Mid-band spectrum needs and mmWaves
Unlocking the future of 5G in ASEAN countries

Virtual Event

21 October 2021

Welcome Remarks

Mr. Chenda Thong, Chairman of TRC

Session 1 – Opening

21 October 2021

Opening Remarks

Mr. Guillaume Mascot, Lead, ASEAN (GSA) & Head of Gov Affairs (Nokia)

Estimating mid-band needs

Stefan Zehle, CEO (Coleago Consulting)

October 2021

IMT spectrum demand
Estimating the mid-band spectrum needs in the 2025-2030 time frame

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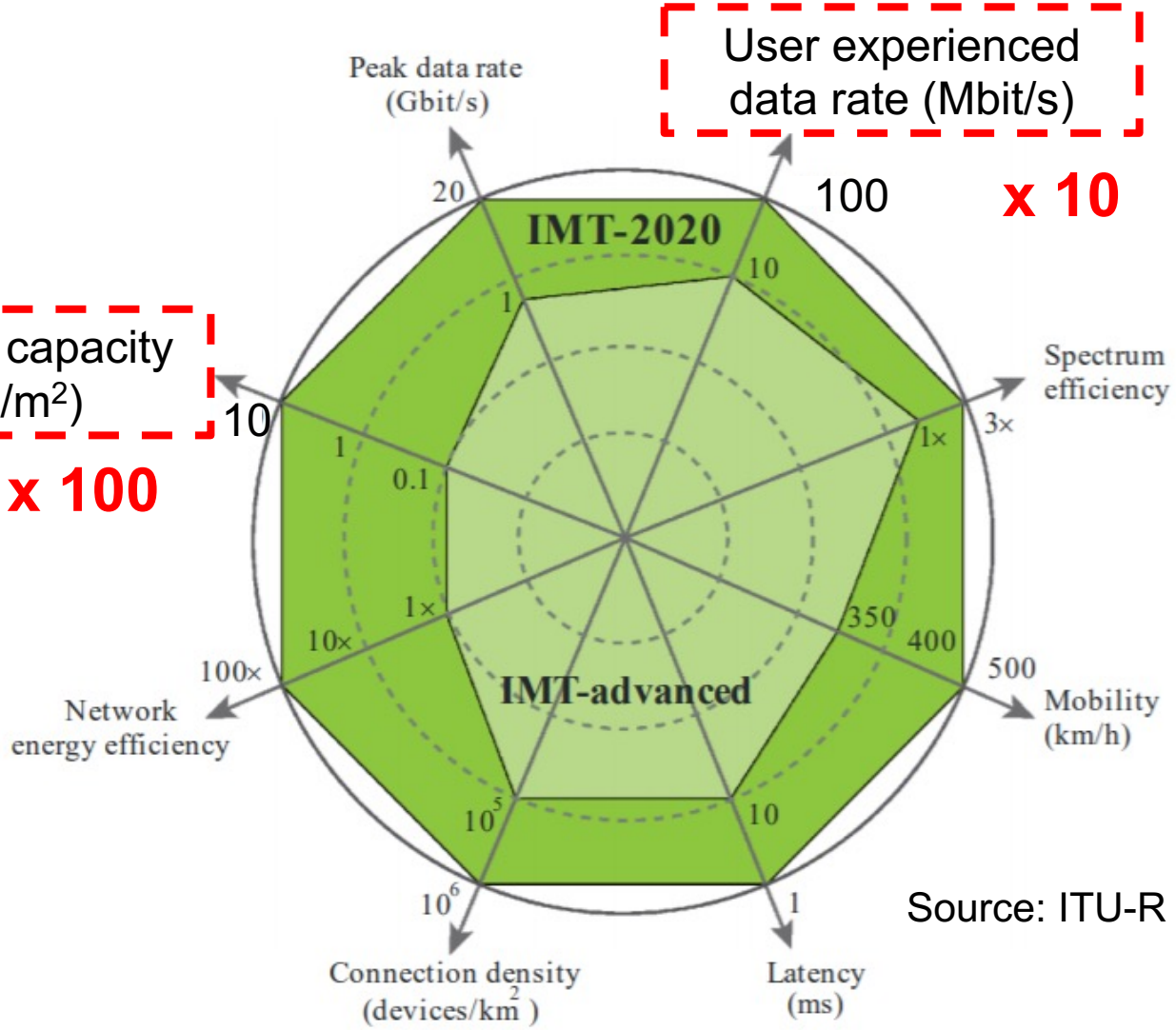
IMT 2020 requirements drive the need for spectrum

One of the pillars in the vision for 5G is to provide ubiquitous high-speed wireless mobile connectivity:

"IMT-2020 is expected to provide a user experience matching, as far as possible, that of fixed networks".

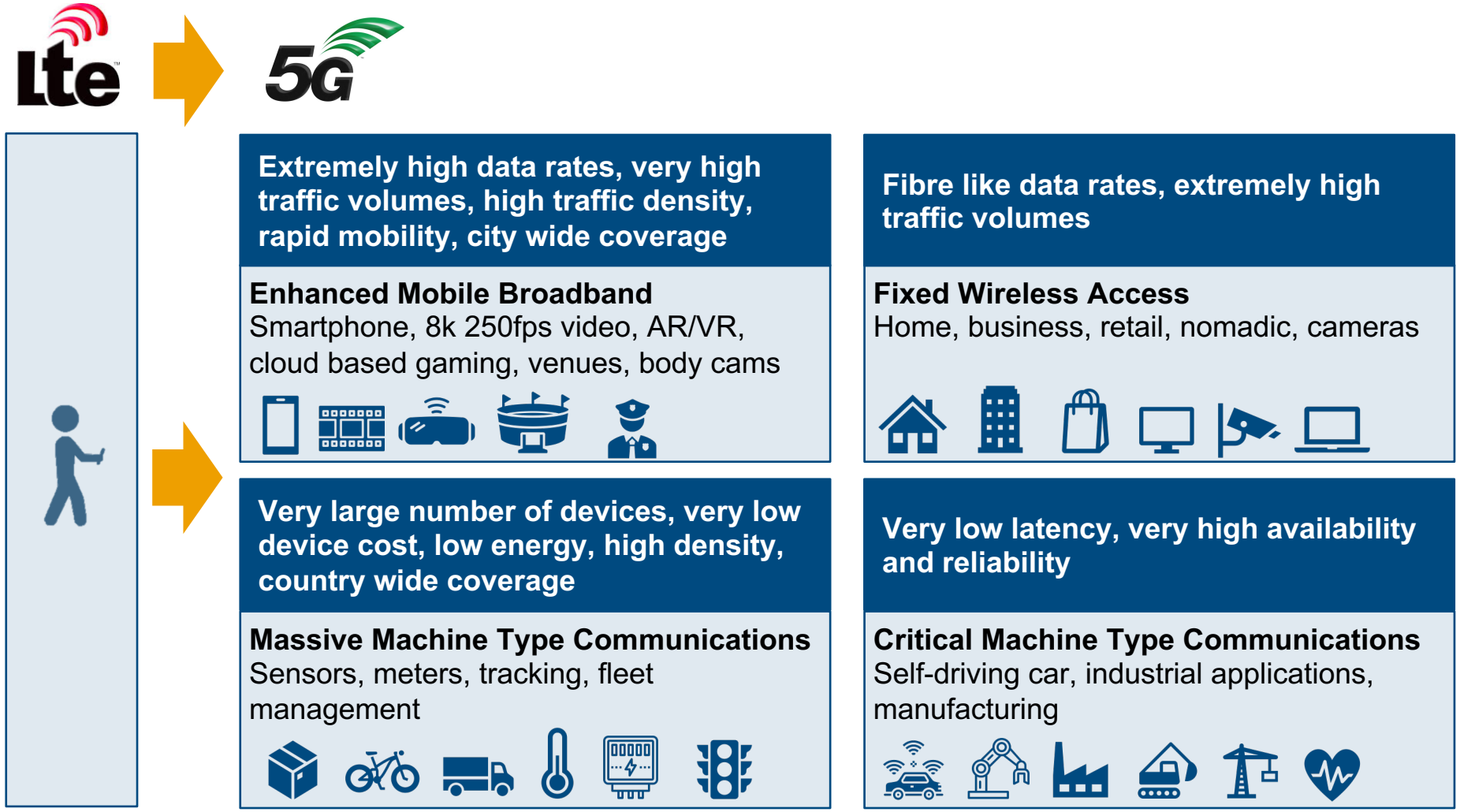
5G must deliver a near guaranteed user experienced mobile data rate of 100 Mbit/s in the downlink and 50 Mbit/s in the uplink and accommodate 1 million connections per km².

Enhancement of capabilities from IMT-Advanced to IMT-2020



Source: ITU-R

5G is not simply a continuation of the mobile business as we know it



The 5G vision is for a ubiquitous fibre-like user experience and connectivity for a wide range of new uses coupled with new features, such as:

- an expectation of a near guaranteed data rate, seamless,
- low latency communication,
- smart city and other IoT,
- self-driving vehicles,
- network slicing

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To deliver the 5G vision poses huge challenge in cities with a high traffic density and a substantial amount of mid-bands spectrum is required

Sub-1GHz band 600 - 900 MHz
deep indoor and rural coverage layer, legacy technologies and 5G

Lower mid-band 1.5 – 2.6 GHz
basic capacity layer, legacy technologies and 5G

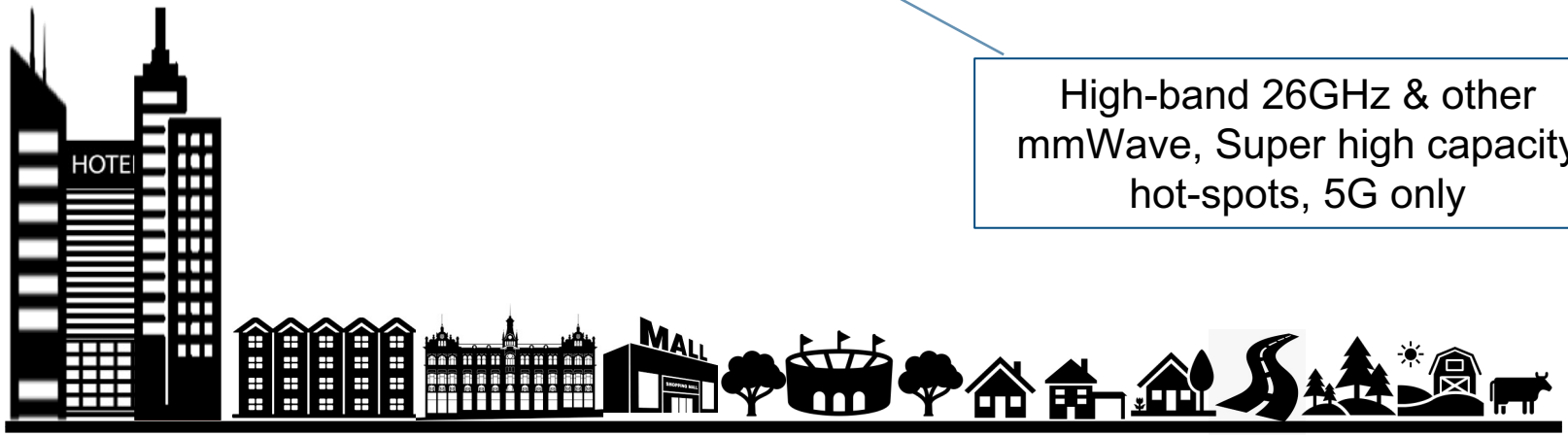
Upper mid-band 3.3-4.2, 4.5-4.99, 6GHz
city-wide speed coverage layer, 5G only

IMT 2020 Requirements

User experienced 100 Mbit/s DL and 50 Mbit/s UL rate

Area traffic capacity of 10 Mbit/s/m^2

High-band 26GHz & other mmWave, Super high capacity hot-spots, 5G only



Dense Urban **Urban** **Suburban** **Rural**

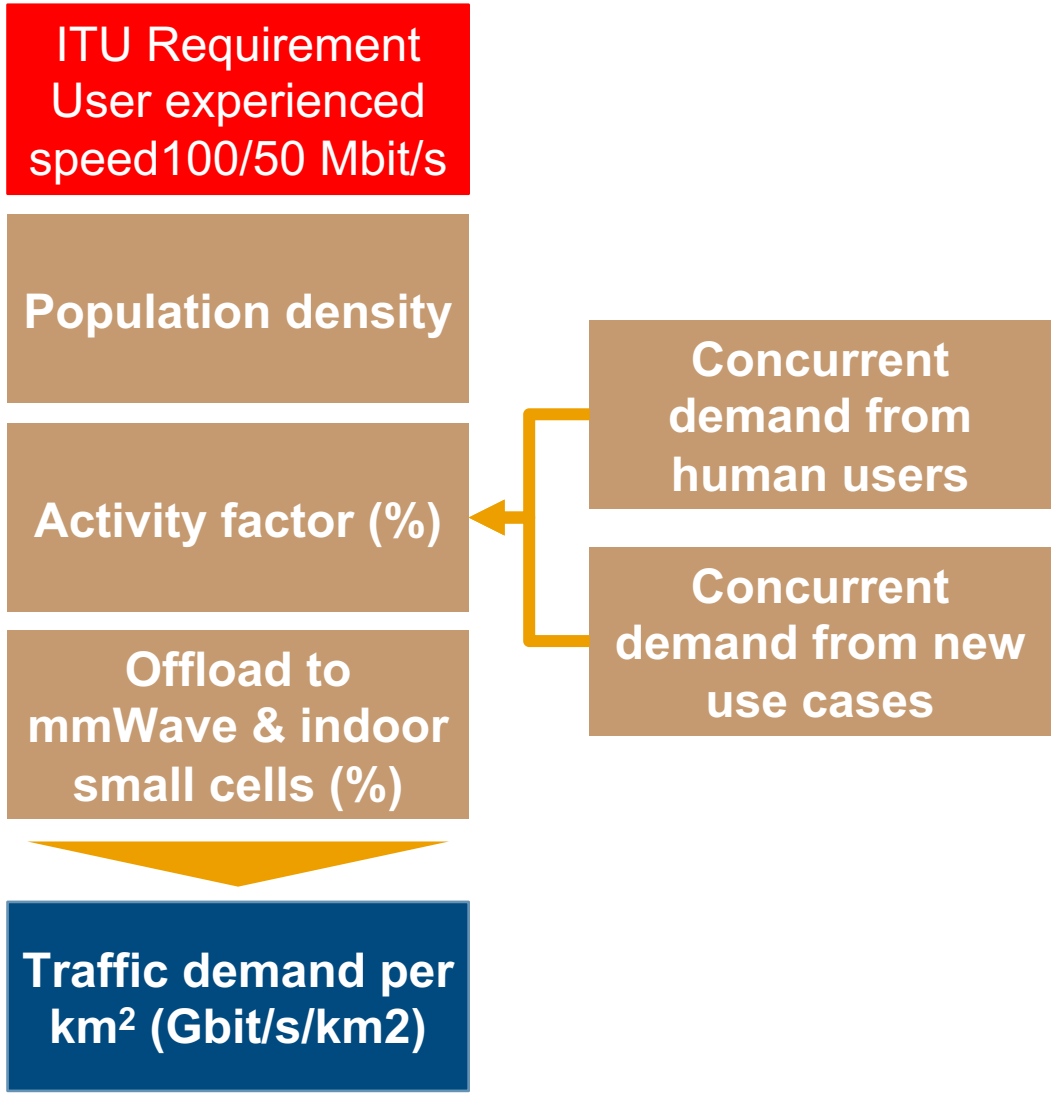
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The required 100 Mbit/s DL and 50 Mbit/s UL user experienced data rate is the key driver to for additional mid-band spectrum

Area Traffic Demand

- We use the **population density** in cities as a proxy for mobile area traffic demand density that is triggered by both human and non-human users.
- Concurrent bandwidth demand from both human users and other use cases is presented in the form of an **activity factor** ranging from 10% to 25%. The activity factor is a proxy for the demand by both human users and non-human users.
- The mobile area traffic density demand is the net demand after deducting **offloading traffic to high bands sites and indoor small cells**.

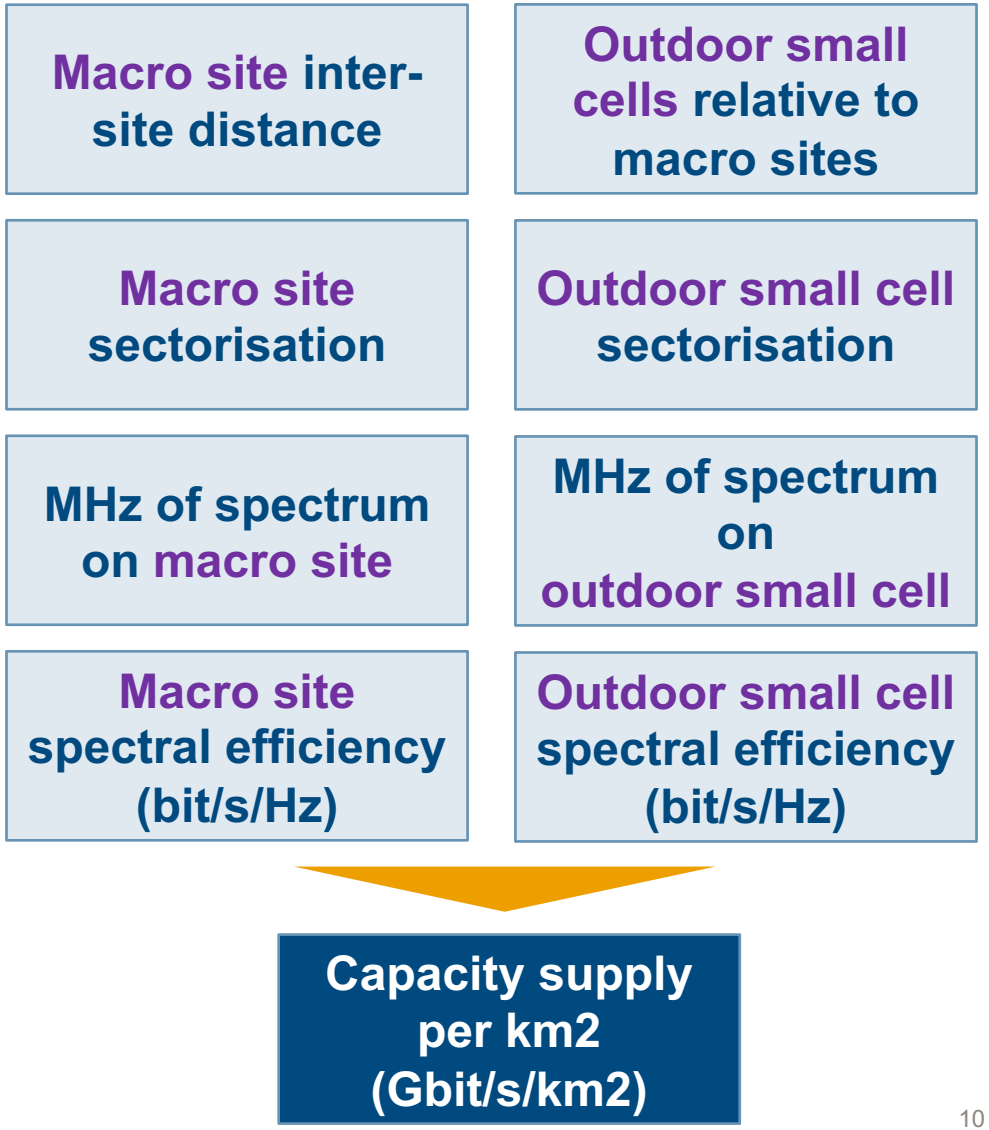


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We assume that in the 2025-2030 time frame all spectrum is used for 5G and there will be 3 outdoor mid-band small cells per macro site

Area Traffic Capacity Supply

- The “baseline spectrum” for each city includes spectrum already in use by mobile operators as well as expected future assignments in the period of 2021 to 2025.
- Depending on the specific city among the 35 cities addressed, the baseline spectrum varies from 725 MHz up to 1,420 MHz.
- We assume that within the 2025 to 2030 time frame, mobile operators will have made the investment to use all “baseline spectrum” for 5G.
- We assume that each operator will deploy 3 outdoor small cells per each of its macro sites, invest in MIMO upgrades, install indoor small cells, and deploy high-bands (mmWave) spectrum on outdoor and indoor sites.



