployments for 5G and its evolution.
**Commercial Interest**

### Additional Mid-Band Spectrum Need

<table>
<thead>
<tr>
<th>World Bank income group</th>
<th>Mid-Band baseline</th>
<th>DL and UL total (including baseline) mid-band spectrum need, MHz (city average)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50 UL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80 UL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
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<tr>
<td></td>
<td></td>
<td>700</td>
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<tr>
<td></td>
<td></td>
<td>800</td>
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<tr>
<td></td>
<td></td>
<td>900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1200</td>
</tr>
</tbody>
</table>

**Source:** [Coleago](#)

(*) Additional mid-band spectrum need to meet DL speed from "X" axis as well as 50% UL (see table)

**Source:** [Coleago](#)
Commercial Interest
Large contiguous bandwidth in mid-bands mitigates climate change

- Climate change KPI: impact in terms of Kg of CO₂
- Stage 1: equipment manufacturing distribution and installation
  - BSs, application servers and UE
  - Including site construction (new spectrum vs. densification)
- Stage 2: use
  - Minimize power consumption (new spectrum vs. densification)
- Stage 3: end of life
- In order to minimize impacts on climate, spectrum policy should aim at limiting the number of sites and large contiguous channels
- Interesting study by ARCEP in France

### Power consumption dependence on mid-band spectrum availability

<table>
<thead>
<tr>
<th></th>
<th>Paris</th>
<th>Hamburg</th>
<th>Mexico City</th>
<th>Mumbai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference macro site power consumption</td>
<td>6kW</td>
<td>6kW</td>
<td>6kW</td>
<td>6kW</td>
</tr>
<tr>
<td>Reference small cell power consumption</td>
<td>0.5kW</td>
<td>0.5kW</td>
<td>0.5kW</td>
<td>0.5kW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>With additional mid band spectrum</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td># of macro sites</td>
<td>1,752</td>
<td>170</td>
<td>6,236</td>
<td>8,12</td>
</tr>
<tr>
<td># of outdoor small cells (including the baseline)</td>
<td>5,256</td>
<td>510</td>
<td>18,708</td>
<td>20,436</td>
</tr>
<tr>
<td>Consumption reduction due to power saving features</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Uplift in power assumed due to additional spectrum</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Reference power consumption (MW)</td>
<td>12.6</td>
<td>1.2</td>
<td>44.9</td>
<td>49.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Without additional mid band spectrum</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
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</tr>
<tr>
<td># of outdoor small cells (including the baseline)</td>
<td>48,234</td>
<td>2,739</td>
<td>238,967</td>
<td>234,321</td>
</tr>
<tr>
<td>Consumption reduction due to saving features</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Reference power consumption (MW)</td>
<td>27.7</td>
<td>1.9</td>
<td>125.5</td>
<td>126.4</td>
</tr>
</tbody>
</table>

Relative increase in power consumption: 2.2x, 1.6x, 2.8x, 2.6x

**Extreme densification = 2.3x Mid-band**

The extreme radio network densification required to deliver the 5G requirements, in the absence of additional mid-band spectrum would lead to a significant relative increase in terms of the energy consumption and radio network complexity and cost.
Large contiguous bandwidth in mid-bands improves business sustainability.

