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

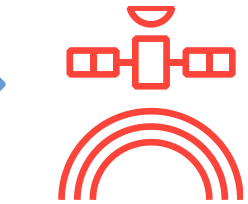
30 September – 3 October 2019,
Bangkok, Thailand

Meet us

What we do

‘Committed to Connecting the World’

3 Sectors



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

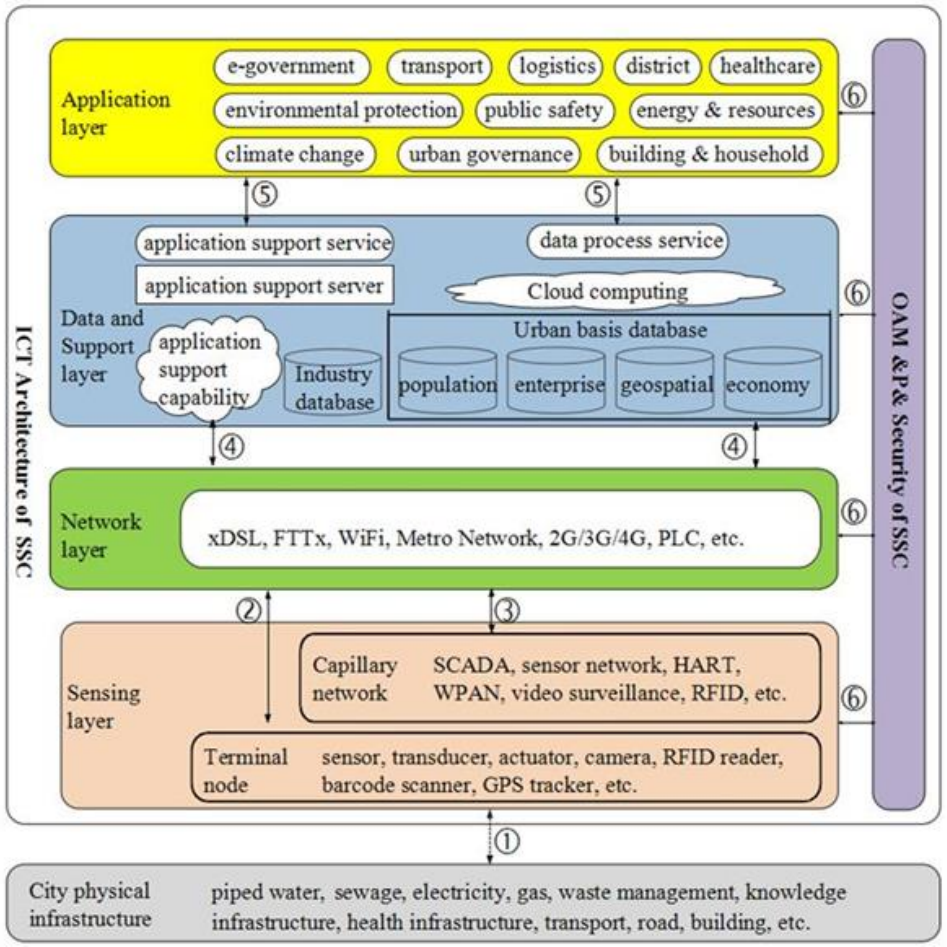
+800 MEMBERS FROM THE PRIVATE SECTOR, ACADEMIA AND INTERNATIONAL AND REGIONAL ORGANIZATIONS

Digital transformation is key to accelerate our progress towards SDGs..

17 Sustainable Development Goals

169 Targets

Digital transformation requires an ecosystem approach



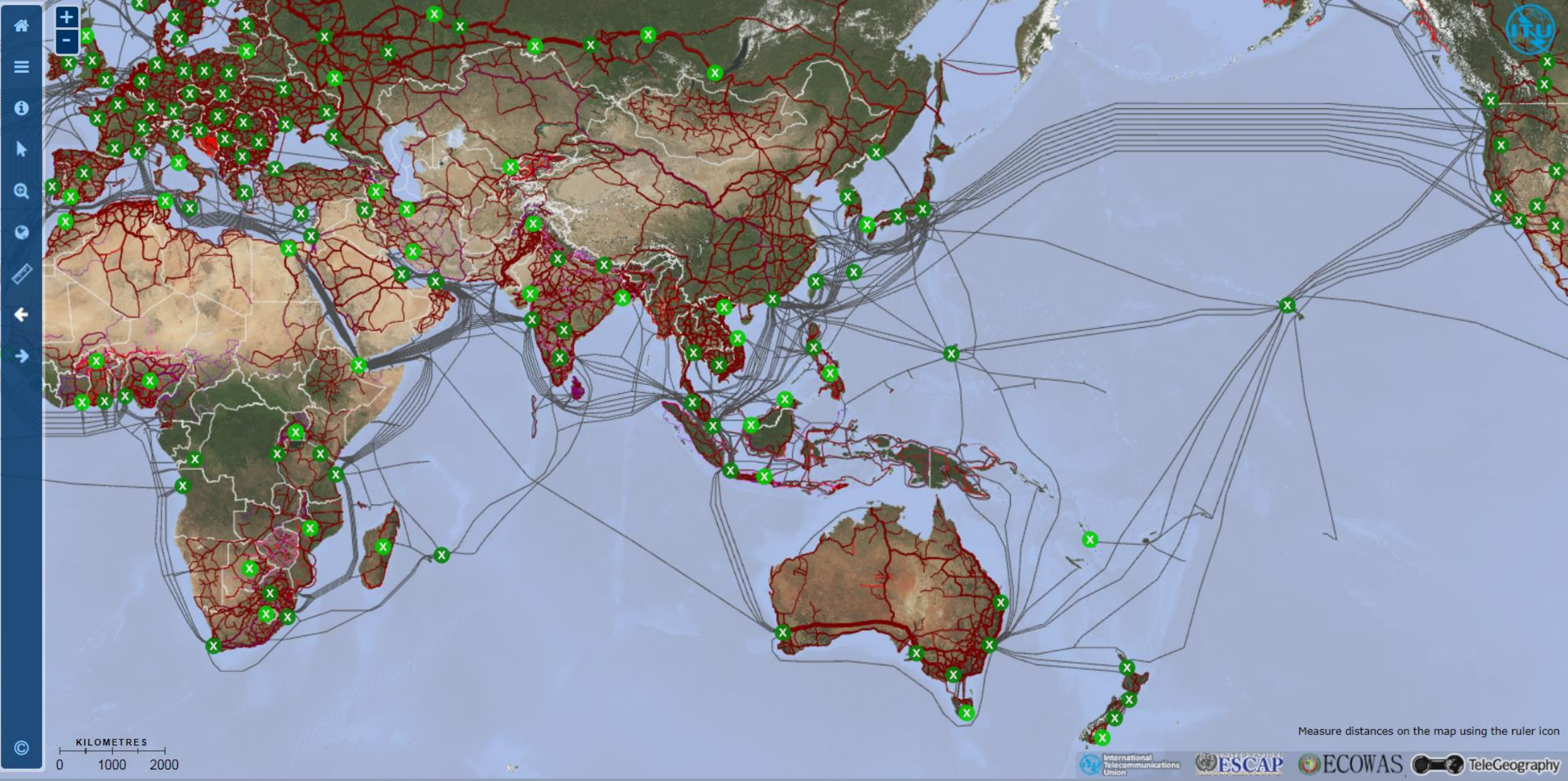
+

Enabling Environment , Digital Inclusion

Skills and capacity Building

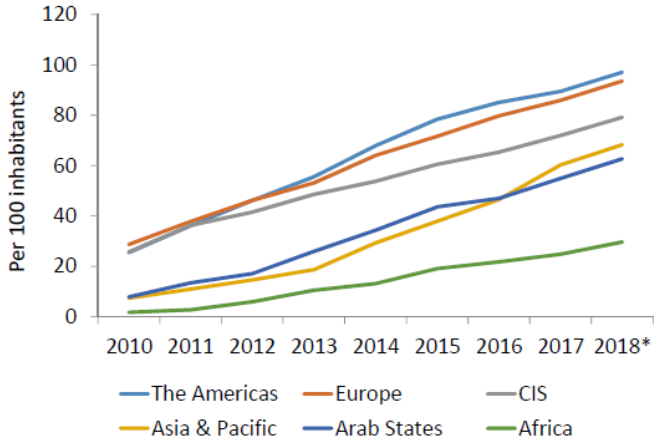
Innovation

Source: ITU-T Focus Group on Smart Sustainable Cities



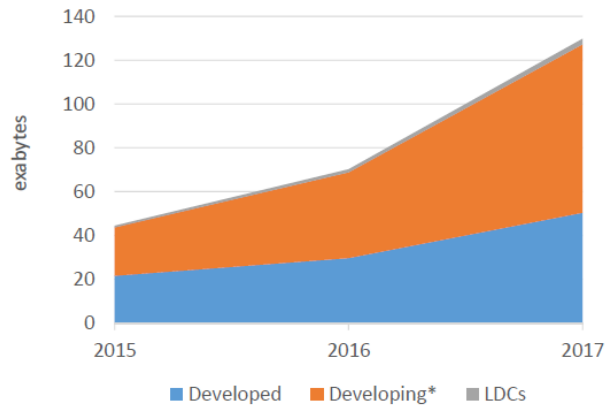
Digital infrastructure - Key to digital transformation

LDCs and LLDCs need catalyst to accelerate their journey..



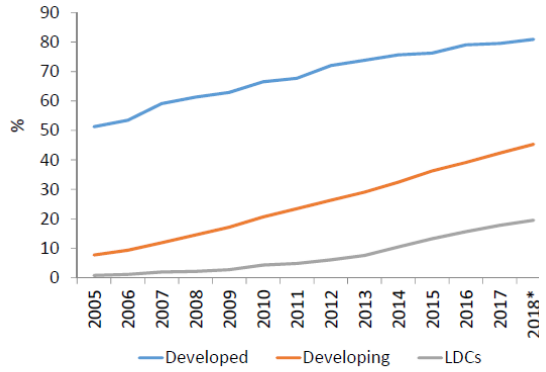
Note: * ITU estimate.
Source: ITU.

Active mobile-broadband subscriptions per 100 inhabitants, by region, 2010–2018*



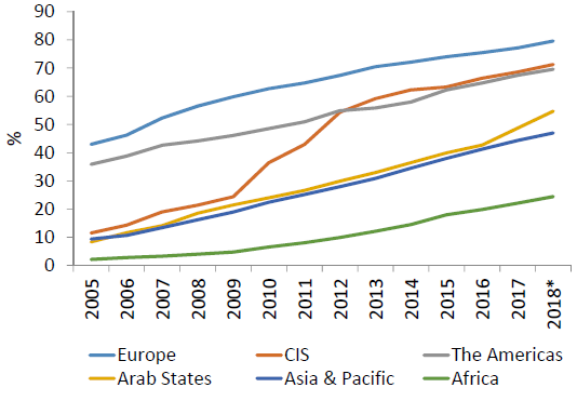
Note: * Excluding LDCs.
Source: ITU.

Mobile-broadband traffic, exabytes, 2015–2017



Note: * ITU estimate.
Source: ITU.

