ITU Asia-Pacific Centre of Excellence Training
On
“Traffic engineering and advanced wireless network planning”

30 September – 3 October 2019,
Bangkok, Thailand
Meet us

What we do

‘Committed to Connecting the World’

ITU Radiocommunication
Coordinating radio-frequency spectrum and assigning orbital slots for satellites

ITU Standardization
Establishing global standards

ITU Development
Bridging the digital divide

193 MEMBER STATES

+800 MEMBERS FROM THE PRIVATE SECTOR, ACADEMIA AND INTERNATIONAL AND REGIONAL ORGANIZATIONS
Digital transformation is key to accelerate our progress towards SDGs.

17 Sustainable Development Goals

169 Targets
Digital transformation requires an ecosystem approach.
Digital infrastructure - Key to digital transformation
LDCs and LLDCs need catalyst to accelerate their journey.

- Active mobile-broadband subscriptions per 100 inhabitants, by region, 2010–2018*
- Mobile-broadband traffic, exabytes, 2015–2017
- Individuals using the Internet by development status, 2005–2018*
- Individuals using the Internet, by region, 2005–2018*
Growth in Number of Users of Messaging and Hybrid Networks, 2011-2017

Source: Various, including Activate.com.

<table>
<thead>
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<th>2016</th>
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<td>7.74 bn (ITU)</td>
<td>8.3 bn (GSMA)</td>
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<td>7.5 bn (GSMA)</td>
<td>7.8 bn (E)</td>
<td>8.4 bn (E)</td>
<td>8.6 bn (E)</td>
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<td>7.2 bn (E)</td>
<td>7.5 bn (E)</td>
<td>7.8 bn (E)</td>
<td>8.4 bn (E)</td>
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<td><strong>Unique mobile</strong></td>
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<td>4.8 bn (GSMA)</td>
<td>5 bn (GSMA)</td>
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<td>5.1 bn (E)</td>
<td>5.3 bn (E)</td>
<td>5.7 bn (E)</td>
<td>5.8 bn (E)</td>
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<td></td>
<td>4.8 bn (GSMA)</td>
<td>5.1 bn (E)</td>
<td>5.3 bn (E)</td>
<td>5.7 bn (E)</td>
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<td><strong>LTE subscriptions</strong></td>
<td>1.1 bn (GSMA)</td>
<td>1.8 bn (GSMA)</td>
<td>2.6 billion (GSMA)</td>
<td>4.1 bn (GSMA)</td>
<td>4.5 bn (GSMA)</td>
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<td>1.1 bn (E)</td>
<td>1.9 bn (E*)</td>
<td>2.8 bn (E*)</td>
<td>4.9 bn (E)</td>
<td>5.3 bn (E)</td>
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<td></td>
<td>1.37 bn (ABI Research)*</td>
<td>2 bn (Strategy Analytics)*</td>
<td>3.6 bn (4G Am)</td>
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<td>1.068 bn (GSA)</td>
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<td><strong>5G subscriptions</strong></td>
<td>-/-</td>
<td>-/-</td>
<td>-/-</td>
<td>70 m (GSMA)</td>
<td>220 m (GSMA)</td>
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<td>55 million (E)</td>
<td>190 million (E)</td>
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<td><strong>Mobile broadband</strong></td>
<td>3.2 bn (ITU)</td>
<td>3.65 bn (ITU);</td>
<td>4.2 bn (ITU)</td>
<td>6.5 bn (GSMA)</td>
<td>6.9 bn (GSMA)</td>
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<tr>
<td>subscriptions</td>
<td>3.4 bn (GSMA)</td>
<td>4.1 bn (GSMA)</td>
<td>4.8 bn (E)</td>
<td>7.0 bn (E)</td>
<td>7.5 bn (E)</td>
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<td></td>
<td>3.6 bn (E)</td>
<td>4.5 bn (E)</td>
<td>5.3 bn (E)</td>
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<td><strong>Smartphone</strong></td>
<td>3.3 bn (GSMA)</td>
<td>3.9 bn (GSMA)</td>
<td>4.5 bn (GSMA)</td>
<td>5.9 bn (GSMA)</td>
<td>6.2 bn (GSMA)</td>
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<tr>
<td>subscriptions</td>
<td>3.3 bn (E)</td>
<td>3.8 bn (E)</td>
<td>4.4 bn (E*)</td>
<td>5.8 bn (E)</td>
<td>6.3 bn (E*)</td>
</tr>
<tr>
<td><strong>Fixed broadband</strong></td>
<td>820m (ITU)</td>
<td>884m (ITU)</td>
<td>979m (ITU)</td>
<td>1.1 bn (E*)</td>
<td>1.2 bn (E*)</td>
</tr>
<tr>
<td>(ITU)</td>
<td></td>
<td></td>
<td>1bn (E*)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Internet users</strong></td>
<td>3.21 bn (ITU)</td>
<td>3.49 bn (ITU)</td>
<td>3.58 bn (ITU)</td>
<td>4.16 bn (ITU)</td>
<td>-/-</td>
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<tr>
<td>(ITU)</td>
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<td><strong>Facebook users</strong></td>
<td>1.59 bn MAU</td>
<td>1.71 bn MAU</td>
<td>2.13 bn MAU</td>
<td>2.13 bn MAU</td>
<td>-/-</td>
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<tr>
<td>(Dec 2015)</td>
<td>1.04 bn DAU*</td>
<td>1.13 bn DAU</td>
<td>1.4 bn DAU</td>
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<tr>
<td><strong>LINE users</strong></td>
<td>215 million</td>
<td>217 million</td>
<td>207 million</td>
<td>203 million</td>
<td>-/-</td>
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<tr>
<td></td>
<td>217 million</td>
<td>207 million</td>
<td>203 million</td>
<td></td>
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<tr>
<td><strong>Sina Weibo users</strong></td>
<td>222 million</td>
<td>313 million</td>
<td>392 million</td>
<td>411 million</td>
<td>-/-</td>
</tr>
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<td></td>
<td>313 million</td>
<td>392 million</td>
<td>411 million</td>
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<tr>
<td><strong>Vkontakte users</strong></td>
<td>66.5 million</td>
<td>77.8 million</td>
<td>81.1 million</td>
<td>97 million</td>
<td>-/-</td>
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<td>77.8 million</td>
<td>81.1 million</td>
<td>97 million</td>
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<tr>
<td><strong>WeChat users</strong></td>
<td>600 million*</td>
<td>806 million</td>
<td>963 million</td>
<td>1 billion</td>
<td>-/-</td>
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<td></td>
<td>806 million</td>
<td>963 million</td>
<td>1 billion</td>
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<td></td>
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<tr>
<td><strong>Smartphone stock</strong></td>
<td>2.2 bn (Del)</td>
<td>-/-</td>
<td>-/-</td>
<td>2.1 bn (BI)*</td>
<td>-/-</td>
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<td></td>
<td></td>
<td></td>
<td>2.1 bn (BI)*</td>
<td></td>
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</table>