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We have modelled the 5G mobile area traffic demand and capacity supply in 36 cities around the world

We focus on cities with population densities of more than 8,000 per km^2

We analysed 36 cities: Tehran – Amsterdam – Munich – Marseille – Hamburg – Minsk – Baku – Makkah – Milan – Lyon – Rome – Berlin – Amman – Tashkent – Johannesburg – Bangkok – Riyadh – Bangkok - Barcelona – Madrid – Bogotá - Mexico City – Istanbul – Jakarta – Beijing – Paris – Nairobi – Cairo – Tokyo - Ho Chi Minh City - New York – Moscow - Sao Paulo – Mumbai - Hong Kong – Yangon - Lagos

- Our analysis covers only a small sample of cities with high-density clusters of at least 40 km^2.
- Based on data provided in Demographia World Urban Areas, (Built Up Urban Areas or World Agglomerations), 16th annual edition, June 2020, we estimate that 626 urban areas have clusters of at least 40 km^2 with a population density of 8,000 or more.
- These cities can be found in all six ITU Regional groups (APT, ASMG, ATU, CEPT, CITEL, RCC).
- Together these cities contain an estimated 1.64 billion people. This scale provides a good illustration that allocating additional upper mid-band spectrum to IMT is of significance for a large proportion of the world's population.

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Despite the investments to supply mobile area traffic capacity, there will be a significant shortfall of upper mid-band spectrum

In 36 cities we examined, substantial amounts of mid-band spectrum are found to be required to deliver the 5G vision in an economically feasible manner, taking different national income levels into consideration.

Category by income grouping *	Minimum estimate	Maximum estimate
High income cities	1,260 MHz	3,690 MHz
Upper middle income cities	1,020 MHz	2,870 MHz
Lower middle income cities	1,320 MHz	3,260 MHz

* World bank income classification GDP per capita

- Policymakers will, therefore, need to consider making more spectrum in mid-band and prepare national spectrum roadmaps that consider future 5G area traffic demand density.
- There is a concern in the mobile industry that regulators may not be fully aware of the scale of the 5G traffic density challenge in urban areas.
- Specifically, there is a concern that regulators may not be planning to clear and award enough mid-band licensed 5G spectrum between now and 2030.

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Small cell densification beyond what we assumed in our model is not an economically feasible substitute for additional mid band spectrum

The small cell vs. spectrum trade off

- Our spectrum demand model assumes 3 small cells per macro site.
- Beyond that, a city with a population density of 18,000 per km^2 and 7.2 macro sites per km^2, 177 additional outdoor small cells per km^2 are required to deliver the same capacity as an additional 1,250 MHz.
- Considering an urban area of 100 km^2, 17,700 additional small cells would be required (compared to 720 macro sites) in the absence of an additional 1,250 MHz of mid-band spectrum.

Not having additional mid bands spectrum is highly problematic

- The significant numbers of outdoor small cells with relatively small inter-site distances
  - will have a negative impact on the city environment from an aesthetics point of view,
  - will increase power consumption, and
  - would be very costly thus making 5G less affordable for lower income groups.
- Such small inter-site distances, over such large areas, may not be practically possible from an interference point of view. Operators would push against the technical limits of network densification.

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High bands (mmWave) are not a substitute to additional mid bands spectrum

mmWave spectrum

We explored whether mmWave could be a substitute to additional mid band spectrum.

- Our model assumes mmWave deployment in traffic hotspots which alleviates some of the spectrum need for mid-band spectrum.
  - We assume that 20 to 35% of traffic in cities will be offloaded to mmWave.
- If no additional mid bands spectrum is made available, all options for further densification would require several thousands new mmWave macro sites and/or new mmWave small cells over large areas i.e. not only locally.
- The small inter-site distances for mmWave sites due to the need to provide consistent speed coverage across the entirety of the city area, this would involve several thousands of mmWave sites to be built in each city.
- **The mmWave densification approach would not represent a viable option**, being
  - very costly and
  - undesirable from an environmental perspective.

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A reasonableness check

City average area traffic density

- The cities in our sample show results in area traffic density of 300 to 500 Gbit/s/km^2.
- Let's compare this to the ITU-R IMT-2020 area traffic requirement of 10 Mbit/s/m^2 translating it into Gbit/s/km^2.
  - Multiply by 1,000,000 to get from m^2 to km^2 and divide by 1,000 to get from Mbit/s to Gbit/s gives 10,000 Gbit/s/km^2.
- 300-500 Gbit/s/km^2 on average across the whole city is only 3% to 5% of the local peak which demonstrates that our numbers are modest.

Peak area traffic density – mobile users

London Route Master Bus

Area 2.5x10 m (m^2)	25
Capacity (passengers)	80
% using video	10%
4K video speed (Mbit/s)	20
Area traffic demand Mbit/s/m^2	6.4



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Outside cities additional upper mid-band spectrum provides a sustainable path to bridge the urban-rural digital divide

Spectrum for 5G FWA in rural

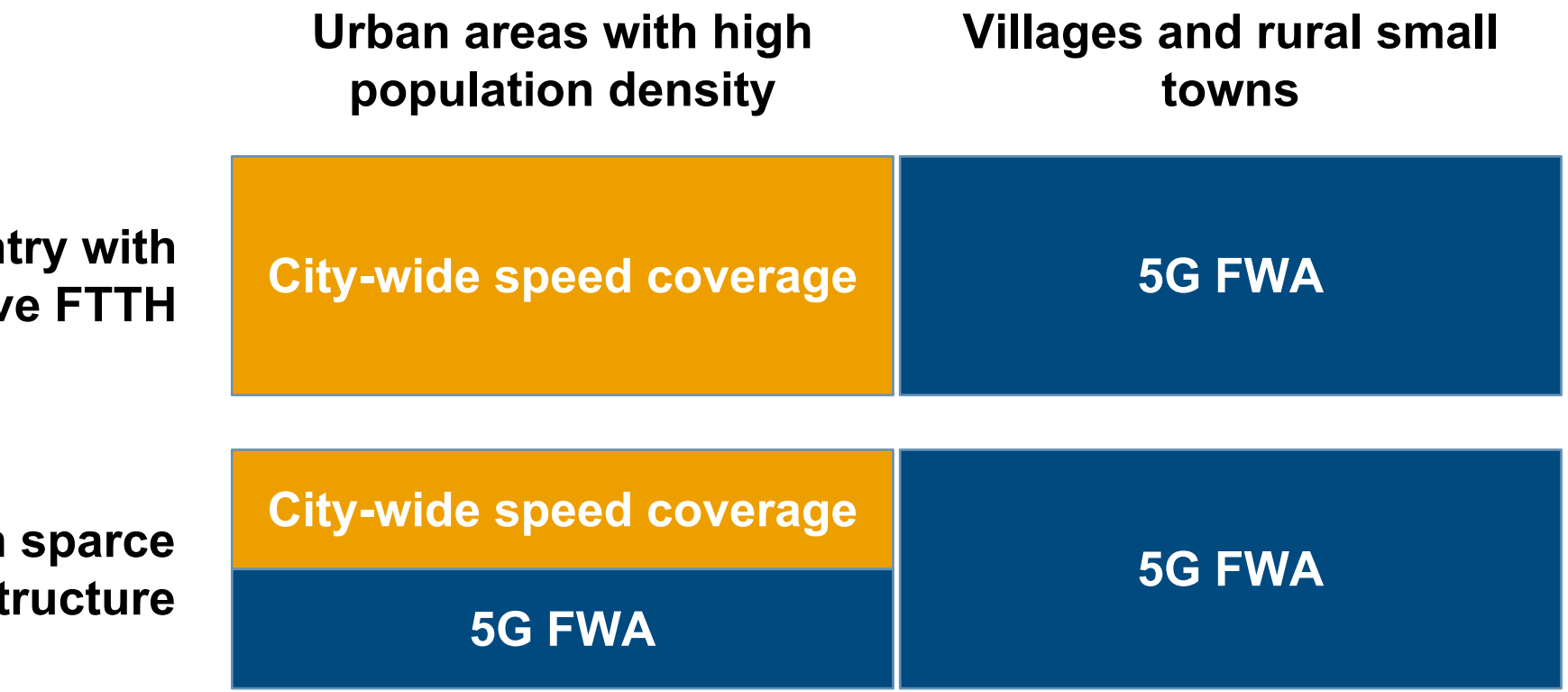
Additional spectrum would provide sufficient bandwidth to ensure that FWA will be a cost effective solution spectrum able to address the needs for 100 Mbit/s connectivity as a long-term solution for rural small towns and villages.



- There are 1.1 to 1.2 billion households worldwide without broadband access and FWA is the fastest growing method of bringing fixed broadband to the unconnected.
- Upper mid-band spectrum has a key role to play in providing fibre-like access via 5G at an affordable price.
- The ITU and UNESCO Broadband Commission for Sustainable Development 2025 Targets make this explicit: *"By 2025, entry-level broadband services should be made affordable in developing countries, at less than 2% of monthly gross national income per capita."*
- Alternative rural connectivity solutions based on satellite or fibre typically have higher costs and, therefore, outside the affordability of households and business in villages and rural small towns, particularly in lower-middle and low income countries.

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Conclusion: Demand drivers for mid-band spectrum is driven by both urban and rural in developing and developed countries



Without 1.2 to 3 GHz of additional mid-band spectrum the urban - rural digital divide my widen rather than narrow.

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Summary of key findings

- ✓ The total mid-band spectrum needs when averaged over all 36 examined cities is estimated to be 2,020 MHz in the 2025-2030 time frame.
- ✓ In areas with a population density below 8,000 per km^2, additional spectrum would also deliver benefits. The benefits would be a lower site density or higher speeds. A lower site density translates into
  - a lower cost per bit which in turn will translate into lower retail prices
  - as well as less overall power consumption.
- ✓ In developing countries, the availability of additional mid-band spectrum would enable operators to deliver fibre-like 5G FWA to rural towns and villages.
- ✓ In countries which have good urban and suburban broadband infrastructure, the availability of additional mid-band spectrum would reduce the cost of bringing 100 Mbit/s connectivity to the remaining unconnected rural towns/villages. For example, in Europe, a 79% cost-reduction compared to FTTH.
- ✓ Outside populated areas, substantial capacity is required on major transport routes (highways and railways) to serve the connected vehicles and smart road use cases.

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The GSMA Insights

Luiz Felippe Zoghbi, Spectrum Policy Manager (GSMA)

The importance of mid-band spectrum









Mid-bands can offer a good mixture of coverage and capacity

Access to an over time increasing amount of mid-band spectrum is key to the 5G era

GSMA Insights

Densely populated cities need, on average, a total of 2 GHz of mid-band spectrum. Precise spectrum demands vary depending on population density, fibre availability and other factors. This means there is no simple correlation between a country's income level and its spectrum demand. However, additional spectrum is required beyond existing ITU, regional or national plans in all cases.

IMT-2020 requirements will be at risk with less spectrum, and significantly more base stations would be needed without sufficient assignments. Where densification is possible, the total cost of networks would be 3-5x higher over a ten-year period if there is a deficit of 800-1000 MHz. This equates to $782mn-$5.8bn in extra investment in each city.

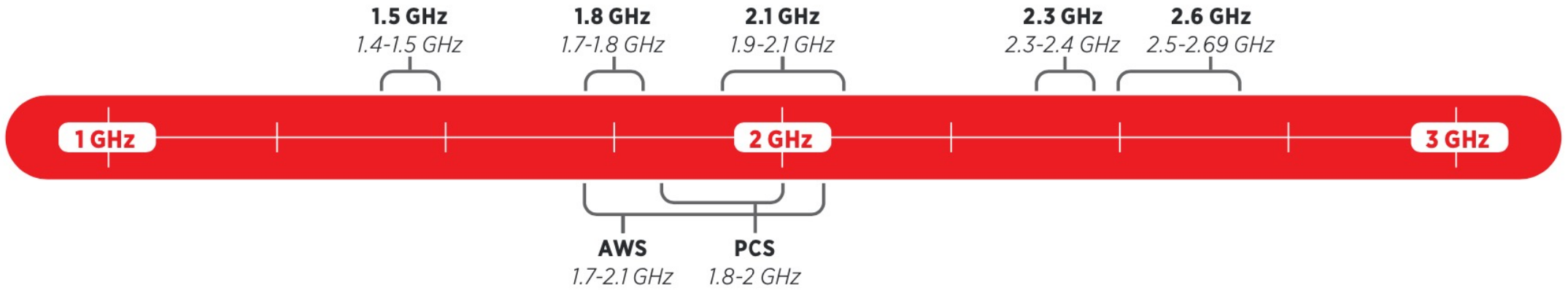
Additional base stations will generate a carbon footprint 1.8-2.9x higher without sufficient spectrum. The additional network densification mentioned above would increase mobile network energy consumption in the cities by 1.8-2.9x, as well as in the manufacturing process. Importantly, such a high level of densification may not even be feasible for other reasons (such as too much interference, site availability, restrictive electromagnetic field rules). This can be avoided through the timely availability of the right spectrum.

Affordable fixed wireless access will raise demand. The additional spectrum in mid-bands will allow each cell site to support 3.5-6x more homes with 5G FWA. This would create significant cost-savings in network roll-out and drive affordable connectivity in areas where other broadband solutions are not economically viable (e.g., where fibre is not widely available or remains limited to bigger cities).

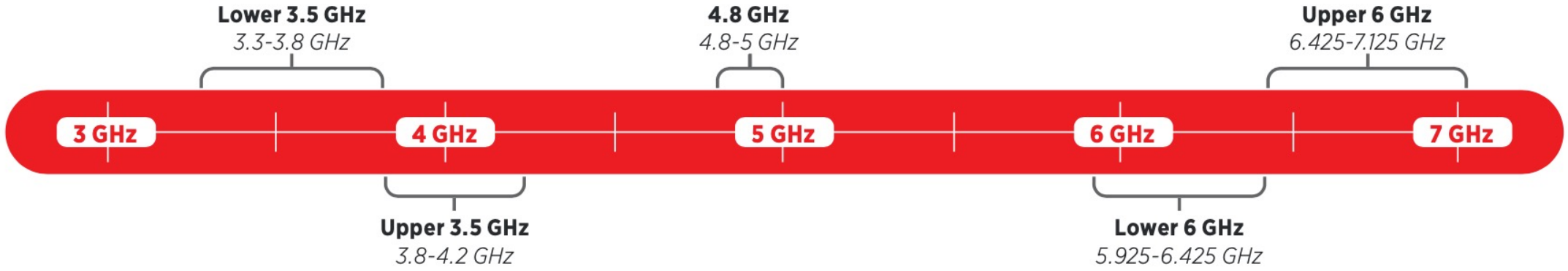
With WRC-23 approaching, positive engagement on mid-band solutions for IMT will provide vital support to the harmonisation of spectrum and give clear technical guidance for regulators. Coordinated regional decisions will lead to a WRC which enables the future of 5G and supports wider broadband take-up by increasing capacity and reducing costs.