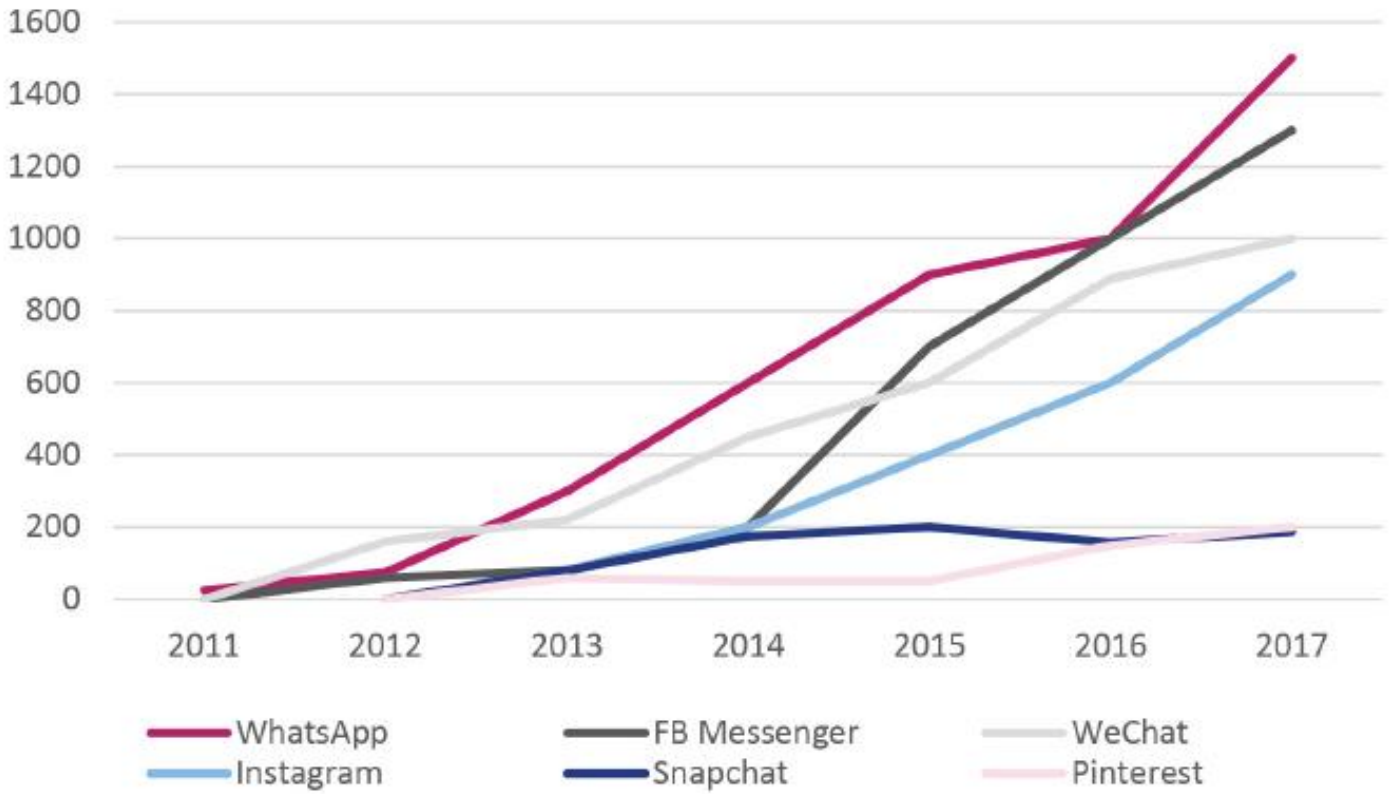
Individuals using the Internet by development status, 2005–2018*



Note: * ITU estimate.
Source: ITU.

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.

Estimates of the Global Market: 2015, 2016, 2017, 2020 and 2021

	2015	2016	2017	2020	2021
Mobile cellular subscriptions	7.2 bn (ITU) 7.2 bn (GSMA) 7.2 bn (E)	7.4 bn (ITU) 7.5 bn (GSMA) 7.5 bn (E)	7.74 bn (ITU) 7.8 bn (E)	8.3 bn (GSMA) 8.4 bn (E)	8.4 bn (GSMA) 8.6 bn (E)
Unique mobile phone users	4.6 bn (GSMA) 5.0 bn (E)	4.8 bn (GSMA) 5.1 bn (E)	5 bn (GSMA) 5.3 bn (E)	5.4 bn (GSMA) 5.7 bn (E) 5.4 bn (Cisco)[3]	5.5 bn (GSMA) 5.8 bn (E)
LTE subscriptions	1.1 bn (GSMA) 1.1 bn (E) 1.37 bn (ABI Research)[4] 1.068 bn (GSA)	1.8 bn (GSMA) 1.9 bn (E*) 2 bn (Strategy Analytics[5])	2.6 billion (GSMA) 2.8 bn (E*)	4.1 bn (GSMA) 3.5 bn (ABI) 4.8 bn (E) 3.6 bn (4G Am)	4.5 bn (GSMA) 5.3 bn (E)
5G subscriptions	-/-	-/-	-/-	70 m (GSMA) 55 million (E)	220 m (GSMA) 190 million (E)
Mobile broadband subscriptions	3.2 bn (ITU) 3.4 bn (GSMA) 3.6 bn (E)	3.65 bn (ITU); 4.1 bn (GSMA) 4.5 bn (E)	4.2 bn (ITU) 4.8 bn (GSMA) 5.3 bn (E*)	6.5 bn (GSMA) 7.0 bn (E)	6.9 bn (GSMA) 7.5 bn (E)
Smartphone subscriptions	3.3 bn (GSMA) 3.3 bn (E)	3.9 bn (GSMA) 3.8 bn (E)	4.5 bn (GSMA) 4.4 bn (E*)	5.9 bn (GSMA) 5.8 bn (E)	6.2 bn (GSMA) 6.3 bn (E*)
Fixed broadband (ITU)	820m (ITU)	884m (ITU)	979m (ITU) 1bn (E*)	1.1 bn (E*)	1.2 bn (E*)
Internet users (ITU)	3.21 bn (ITU)	3.49 bn (ITU)	3.58 bn (ITU)	4.16 bn (ITU)	-/-
Facebook users	1.59 bn MAU 1.04 bn DAU[6] (Dec 2015)	1.71 bn MAU 1.13 bn DAU	2.13 bn MAU 1.4 bn DAU	-/-	-/-
LINE users	215 million	217 million	207 million	203 million	-/-
Sina Weibo users	222 million	313 million	392 million	411 million	-/-
Vkontakte users	66.5 million	77.8 million	81.1 million	97 million	-/-
WeChat users	600 million*	806 million	963 million	1 billion	-/-
Smartphone stock	2.2 bn (Del)	-/-	-/-	2.1 bn (BI)[7]	-/

Source: Various. EST = Estimate. BI= Business Intelligence; Del = Deloitte; Facebook, E = Ericsson Mobility Report June 2018 at: https://www.ericsson.com/assets/local/mobility-report/documents/2018/ericsson-mobility-report-june-2018.pdf GSMA = GSMA database.

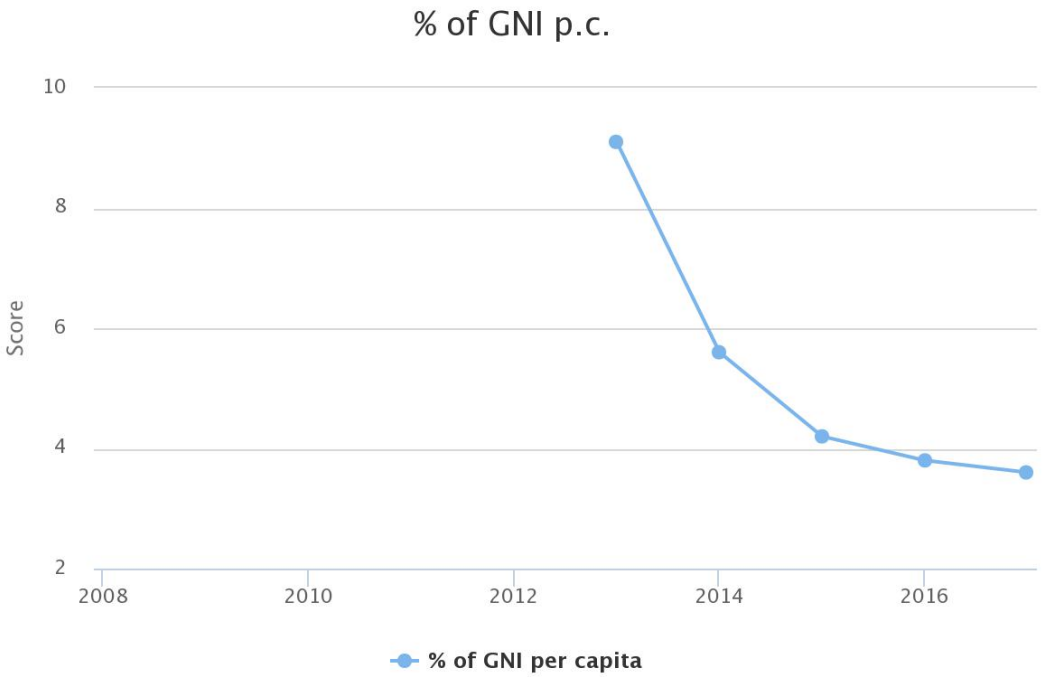
MAU = monthly active users; DAU = daily active users.

** Mid-year figures. https://investor.fb.com/investor-news/press-release-details/2018/Facebook-Reports-Fourth-Quarter-and-Full-Year-2017-Results/default.aspx and https://zephoria.com/top-15-valuable-facebook-statistics/*

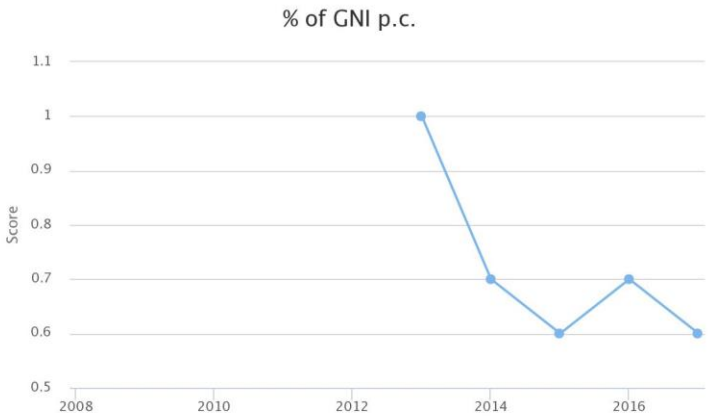
Mobile broadband affordability

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

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



WORLD



DEVELOPED

DEVELOPING

LDCs

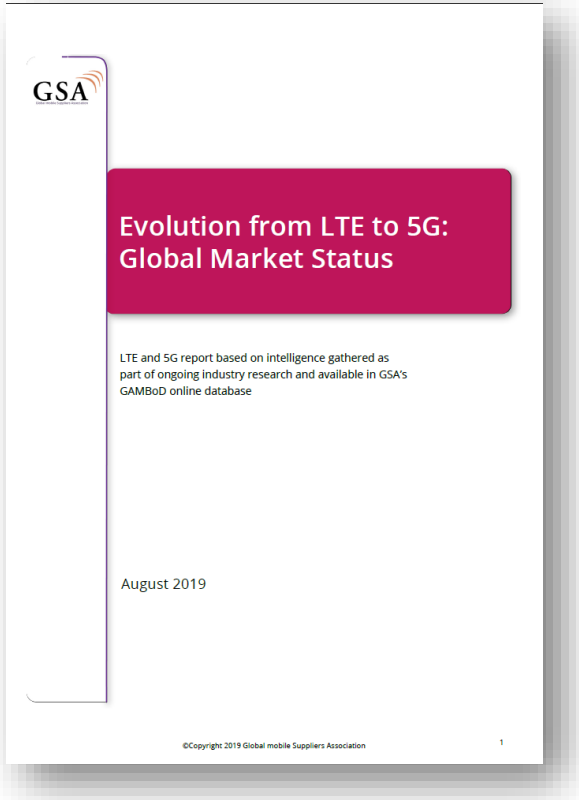
https://www.itu.int/net4/ITU-D/ipb/#ipbtimeseries-tab

Definition

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.*



https://gsacom.com/

•**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.