Contiguous 100 MHz + M-MIMO enable 10 Gbit/s capacity

Contiguous 80-100MHz save Operator cost

Radio network cost dependence on mid-band spectrum availability

<table>
<thead>
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<th>Paris</th>
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<th>Mumbai</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional mid band spectrum assumed (MHz)</td>
<td>1,250</td>
<td>500</td>
<td>900</td>
<td>1,200</td>
</tr>
<tr>
<td># of macro sites</td>
<td>1,752</td>
<td>170</td>
<td>6,236</td>
<td>6,812</td>
</tr>
<tr>
<td># of outdoor small cells (including the baseline)</td>
<td>5,256</td>
<td>18,708</td>
<td>20,436</td>
<td></td>
</tr>
<tr>
<td>Reference radio network capex cost over 10 yrs, (USD m)</td>
<td>140</td>
<td>499</td>
<td>545</td>
<td></td>
</tr>
<tr>
<td>Reference radio network opex cost over 10 yrs, (USD m)</td>
<td>259</td>
<td>920</td>
<td>1,005</td>
<td></td>
</tr>
<tr>
<td>Reference total radio network cost over 10 yrs, (USD m)</td>
<td>399</td>
<td>1,419</td>
<td>1,550</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Without additional mid band spectrum</th>
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<th>Mumbai</th>
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<td>48,234</td>
<td>238,967</td>
<td>234,321</td>
<td></td>
</tr>
<tr>
<td>Reference radio network capex cost over 10 yrs, (USD m)</td>
<td>570</td>
<td>7,685</td>
<td>7,635</td>
<td></td>
</tr>
<tr>
<td>Reference radio network opex cost over 10 yrs, (USD m)</td>
<td>1,051</td>
<td>4,983</td>
<td>4,951</td>
<td></td>
</tr>
<tr>
<td>Reference total radio network cost over 10 yrs, (USD m)</td>
<td>1,621</td>
<td>7,685</td>
<td>7,635</td>
<td></td>
</tr>
</tbody>
</table>

Relative increase in radio network cost: 4.1x 2.6x 5.4 4.9x

Source: Coleago 2021

$ = 4.2x$ Mid-band

Other band
Using additional mid-bands spectrum for FWA would reduce the cost to deliver the EU 100 Mbit/s connectivity target by €42 billion

- The **total investment** required to cover 100% of households in the EU with FTTH is estimated at €123 bn, €53 bn investment needs to be made in **rural areas**.
- With **rural FWA**, an additional **2 GHz** of spectrum, leads to an investment saving of **79%** (from €53 bn to €11 bn).
- **5G IMT** has a capital expenditure avoidance value of €42 bn, for FWA alone, i.e. not counting the capex avoidance value for mobile 5G.
- If only **1 GHz** of additional mid-bands spectrum is made available, the saving is **€40 bn**.
Millimeter Wave 5G will be commercial in a large scale in 2025-2030
Need for balance between mid-bands spectrum for macro cellular (wide area) networks and low/medium power (local area) deployments

- Low/medium power deployments – using licensed or unlicensed spectrum – should not be assigned as much spectrum as wider area mobile networks.
- Cells with smaller radius:
  - Capture less users and traffic (per cell);
  - Geographic reuse across local networks with sufficient isolation.
- High bands also play a role for low/medium power networks.

The amount of mid-band spectrum for low/medium-power deployments is currently **1.6 times larger** than for macro cellular networks.

The imbalance would grow **up to 2.4 times** if the upper 6 GHz band will be used for low/medium-power.

A **more reasonable balance, 0.9 times**, can be achieved if the upper 6 GHz band is made available for macro cellular networks.

There is a need for European roadmap for wide-area / nationally licensed mid-band spectrum to address the needs of macro-cellular 5G evolution and 6G.

It is apparent that the upper 6 GHz band represents the only remaining mid-band opportunity in Europe.

NOTE: the diagram shows the harmonized frequency bands in the EU

(*) the band might not become widely available for macro in all Member States

(**) based on EC Mandate (Dec. '21)
RLAN spectrum and FBB evolution

Home Wi-Fi will require < 500 Mbit/s in the next 5-10 years

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Target DL throughput</th>
<th>Bandwidth (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 Gbit/s</td>
<td>480 MHz</td>
</tr>
<tr>
<td>B</td>
<td>1 Gbit/s</td>
<td>480 MHz</td>
</tr>
</tbody>
</table>

4 ant. per AP, 2 ant. per STA: 480 MHz
4 ant. per AP, 4 ant. per STA: 320 MHz
8 ant. per AP: 480 MHz

Currently available spectrum will be sufficient to address home Wi-Fi demand. The 14 GHz of bandwidth at 60 GHz can also play an important role for short-range communications. Other high bands can also be considered for Wi-Fi use in the coming years, for example, the Q-band (42-48 GHz) is already supported by the IEEE standard (802.11aj-2018) together with the 60 GHz band.