Meeting the mid-band spectrum needs

Lower Mid-Band Spectrum



Upper Mid-Band Spectrum



The GSMA recommends that governments and regulators:

- 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 IMT-2020 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

Download the report and GSMA Insights



https://www.gsma.com/spectrum/wp-content/uploads/2021/07/5G-Mid-Band-Spectrum-Needs-Vision-2030.pdf



https://www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf

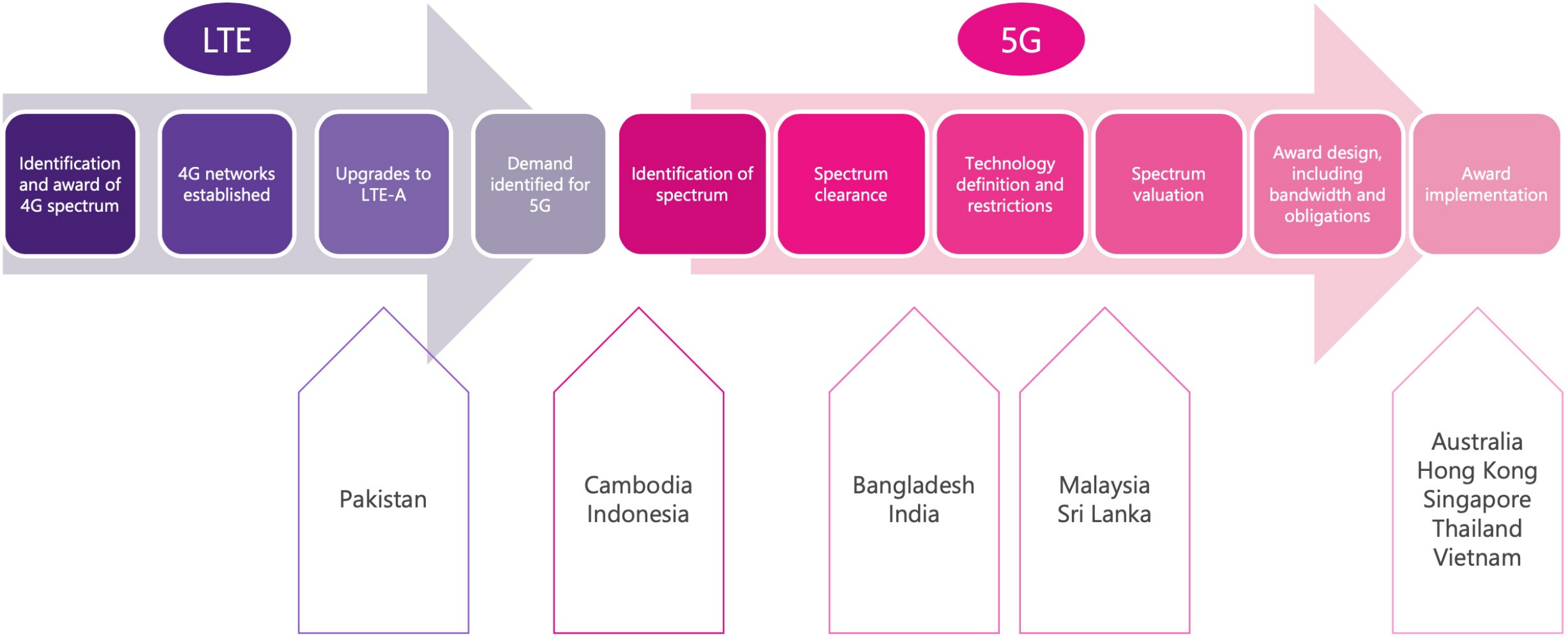
APAC Roadmap Report – The scope

- Details of which spectrum is envisioned for 5G use in APAC.
- International best practice in awarding 5G spectrum.
- A categorisation of countries based on the current state of awards so the GSMA can identify which countries are most advanced in their plans for 5G release, and which suffer from significant constraints on release of spectrum.
- An overview of how spectrum should be released, including details of the identification, clearance, award and assignment stages.

Data provided by GSMAi, country regulators and operators

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APAC Roadmap Report – Universal Roadmap



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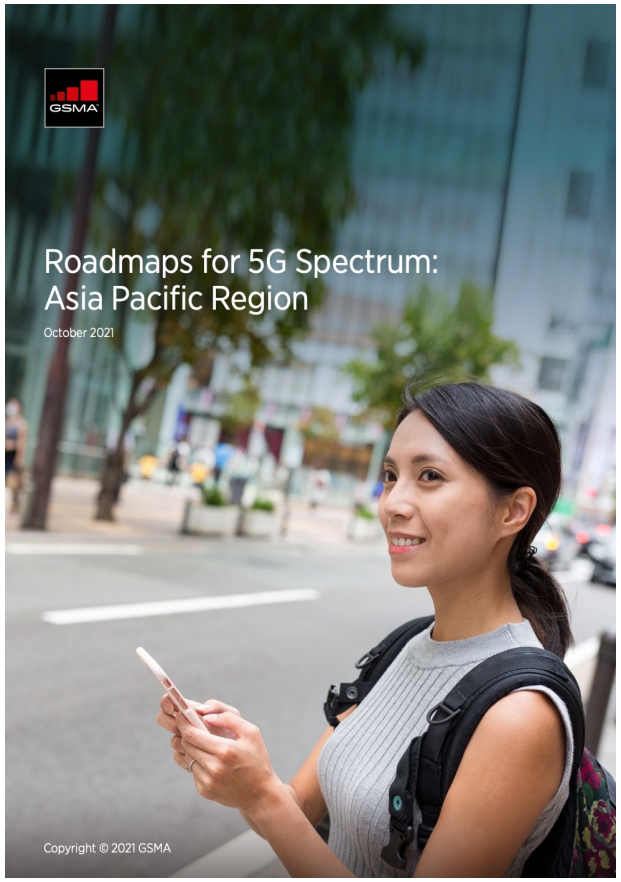
APAC Roadmap Report

Some Recommendations

- Build a roadmap that considers short-, mid- and long-term planning.
- Tackle all the areas of spectrum management, including:
  - What spectrum will be available and when
  - Assignment methodologies and renewal procedure
  - Refarming, resourcing, pricing and spectrum sharing
- Adopt harmonised band plans to minimise interference issues – in particular cross border, considering low-, mid- and high-bands.
- We recommend that the bands currently awarded for other services to be analysed for options with the potential to allow for 4G and 5G services.

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APAC Roadmap Report



To be released on November and will be shared via email and on the link for this event

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3.5 GHz range

Luiz Felippe Zoghbi, Spectrum Policy Manager (GSMA)

Coverage and Cost

Coverage

92%



of the world's population is covered by Mobile Broadband

Mobile Broadband now connects around

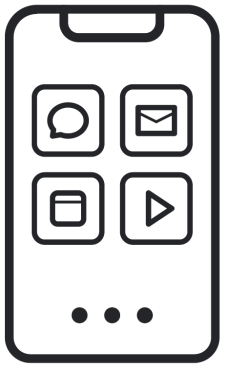
4BN

PEOPLE TO THE INTERNET



Usage Gap

3.9BN MORE PEOPLE ARE NOT CONNECTED BUT



3.2BN LIVE WITHIN MOBILE BROADBAND COVERAGE

Spectrum Needs of 5G

Harmonising for cost efficiency and coverage

Low-band

470-960 MHz

Mid-band

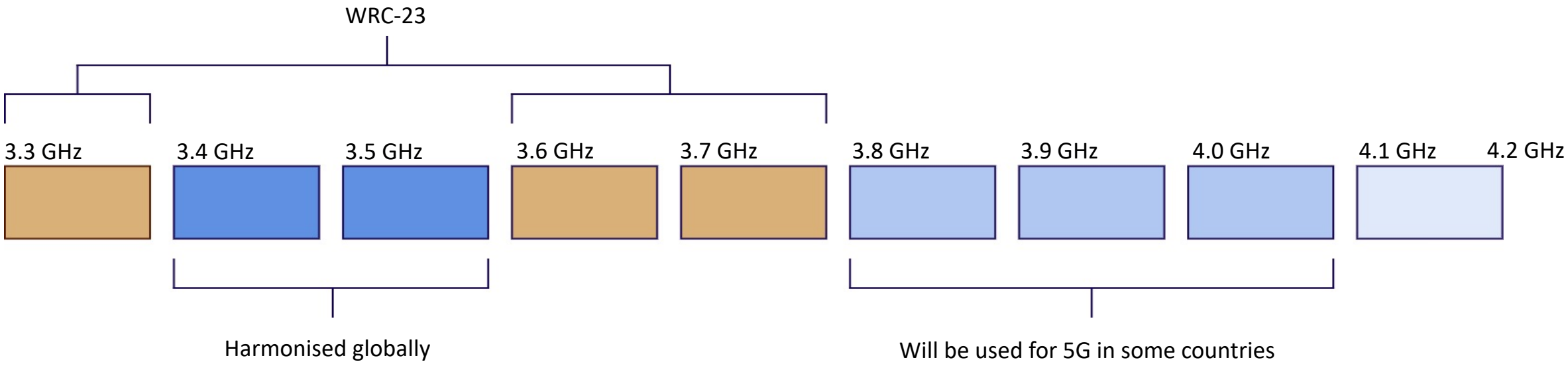
3300-3800 MHz
4800-4990 MHz
6425-7125 MHz

Capacity bands

10-10.5 GHz can add to existing mmWave capacity

3.5 GHz range

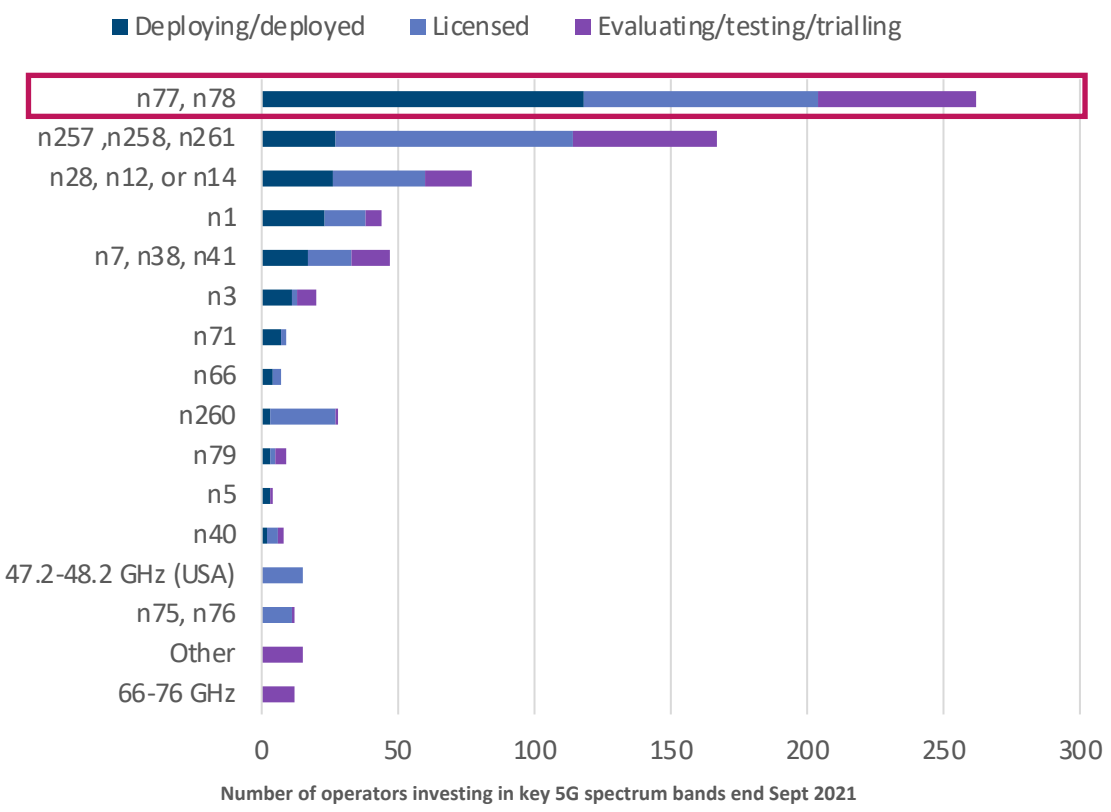
100 MHz channels improve performance and reduce cost of connectivity



3.3-3.8 GHz: 5G Launch Band

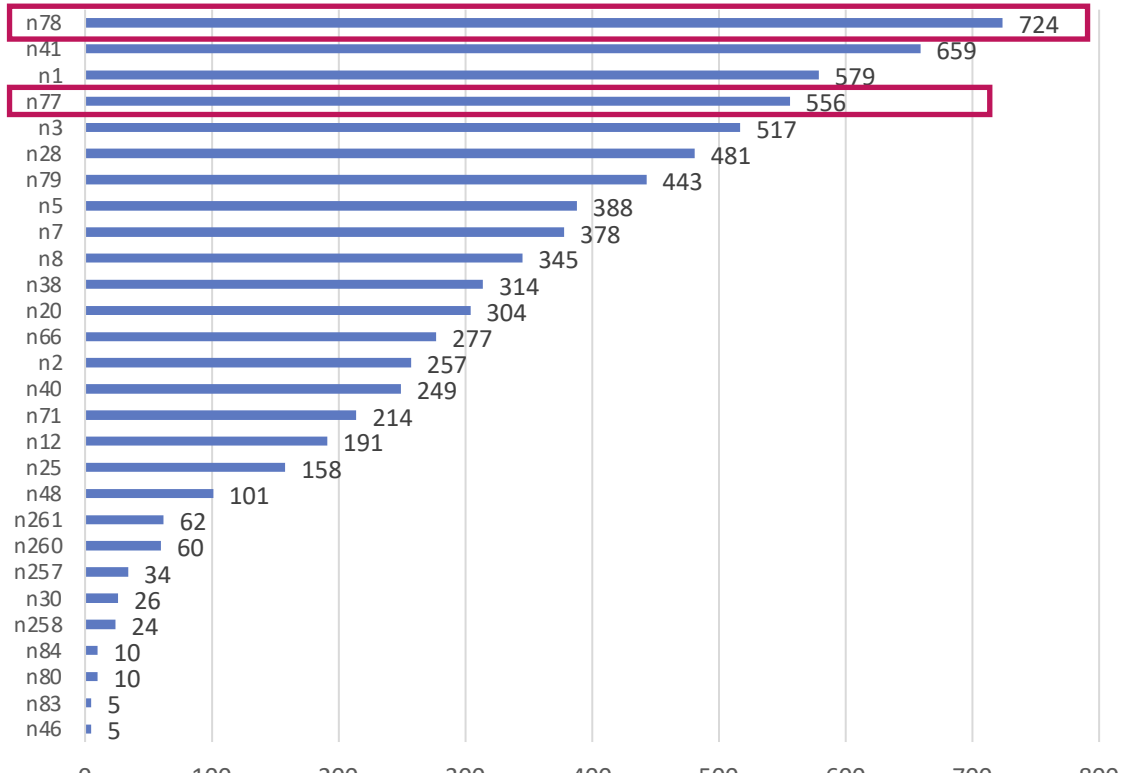
Strongest ecosystem already for 5G in 3.5 GHz range

>200 operators licensed or deployed/deploying in 3.3-4.2 GHz



Number of operators investing in key 5G spectrum bands end Sept 2021

574 devices commercially available supporting C-Band spectrum, more than 730 announced



Announced 5G device models supporting 5G bands end Sept 2021

3.3-3.8 GHz: 5G launch band

Global Growth Driven by WRC Process

- Global mobile demand for 3.5 GHz range within and outside IMT identifications
- Multiple WRCs have treated the band but in-country assignments still reach far beyond ITU agreements in early-adopter countries
- WRC-23 Agenda Item 1.3 takes softest possible approach and offers Africa the chance to join global club with MOBILE allocation

WRC-07	WRC-12	WRC-15	WRC-19	WRC-23
80 countries sign into footnotes for 3.4-3.6 GHz	New Agenda Item agreed to discuss 3.4-4.2 GHz, inter alia	3.4-3.6 GHz harmonised; some additional identifications at 3.3-3.4 and 3.6-3.7 GHz	New Agenda Item agreed for WRC-23	Parts of 3.3-3.8 GHz being discussed for Regions 1 and 2

Fair Sharing 3.5 GHz:

IMT / FSS Co-existence

- Incumbents: FSS
- IMT and FSS co-existence occurring all over the world both in-band (geographically separated) and adjacent band
- Existing methodologies allow regulators to make informed decision on spectrum sharing before WRC decisions or IMT deployment
- Significant volumes of existing research on co-existence including: https://www.gsma.com/spectrum/wp-content/uploads/2021/04/Transfinite-3.4-3.8-GHz-Compatibility.pdf

Possibilities for the TVROs

To allow mobile services in the 3.5 GHz Range

>higher 3.5 GHz

- TVROs to above 3.8 GHz, for example.
- New filters already available
- Minimum guard band needed

Ku Band

- TVRO to the Ku band
- More expensive
- Possible first move to release up to 4.2 GHz
- Does not consider the decrease of TVRO

As is

- Keeping the TVROs in 3.625 GHz+
- Filters work as well
- Restricts the amount of spectrum

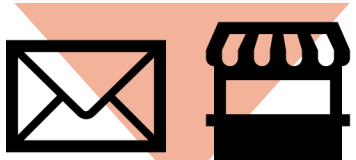
STBs and Filter distribution

100% dependant households

Low income families

Reactively

Checked

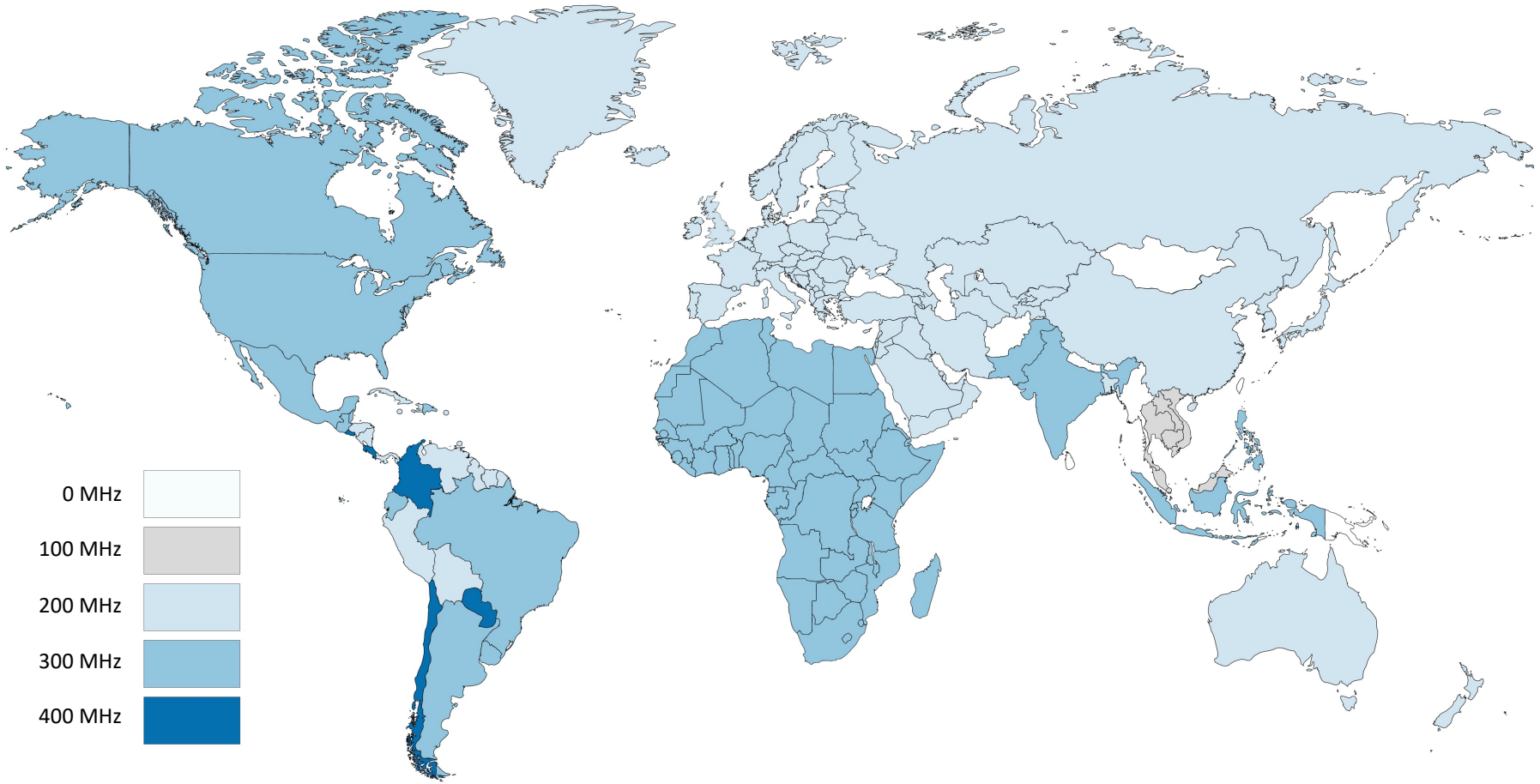


3.5 GHz: the Radio Regulations today

ITU agreements cover small amount of use – but MOBILE allocation covers ASEAN in Region 3