MAU = monthly active users; DAU = daily active users.

Mobile broadband affordability
(Entry Level Broadband - Target less than 2% GNI by 2025)

MOBILE BROADBAND BASKET, PRE-PAID HANDSET BASED (500 MB)

https://www.itu.int/net4/ITU-D/ipb/#ipbtimeseries-tab
Res. ITU-R 56-1: Naming for International Mobile Telecommunications

Since ITU is the internationally recognized entity that has sole responsibility to define and to recommend the standards and frequency arrangements for IMT systems, with the collaboration of other organizations such as standard development organizations, universities, industry organizations and with partnership projects, forums, consortia and research collaborations, therefore the RA-15 debated especially on naming of IMT systems.

- the existing term IMT-2000 continues to be relevant and should continue to be utilized;
- the existing term IMT-Advanced continues to be relevant and should continue to be utilized;
- However for systems, system components, and related aspects that include new radio interface(s) which support the new capabilities of systems beyond IMT-2000 and IMT-Advanced, the term “IMT-2020” be applied
- In addition it was resolved that the term “IMT” would be considered the root name that encompasses all of IMT-2000, IMT-Advanced and IMT-2020 collectively.
• 884 operators actively investing in LTE, including those evaluating/testing and trialling LTE and those paying for suitable spectrum licences (excludes those using technology neutral licences exclusively for 2G or 3G services).
• 769 operators running LTE networks providing mobile and/or FWA services worldwide.
• 194 commercial VoLTE networks in 91 countries and a total of 262 operators investing in VoLTE in 120 countries.
• 304 launched or launched (limited availability) LTE-Advanced networks in 134 countries. Overall, 335 operators are investing in LTE-Advanced technology in 141 countries.
• Ten launched networks that support user equipment (UE) at Cat-18 DL speeds within limited geographic areas, and one supporting Cat-19 (in a limited area).
• 228 operators with TDD licences and at least 164 operators with launched LTE-TDD networks.
• 151 operators investing in NB-IoT in 72 countries; of these, 98 NB-IoT networks are deployed/launched in 53 countries. 62 operators are investing in LTE-M/Cat-M1 in 36 countries; of these, 38 LTE-M/Cat-M1 networks are deployed/commercially launched in 26 countries.
• 296 operators in 100 countries have launched with limited availability, deployed, demonstrated, are testing or trialling, or have been licensed to conduct field trials of mobile 5G or FWA 5G.
• 56 operators in 32 countries have announced the deployment of 5G within their live network.
• 39 operators have announced 3GPP 5G service launches (or limited service launches).
194 operators in 91 countries have launched VoLTE voice services.

335 operators in 141 countries are investing in LTE-Advanced.

Figure 1: Growth of LTE: networks launched each year, and cumulative (including mobile and FWA networks)

Figure 7: Countries with launched VoLTE networks

Figure 8: Countries with launched LTE-Advanced networks

https://gsacom.com/
By July 2019, there were 151 operators investing in NB IoT in 72 countries, up from 148 operators in 71 countries in May 2019.

The number of deployed/launched NB-IoT networks was 98 in 53 countries, up from 78 operators in 45 countries in January 2019.

There are 62 operators investing in LTE-M networks in 36 countries, up from 57 operators in 34 countries in January 2019. Thirty-eight operators have deployed/launched LTE-M networks in 26 countries, up from 30 operators in January 2019.
GSA has identified 56 operators in 32 countries that have stated that they have activated one or more 5G sites within their live commercial network (excludes those that have only deployed test sites).