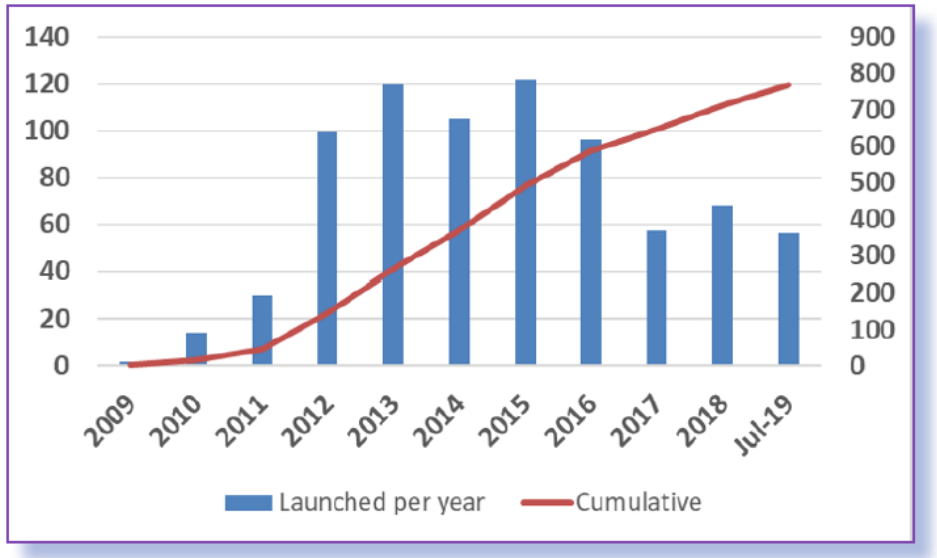
••• **151** operators investing in NB-IoT in 72 countries; of these, **98** NB-IoT networks are deployed/launched in **53** countries. **62** operators are investing in LTE-M/Cat-M1 in **36** countries; of these, **38** LTE-M/Cat-M1 networks are deployed/commercially launched in 26 countries.

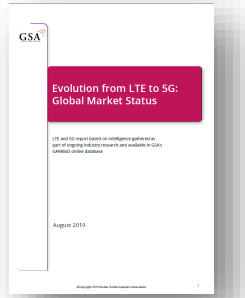
••• **296** operators in **100** countries have launched with limited availability, deployed, demonstrated, are testing or trialling, or have been licensed to conduct field trials of mobile 5G or FWA 5G.

••• **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).

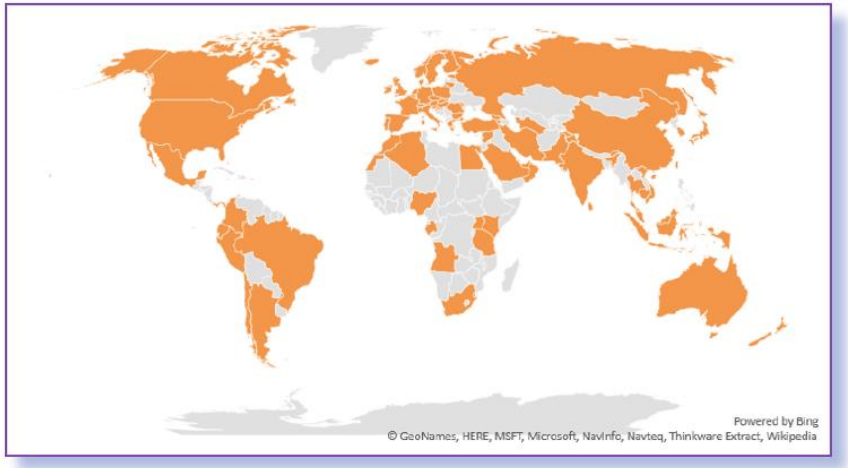
Figure 1: Growth of LTE: networks launched each year, and cumulative (including mobile and FWA networks)





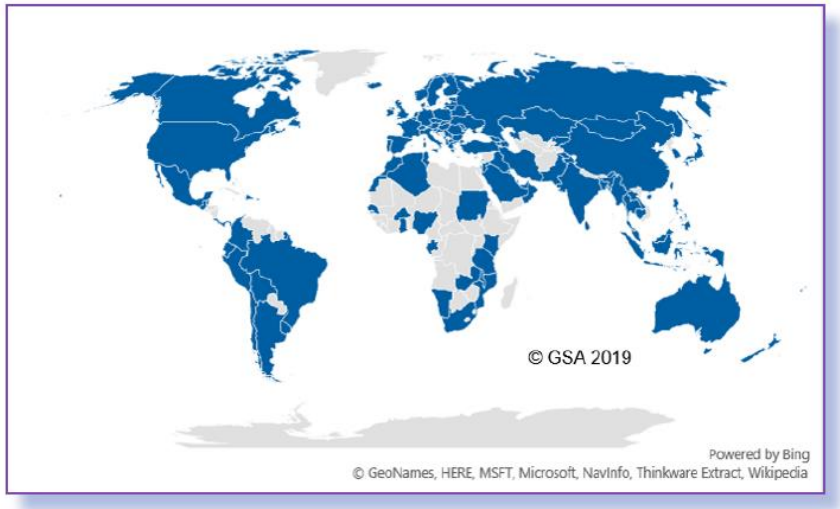
https://gsacom.com/

Figure 7: Countries with launched VoLTE networks

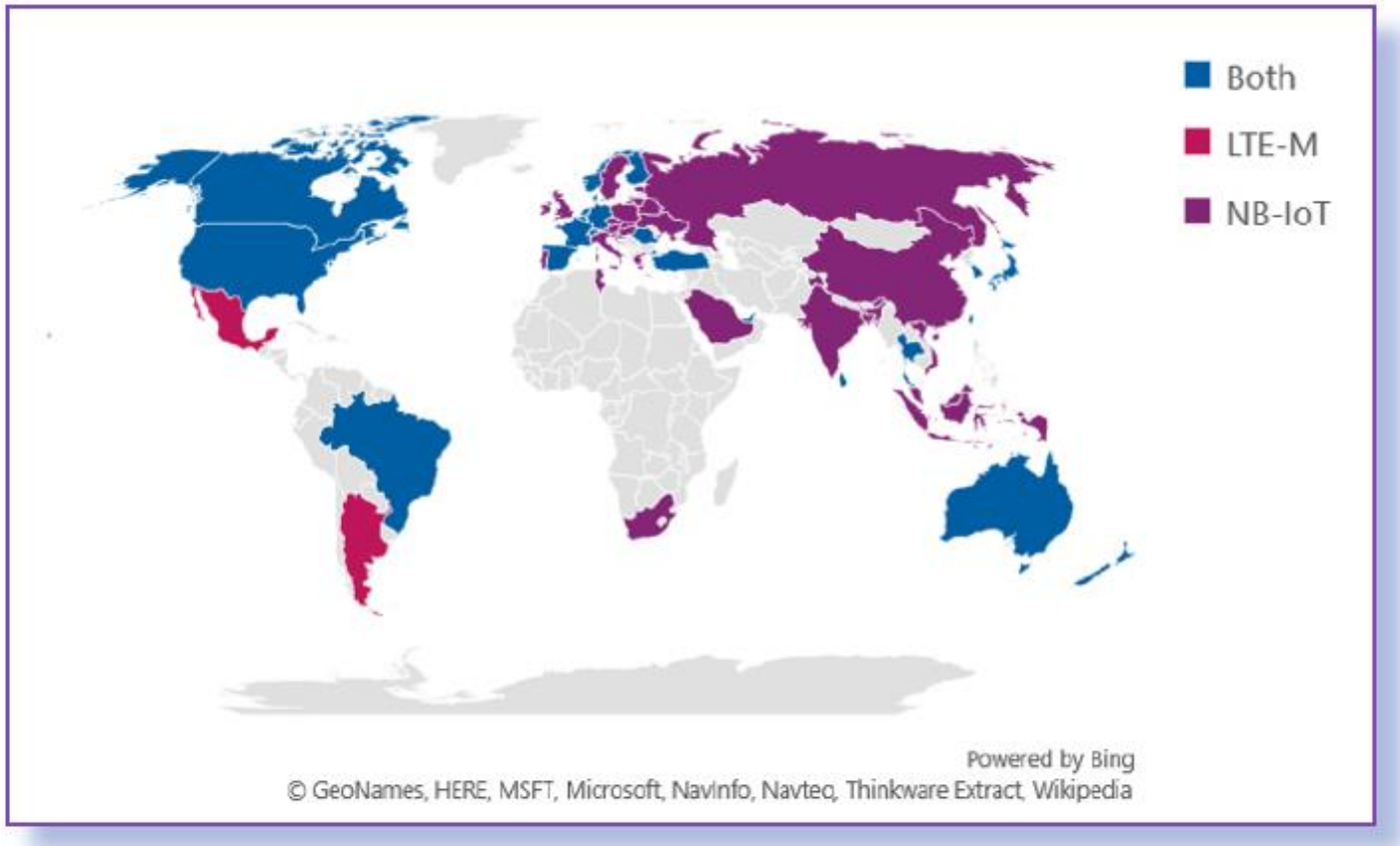


194 operators in 91 countries have launched VoLTE voice services

Figure 8: Countries with launched LTE-Advanced networks



335 operators in 141 countries are investing in LTE-Advanced



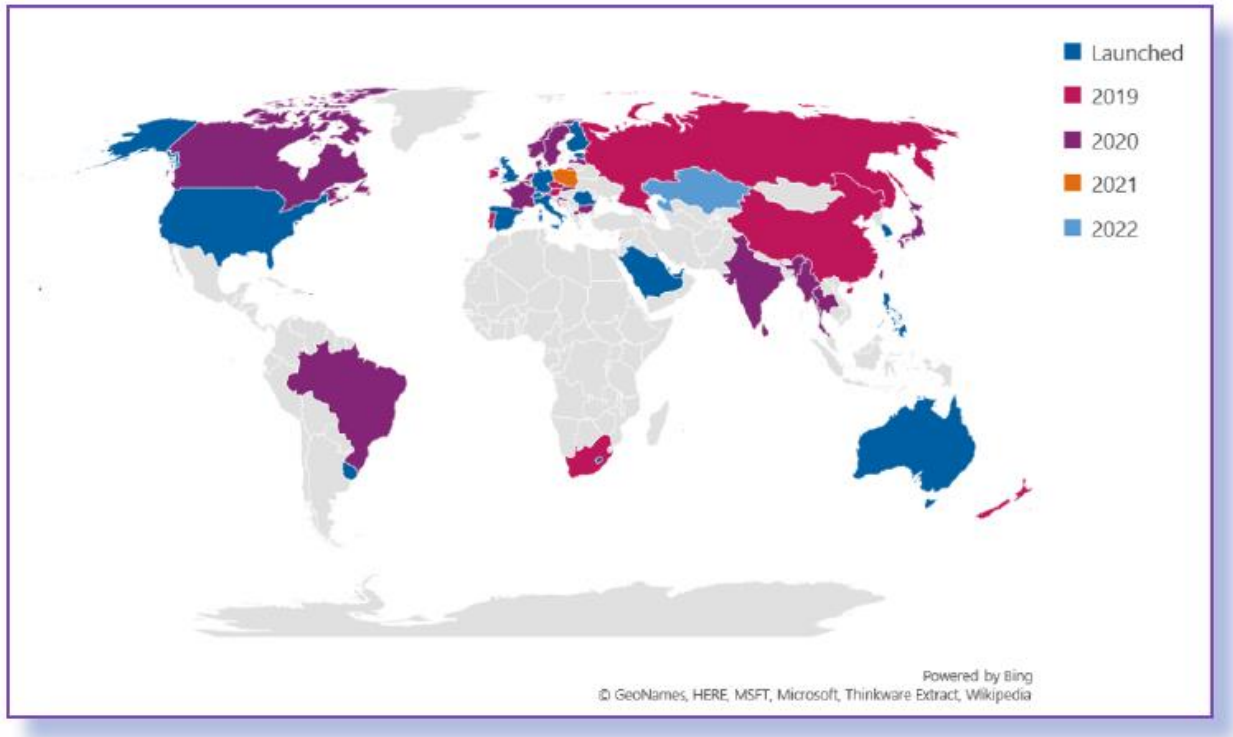
By July 2019, there were 151 operators investing in NB IoT in 72 countries, up from 148 operators in 71 countries in May 2019.