1. Progress at WRCs does not always match market forces and early adopters have moved well past decisions

2. WRC-23 can play catch up and give regulators chance to plan for 5G with sufficient channel bandwidth to lower costs



Reality: beyond the Radio Regulations

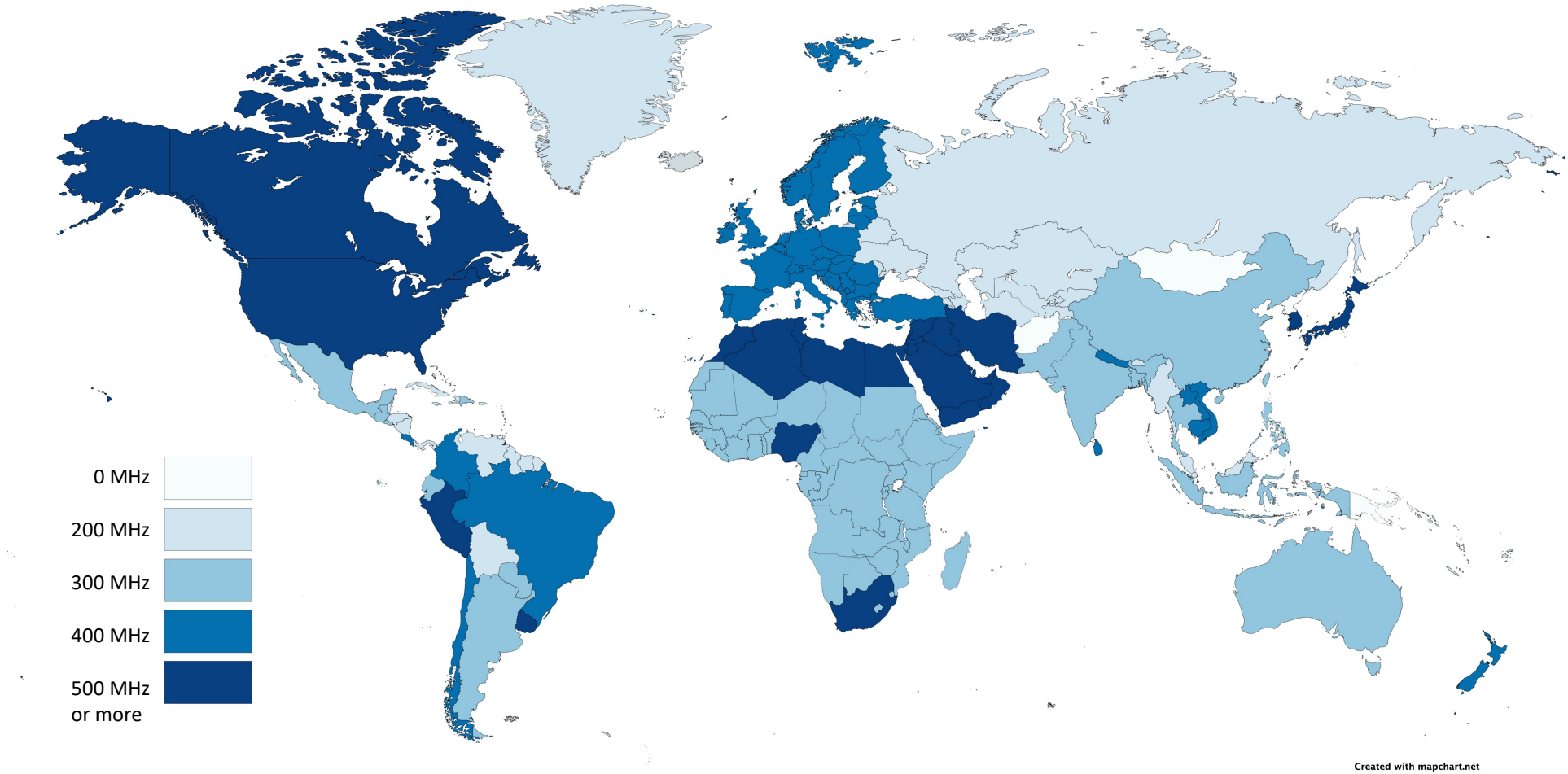
Developing world starting to look at wide 3.5 GHz assignments

3

Regional evolution beyond WRC decisions has seen wider harmonised capacity – and lower costs - in most developed markets.

4

Radio regulations and reality do not match. Wider harmonised capacity is needed to ensure balanced spectrum availability across markets.



Channel bandwidth and network performance

Network and user equipment benefits from optimal assignment

Wider channels provide cost savings and many other benefits:



Cost Efficiency



Planning 5G with enough spectrum to allow sufficient bandwidth will increase performance and significantly reduce costs.

Wider channels mean fewer base stations

CHANNEL SIZE IMPACT

100 MHz → 60 MHz

64%

INCREASE IN NUMBER OF CELL SITES

WRC-23 can make huge savings on 5G roll-out

ASEAN BENEFITS

Adding additional bandwidth to the baseline 200 MHz in 3.5 GHz range*

ADDITIONAL 300MHz

$3.5bn

ADDITIONAL 700MHz

$5.5bn

https://www.gsma.com/spectrum/resources/3-5-ghz-range-for-5g/

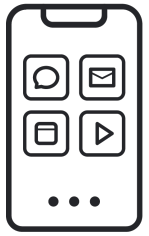
3.5 GHz Priorities

Maximising the Use of 5G Launch Band

100 MHz Channels	• Mobile needs 100 MHz channels to drive down cost and enhance performance • Battery life and lower energy use also driven by wider channels
3.3-3.8 GHz	• Global discussion to harmonise 3.3-3.8 GHz do no include APAC; • … But MOBILE allocation already exists to cover assignments
3.8-4.2 GHz	• APAC covered by existing MOBILE allocation • Spectrum already being brought into use in many densely populated countries • Band n77 ecosystem is significant, growing and covers the whole band







4.8 GHz take-up

Ye Min, Senior Manager of Spectrum and Policy (Huawei)

4400-5000 MHz band n79

Ye Min

GSA

21 October 2021

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4400-5000 MHz band outlook

- 4400-5000 MHz frequency range is defined in 3GPP as band n79 (in Rel15)
- Co-primary mobile allocation of all sub-bands
- Potentially an initial mid-band spectrum for 5G in countries/regions where the C-band (3.3-4.2 GHz) has limited availability or is not available yet
- 4400-5000 MHz band can serve as one of the complementary bands to the already available mid-bands
- Momentum for IMT use is building significantly:
  - Several countries/territories make available or plan the band or parts of it : China, Hong Kong S.A.R, Japan, Republic of Korea, Russia, Vietnam
  - 42 countries in RR footnotes No. 5.441A and 5.441B (WRC-19)

Allocation to services		
Region 1	**Region 2**	**Region 3**
4 400-4 500	FIXED MOBILE 5.440A	
4 500-4 800	FIXED FIXED-SATELLITE (space-to-Earth) 5.441 MOBILE 5.440A	
4 800-4 990	FIXED MOBILE 5.440A 5.441A 5.441B 5.442 Radio astronomy 5.149 5.339 5.443	
4 990-5 000	FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY Space research (passive) 5.149	

GSA encourages administrations to make available the spectrum within the 4.4-5 GHz band for IMT use

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4400-5000 MHz outlook

4800-4990 MHz (4.8 GHz band)

IMT identification at WRC-19 in RR footnotes:

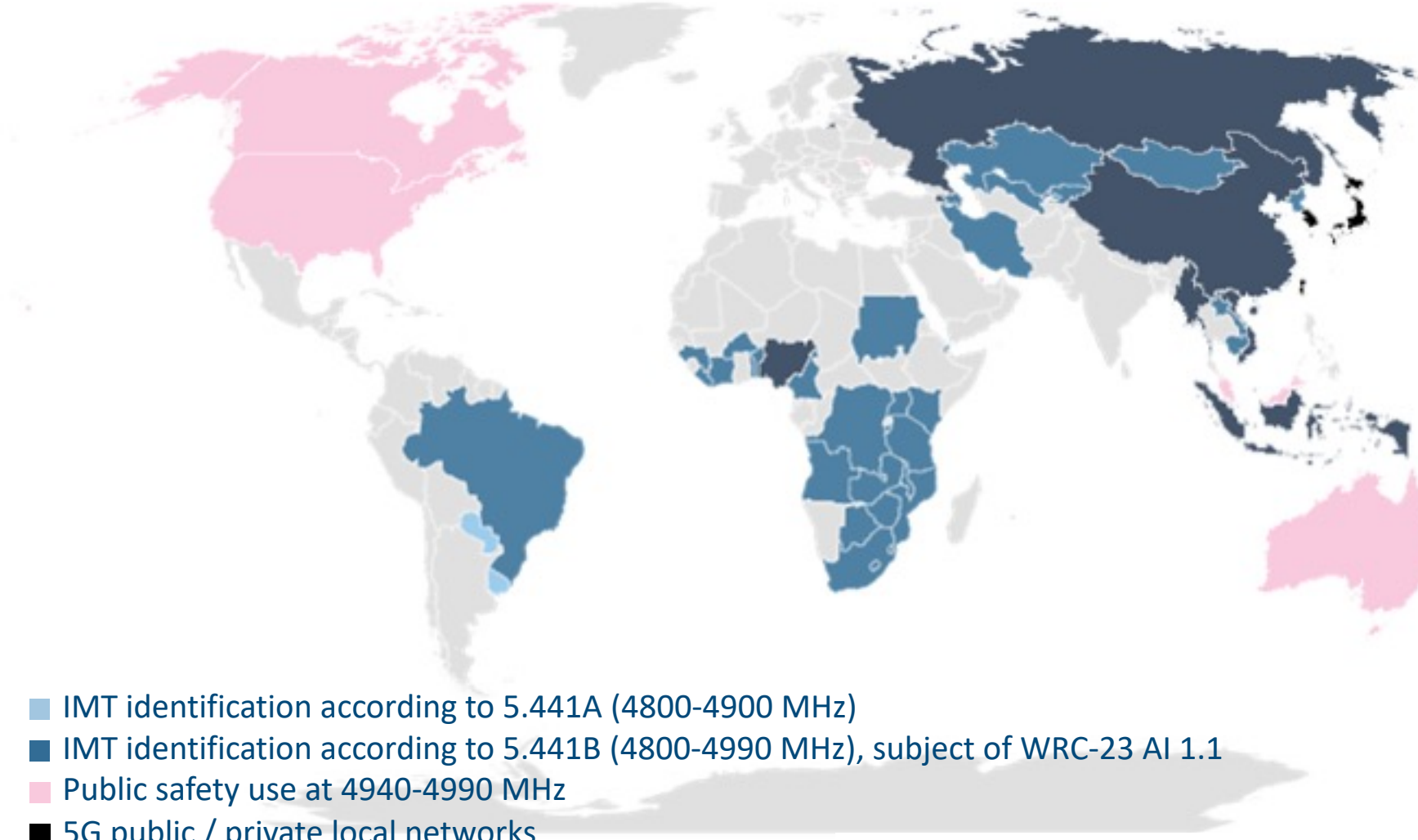
- 4800-4900MHz: 3 countries (Brazil, Paraguay and Uruguay) identified under footnote 5.441A
- 4800-4990 MHz: 40 countries identified under footnote 5.441B (Brazil in both notes)
- Technical conditions attached to the footnote 5.441B will be reviewed at WRC-23 (AI 1.1)

4940-4990 MHz (4.9 GHz Public Safety band)

- Resolution 646 (WRC-03, updated at WRC-15, WRC-19) encourages administrations in Region 3 to consider parts of the harmonized frequency ranges 406.1-430 MHz, 440-470 MHz and 4 940-4 990 MHz for their PPDR applications.
- Recommendation ITU-R M.2015-2 “Frequency arrangements for public protection and disaster relief (PPDR) radiocommunication systems in UHF bands in accordance with Resolution 646” – includes arrangements for the band 4940-4990 MHz for PS applications in Region 3 and 2.

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Portions of the band in use or under consideration in all ITU Regions



- IMT identification according to 5.441A (4800-4900 MHz)
- IMT identification according to 5.441B (4800-4990 MHz), subject of WRC-23 AI 1.1
- Public safety use at 4940-4990 MHz
- 5G public / private local networks
- Potential IMT use of the 4400-5000 MHz band

5G public mobile networks:
Japan: 4500-4600 MHz
Hong Kong S.A.R: 4800-4960 MHz
Vietnam: 4800-5000 MHz
China: 4800-4960 MHz

5G private local networks:
Japan: 4600-4800; 4800-4900 MHz
Taiwan, China: 4800-4900 MHz
Rep. of Korea: 4720-4820 MHz

Potential IMT use in 4400-5000 MHz band:
China: 4400-4500 MHz
Russia
Armenia
Myanmar
Indonesia
Macau S.A.R
Taiwan, China

NOTE: Andorra, Moldova, Montenegro have implemented CEPT ECC/REC/(08)04 targeting BB disaster relief (BBDR) radio applications at 4940-4990 MHz

4400-5000 MHz band overview: APAC

- Potentially an initial mid-band spectrum for 5G in countries/regions where the C-band (3.3-4.2 GHz) has limited availability or is not available yet
- Japan: 4500-4600 MHz awarded to NTT Docomo in H1 2019
  4600-4800 and 4800-4900 MHz for local 5G private networks (Q1 2021)
- China: Awarded 4800-4900 MHz to China Mobile and 4900-4960 MHz to China Broadcast Netwok
  4400-4500 MHz band has been identified as IMT band the Radio Frequency Allocation Table
- Hong Kong S.A.R: Awarded the 4840-4920 MHz band in Oct. 2019
  Award of 4800-4840 and 4920-4960 MHz in Oct. 2021
- Taiwan, China: NCC consultation on the use of 4800-4900 MHz band for mobile broadband private networks (Apr. 2021)
  Possible auction of parts of 4400-5000 MHz in the 2nd auction for 5G spectrum in 2023
- Vietnam: Possibility to open the 4800-5000 MHz for IMT (likely in 2022) after licensing 2600, 2300 and 3600 GHz bands
- Republic of Korea: Award of 4720-4820 MHz band to companies in the verticals field to deploy private 5G networks
- Australia: 4400-4500 MHz: mainly for defense and national security (DoD), for aeronautical mobile telemetry
  4800-4990 MHz: primary allocation for fixed and mobile services, mainly defense and national security use
  - 4950–4990 MHz: also allocated to the radio astronomy service on a primary basis
  - 4940-4990 MHz: for defense and national security arrangements, principally for high-speed localized coverage
- Rest of APAC: Macau, Myanmar, Indonesia - considering to award portions of the band.