The number that have announced the launch of commercial services remains much lower however, as operators have had to await the availability of 5G devices.
IoT Technologies

Fixed & Short Range

i. RFID
ii. Bluetooth
iii. Zigbee
iv. WiFi

Long Range

Non 3GPP Standards
1. LORA
2. SIGFOX
3. Weightless
4. Others

3GPP Standards
1. LTE-M
2. EC-GSM
3. NB-IOT
4. 5G
Click on the coverage map to find details of LoRaWAN® Networks by individual country. The extent of LoRaWAN® network coverage globally is significant and expanding on a monthly basis. Please contact the LoRa Alliance members for specific information about their networks.

142 Countries with LoRaWAN® Deployments

121 Network Operators in 58 countries

76 LoRa Alliance Member Operators

[Map of LoRaWAN coverage around the world]

https://www.lora-alliance.org/
https://www.sigfox.com/en/coverage
5G usage scenarios from the ITU-R IMT-2020 Vision Recommendation

- Enhanced mobile broadband
  - Gigabytes in a second
  - 3D video, ultra-high definition (UHD) screens
- Smart home/building
- Work and play in the cloud
- Augmented reality
- Industry automation
- Future IMT
- Mission critical applications, e.g. e-health
- Self-driving car

Massive machine type communications

Ultra-reliable and low latency communications

IMT-2020 standardization process

Setting the stage for the future: vision, spectrum, and technology views

- Development plan
- Market/service view
- Technology/market research kick off
- Technical performance requirements
- Vision – IMT for 2020
- Name
- 6 GHz spectrum view
- Process optimization
- Invitation for proposals
- Sharing study proposals (IMT-WRC-19)
- Sharing studies

2012-2015
2016-2017
2018-2019
2019-2020

- Proposals
- Evaluation
- Consensus building
- CP1 report (IMT-WRC-19)
- Sharing study reports (WRC-19)
- Spectrum build arrangements
- Orchestration and radio framework
- Detailed IMT-2020 radio specifications
- Future enhancement/update plan and process

Defining the technology
Internet and IP traffic

Note: Fixed Internet traffic refers to traffic through fixed network providers on different platforms. Mobile Internet traffic refers to traffic through mobile-cellular networks. IP traffic refers to the sum of fixed and mobile Internet traffic (denoting all IP traffic crossing an Internet backbone) as well as non-Internet IP traffic (e.g. IP WAN, IP transport of TV and video-on-demand).

Source: ITU based on Cisco and company reports.
The 4th Wave: We are about to enter the golden age of mobile

4th Wave

Source: Operator’s Dilemma (Opportunity): The Fourth Wave

http://www.chetansharma.com
Commercial 5G networks are expected to start deployment after 2020 as 5G standards are finalized. Republic of Korea has launched 5G.

By 2025, the GSM Association (GSMA) expects 5G connections to reach 1.1 billion, some 12 per cent of total mobile connections. It also forecasts overall operator revenues to grow at a CAGR of 2.5 per cent, to reach USD 1.3 trillion by 2025.

<table>
<thead>
<tr>
<th></th>
<th>1G</th>
<th>2G</th>
<th>3G</th>
<th>4G</th>
<th>5G</th>
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<tbody>
<tr>
<td><strong>Approximate deployment date</strong></td>
<td>1980s</td>
<td>1990s</td>
<td>2000s</td>
<td>2010s</td>
<td>2020s</td>
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<tr>
<td><strong>Theoretical download speed</strong></td>
<td>2kbit/s</td>
<td>384kbit/s</td>
<td>56Mbit/s</td>
<td>1Gbit/s</td>
<td>10Gbit/s</td>
</tr>
<tr>
<td><strong>Latency</strong></td>
<td>N/A</td>
<td>629 ms</td>
<td>212 ms</td>
<td>60-98 ms</td>
<td>&lt; 1 ms</td>
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</table>
The values in the figures above are targets for research and investigation for IMT-2020 and may be revised in the light of future studies. Further information is available in the IMT-2020 Vision (Recommendation ITU-R M.2083)
5G and Socio-Economic Benefits

One report estimates that 5G will underwrite USD 12.3 trillion of global economic output by 2035, with the greatest growth in sales activity coming from manufacturing because of an anticipated increase in spending on 5G equipment. This is followed by sales growth in the ICT sector driven by higher expenditure on communications services. Investment in the value chain is expected to generate a further USD 3.5 trillion in output and provide support for 22 million jobs by 2035.

The European Commission (EC) estimates the total cost of 5G deployment across the 28 Member States will be EUR 56 billion, resulting in benefits of EUR 113.1 billion per annum arising from the introduction of 5G capabilities, and creating 2.3 million jobs. It is also estimated that benefits are largely driven by productivity in the automotive sector and in the workplace generally. Most of the benefits are expected in urban areas while only 8 per cent of benefits (EUR 10 billion per annum) will be realized in rural areas.