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.

https://gsacom.com/

Figure 14: Earliest expected 5G commercial launch dates (includes mobile or FWA, includes limited availability launches)



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.

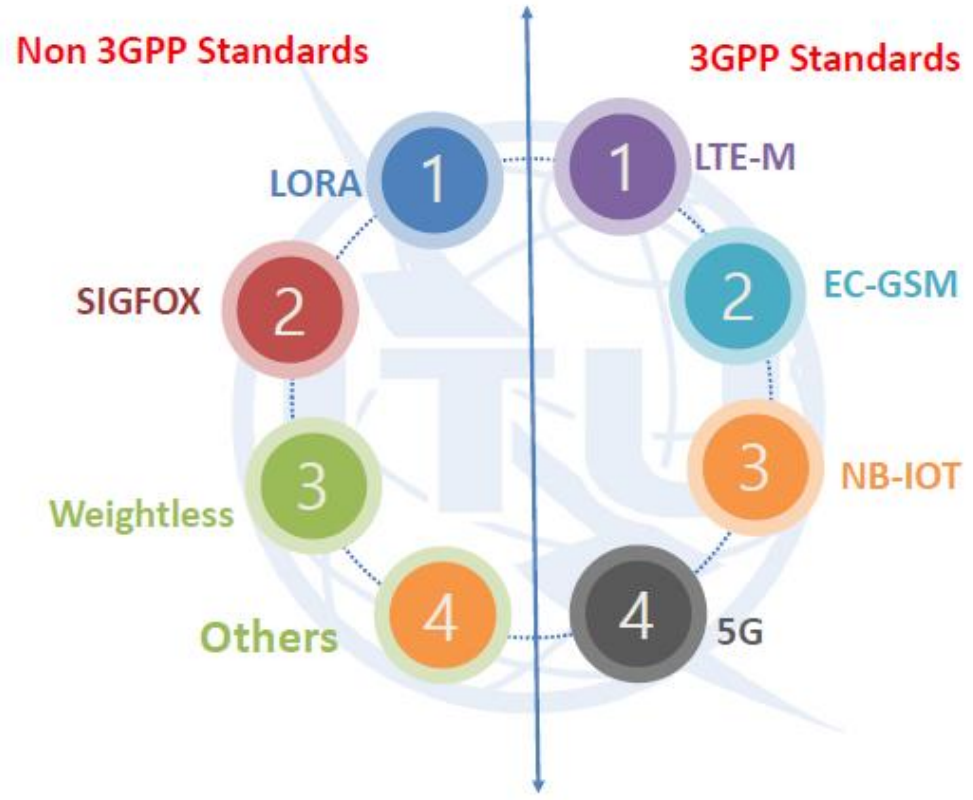
https://gsacom.com/

IoT Technologies

Fixed & Short Range

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

Long Range



LoRaWAN

LoRa Alliance®

LoRa Alliance® ▾ LoRaWAN® ▾ Certification ▾ News Events ▾ Membership ▾ Resource Hub >

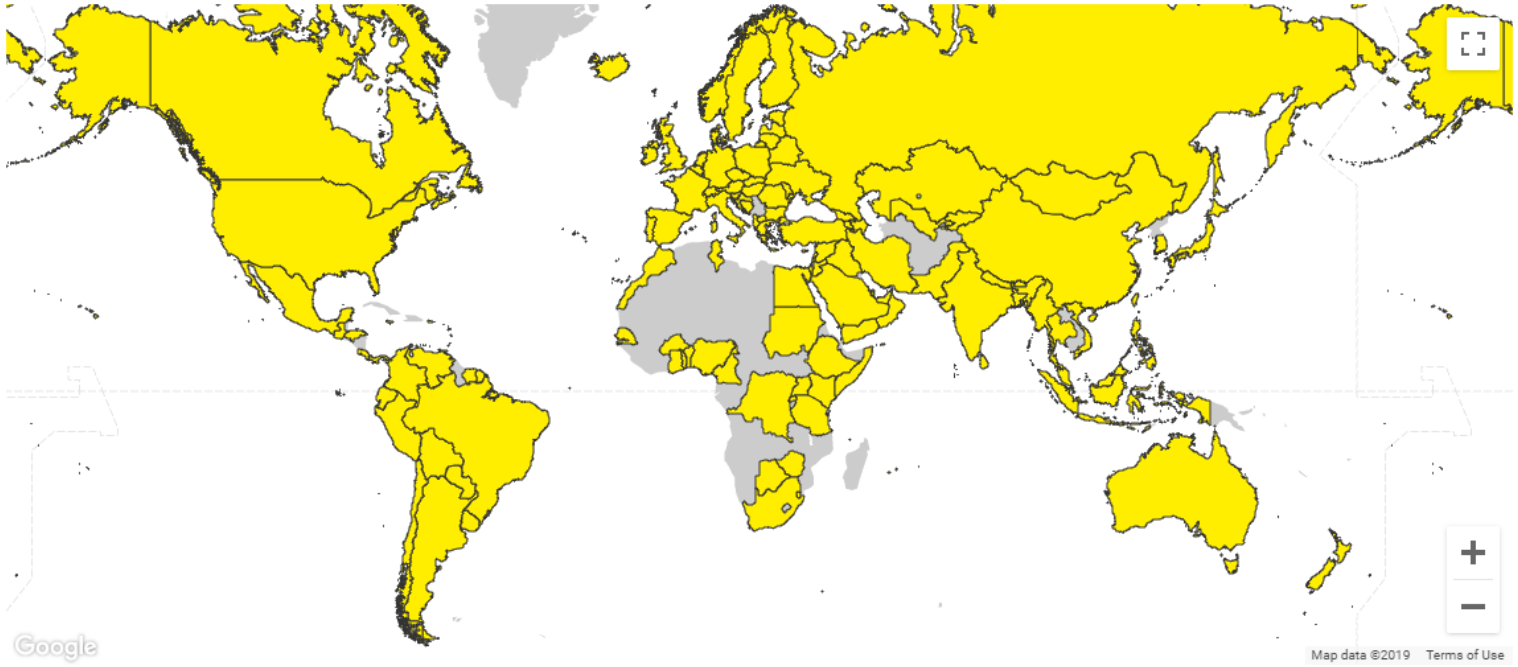
Click on the coverage map to find details of LoRaWAN® Networks by individual country. The extent of LoRaWAN® network coverage globally is significant and expanding on a monthly basis. Please contact the LoRa Alliance members for specific information about their networks.

142 Countries with LoRaWAN® Deployments

121 Network Operators in 58 countries

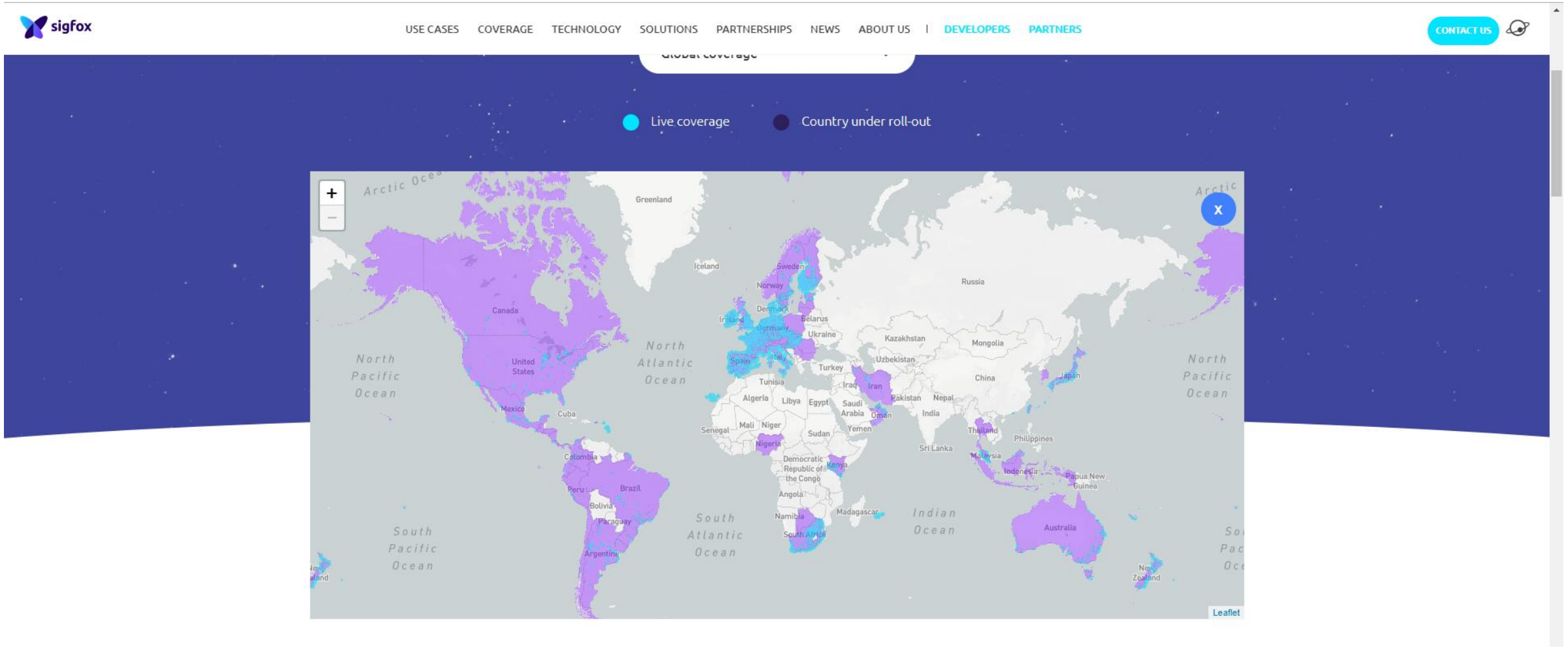
76 LoRa Alliance® Member Operators

LoRaWAN® Global Network Coverage | LoRaWAN® Public Network Operators | LoRaWAN® Open Community Networks