(*) Based on simulations. Key assumptions: 802.11ax (Wi-Fi 6), maximum channel bandwidths of 160 MHz, 70% MAC efficiency, dense residential setting (3 story apartment building with 10 apartments on each floor, wall loss of 11 dB (both for inner and outer walls), 18 dB loss for floors.
## RLAN spectrum and FBB evolution

<table>
<thead>
<tr>
<th>FBB Technology</th>
<th>Market introduction</th>
<th>Large scale</th>
<th>Average speed delivered to household</th>
</tr>
</thead>
<tbody>
<tr>
<td>10G PON</td>
<td>2019</td>
<td>By 2026</td>
<td>1.3 Gbit/s</td>
</tr>
<tr>
<td>50G PON</td>
<td>By 2023</td>
<td>By 2029</td>
<td>6.6 Gbit/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Next generation PON</td>
<td>Preliminary research ongoing</td>
<td>Not in this decade</td>
<td>&gt; 10 Gbit/s</td>
</tr>
</tbody>
</table>

New FTTx technology generation every 8 – 10 years delivering ca. four-times faster speeds to end users compared to the previous generation
Affordable annual spectrum cost to incentivize network investments

Accumulated spectrum cost will reach the highest level in 5G era

Lower spectrum price with flexible payment relieves MNOs’ burden

Germany
- Annual amortization: €3.3Bn
- ~10% of annual revenue

UK
- Annual amortization: €1.3Bn
- ~8% of annual revenue

SPI (Spectrum Price Index) = Total spectrum price / Annual revenue

Lower total 5G spectrum price: 5G SPI < 2

Installment payment
- Installment payment in 20 years
- Installment payment in 10 years
- Installment payment in 5 years
- Deferred payment

<table>
<thead>
<tr>
<th>Country</th>
<th>3 years deferred payment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>10%</td>
</tr>
<tr>
<td>UK</td>
<td>11%</td>
</tr>
<tr>
<td>Korea</td>
<td>12%</td>
</tr>
<tr>
<td>Thailand</td>
<td>13%</td>
</tr>
<tr>
<td>Chile</td>
<td>14%</td>
</tr>
<tr>
<td>KSA</td>
<td>15%</td>
</tr>
<tr>
<td>Finland</td>
<td>16%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>17%</td>
</tr>
<tr>
<td>Brazil</td>
<td>18%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>19%</td>
</tr>
</tbody>
</table>
5G Advanced: Internet of Everything to Intelligent Connection of Everything

IMT-2020: 5G
100 Mbit/s any time, anywhere
Today (3GPP Rel. 16)

5G Advanced
Ongoing evolution
2024+ (3GPP Rel. 18)

5G Advanced key technologies

- **E2E Affordable in 6GHz/mmWave**
  - For DOU and user experience increase
  - Uplink Gbps

- **FDD Massive MIMO**
  - For HD video uplink and machine vision

- **5GtoB+V2X**
  - REDCAP, accurate positioning and sensing

- **SUL (Super Uplink)**
  - For uplink capacity and coverage improvement

...
New spectrum for 6G

- Low, mid and high bands already used or identified for IMT should be allowed for 6G usage in the future.
- To secure enough spectrum for 6G to accommodate future use-cases, additional new spectrum is needed:
  - The 7-24 GHz range should be studied for 6G targeting large contiguous bandwidth (e.g. 500 MHz to 1 GHz)
    - spectrum of 7-15 GHz may be prioritized; possibilities of global or regional harmonization should be considered
  - For the 24-100 GHz range, taking into account that 66-71 GHz has a global IMT identification, additional new spectrum (71-76 GHz) can be considered to form a wider contiguous bandwidth, in order to also support various new 6G applications
  - For the sub-THz/THz bands (100 GHz and beyond), the bands of 100-300 GHz with wider contiguous blocks can be explored, e.g. W-band and D-band
Ubiquitous Metaverse: indoor and outdoor