The ITU suggests that policy-makers undertake an independent economic benefits assessment since third party estimates are not endorsed by the ITU.
Services that 5G would enable
5G: 16 key issues for policy-makers to consider

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<tbody>
<tr>
<td>1)</td>
<td>Investment case</td>
<td>Policy-makers may consider undertaking their own independent economic assessment of the commercial viability of deploying 5G networks.</td>
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<tr>
<td>2)</td>
<td>4G network strategy</td>
<td>Until the case for 5G networks can be clearly made, policy makers may consider enhancing the availability of and boosting the quality of 4G networks.</td>
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<tr>
<td>3)</td>
<td>Harmonize spectrum</td>
<td>NRAs may consider allocating/assigning globally harmonized 5G spectrum bands.</td>
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<td>4)</td>
<td>Spectrum roadmap</td>
<td>NRAs may consider adopting a spectrum roadmap and a predictable renewal process.</td>
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<tr>
<td>5)</td>
<td>Spectrum sharing</td>
<td>NRAs may consider allowing sharing to maximize efficient use of available spectrum, particularly to benefit rural areas.</td>
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<tr>
<td>6)</td>
<td>Spectrum pricing</td>
<td>NRAs may consider selecting spectrum award procedures that favour investment.</td>
</tr>
<tr>
<td>7)</td>
<td>700Mhz spectrum</td>
<td>Policy-makers may consider supporting the use of affordable wireless coverage (e.g. through the 700 MHz band) to reduce the risk of digital divide.</td>
</tr>
<tr>
<td>8)</td>
<td>Fibre investment incentives</td>
<td>Policy-makers, where the market has failed, may consider stimulating fibre investment and passive assets through PPPs, investment funds and the offering of grant funding, etc.</td>
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</table>
5G: 16 key issues for policy-makers to consider

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<tr>
<td>9)</td>
<td>Fibre tax</td>
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<td>10)</td>
<td>Copper migration to fibre</td>
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<td>11)</td>
<td>Wireless backhaul</td>
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<td>12)</td>
<td>Access/sharing of passive infrastructure</td>
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<td>13)</td>
<td>Access costs</td>
</tr>
<tr>
<td>14)</td>
<td>Asset database</td>
</tr>
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<td>15)</td>
<td>Wayleave (rights of way) agreements</td>
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<td>16)</td>
<td>5G test beds</td>
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</table>
Network sharing (examples)

- In November 2017, the Netherlands passed a bill designed to accelerate broadband roll-outs. It mandated all owners/administrators of networks and related infrastructure to comply with reasonable requests for shared access and/or coordinated network deployment, and to share information about their infrastructure.
- Indonesia’s Ministry of Communications and Information Technology is working toward new rules to encourage the development of passive infrastructure sharing such as ducts, poles, towers, cabinets, etc.
- UK telecoms regulator Ofcom is running a market consultation to mandate the incumbent operator and significant market player BT to offer duct fibre access to rival operators. Previous attempts to mandate dark fibre access failed.
- In Italy, ultra-fast broadband legislation has enabled TIM and UTILITALIA (the federation of electricity, gas, water and environment companies) to sign a memorandum of understanding to facilitate the use of pre-existing infrastructures of more than 500 local utility operators to deploy fibre networks.

Streamlining the deployment of small cells (examples)

In September 2017, a California bill was passed streamlining small cell deployment by permitting its use and making such deployment no longer subject to a local discretionary permit or with specified criteria. The new legislation standardizes small cell deployments across the state. In addition, the bill:

- Grants providers non-discriminatory access to public property
- Allows local governments to charge permit fees that are fair, reasonable, non-discriminatory and cost-based
- Limits the costs charged by local governments of attaching equipment to USD 250
- Stops local governments putting an unreasonable limit on the duration of the permit on the telecom facility

A similar approach has been proposed in a bill in Florida, requiring an authority to process applications for siting small cell equipment on utility poles on a non-discriminatory basis and approving applications within set time-scales. The bill also proposes that authorities may not enter into any exclusive arrangements entitling providers to attach equipment to authority utility poles. Furthermore, the bill states that authorities may not charge more than USD 15 per year, per utility pole.

In Washington State, a bill proposes to authorize the installation of small cell facilities on publicly owned assets and limits charges to USD 500 per annum. In Illinois, a bill proposes that local government may not prohibit, regulate or charge operators to deploy small cell wireless equipment.

Network sharing (examples)

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Network sharing (examples – commercially driven)

- In Spain, telecoms operator MASMOVIL has passed the ten million household threshold using a fibre network that it shares with Orange Espana through a network-sharing pact.
- In Portugal, Vodafone and operator NOS have signed an agreement to deploy and share a fibre network that will be marketed to around 2.6 million homes and businesses. The two companies provide access to each other’s networks on agreed commercial terms.
- New Zealand’s wholesale network operator, Chorus, is calling on the government to begin formulating plans for a single 5G mobile network – one which can be shared by all service providers, a more sustainable approach than having a separate 5G network for each of the country’s three mobile operators.
- Vodafone Cameroon has recently signed a ‘strategic national network sharing agreement’ with CamTel, allowing Vodafone to use CamTel’s existing network infrastructure in Douala and Yaounde and to expand its coverage to new locations across the country.
- Telenor Denmark and Telia Denmark have signed a services contract with Nokia to manage their shared mobile networks run by one infrastructure company (TT-Netvaerket).
- Econet Wireless (Zimbabwe), has stated it is open to infrastructure sharing, under an equitable ‘one-for-one’ infrastructure.