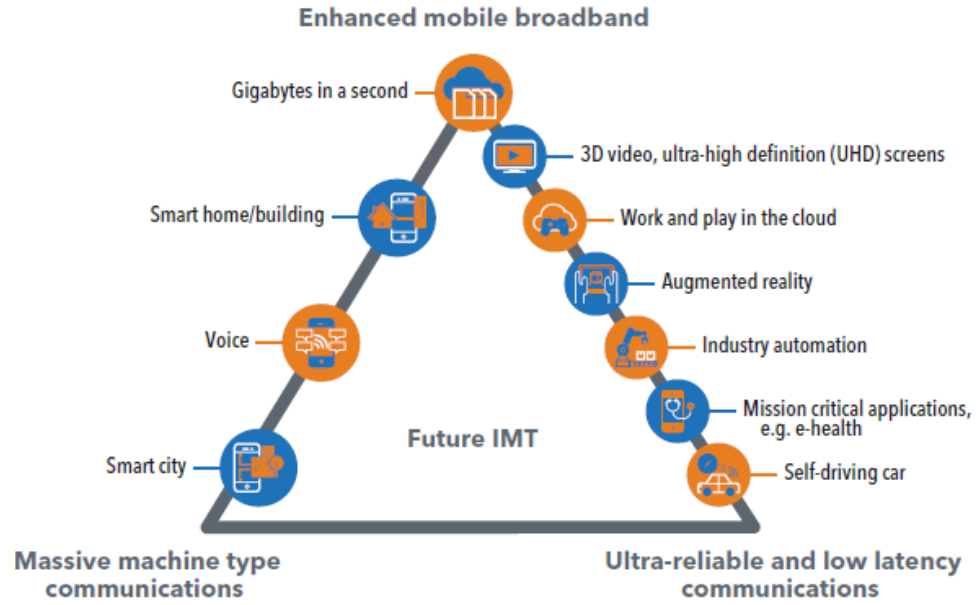
https://www.lora-alliance.org/

Sigfox



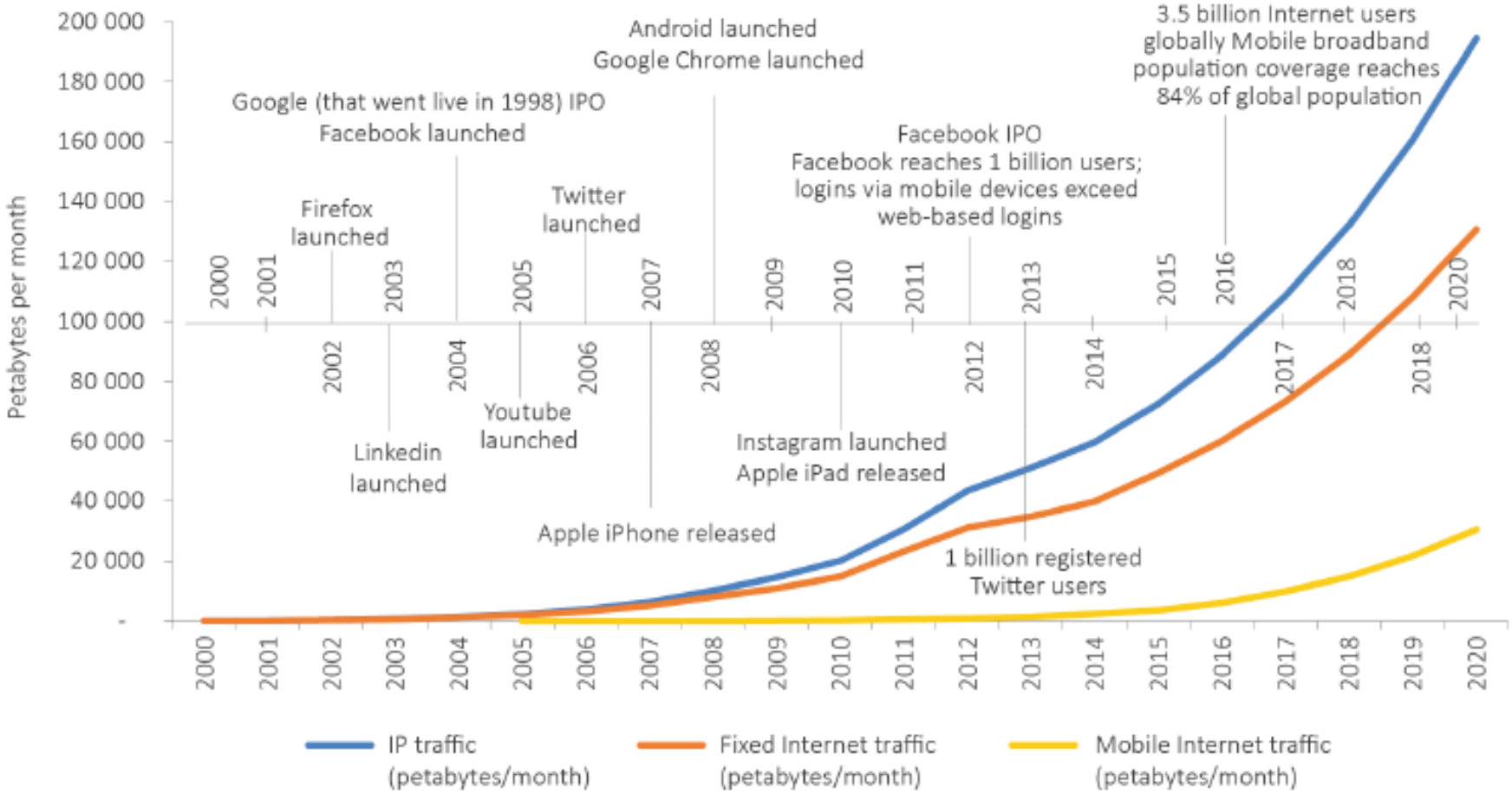
https://www.sigfox.com/en/coverage

5G usage scenarios from the ITU-R IMT-2020 Vision Recommendation



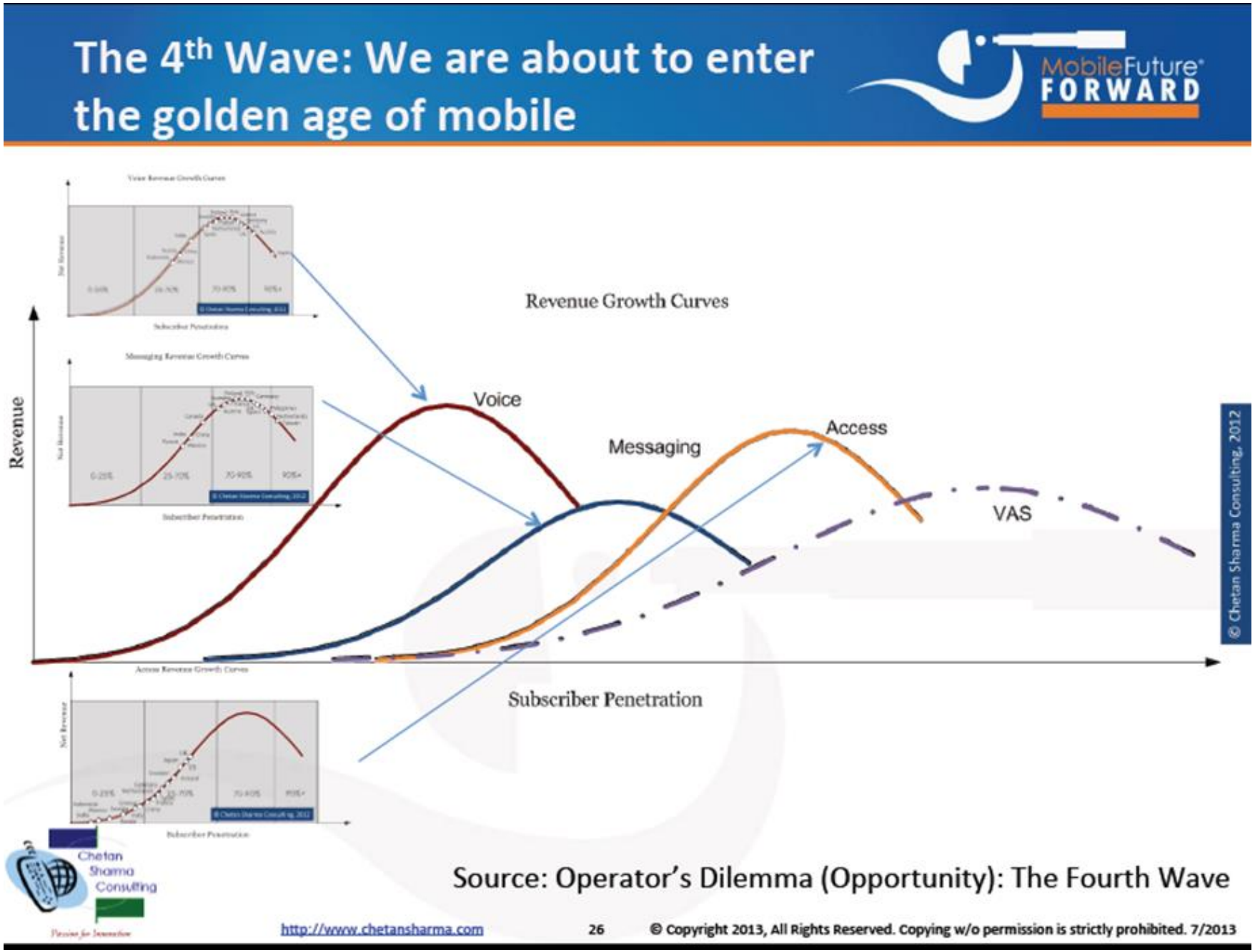
IMT-2020 standardization process

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.

4th Wave


The 4th Wave: We are about to enter the golden age of mobile
MobileFuture FORWARD
Revenue Growth Curves
Revenue
Voice
Messaging
Access
VAS
Subscriber Penetration
© Chetan Sharma Consulting, 2012
Chetan Sharma Consulting
Source: Operator's Dilemma (Opportunity): The Fourth Wave
http://www.chetansharma.com
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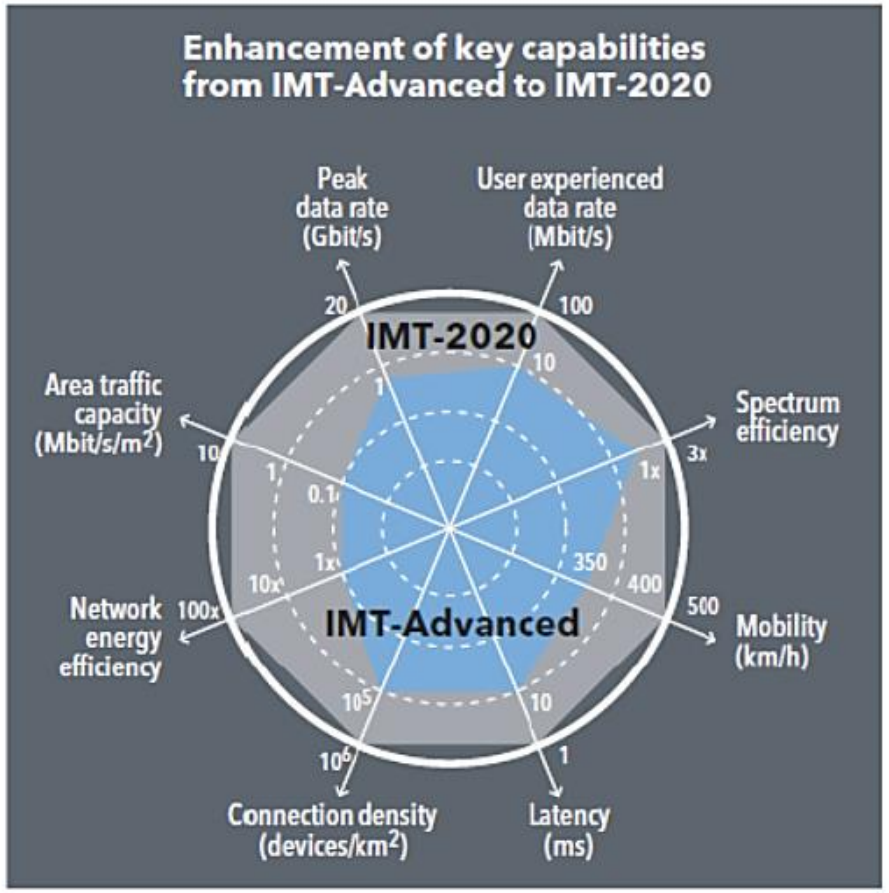
5G