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4.4-5 GHz band overview: Europe and RCC countries

- Europe: limited use due to military and public safety considerations.
  - 4200-5000 MHz band has been harmonised by NATO and NATO member nations for military use as defined in the NATO Joint Civil/Military Frequency Agreement (NJFA) 2014.
  - CEPT countries: ECC/REC/(08)04 recommends the 4940-4990 MHz band as an optional band for Broad Band Disaster Relief (BBDR) radio applications, whilst the preferred band for this application is 5150-5250 MHz. Only 3 countries (Andorra, Moldova, Montenegro) that have implemented this Recommendation also included the 4940-4990 MHz band. BBDR radio applications should not claim protection from, nor cause interference to radio services in these bands.
- Russia:
  - 4800-4990 MHz is allocated for 5G piloting (RF Spectrum Commission Decision # 18-48-02). Currently there are issues in cross border coordination with NATO countries
  - 4400-4990 MHz is considered as a potential 5G band with a minimum contiguous allocation per operator of 50 MHz (RF Spectrum Commission Decision #19-53-05 24/12/2019)
  - The “national 5G roadmap” adopted by the Russian government on Nov 16, 2020, prescribes to use domestically-manufactured network equipment in 5G commercial networks
- RCC: several countries are reported to show interest in the band
  - Armenia, Azerbaijan, Russia, Kazakhstan, Uzbekistan, Kyrgyzstan joined RR No 5.441B on 4900 MHz at WRC-19 and considers it as a suitable 5G band
  - RCC position on AI 1.1 of WRC-23: remove the pfd limit from footnote RR No. 5.441B, enable all countries using the band for IMT without undue restrictions worldwide

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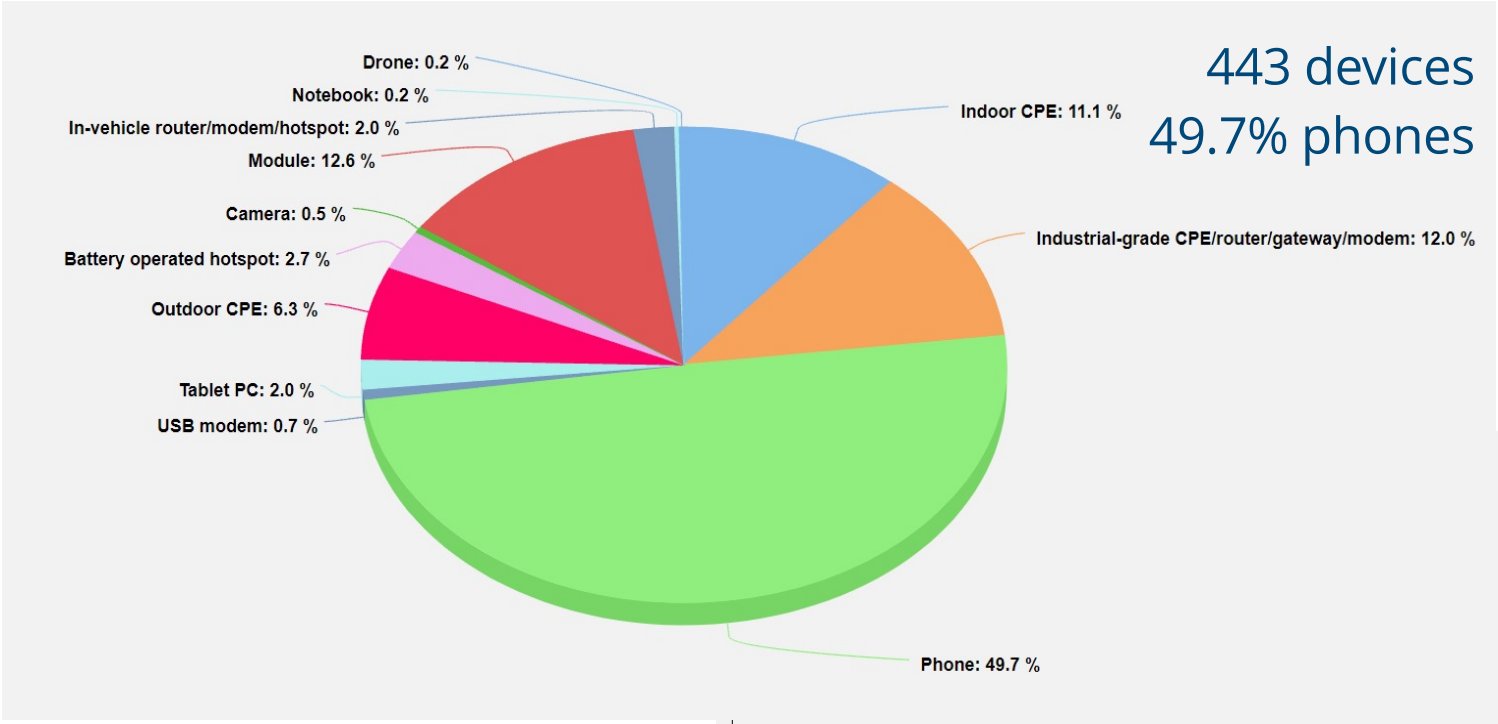
4.4-5 GHz band overview: Americas

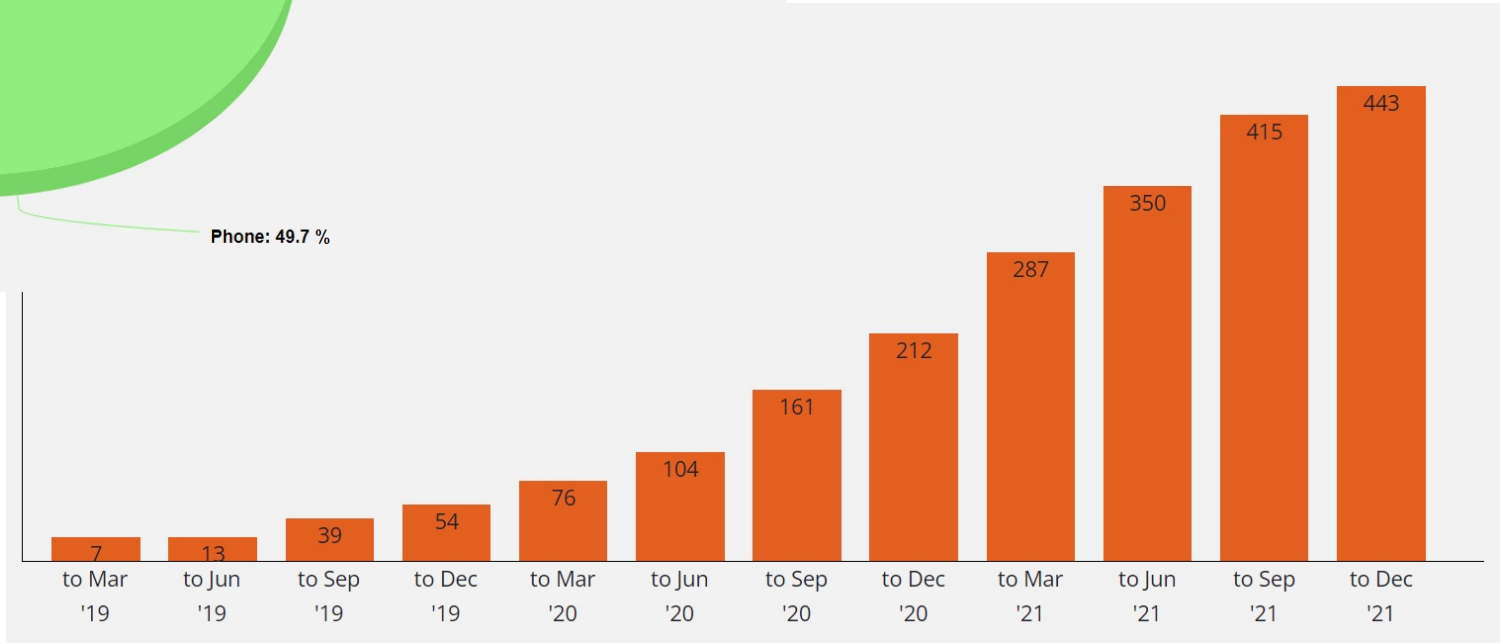
- 4940-4990 MHz band for public safety broadband (Resolution 646, WRC-15)
  - USA: FCC engaged to open the PS band due to its limited (3.5%) and non-efficient use outside major metropolitan areas
    - Sep2020, FCC “Sixth Report and Order” – proposed opening of the band to new types of users, for flexible fixed and mobile services, without restrictions on the type of entities deploying in the band
    - May2021 – spectrum leasing rules to 3rd parties was put on hold by FCC following concerns that the new leasing framework would undermine the availability and usefulness of the spectrum for PS operations
    - Oct2021, FCC “Eighth Further Notice” – seeks inputs on optimizing the use of the 4.9 GHz band for PPDR and national framework, including database for existing licensees. FCC aims at incentivizing PS to use the latest commercially available technologies, including 5G

- 4800-4990 MHz band for possible use for IMT
  - 4800-4900 MHz: Brazil, Paraguay and Uruguay have the IMT identification in RR Footnote 5.441A but no deployment yet
  - 4800-4990 MHz: Brazil has IMT identification under footnote 5.441B, not subject to PFD limit
  - In all the cases, for IMT deployments countries must coordinate with neighbours and IMT stations cannot claim protection from stations of other applications of the mobile service

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Band n79 devices availability





Source: GSA, October 2021

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Recommendations for the band

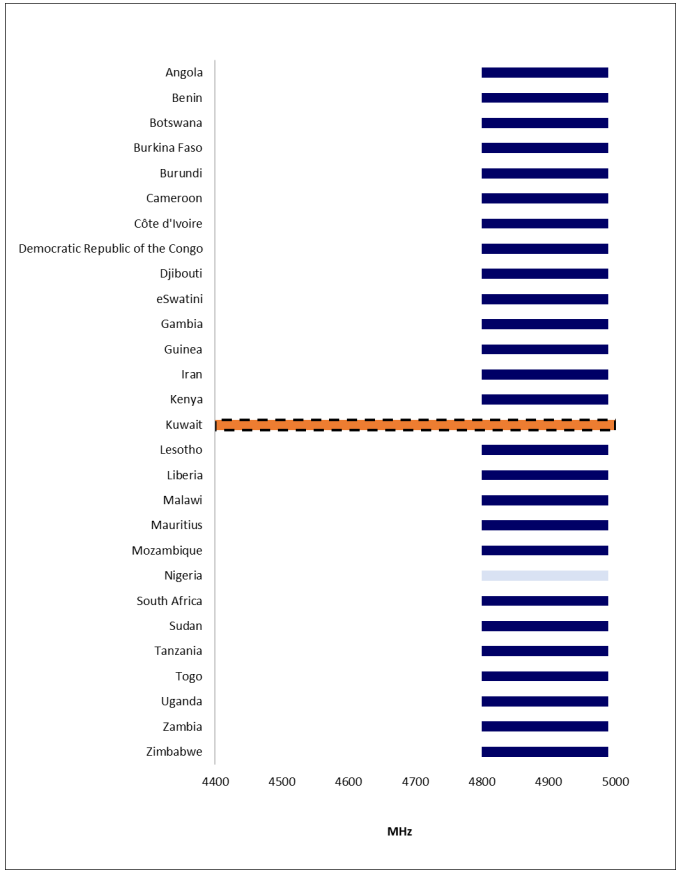
- **4.4-5 GHz** band is suitable for 5G nationwide networks
  - Complementary band to the already available 5G mid-bands (i.e., 3.3/3.4-3.8 GHz)
  - In countries/regions where the 3300-4200 MHz has limited availability or is not available yet, timely access to the 4400-5000 MHz band is even more critical.
  - Regulators should assign ideally blocks of approximatively 100 MHz contiguous spectrum per MNO network
  - GSA encourages administrations to make available the spectrum within the 4.4-5 GHz band for IMT use

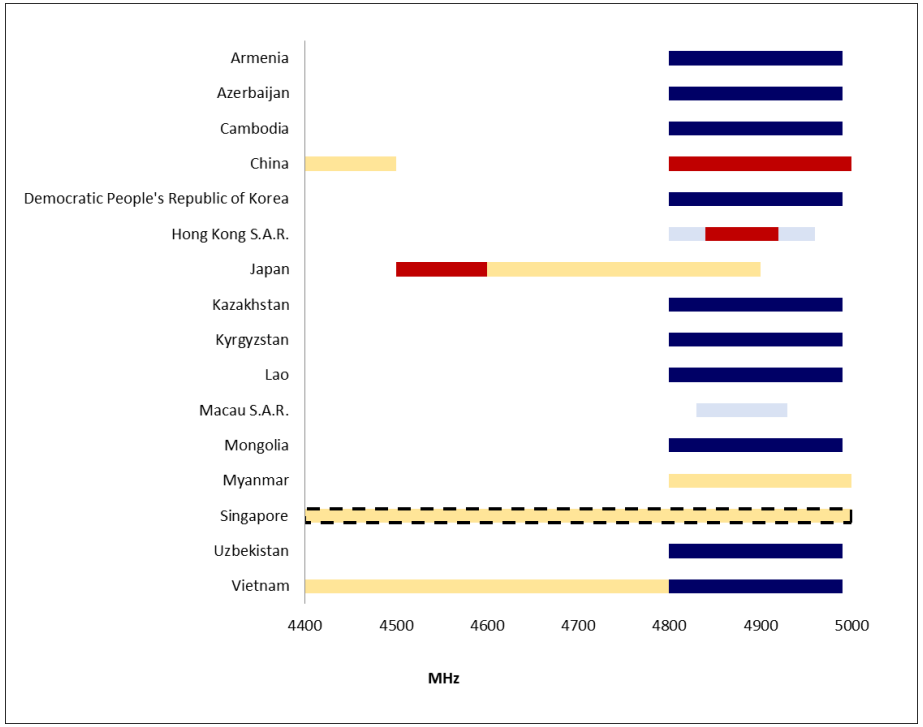
- GSA supports WRC-23 efforts to further harmonize and expand the use of **4800-4990 MHz** for IMT under Agenda Item 1.1
  - The current pfd limit in RR No. 5.441B largely constraints nationwide IMT deployments.
  - Studies under AI 1.1 should focus on regulatory aspects instead of technical ones since the technical sharing studies have been ongoing since after the WRC-15 with limited progress. Any potential solutions to address protection of stations of the AMS/MSS located in international airspace and waters should not constrain nationwide deployments of IMT in the band.
  - GSA also considers that the list of countries planning to use the 4800-4990 MHz band for IMT should not be limited.

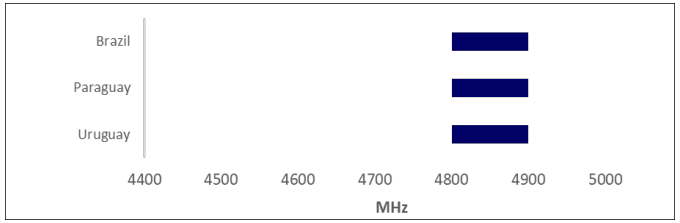
- Increasing the uptake and future planning of 5G networks within the 4.4-5 GHz band builds the global ecosystem for this important 5G mid band

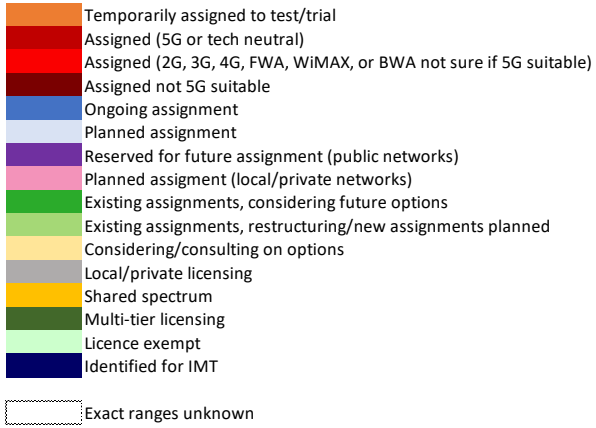
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Global mapping of the 4400-5000 MHz band









Source: GSA, June 2021

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The Future of 6 GHz

Luiz Felippe Zoghbi, Spectrum Policy Manager (GSMA) and Stuart Cooke, Chair GSA Global Spectrum Team (GSA) & Director Spectrum & Industry Affairs (Samsung)

WRC-23 IMT Agenda Items Overview

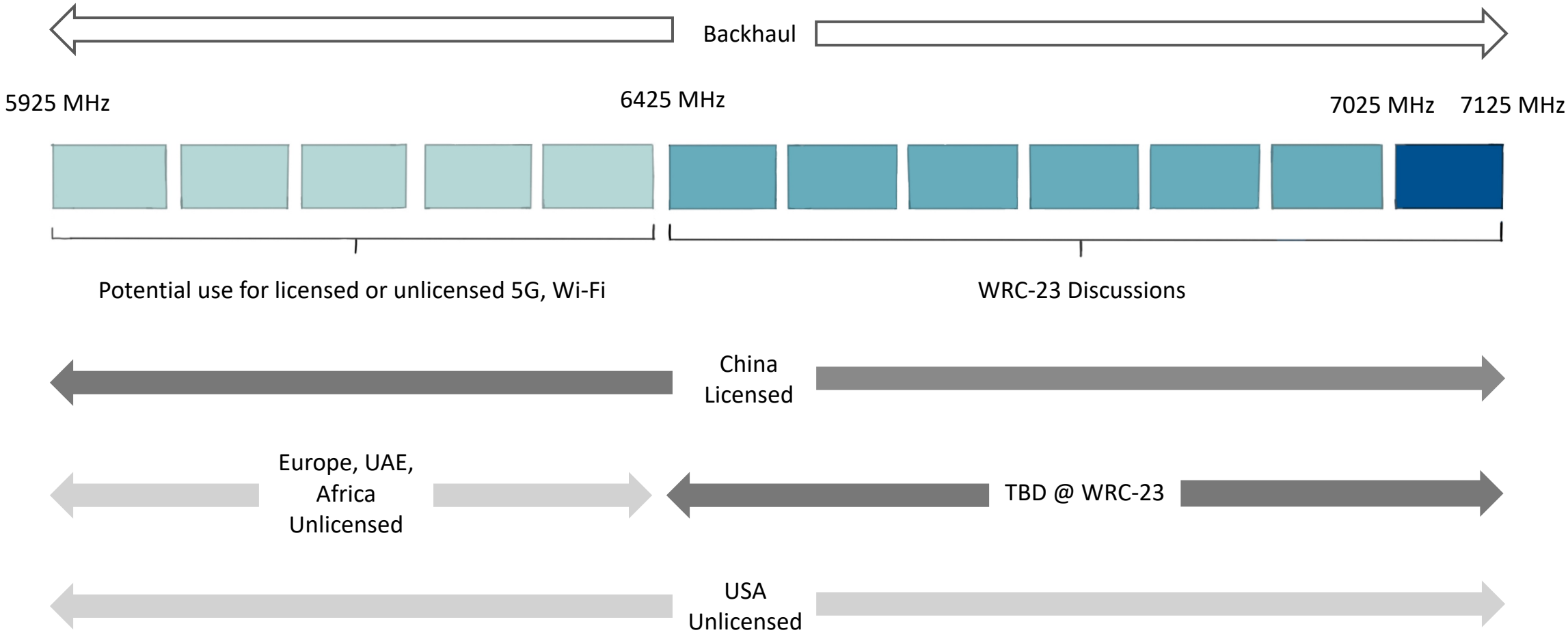


Global Industry Analysis:
GSMA questionnaire responses show support for 6425-7125 MHz as **high priority for future IMT in all three Regions**

- **Harmonisation is key**
- **Economies of scale are expected**
- **WRC-23 can help towards this**

Bands	470-960 MHz	3300-3400MHz	3600-3800MHz	4800-4990 MHz	6425-7025 MHz	7025-7125 MHz	10-10.5 GHz
Region 1	AI 1.5 (IMT)	AI 1.2 (IMT)	AI 1.3 (MS)	AI 1.1 (IMT)	AI 1.2 (IMT)	AI 1.2 (IMT)	
Region 2		AI 1.2 (IMT)	AI 1.2 (IMT)	AI 1.1 (IMT)		AI 1.2 (IMT)	AI 1.2 (IMT)
Region 3				AI 1.1 (IMT)		AI 1.2 (IMT)	