Spectrum Needs of IoT

What are the spectrum needs of IoT?
- Determined by each application’s throughput requirements, but also latency
  - For a given spectral efficiency (b/s/Hz), the lower the latency requirements the larger the bandwidth needed to send a given amount of data
- While many IoT applications might not need high speed connections and/or have very stringent latency requirements, some do (e.g. remote surgery)

In what frequency bands?
- Determined by each IoT application’s range and coverage requirements, but also bandwidth needs of the applications
- Range and coverage requirements also depend on deployment scenarios
  - Point-to-point, mesh, broadcast, multi-cast, etc.
Spectrum Licensing for IoT

Unlicensed spectrum

- **Low cost/no license fees**
- **Regulatory limits (EIRP restrictions)**
- **Non-guaranteed QoS**

- All devices can have access to spectrum, subject to compliance with technical conditions as specified in regulations
- Short range and delay-tolerant applications are typical use cases

Licensed spectrum

- **Better Inference management**
- **Network Security**
- **Reliability**

Mobile operator Network

Reuse cellular infrastructure and device eco-system for M2M/IoT apps

- IMT spectrum can be used for supporting NB-IoT, eMTC and LTE-V2N (eNB-to-vehicle)
- MBB spectrum can also be used for M2M/IoT

Dedicated Network

Private network customized for specific M2M/IoT apps.

Example: In China New bands for M2M:

- 5 905 - 5 925 MHz for LTE-V2X trials
- 2 x 2.3 MHz in 800MHz can be used for NB-IoT
Spectrum - New spectrum bands under study for WRC-19

<table>
<thead>
<tr>
<th>Existing mobile allocation</th>
<th>No global mobile allocation</th>
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<tbody>
<tr>
<td>24.25 – 27.5 GHz</td>
<td>31.8 – 33.4 GHz</td>
</tr>
<tr>
<td>37 – 40.5 GHz</td>
<td>40.5 – 42.5 GHz</td>
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<td>42.5 – 43.5 GHz</td>
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<td>45.5 – 47 GHz</td>
<td>47 – 47.2 GHz</td>
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<td>47.2 – 50.2 GHz</td>
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<tr>
<td>50.4 GHz – 52.6 GHz</td>
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<tr>
<td>66 – 76 GHz</td>
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<td>81 – 86 GHz</td>
<td></td>
</tr>
</tbody>
</table>
IMT Spectrum after WRC-07

IMT Spectrum After WRC-07 (MHZ)

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Region 1 (121 Countries)</th>
<th>Region 2 (35 Countries)</th>
<th>Region 3 (37 Countries)</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>1085 MHz</td>
<td>200</td>
<td>0</td>
<td>292</td>
<td>292</td>
</tr>
<tr>
<td>951 MHz</td>
<td>885</td>
<td>951</td>
<td>885</td>
<td>859</td>
</tr>
<tr>
<td>1177 MHz</td>
<td>885</td>
<td>292</td>
<td>292</td>
<td></td>
</tr>
</tbody>
</table>

- <20% of countries
- 20 to 80% of countries
- 80 to 99% Countries
- 100% Countries
IMT Bands after WRC-15

<table>
<thead>
<tr>
<th>Region 1 (121 Countries)</th>
<th>Region 2 (35 Countries)</th>
<th>Region 3 (37 Countries)</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>1372 MHz (+26%)</td>
<td>1764 MHz (+85%)</td>
<td>1786 MHz (+52%)</td>
<td>1886 MHz (+60%)</td>
</tr>
</tbody>
</table>

- 1372 MHz: 1232 MHz
- 1764 MHz: 1242 MHz
- 1786 MHz: 976 MHz
- 1886 MHz: 910 MHz

- <20% of countries
- 20 to 80% of countries
- 80 to 99% Countries
- 100% Countries

Number of countries using each band for different regions.
IMT spectrum requirements and WRC-19

Agenda items for WRC-23 will be decided during WRC-19, which will contain additional proposals for IMT-2020
Consider **IMT identification** in the following bands, which **have allocations** to the mobile service on a primary basis:

- 24.25 – 27.5 GHz
- 37 – 40.5 GHz
- 42.5 – 43.5 GHz
- 45.5 – 47 GHz
- 47.2 – 50.2 GHz
- 50.4 – 52.6 GHz
- 66 – 76 GHz
- 81 – 86 GHz

And also in the following bands which **may require additional allocations** to the MS on a primary basis:

- 31.8 – 33.4 GHz
- 40.5 – 42.5 GHz
- 47 – 47.2 GHz

Appropriate regulatory actions, incl. additional MS allocations, for **WAS/RLAN** are being studied in the bands between **5 150-5 925 MHz**

▶ Res. 238 (WRC-15)

▶ Res. 239 (WRC-15)
### Overlapping frequency bands (GHz) between some WRC-19 agenda items

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>24.25-27.5</td>
<td>24.25-27.5 (Reg. 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5-39.5 (s-E*)</td>
<td>37-40.5</td>
<td>38-39.5 (globally)</td>
<td></td>
</tr>
<tr>
<td>39.5-42.5 (s-E*)</td>
<td>40.5-42.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47.2-50.2 (E-s*)</td>
<td>47.2-50.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50.4-51.4 (E-s*)</td>
<td>50.4-52.6</td>
<td></td>
<td>51.4-52.4 (E-s*)</td>
</tr>
</tbody>
</table>

* E-s: Earth-to-space; s-E: space-to-Earth.