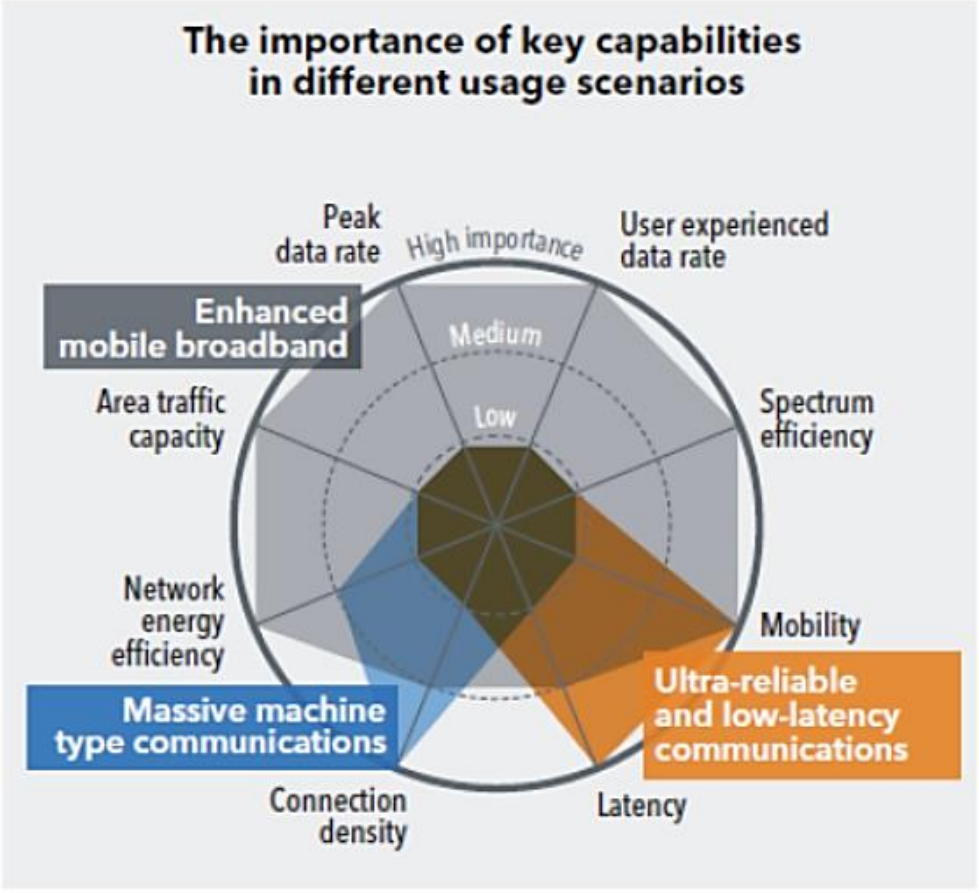
Commercial 5G networks are expected to start deployment after 2020 as 5G standards are finalized. Republic of Korea has launched 5G.

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.

	1G	2G	3G	4G	5G
Approximate deployment date	1980s	1990s	2000s	2010s	2020s
Theoretical download speed	2kbit/s	384kbit/s	56Mbit/s	1Gbit/s	10Gbit/s
Latency	N/A	629 ms	212 ms	60-98 ms	< 1 ms

IMT 2020 Vision





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)***

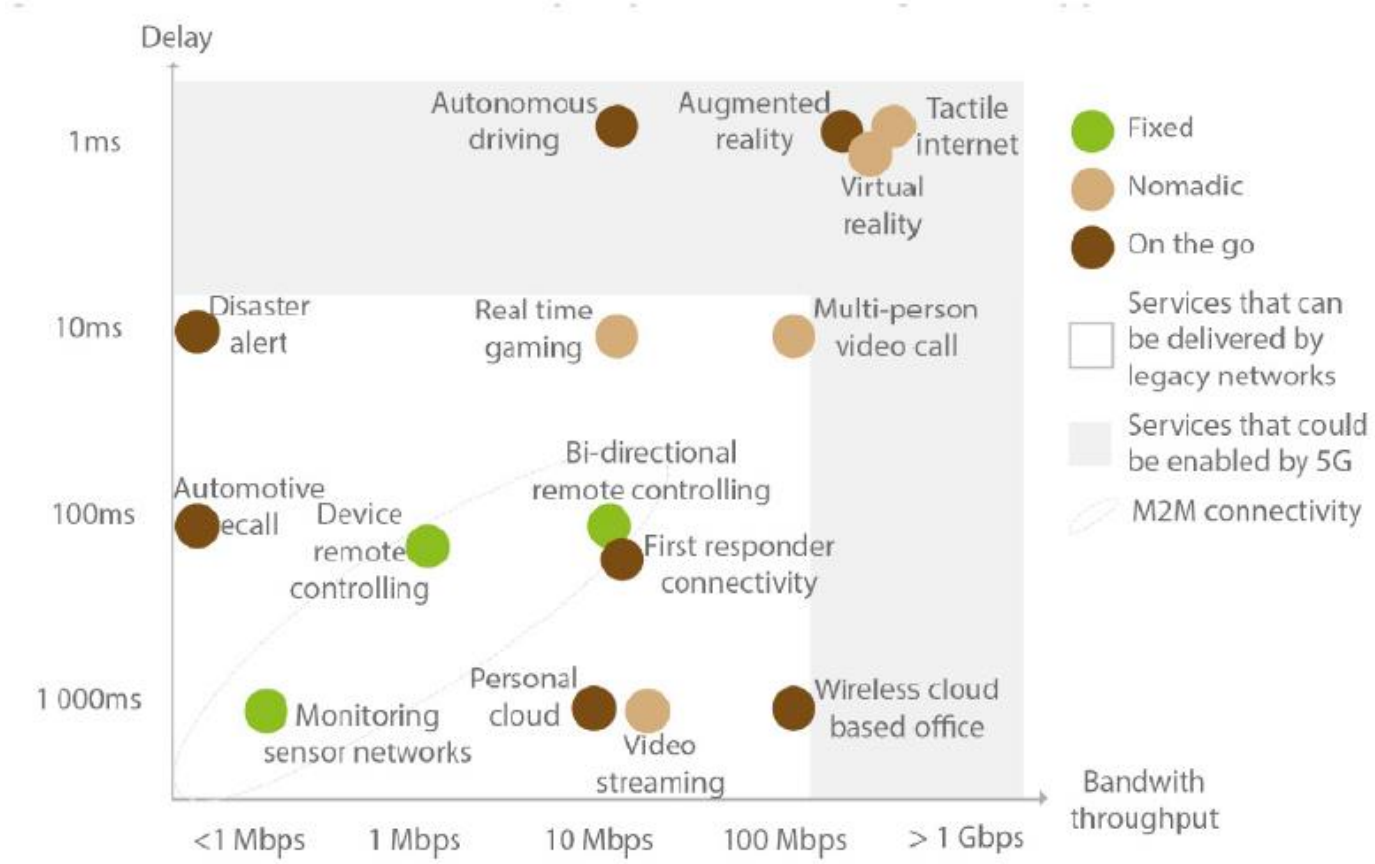
5G and Socio-Economic Benefits

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



Source: GSMA Intelligence, 2015.

5G: 16 key issues for policy-makers to consider

1)	Investment case	Policy-makers may consider undertaking their own independent economic assessment of the commercial viability of deploying 5G networks
2)	4G network strategy	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
3)	Harmonize spectrum	NRAs may consider allocating/assigning globally harmonized 5G spectrum bands
4)	Spectrum roadmap	NRAs may consider adopting a spectrum roadmap and a predictable renewal process
5)	Spectrum sharing	NRAs may consider allowing sharing to maximize efficient use of available spectrum, particularly to benefit rural areas
6)	Spectrum pricing	NRAs may consider selecting spectrum award procedures that favour investment
7)	700Mhz spectrum	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
8)	Fibre investment incentives	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.

5G: 16 key issues for policy-makers to consider

9)	Fibre tax	Policy-makers may consider removing any tax burdens associated with deploying fibre networks to reduce the associated costs
10)	Copper migration to fibre	Policy-makers may consider adopting policies/financial incentives to encourage migration from copper to fibre and stimulate deployment of fibre
11)	Wireless backhaul	Operators may consider a portfolio of wireless technologies for 5G backhaul in addition to fibre, including point-to-multipoint (PMP), microwave and millimeter wave (mmWave) radio relays, high altitude platform systems (HAPS) and satellites
12)	Access/sharing of passive infrastructure	Policy makers may consider allowing access to government-owned infrastructure such as utility poles, traffic lights and lampposts to give wireless operators the appropriate rights to deploy electronic small cell apparatus to street furniture NRAs may consider continuing to elaborate existing duct access regimes to encompass 5G networks allowing affordable fibre deployments
13)	Access costs	Policy-makers/NRAs may consider ensuring reasonable fees are charged to operators to deploy small-cell radio equipment onto street furniture
14)	Asset database	Policy-makers may considerholding a central database identifying key contacts, showing assets such as utility ducts, fibre networks, CCTV posts, lampposts, etc. This will help operators cost and plan their infrastructure deployment more accurately
15)	Wayleave (rights of way) agreements	Policy-makers may agree upon standardized wayleave agreements to reduce cost and time to deploy fibre and wireless networks
16)	5G test beds	Policy-makers may consider encouraging 5G pilots and test beds to test 5G technologies, and use cases, and to stimulate market engagement

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.

Sources: https: / / goo .gl/ kqYCRM (Netherlands), https: / / goo .gl/ vWq7aD (Indonesia), https: / / goo .gl/ vdFxz9 (Ofcom, UK), https: / / goo .gl/ m24g32 (Italy)

Streamlining the deployment of small cells (examples)

In September 2017, a California bill was passed streamlining small cell deployment by per-mitting 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.

Sources: California SB-649, 2017; Florida SB-596, 2017; Washington SB-5711, 2017; Illinois SB-1451, 2017

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.

Sources: https: / / goo .gl/ kqYCRM (Netherlands), https: / / goo .gl/ vWq7aD (Indonesia), https: / / goo .gl/ vdFxz9 (Ofcom, UK), https: / / goo .gl/ m24g32 (Italy)

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.

Sources: https: / / goo .gl/ u2fojb (Spain), https: / / goo .gl/ bT9hZ4 (Portugal), https: / / goo .gl/ vh4LGP (New Zealand), https: / / goo .gl/ AAbapS (Cameroon), https: / / goo .gl/ JmuSnJ (Denmark), https: / / goo .gl/ iSb4sq (Zimbabwe)

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

Spectrum for MTC/IoT applications

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.