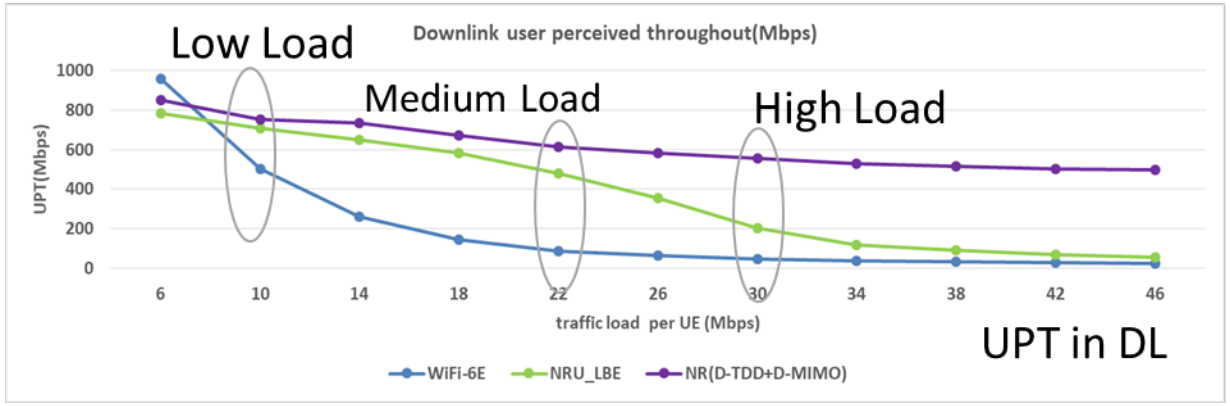
Current plans for 6 GHz

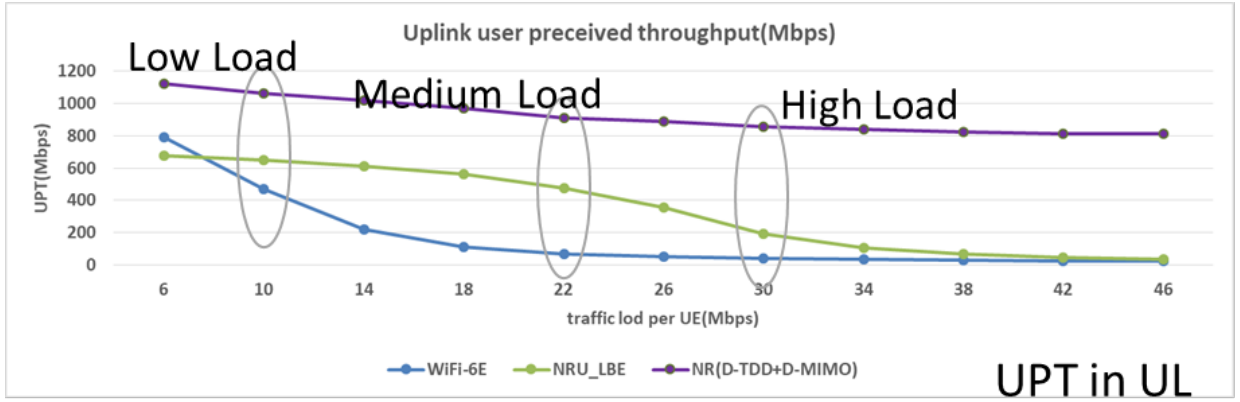


5G-NR vs. 5G-NR-U vs. WiFi-6E

FEATURES	NR R15 / R16	NR-U R16
CF/BW	FR1 (<=7GHz) <= 100MHz x CC,	5/6GHz, <=100MHz x CC

PERFORMANCE	NR R15 / R16	NR-U R16
Target scenario	Citywide coverage	Outdoor / indoor hotspot
Peak throughput	DL: 18.48~19.28 Gbps (8SS/256QAM/100MHzx4CC) UL: 9.08~9.52 Gbps (4SS/256QAM/100MHzx4CC)	Same as NR R15/16
Coverage	Ca. 1000m with 67dBm EIRP (dense urban NLOS, 20MHz CC, PDSCH at 6.7Mbps)	ca. 160m with 36dBm EIRP (dense urban NLOS, 20MHz CC, PDSCH at 6.7Mbps)
Mobility	500km/h	Not target for high mobility scenario
Reliability	99.9999%	Reliability cannot be ensured with unlicensed spectrum → not suitable for URLLC





The GSMA's 6 GHz position

- More mid-band spectrum is vital to help 5G scale.
  - It is estimated that 5G networks need 2 GHz of mid-band spectrum over the next decade to deliver its full potential.
- 6 GHz will be important to help meet this requirement
- Important to consider needs of incumbents (inc. backhaul)
- It is recommended that at least 6425-7125 GHz is made available for licensed 5G
  - The bottom half of the 6 GHz range (5925-6425 MHz) could either be used for licensed 5G or, if needed, opened on a licence-exempt basis with technology neutral rules.

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Conclusions

Market assessment should lead approach

5 925-6 425 MHz	• Follow developments and protect backhaul • Consider market conditions and developments • If there is market need and FTTH, consider for unlicensed use
6 425-7 125 MHz	• Ensure 5G has sufficient bandwidth for lower network density/costs • Look at market metrics: development of 5G means +6 GHz will be needed • Consider options for 5G expansion spectrum: 3.5 GHz and 6 GHz
Approach	• Consider the protection of backhaul for any way forward • Avoid decisions that cannot be reversed • Look at core network availability and 3.5 GHz availability • Safeguard the top 700 MHz for 5G; consider the lower band



GSA

Planning for additional mid-band spectrum

Stuart Cooke

Chair GSA Global Spectrum Team

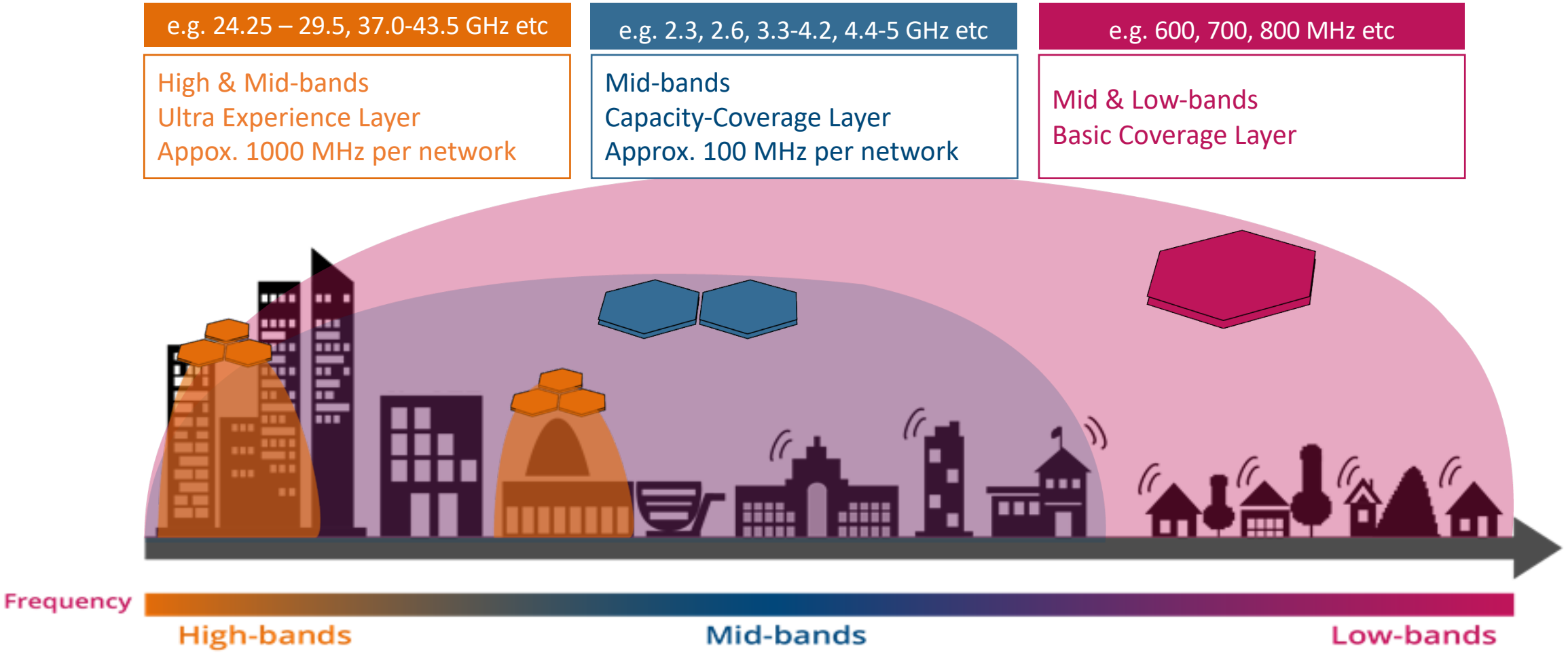
21st October 2021

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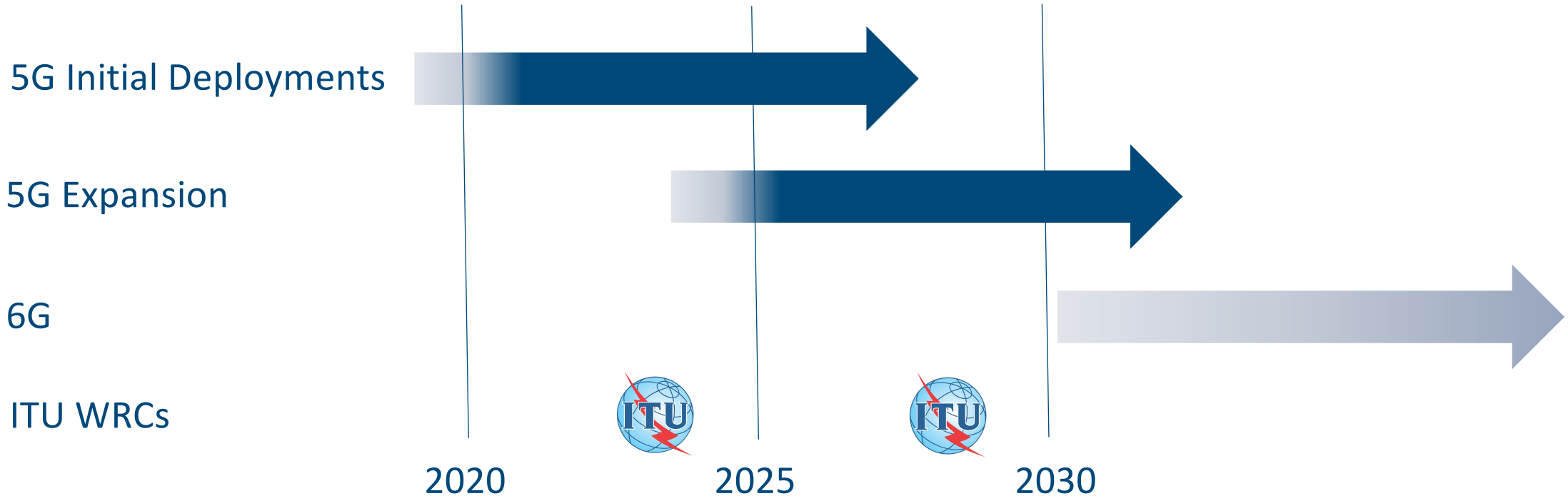
5G Spectrum for Coverage, Capacity and Ultra Experience

(for initial 5G deployments - 2020-2025 time frame)



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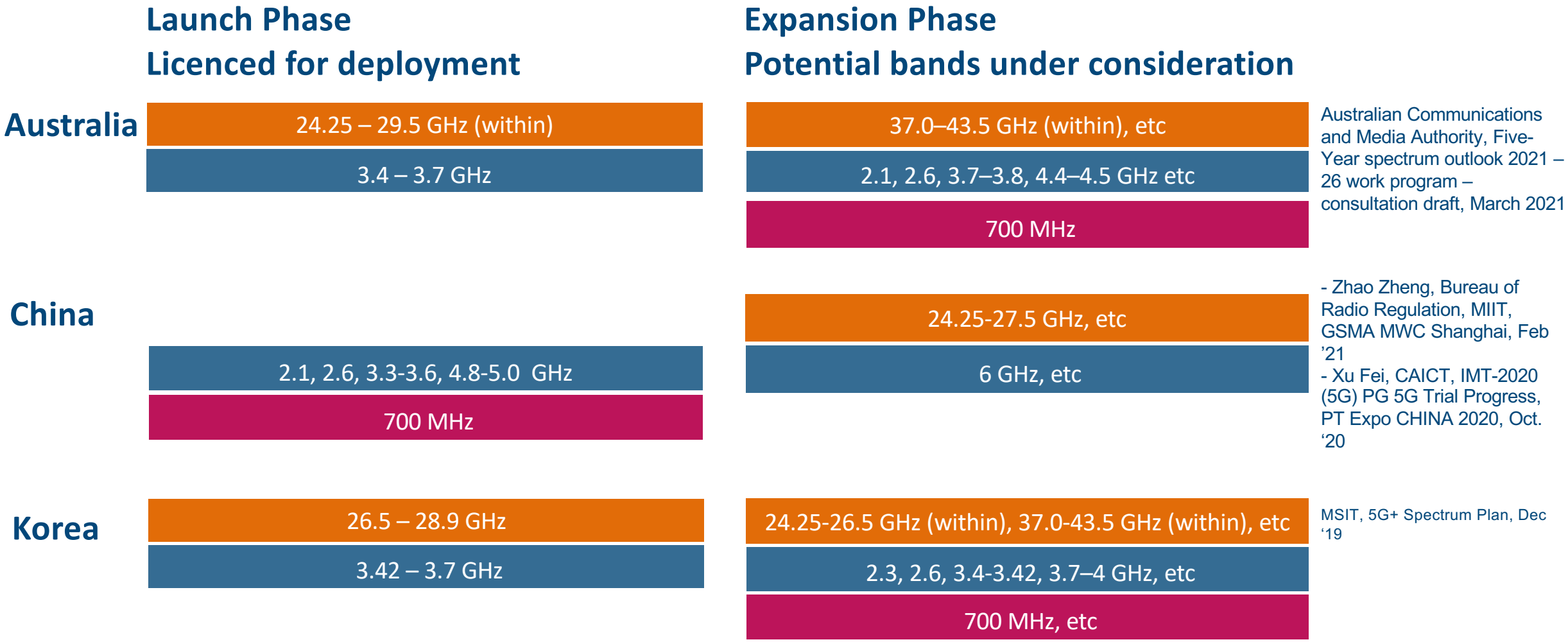
IMT Spectrum 2020-2030



- Initial 5G deployments well underway with licensing & roll outs
- 5G expansion spectrum planning underway in some countries 2023/5+ timeframe
- 6G early research & planning discussions commencing targeting 2030+ timeframe

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APT Examples of 5G Initial Deployment & Expansion Spectrum



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Delivering spectrum to power 5G continual evolution

'..spectrum licensed from low, mid and high bands by 2021 helps enable the vision..'

- 5G Initial Deployments
  - Deployments well underway particularly mid-band (i.e. 2.3, 2.6, 3.3-4.2, 4.4-5.0 GHz etc)
  - Recommend spectrum is licensed from low, mid & high bands by '21
  - GSA supports further harmonization of the 5G initial mid-band 3.3-3.8 GHz through IMT identification of this band at WRC-23 (*)
- 5G Expansion
  - Planning discussions started for expansion of spectrum 2023/25-2030
  - Consider licensing ranges such as 600 MHz, 700 MHz, 2.3, 2.6, 3.8-4.2, 4.4-5.0, 40 GHz, etc, more widely
  - GSA supports studies towards IMT identification at WRC-23 for the upper 6 GHz range and the 10 GHz range which are being studied as part of the WRC-23 (*), noting the different technical and operational characteristics of these bands
  - Administrations are encouraged to begin planning for additional mid-band spectrum from 2025 onwards
  - The amount of spectrum needed for 5G mid-band expansion depends on a number of factors (such as forecast traffic, base station density, amount of existing spectrum from low, mid and high bands, activity factor, etc)
  - One example is a study that the GSMA has developed on additional mid-band spectrum needs (https://www.gsma.com/newsroom/press-release/gsma-calls-for-2-ghz-of-mid-band-spectrum-to-meet-un-targets)

*(*) WRC AI 1.2 'to consider identification of the frequency bands 3 300-3 400 MHz, 3 600-3 800 MHz, **6 425-7 025 MHz, 7 025-7 125 MHz** and 10.0-10.5 GHz for International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis….*
*Resolution **245**; Res2 conduct and complete in time for WRC-23 the sharing and compatibility studies1, with a view to ensuring the protection of services to which the frequency band is allocated on a primary basis, without imposing additional regulatory or technical constraints on those services, and also, as appropriate, on services in adjacent bands, for the frequency bands: 3 600-3 800 MHz and 3 300-3 400 MHz (Region 2); 3 300-3 400 MHz (amend footnote in Region 1); **7 025-7 125 MHz (globally); 6 425-7 025 MHz (Region 1);** 10.0-10.5 GHz (Region 2)…*

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6GHz sharing studies - update

- As the responsible group, ITU-R WP 5D has initiated the sharing and compatibility studies under Agenda Item 1.2.
- At WP 5D #39 Oct. 2021, multiple contributions on 6GHz sharing studies were received
- No conclusions on the studies were agreed and further discussion will continue within WP 5D

Service	Contributions
SRS	5D/831 (GSMA)
SOS	/
FS	5D/778 (RUS)
FSS (E-S)	5D/782 (CME, NIG, AFS, ZWE) 5D/806 (J) 5D/835 (ARS, JOR) 5D/850 (ESOA) 5D/874 (CHN)
FSS (S-E)	5D/835 (ARS, JOR)