Studies to **address mutual compatibility & sharing feasibility** among the **services / applications** for which **allocation/identification is envisaged** under the corresponding Res. relating to the AI in the overlapping bands.
<table>
<thead>
<tr>
<th>Examples</th>
<th>Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)</th>
<th>Spectrum needs in total (GHz)</th>
<th>Spectrum needs (GHz) per range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overcrowded, Dense urban and Urban areas</td>
<td>18.7</td>
<td>➢ 3.3 (24.25-33.4 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 6.1 (37-52.6 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 9.3 (66-86 GHz range)</td>
</tr>
<tr>
<td></td>
<td>Dense urban and Urban areas</td>
<td>11.4</td>
<td>➢ 2.0 (24.25-33.4 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 3.7 (37-52.6 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 5.7 (66-86 GHz range)</td>
</tr>
<tr>
<td>2</td>
<td>Highly crowded area</td>
<td>3.7</td>
<td>➢ 0.67 (24.25-33.4 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 1.2 (37-52.6 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 1.9 (66-86 GHz range)</td>
</tr>
<tr>
<td></td>
<td>Crowded area</td>
<td>1.8</td>
<td>➢ 0.33 (24.25-33.4 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 0.61 (37-52.6 GHz range)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>➢ 0.93 (66-86 GHz range)</td>
</tr>
</tbody>
</table>

Source: Chairman's report TG 5/1 Annex 2: Working document towards Draft CPM text for WRC-19 Agenda Item 1.13
## Future Spectrum need estimation for IMT (24.25 GHz - 86 GHz)

<table>
<thead>
<tr>
<th>Examples</th>
<th>Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)</th>
<th>Spectrum needs in total (GHz)</th>
<th>Spectrum needs (GHz) per range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical performance-based approach (Type 1)</strong> Calculated on single technical performance requirement, i.e. user experienced data rate.</td>
<td>User experienced data rate of 1 Gbit/s with N simultaneously served users/devices at the cell-edge, e.g., Indoor</td>
<td>➢ 3.33 (N=1),&lt;br&gt;➢ 6.67 (N=2),&lt;br&gt;➢ 13.33 (N=4)</td>
<td>Not available</td>
</tr>
<tr>
<td>1</td>
<td>User experienced data rate of 100 Mbits/s with N simultaneously served users/devices at the cell-edge, for wide area coverage</td>
<td>➢ 0.67 (N=1),&lt;br&gt;➢ 1.32 (N=2),&lt;br&gt;➢ 2.64 (N=4)</td>
<td>Not available</td>
</tr>
<tr>
<td>2</td>
<td>eMBB Dense Urban</td>
<td>➢ 0.83-4.17</td>
<td>Not available</td>
</tr>
<tr>
<td>2</td>
<td>eMBB Indoor Hotspot</td>
<td>➢ 3-15</td>
<td>Not available</td>
</tr>
<tr>
<td>3</td>
<td>With a file transfer of 10 Mbits by a single user at cell-edge in 1 msec</td>
<td>➢ 33.33 GHz (one direction)</td>
<td>Not available</td>
</tr>
<tr>
<td>3</td>
<td>With a file transfer of 1 Mbit by a single user at cell-edge in 1 msec</td>
<td>➢ 3.33 GHz (one direction)</td>
<td>Not available</td>
</tr>
<tr>
<td>3</td>
<td>With a file transfer of 0.1 Mbits by a single user at cell-edge in 1 msec</td>
<td>➢ 333 MHz (one direction)</td>
<td>Not available</td>
</tr>
</tbody>
</table>

Source: [Chairman’s report TG 5/1 Annex 2: Working document towards Draft CPM text for WRC-19 Agenda Item 1.13](#)
## Future Spectrum need estimation for IMT (24.25 GHz - 86 GHz)

<table>
<thead>
<tr>
<th>Examples</th>
<th>Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)</th>
<th>Spectrum needs in total (GHz)</th>
<th>Spectrum needs (GHz) per range</th>
</tr>
</thead>
</table>
| Technical performance-based approach (Type 2)  
*Calculated taking into account different technical performance requirements, i.e. user experienced data rate, peak data rate and area traffic capacity* | Dense urban micro | 14.8-19.7 | 5.8-7.7  
(24.25-43.5 GHz range) |
| | Indoor hotspot | | 9-12  
(24.25-43.5 GHz and 45.5-86 GHz range) |
| Information from some countries based on their national considerations | | | 2-6  
(24.25-43.5 GHz range)  
5-10 (43.5-86 GHz range) |

**Source:** Chairman’s report TG 5/1 Annex 2: Working document towards Draft CPM text for WRC-19 Agenda Item 1.13

**Note:** The spectrum needs estimates of the different approaches and examples should be considered separately.
Future Spectrum need estimation for IMT
(24.25 GHz - 86 GHz)