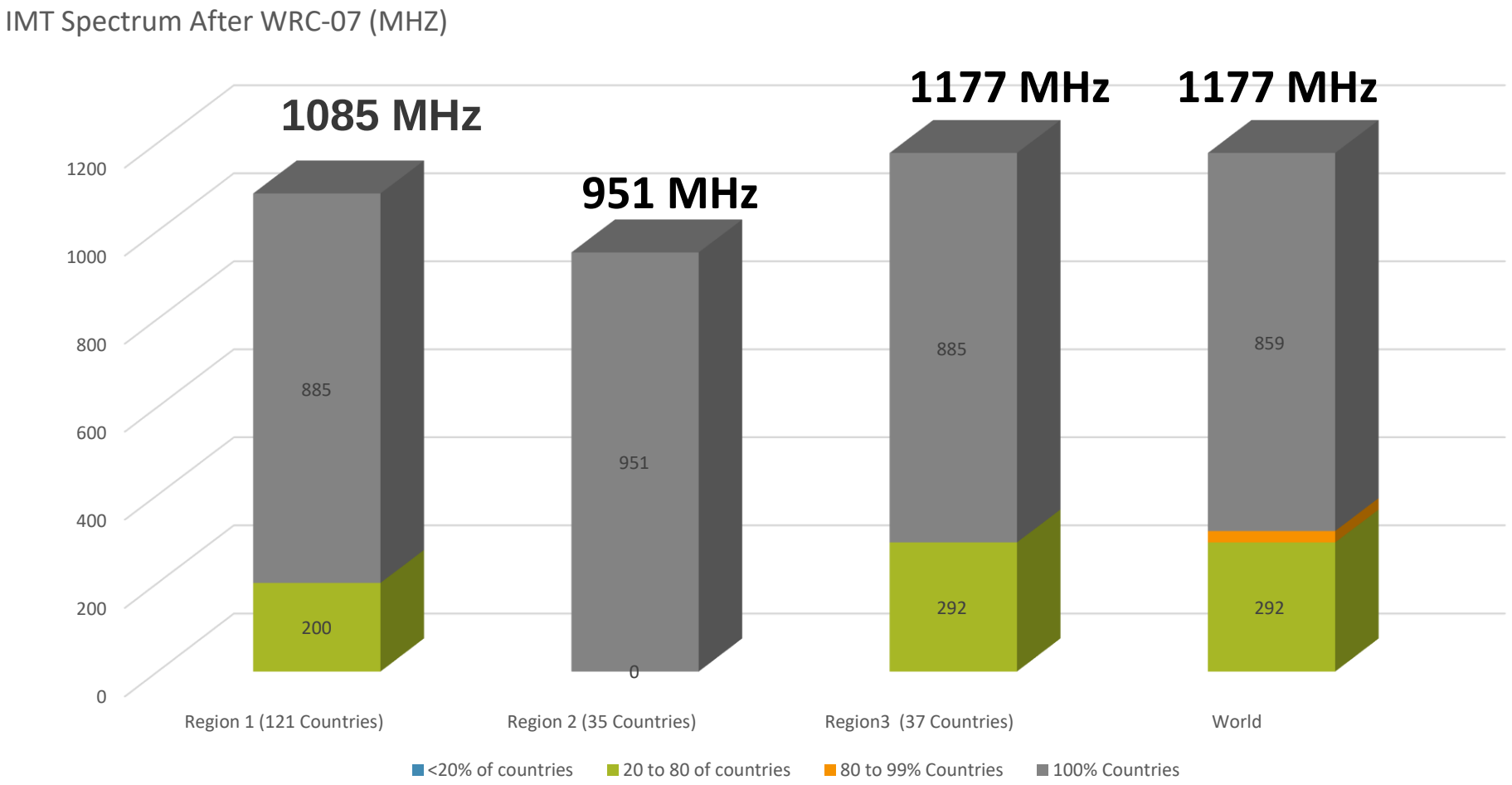
Example: In **China** New bands for M2M:

- 5 905 -5 925 MHz for LTE-V2X trials
- 2 x 2.3 MHz in 800MHz can be used for NB-IoT

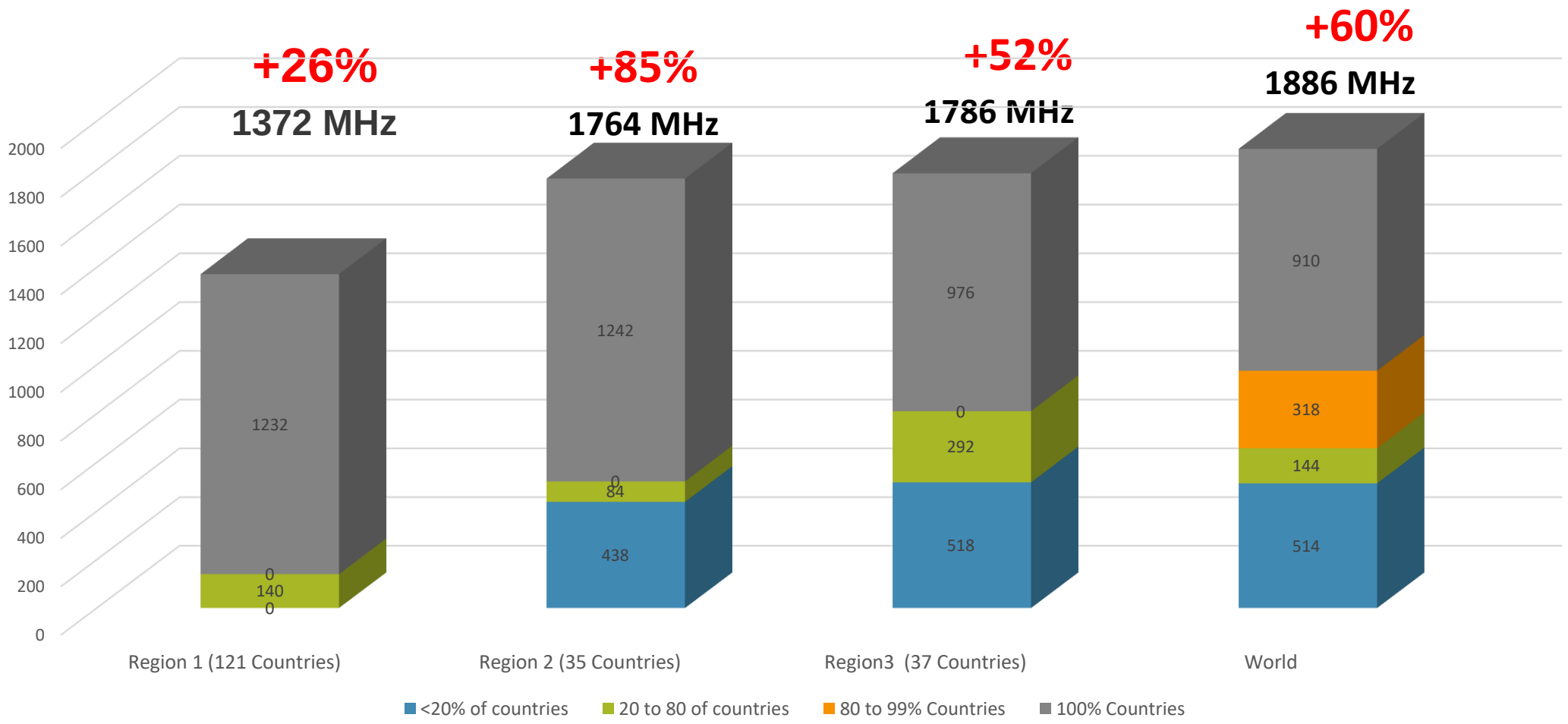
Spectrum - New spectrum bands under study for WRC-19

Existing mobile allocation	No global mobile allocation
24.25 – 27.5 GHz	31.8 – 33.4 GHz
37 – 40.5 GHz	40.5 – 42.5 GHz
42.5 – 43.5 GHz	
45.5 – 47 GHz	47 – 47.2 GHz
47.2 – 50.2 GHz	
50.4 GHz – 52.6 GHz	
66 – 76 GHz	
81 – 86 GHz	

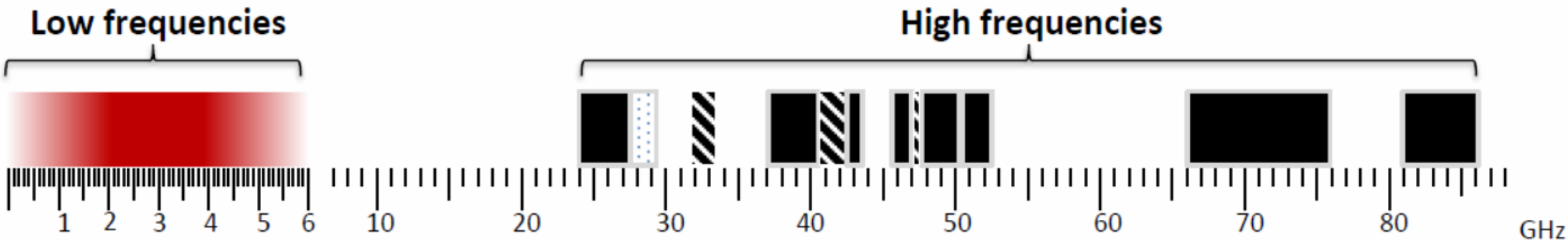
IMT Spectrum after WRC-07



IMT Bands after WRC-15



IMT spectrum requirements and WRC-19



- In scope of WRC-19, already allocated to Mobile Service
- In scope of WRC-19, require allocation to Mobile Service
- Not in scope of WRC-19, but allocated to Mobile Service
- In scope of previous WRCs

Agenda items for WRC-23 will be decided during WRC-19, which will contain additional proposals for IMT-2020

Broadband applications in the MS (WRC-19 agenda items 1.13 and 1.16)

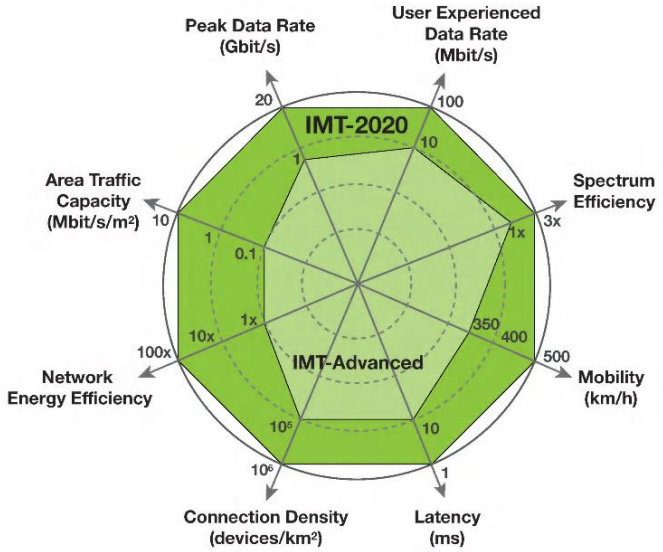
Consider **IMT identification** in the following bands, which **have allocations to the mobile service on a primary basis**:

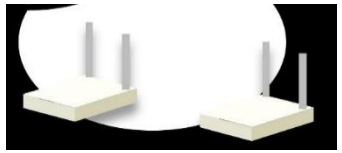
- **24.25 – 27.5 GHz**
- **37 – 40.5 GHz**
- **42.5 – 43.5 GHz**
- **45.5 – 47 GHz**
- **47.2 – 50.2 GHz**
- **50.4 – 52.6 GHz**
- **66 – 76 GHz**
- **81 – 86 GHz**

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**

► **Res. 238 (WRC-15)**





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

► **Res. 239 (WRC-15)**

Overlapping frequency bands (GHz) between some WRC-19 agenda items

AI1.6 – NGSO FSS Res. 159 (WRC-15)	AI1.13 – IMT Res. 238 (WRC-15)	AI1.14 – HAPS Res. 160 (WRC-15)	AI9.1 (9.1.9) – FSS Res. 162 (WRC-15)
	24.25-27.5	24.25-27.5 (Reg. 2)	
37.5-39.5 (s-E*)	37-40.5	38-39.5 (globally)	
39.5-42.5 (s-E*)	40.5-42.5		
47.2-50.2 (E-s*)	47.2-50.2		
50.4-51.4 (E-s*)	50.4-52.6		51.4-52.4 (E-s*)
* 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

Future Spectrum need estimation for IMT
(24.25 GHz - 86 GHz)