- The Metaverse will involve AR/VR/XR in indoor and outdoor scenarios.
- **Wide-area outdoor mobility** will be an important element of the Metaverse.
- The smartphone must connect to the 5G macro-cellular mobile network with sufficient bandwidth. XR headsets might also directly connect to the mobile network. These can be supported by 5G NR @ upper 6 GHz.
- **Short-range personal area connections** (e.g., between smartphone and XR headsets) can be addressed with:
  - Wi-Fi/WiGig/IMT sidelink @ 60 GHz
  - Wi-Fi @ 5 GHz and lower 6 GHz (VLP)
- Various chipset suppliers have been developing 60 GHz products targeting AR/VR headsets, there are already WiGig XR headsets on the market.

Wide area connectivity at upper 6 GHz

Short-range connectivity at 60 GHz (and 5 GHz, L6 GHz)

High data-rate (Gbit/s)

Mobile communications anytime, anywhere,

It will be an important element of the Metaverse, enabled by macro-cellular networks at the upper 6 GHz.
Content

- Key challenges and opportunities
- The previous decade: Europe great spectrum policy leadership
- This decade: great opportunity to keep the European leadership
- 5G spectrum policy approaches globally
- Key issue for the new European spectrum roadmap
- Key takeaways
Key takeaways (1/3)

- Key opportunity to exploit: Internet of everything to intelligent connection of everything facilitated by 5G and its evolution
- Key challenge to manage: investments sustainability

The previous decade: great spectrum policy leadership
- Digital agenda for Europe
- RSPP
- 5G Action Plan
- CEPT Workshop on 5G
- RSPG Opinion on 5G
- EC 5G Mandates

This decade: great opportunity to keep leadership
- 2030 Digital Compass
- Connectivity toolbox
- 2030 Policy Programme
- New RSPP – towards a European spectrum roadmap to support the evolution of 5G?
Key takeaways (2/3)  
Key issue for the new European spectrum roadmap

**Spectrum policies and roadmap to support 5G evolution**
- 5G Advanced
- 6G
- Indoor and outdoor Metaverse (enhanced, real-time interactive experience across physical and digital worlds)

**Spectrum policy for sustainable investments**
- Low, mid- and high bands spectrum is key
  - UHF spectrum policy to support the transition from legacy TV to modern multimedia communications
  - Need for 2 GHz mid-bands in 2025-2030
  - Large scale mmW in 2025-2030
- Large contiguous bandwidth for business sustainability
- FWA role within VHCNs
- Enhanced uplink connectivity to address new use cases
- Balance:
  - Between additional spectrum availability and densification
  - Between mid-bands spectrum for macro cellular (wide area) networks and low/medium power (local area) deployments
  - Between licensed and unlicensed
- RLAN spectrum and FBB evolution
- Spectrum sharing
- Mitigate climate change
- Sustainable spectrum fees, investment obligations

A single, visionary, holistic view is needed to drive the spectrum strategy and its execution at European level.
Key takeaways (3/3)

- Europe needs to be united in its spectrum policy, coordination at European level is important

- There is a need to keep a balance between European wide strategy and harmonization and the individual national interests and agendas of Member States

- The European Commission has been essential in keeping the balance during last decade
- The European Commission should continue to play its role in driving a future proof unified strategy and roadmap across all Member States to support the 5G evolution and maintain the policy leadership globally

- Tight cooperation with industry is important, Huawei remains committed to sharing its technical expertise on the 5G business and technology evolution
Thank you.