<table>
<thead>
<tr>
<th>Deployment scenarios</th>
<th>Indoor hotspot</th>
<th>Dense urban</th>
<th>Urban macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>24.25-86 GHz</td>
<td>24.25-43.5 GHz</td>
<td>&lt;6 GHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;6 GHz</td>
<td>&lt;6 GHz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deployment scenario</th>
<th>Micro</th>
<th>Indoor hotspot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total spectrum needs for 24.25-86 GHz</td>
<td></td>
<td>14.8-19.7 GHz*</td>
</tr>
<tr>
<td>Spectrum needs for 24.25-43.5 GHz</td>
<td>5.8-7.7 GHz</td>
<td></td>
</tr>
<tr>
<td>Spectrum needs for 45.5-86 GHz</td>
<td></td>
<td>9-12 GHz</td>
</tr>
</tbody>
</table>

* Considering the coexistence between multiple network operators (e.g. the guard band(s) may be required in the case of multiple network operators scenarios), the total spectrum needs are expected to be increased.

** The division in this table regarding frequency ranges and deployment scenarios is just an indicative example on how spectrum needs could be distributed for different spectrum sub-ranges within 24.25-86 GHz and different deployment scenarios. This table should not be understood nor used to exclude any possible IMT-2020 deployment options in the range 45.5-86 GHz.

Source: WP 5D Liaison statement to Task Group 5/1
Future Spectrum need estimation for IMT
(24.25 GHz - 86 GHz)

Source: WP 5D Liaison statement to Task Group 5/1
Smart Sustainable Cities, ICT Applications & E-Government: Incorporating Data, Network And AI Technologies Towards More Efficient Cities”

Ismail Shah & Cristina Bueti
ITU

Jeju, Republic of Korea from 15-18 July 2019
ITU Activities on IoT & Smart Sustainable Cities

- Development and implementation of standards
- Research & pre-standardization work
- Projects, Open platform for knowledge sharing and raising awareness

- ITU-T Study Group 20
- Focus Group on Data Processing Management (FG-DPM) & Focus Group on Environmental Efficiency for AI and other Emerging Technologies (FG-AI4EE)
- U4SSC – a UN initiative KPIs for SSC Worldwide & regional events
SG20: IoT and Smart Cities & Communities

Lead Study Group on:
- Internet of things (IoT) and its applications
- Smart cities and communities, including its e-services and smart services
- Internet of things identification

4 Regional Groups
- SG20RG-LATAM
- SG20RG-ARB
- SG20RG-AFR
- SG20RG-EECAT

Collaboration with other SDOs
- Joint Coordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SC&C)
- For example: OneM2M, ISO, IEC
Creating value with IoT: A few applications

**Smart Agriculture**
- Smart greenhouse
- Soil monitoring sensors
- Smart irrigation sprinkler controllers

**Smart Building**
- IoT-based smart grid
- IoT-enabled security
- Secure remote health monitoring

**Smart Water Management**
- Smart water meters
- Water quality monitoring with IoT sensors
- IoT rainwater harvesting systems

Icons adapted from fontawesome.com
Creating value with IoT: A few applications

Smart Cities
- IoT for urban and spatial planning
- Internet of living things
- Smart Learning
- Smart waste collection and consumption monitoring
- Quality checks and maintenance using cameras and sensors
- Cloud computing for supply chain management
- Real-time traffic management
- Parking monitoring

Smart Manufacturing
- IoT for urban and spatial planning
- Internet of living things
- Smart Learning
- Smart waste collection and consumption monitoring
- Quality checks and maintenance using cameras and sensors
- Cloud computing for supply chain management
- Real-time traffic management
- Parking monitoring

Intelligent Transport Systems
- Fuel leak wireless detection systems
- Real-time traffic management
- Parking monitoring

Icons adapted from fontawesome.com
What is SG20 currently working on:

Internet of things (IoT)
- Drones for IoT
- IoT requirements for edge computing
- Artificial Intelligence and IoT
- Accessibility for IoT
- Blockchain and IoT
- IoT for developing countries
- Intelligent Transport Systems (ITS) based on IoT
- Privacy and trust of IoT systems
- Interoperability
- Edge computing
- IoT-devices authentication
- Digital twins for IoT

Smart cities and communities
- Open Data in Smart Cities
- Use cases, requirements and architectures for Smart cities and communities
- Smart Services in rural communities
- Disaster notification of the population in smart cities and communities
- Smart Tourist destinations
- Smart City Infrastructure

Data management & processing
- Data structure and data transfer protocol for automotive emergency response system
- Function description and metadata of Spatio-temporal Information Service for SSC
- Integrity
ITU-T SG20 last meeting main results
Geneva, Switzerland, 9-18 April 2019

Statistics:

170 Participants
4 Draft Recommendations consented
1 Draft Recommendation determined
1 Supplement agreed
7 New work items
# ITU-T SG20 Main outcomes
Geneva, Switzerland, 9-18 April 2019