	Examples	Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)	Spectrum needs in total (GHz)	Spectrum needs (GHz) per range
Application-based approach ITU-R M.1651	1	Overcrowded, Dense urban and Urban areas	**18.7**	➢ 3.3 (24.25-33.4 GHz range) ➢ 6.1 (37-52.6 GHz range) ➢ 9.3 (66-86 GHz range)
		Dense urban and Urban areas	**11.4**	➢ 2.0 (24.25-33.4 GHz range) ➢ 3.7 (37-52.6 GHz range) ➢ 5.7 (66-86 GHz range)
	2	Highly crowded area	**3.7**	➢ 0.67 (24.25-33.4 GHz range) ➢ 1.2 (37-52.6 GHz range) ➢ 1.9 (66-86 GHz range)
		Crowded area	**1.8**	➢ 0.33 (24.25-33.4 GHz range) ➢ 0.61 (37-52.6 GHz range) ➢ 0.93 (66-86 GHz range)

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

Future Spectrum need estimation for IMT
(24.25 GHz - 86 GHz)

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

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)

	Examples	Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)	Spectrum needs in total (GHz)	Spectrum needs (GHz) per range
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 (24.25-43.5GHz and 45.5-86 GHz range)
Information from some countries based on their national considerations	–	–	**7-16**	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)

Deployment scenarios	Indoor hotspot	Dense urban		Urban macro
		Micro	Macro	
Frequency range	24.25-86 GHz	24.25-43.5 GHz	<6 GHz	<6 GHz

Deployment scenario	Micro	Indoor hotspot
Total spectrum needs for 24.25-86 GHz	14.8-19.7 GHz*	
Spectrum needs for 24.25-43.5 GHz	5.8-7.7 GHz	9-12 GHz
Spectrum needs for 45.5-86 GHz	–**	

** 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.*

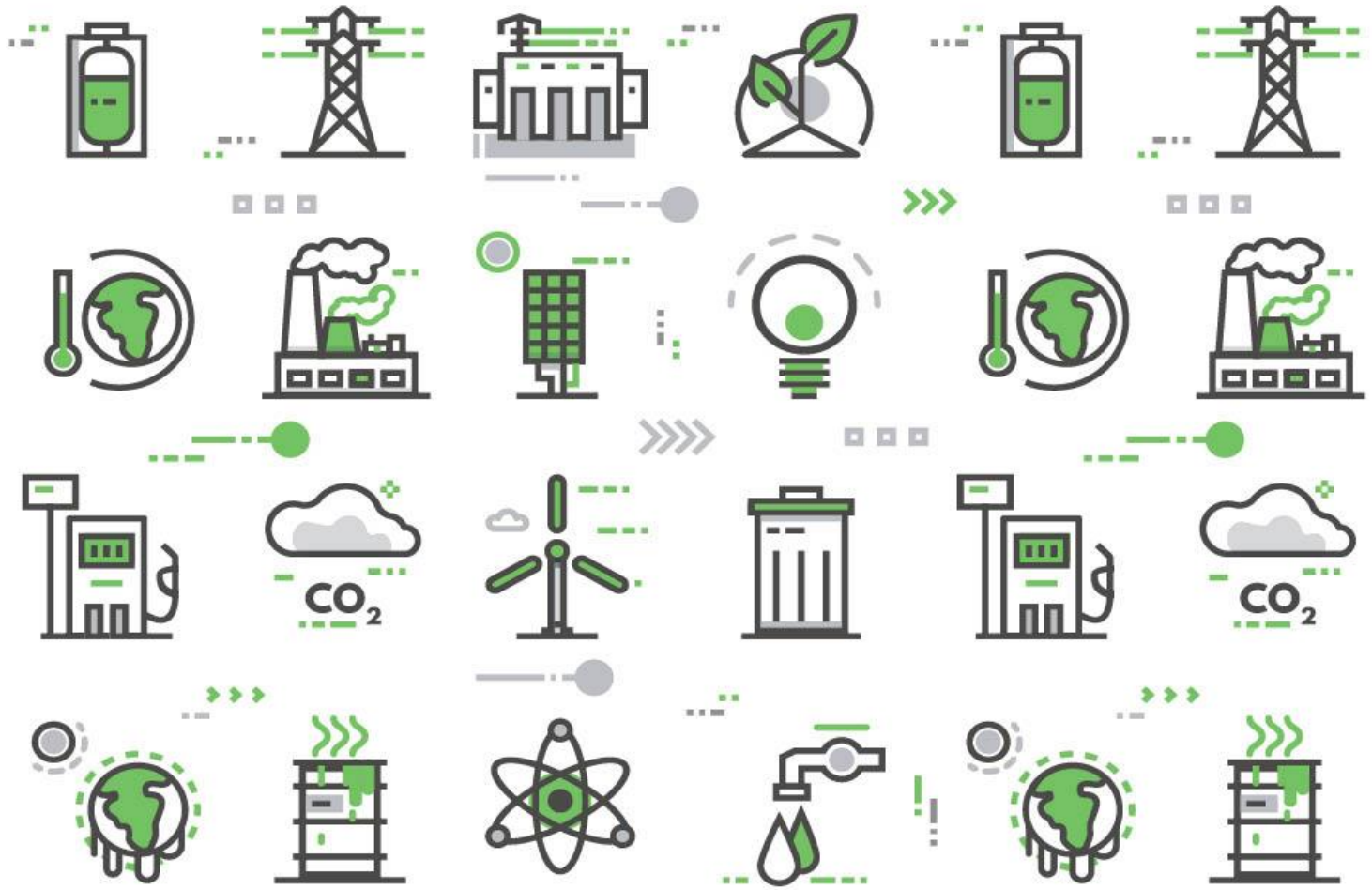
*** The division in this table regarding frequency ranges and deployment scenarios is just an indicative example on how spectrum needs could be distributed for different spectrum sub-ranges within 24.25-86 GHz and different deployment scenarios. This table should not be understood nor used to exclude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

ITU Activities on IoT & Smart Sustainable Cities

Development and implementation of standards → ITU-T Study Group 20

Research & pre-standardization work → Focus Group on Data Processing Management (FG-DPM) & Focus Group on Environmental Efficiency for AI and other Emerging Technologies (FG-AI4EE)

Projects, Open platform for knowledge sharing and raising awareness → 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-AFR
- SG20RG-ARB
- 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

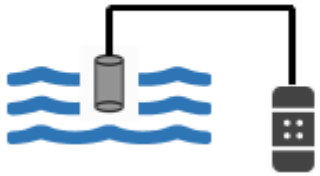
IoT-based smart grid

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

Smart Learning

Internet of living things

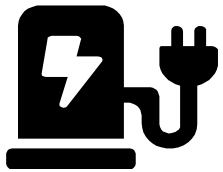
Smart Manufacturing

Smart waste collection and consumption monitoring

Quality checks and maintenance using cameras and sensors

Cloud computing for supply chain management

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

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

1 draft Recommendation determined

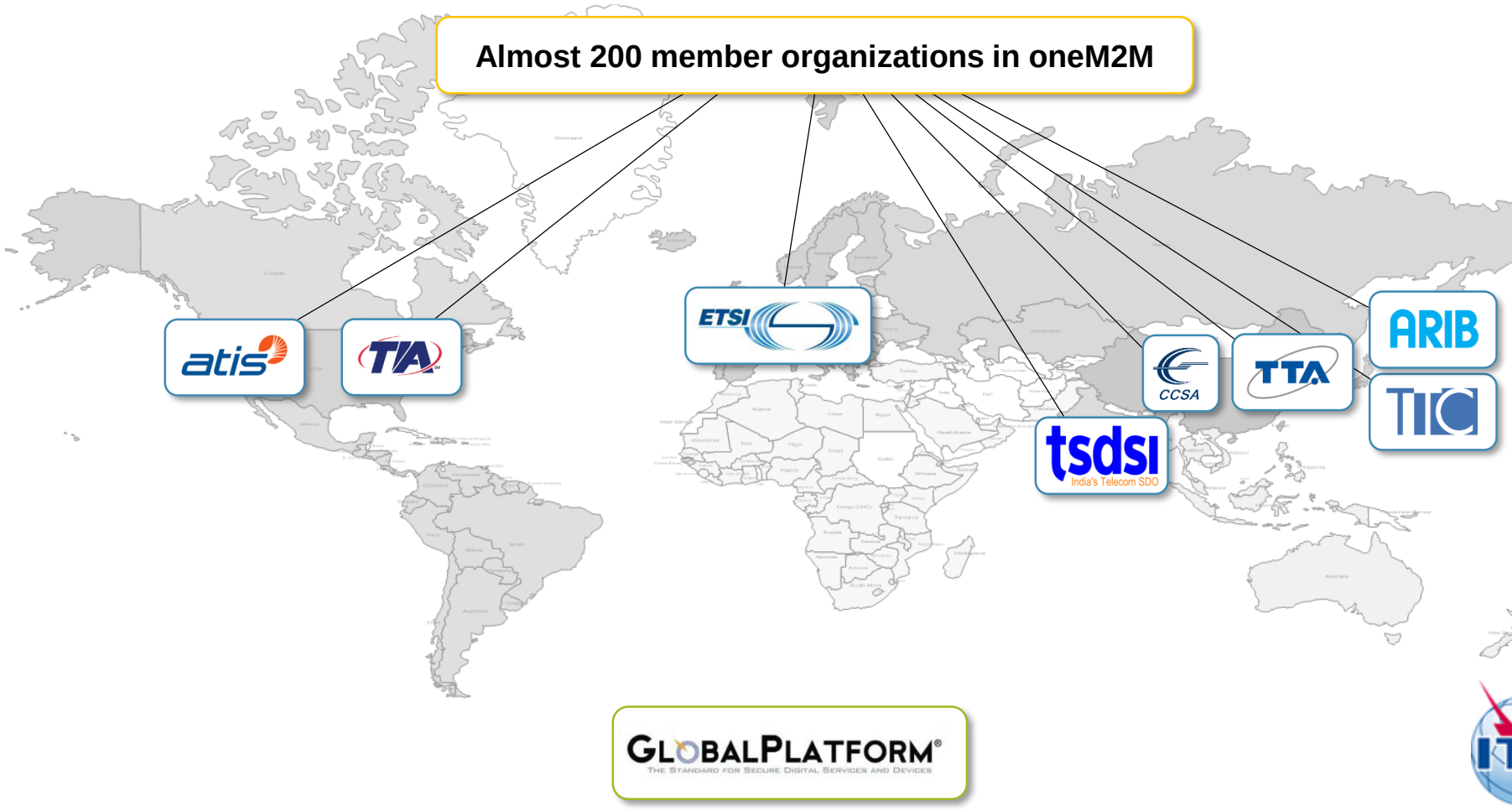
ITU-T Rec. Number	Work item or provisional name	Title	Q
Y.4556	Y.SC-Residential	Requirements and functional architecture of smart residential community	4/20

ITU-T SG20 Main outcomes
Geneva, Switzerland, 9-18 April 2019

7 new work items

Question	Working title	Title
1/20	Y.rrm-data	Requirements and reference model of IoT related data from city infrastructure
3/20	Y.IoT-AOS-prot	Protocols of supporting autonomic operations in the Internet of things
4/20	Y.smart-education	Requirements and reference architecture of smart education
4/20	Y.BC-SON	Framework of blockchain-based self-organization networking in IoT environments
4/20	Y.IoT-SCS	Requirements and functional architecture for smart construction site services
4/20	Y.UAV-BSI	Requirements and functional architecture of base station inspection services using unmanned aerial vehicles
4/20	Y.smoke-detection	Requirements and Functional Architecture of Smart Fire Smoke Detection Service

oneM2M Partnership Project



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

- 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**

[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

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