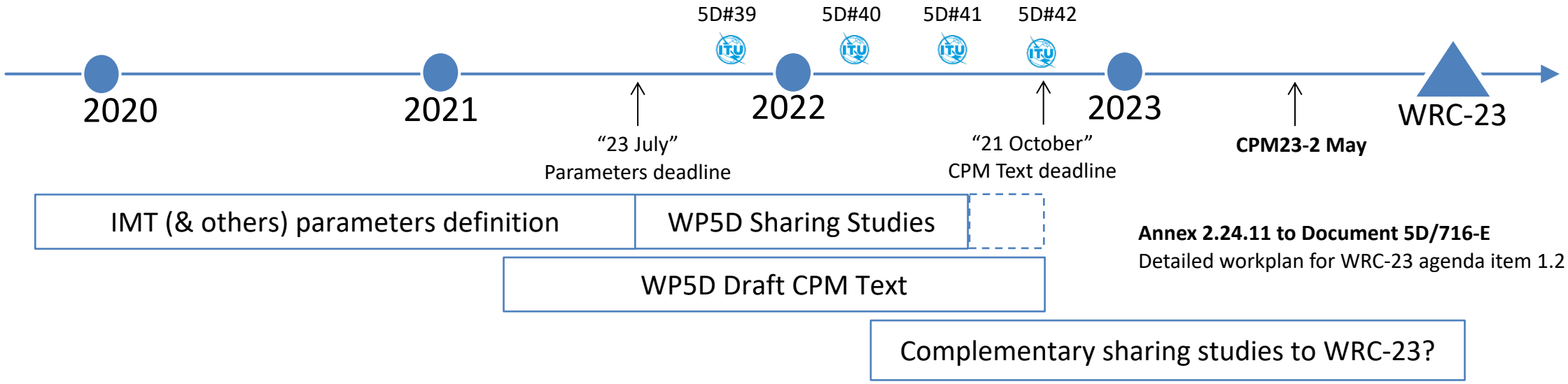
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6GHz sharing studies - update

- As the responsible group, ITU-R WP 5D has initiated the sharing and compatibility studies under Agenda Item 1.2.
- At WP 5D #39 Oct. 2021, multiple contributions on 6GHz sharing studies were received
- FSS (Earth to Space) Sharing studies are diverging with margins ranging from +10 dB (5D/782 (CME, NIG, AFS, ZWE and 5D/874 (CHN)) to -13.5 dB (5D/850 (ESOA))
  - Detailed discussions were held by email in order to understand each approach
  - As a result, the group still needs to work on a number of assumptions in order to shrink the margin variance in dB
    - Clutter loss, apportionement, BS density, Ra/Rb options, …
- FSS (Space to earth), study (5D/835 KSA/JOR) using Rec. ITU-R M.2101 based Monto Carlo simulation shows sharing is not feasible. It means mitigation measures e.g. separation distance is needed.
- FS (5D/778 RUS) study using Rec. ITU-R M.2101 based Monto Carlo simulation shows separation distance <1km up to 64km for different cases
- SRS study (5D/831 (GSMA)) using Rec. ITU-R M.2101 based Monto Carlo simulation shows sharing is feasible with 50dB margin in the ”Far away mission’s stages”. It was suggested to also look at the early launch or close to return phases

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TIMELINE FOR PARAMETERS, SHARING STUDIES AND CPM TEXT



Annex 2.24.11 to Document 5D/716-E
Detailed workplan for WRC-23 agenda item 1.2

Meeting	Dates	Workplan
5D and etc	23rd July 2021	Submission of characteristics, protection criteria and propagation models
5D#39	October 2021	Start substantial work on sharing studies; update draft CPM text
5D#40	February 2022	Continue sharing studies; update draft CPM text
5D WG Spectrum	April 2022 (19-22/4)	"Interim meeting" of WP5D WG Spectrum Aspects to focus on AI 1.1, 1.2 and RR 21.5
5D#41	June 2022	Finalize sharing studies; update draft CPM text
5D#42	October 2022	Finalize draft CPM text until 14 Oct. 2022*
CPM 23-2	[1st half of May 2023] (if hosted outside of Geneva)	Finalize CPM text
WRC-23	20 Nov. – 15. Dec. 2023	WRC-23 decision

* According to CA/251(Add.1), the final draft CPM texts from the responsible groups shall be received by the respective CPM-23 Chapter Rapporteurs by 21 October 2022 at the latest; the submission deadline of 21 October 2022 is based on assumption that CPM23-2 is in Q2-2023, may be postponed based on actual CPM23-2 dates

Planning for additional mid-bands spectrum

- Regulators should assign a minimum of 100 MHz contiguous blocks per MNO network by 2021, ideally from within the 3300-4200 MHz range, for initial 5G deployments

- Further to this, additional mid-band spectrum will be required in the 2025-2030 timeframe. Administrations are therefore encouraged to begin planning for additional mid-band spectrum accordingly

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GSA

Mid-band spectrum needs and mmWaves
Unlocking the future of 5G in ASEAN countries

Virtual Event

21 October 2021

Current and future use of mmWaves

Yiran Jin, Head of mmWave group (GSA) and Standardisation Engineer (Samsung)

Session 5: Current and Future use of mm Waves

Yiran JIN

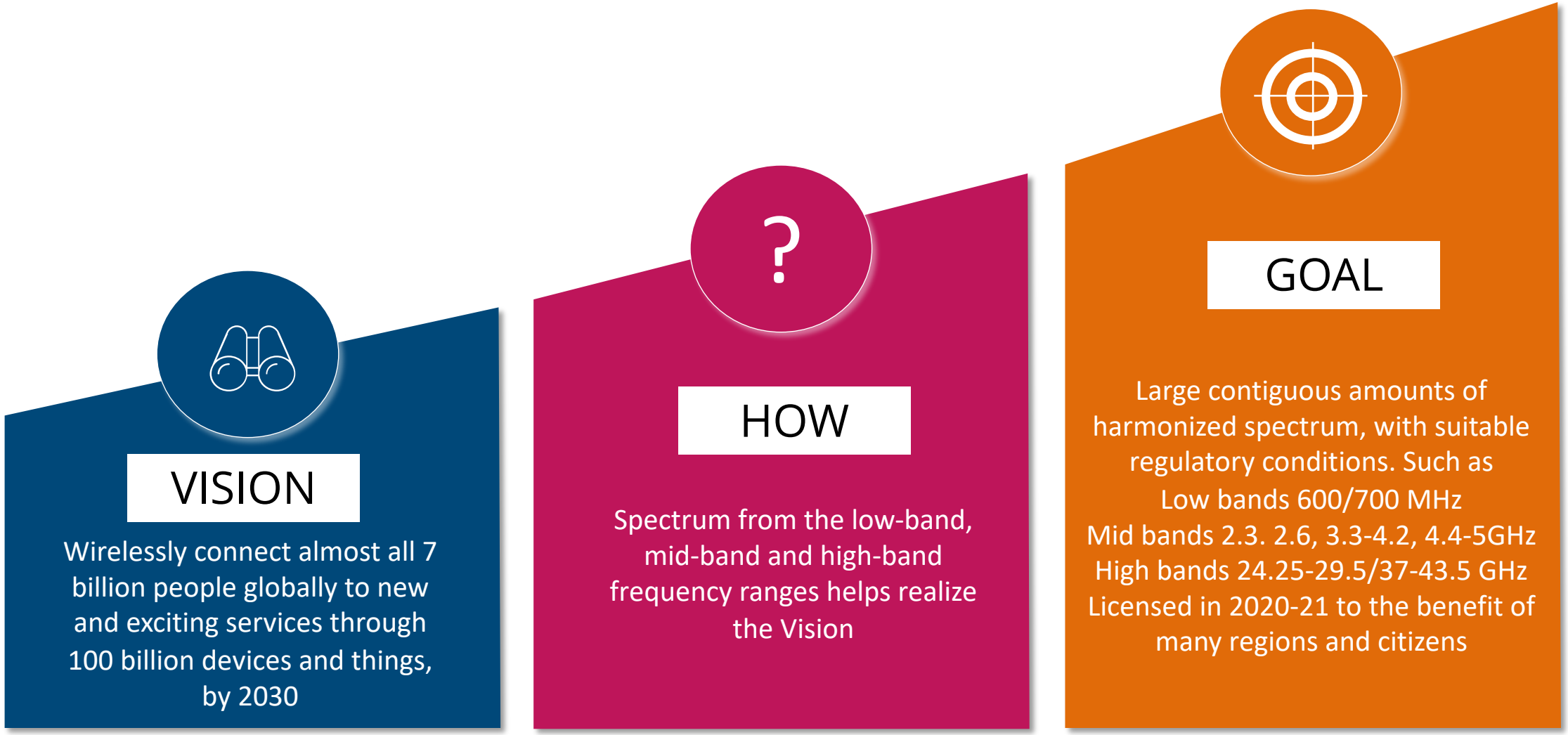
High Band Team Coordinator, GSA

21 October 2021

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Wireless Vision

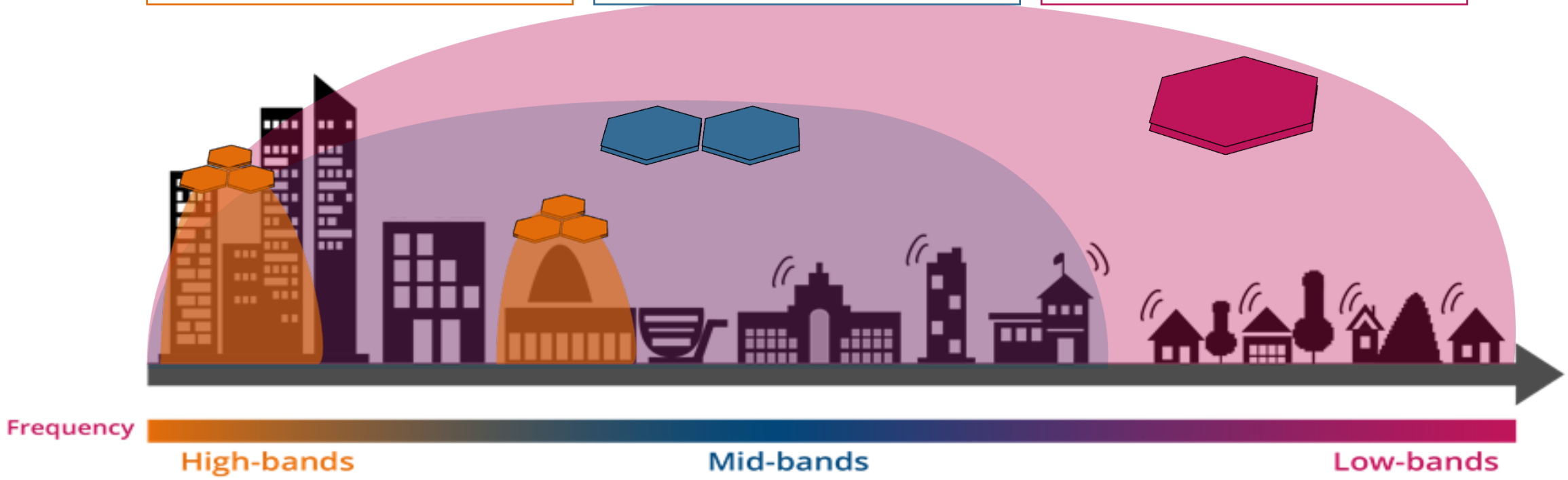
'..spectrum licensed from low, mid and high bands by 2020/21 helps enable the vision..'



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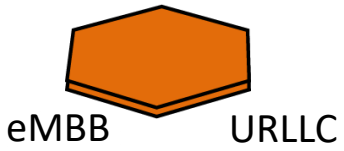
5G Spectrum for Coverage, Capacity and Ultra Experience

e.g. 24.25 – 29.5, 37.0-43.5 GHz etc	e.g. 2.3, 2.6, 3.3-4.2, 4.4-5 GHz etc	e.g. 600, 700, 800 MHz etc
High & Mid-bands Ultra Experience Layer Appox. 1000 MHz per network	Mid-bands Capacity-Coverage Layer Approx. 100 MHz per network	Mid & Low-bands Basic Coverage Layer



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5G Spectrum



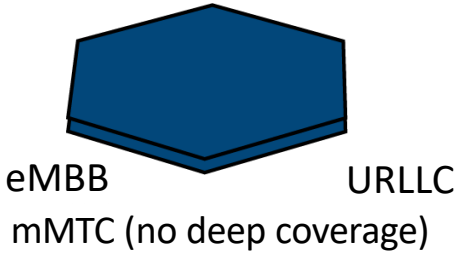
High Band

e.g. 24.25 – 29.5 GHz | 37.0 – 43.5 GHz etc.

Extreme Capacity

800-1000 MHz spectrum per MNO/Network contiguous from 2020/2021 onwards

Additional High band spectrum may be required for MNOs by 2023/2025



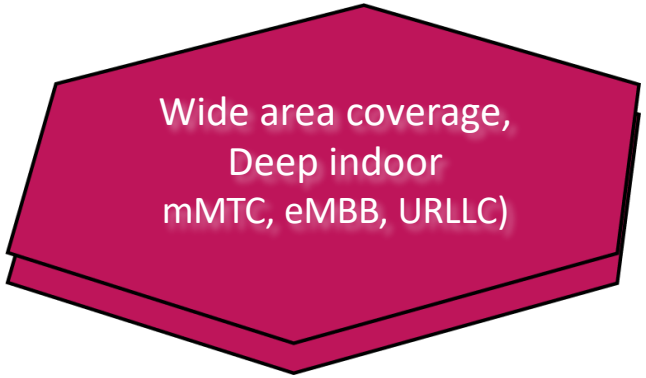
Mid Band

e.g. 2.3, 2.6 GHz | 3.3 – 4.2 GHz | 4.4 – 5 GHz etc.

Coverage & Capacity

80-100 MHz spectrum per MNO/Network contiguous from 2020/2021 onwards

Additional Mid band spectrum may be required for MNOs by 2023/2025



Low Band

e.g. 600 MHz | 700 MHz etc.

Extended Coverage

Up to 20 MHz channel bandwidth from 2020/2021 onwards

Additional Low band spectrum may be required for MNOs by 2023/2025

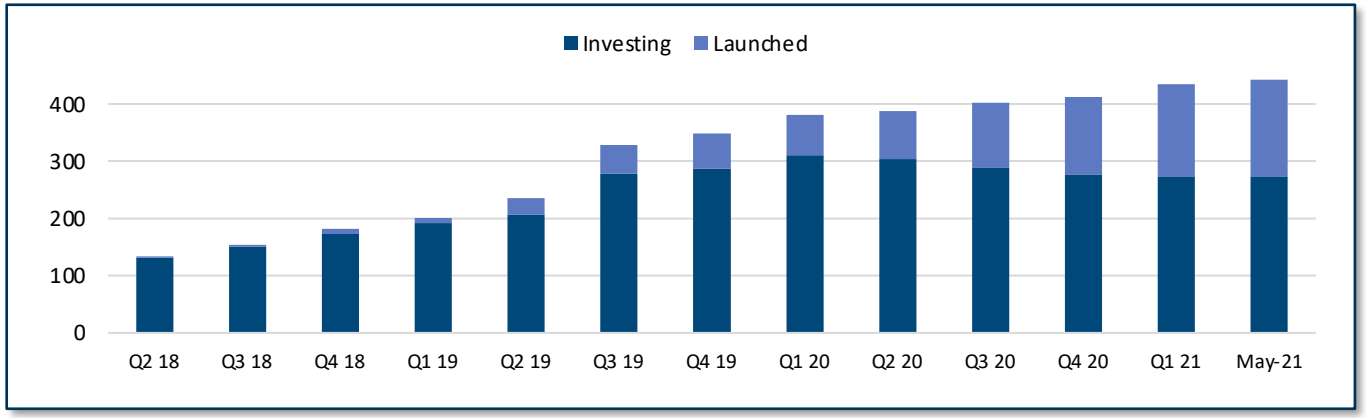
Various applications and services require access to spectrum from low, mid and high bands

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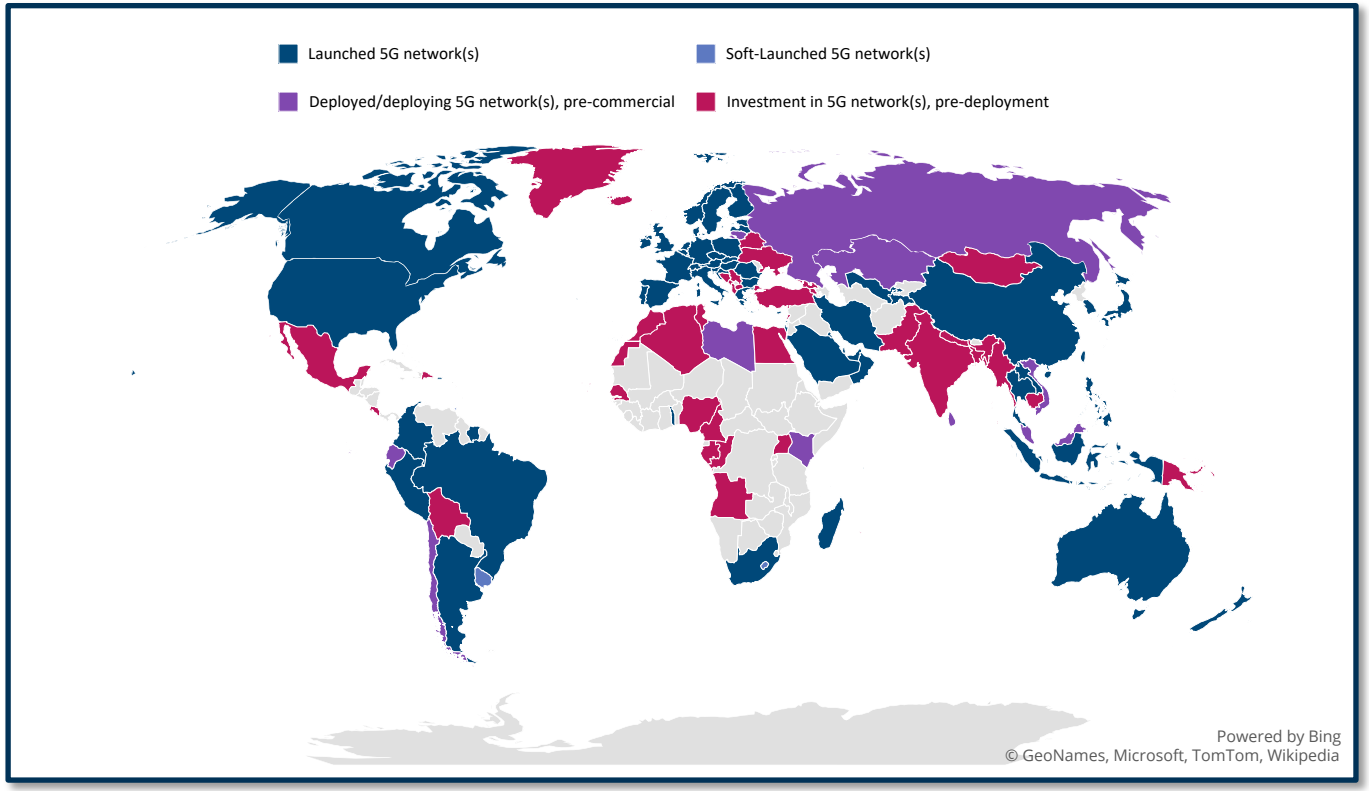
5G rollout continues to accelerate

- 443 operators in 133 countries/territories are investing in 5G networks in the form of tests, trials, pilots, planned and actual deployments.
- Of those, 169 operators in 70 countries/territories have launched commercial 3GPP-compatible 5G services (either mobile or FWA).
  - 159 of those have launched 5G mobile services
  - 54 have launched 5G FWA services
- 79 operators are identified as investing in 5G standalone (including those evaluating/testing, piloting, planning, deploying as well as those that have launched 5G SA networks).