## 4 draft Recommendations consented

<table>
<thead>
<tr>
<th>ITU-T Rec. Number</th>
<th>Draft new/revised Rec. No.</th>
<th>Title</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y.4206</td>
<td>Y.UCS-reqts</td>
<td>Requirements and capabilities of user-centric work space service</td>
<td>2/20</td>
</tr>
<tr>
<td>Y.4207</td>
<td>Y.SEM</td>
<td>Requirements and capability framework of Smart Environmental Monitoring</td>
<td>2/20</td>
</tr>
<tr>
<td>Y.4460</td>
<td>Y.dev-IoT-arch</td>
<td>Architectural reference model of devices for IoT applications</td>
<td>3/20</td>
</tr>
<tr>
<td>Y.4906</td>
<td>Y.AFDTS</td>
<td>Assessment Framework for digital transformation of sectors in smart cities</td>
<td>7/20</td>
</tr>
</tbody>
</table>

## 1 draft Recommendation determined

<table>
<thead>
<tr>
<th>ITU-T Rec. Number</th>
<th>Work item or provisional name</th>
<th>Title</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y.4556</td>
<td>Y.SC-Residential</td>
<td>Requirements and functional architecture of smart residential community</td>
<td>4/20</td>
</tr>
</tbody>
</table>
### ITU-T SG20 Main outcomes
Geneva, Switzerland, 9-18 April 2019

<table>
<thead>
<tr>
<th>Question</th>
<th>Working title</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/20</td>
<td>Y.rrm-data</td>
<td>Requirements and reference model of IoT related data from city infrastructure</td>
</tr>
<tr>
<td>3/20</td>
<td>Y.IoT-AOS-prot</td>
<td>Protocols of supporting autonomic operations in the Internet of things</td>
</tr>
<tr>
<td>4/20</td>
<td>Y.smart-education</td>
<td>Requirements and reference architecture of smart education</td>
</tr>
<tr>
<td>4/20</td>
<td>Y.IoT-SCS</td>
<td>Requirements and functional architecture for smart construction site services</td>
</tr>
<tr>
<td>4/20</td>
<td>Y.UAV-BSI</td>
<td>Requirements and functional architecture of base station inspection services using unmanned aerial vehicles</td>
</tr>
<tr>
<td>4/20</td>
<td>Y.smoke-detection</td>
<td>Requirements and Functional Architecture of Smart Fire Smoke Detection Service</td>
</tr>
</tbody>
</table>
oneM2M Partnership Project

Almost 200 member organizations in oneM2M

- 8 regional Standards Development Organizations jointly develop the oneM2M technical specifications.
- oneM2M specifications are then referenced by regional legal and regulatory bodies.
- BBF and OMA specifications are re-used.
- oneM2M specifications became also ITU-T recommendations see Y.4500.x series.

founded July, 24th 2012
TP#1: Sep 24th-29th 2012

[1] Partnership Agreement V 2.0 (Approved March 2013)
IOT and regulatory issues

Numbering, addressing and number portability issues

- Public Numbers
  - National E.164 numbers;
  - International/global E.164 numbers assigned by the ITU;
  - National E.212 IMSI (International Mobile Subscriber Identity);
  - International/global E.212 IMSI with MNCs under MCC40 901 assigned by the ITU.
- Eligibility to receive MNCs
- Sufficiency of numbering resources
- IP addresses (IPv4 to IPv6 transition)
- MAC addresses
- How to switch the IoT devices when changing operators?
- OTA (Over-the-air) programming of SIMs

Source: BEREC Report “Enabling the Internet of Things” 12 February 2016,
IoT and regulatory issues

- Licensed Vs Non Licensed spectrum
- Area of license
- Numbering
- Standardization
- Infrastructure sharing
- Access to data and open IOT platforms
- Data analytics
- Mobile data roaming
- Consumer protection
- Quality of Service
- USO
- Taxation

One world, one global SIM: How ITU-allocated ‘global IMSI ranges’ support IoT and M2M connectivity

https://news.itu.int/one-world-one-global-sim/

Global International Mobile Subscriber Identity (IMSI) ranges are signified by the shared Mobile Country Code ‘901’, a code without ties to any particular country.
PRIVACY AND SECURITY ISSUES

- Privacy Issues as in IoT environment, data is collected and shared automatically by devices, and some may be critical in nature
  - Data protection vs Open data
  - Applicable laws
  - Entity responsible for data protection
  - Who can have access to the data collected?
  - Data classification and processing
  - Consent of data owner?
  - National vs International collection and sharing of data
- Security of device and data
- Consumer protection
- IoT devices should follow a security and privacy “by design” approach

| Open data and APIs | IoT data is often held in “silos” that are difficult to integrate without time-consuming data discovery and licensing. IoT platforms can be industry and vendor-specific, limiting opportunities for SMEs and startups to participate. | City and country initiatives to provide for the sharing of information by individuals and organizations under non-proprietary, open source licences. | Further work to encourage cataloguing of and contributions to open datasets. National and local government authorities are in a key position to do this, and could collaborate through Open Government Partnership. |
IoT and regulatory issues
INTEROPERABILITY AND STANDARDS

- IoTs have both public and proprietary standards currently
- Standardization is important for Interoperability, reducing costs and barriers to entry
  - ITU-T SG 20 (IOT and Smart Cities, Smart Communities)
  - National Standardization bodies
  - International Standardization bodies
- How to coordinate interoperability amongst public and private sector entities?
  e.g. parking meters, thermostats, cardiac monitors, tires, roads, car components, supermarket shelves
- Cross-sectoral collaboration is very important as IoT are deployed in multiple sectors
Thank You