Growth of 5G - number of operators investing, and operating commercial networks



Map of 5G networks

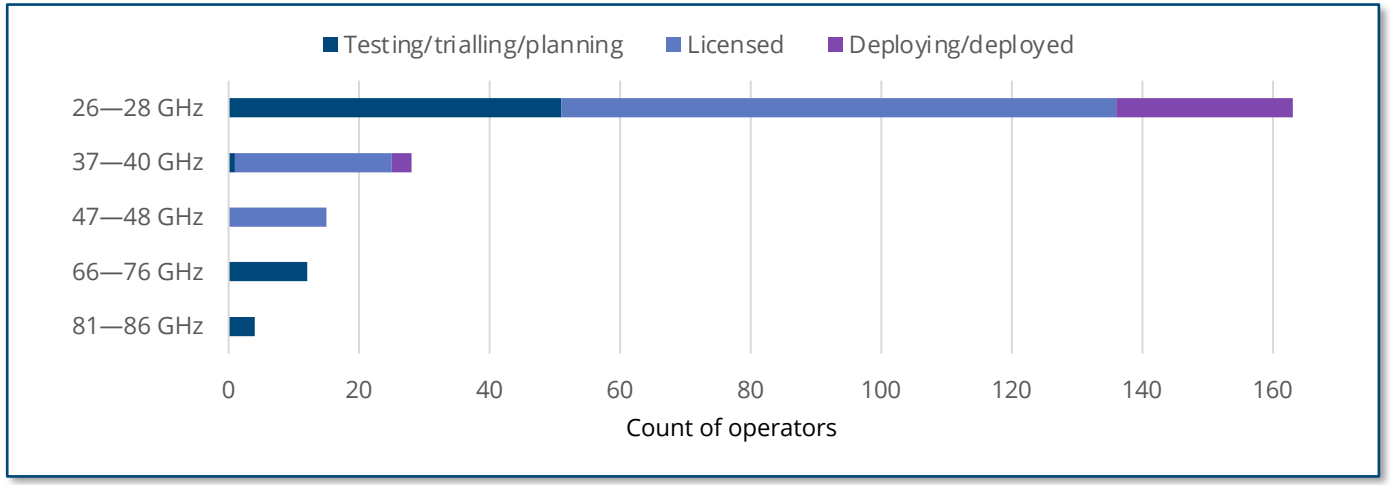


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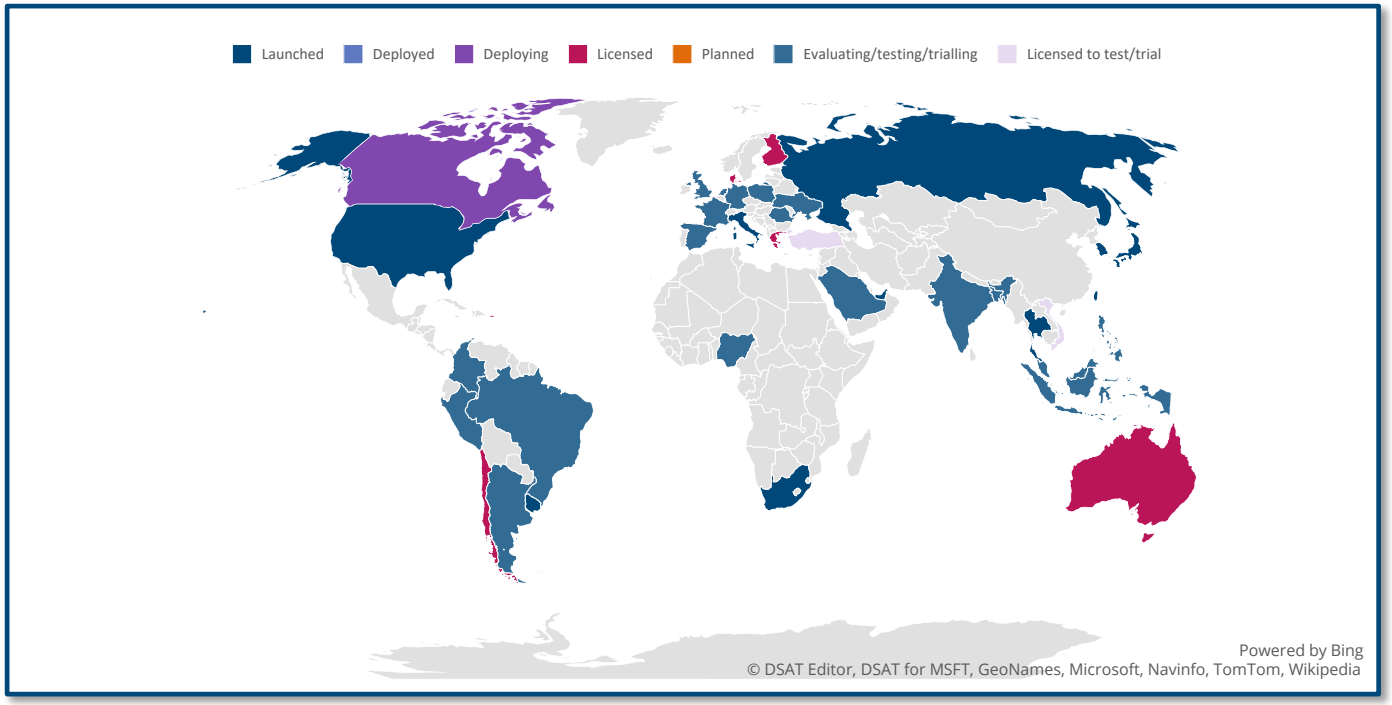
mmWave rollout is happening too

- 187 operators in 48 countries/territories have been investing in 5G mmWave (testing, trialling, planning, acquiring licences, deploying, or operating networks)
  - 26/28 GHz
  - 37-40 GHz
  - 47-48 GHz
  - Plus historically some trials at 66-76 GHz and 81-86 GHz
- 132 operators in 22 countries/territories hold licences enabling mmWave deployment in one of 26/28 GHz, 37-40 GHz and 47-48 GHz
- 28 operators identified as actively deploying mmWave spectrum for 5G

Count and status of operator mmWave investments



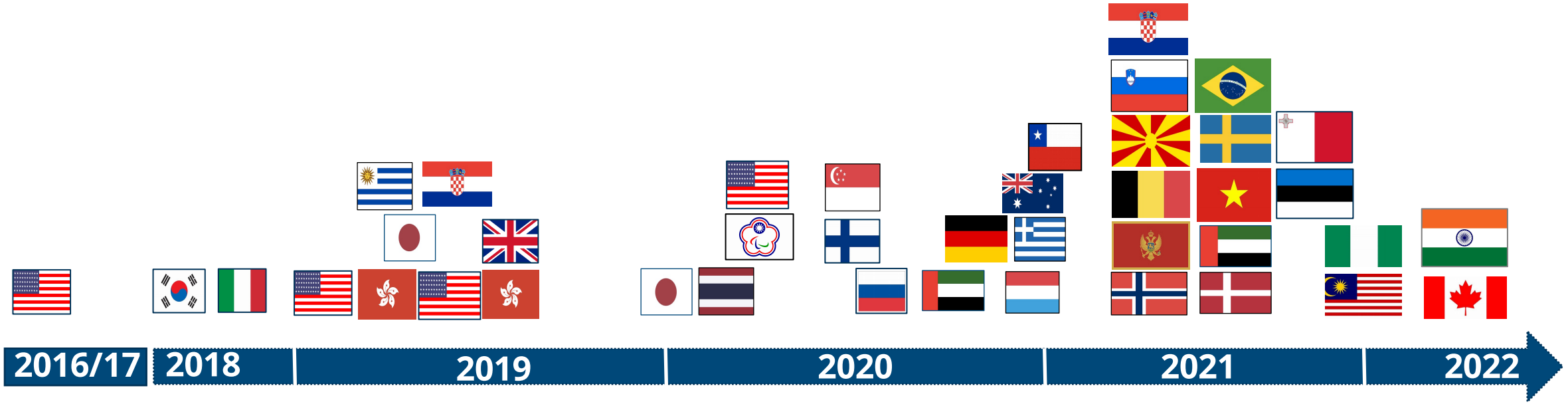
Use of 5G spectrum between 24.25 GHz and 29.5 GHz



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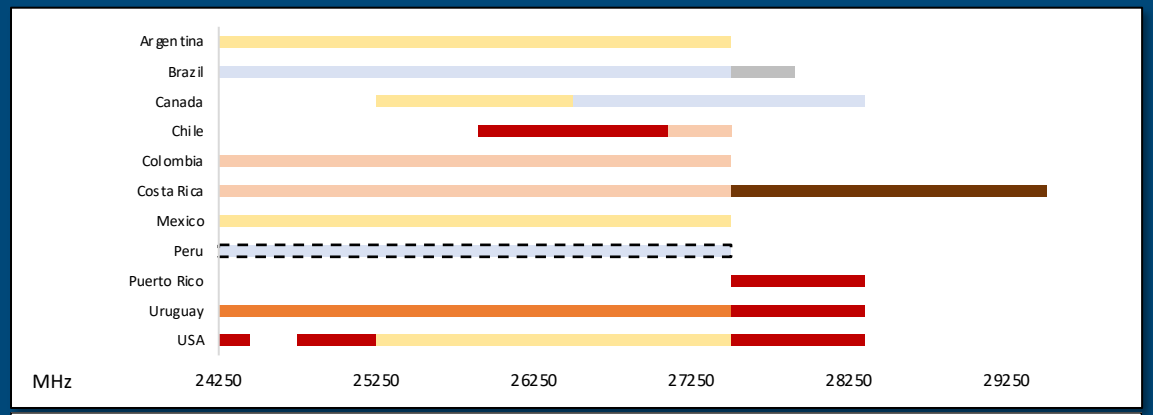
5G licensing – high ‘mmWave’ bands
(within 24.25-29.5GHz range)

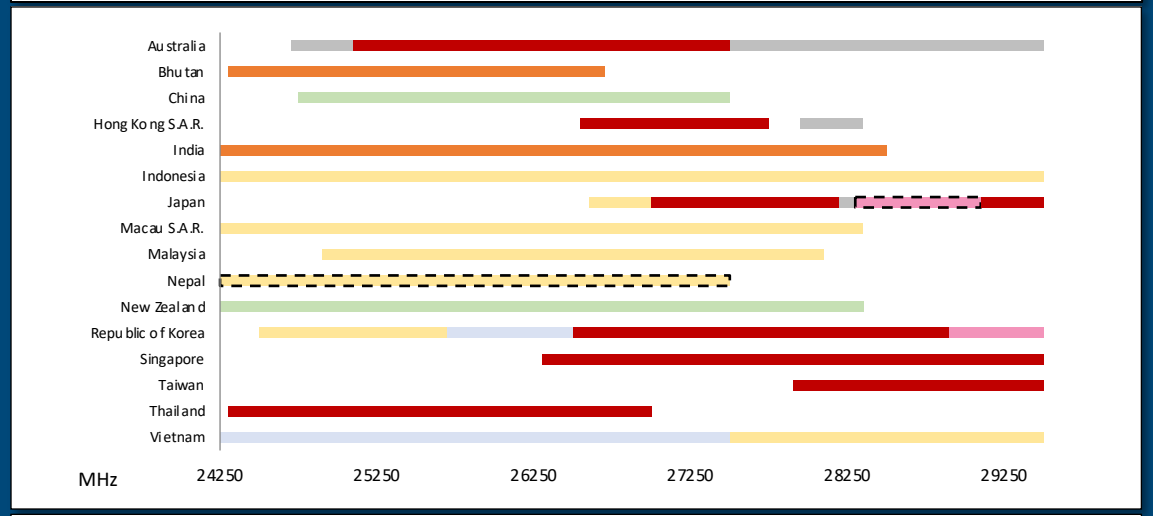
- High Bands mmWave licensing (in addition to mid bands) global momentum building
  - 112 operators licensed (including local/regional assignments)
  - Of which 27 deploying/deployed
- Leading countries/territories licensing mmWave in addition to mid and low bands
- Many countries looking at making some spectrum within the range 24.25-29.5 GHz available
- 40 GHz (37.5-43.5 GHz) range also gradually emerging (USA auctioned, ECC developing frequency arrangements)

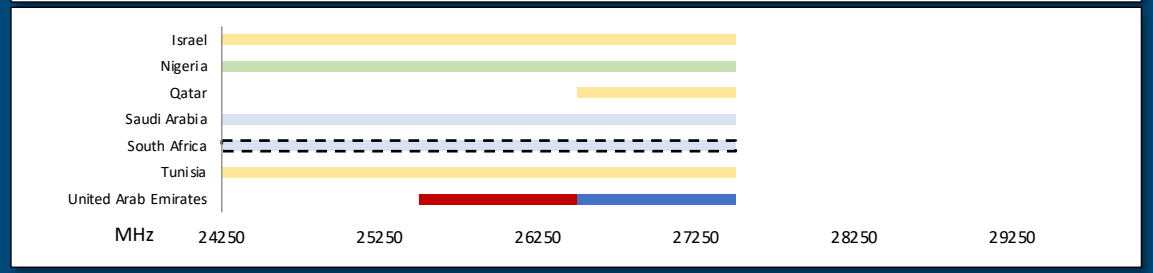


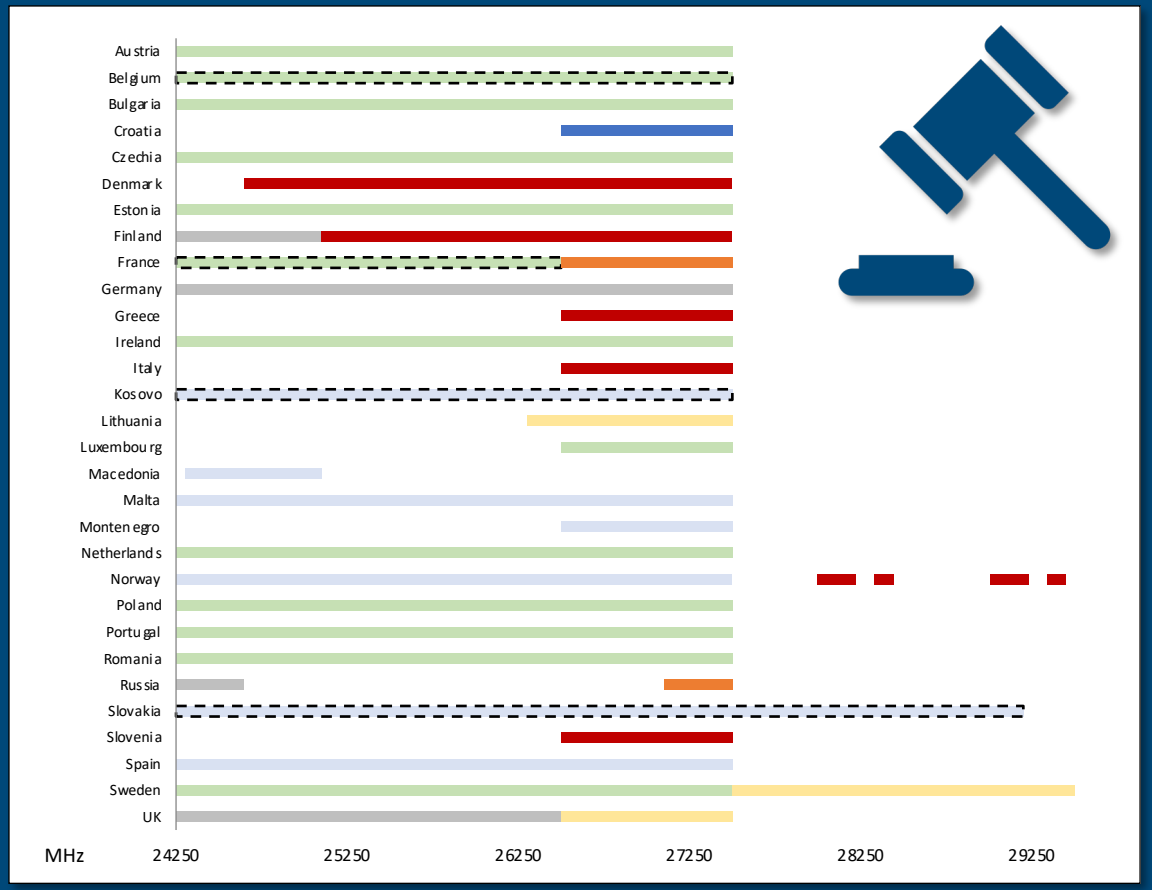
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Many more countries/territories are considering or planning mmWave spectrum assignment









Assigned* | Ongoing assignment* | Reserved for future assignment* | Planned assignment*
Local licensing** | Local licensing – multi tier*** | Ongoing consultation | Considering the options
Precise range is Unknown | Temporarily assigned to test/trial | Planned assignment – local licensing **
Shared spectrum (indoor use) | Shared spectrum (indoor use) planned | Identified for IMT

In many countries there are existing non-5G licences that are due for expiry within a few years. These are not shown on the charts.
* Nationwide or regional individual licensing for MNOs' public networks
** Spectrum set aside for individual licensing on a local basis for 5G private networks
*** Spectrum set aside for multi-tier approach (including individual assignment on a local basis and license-exempt)

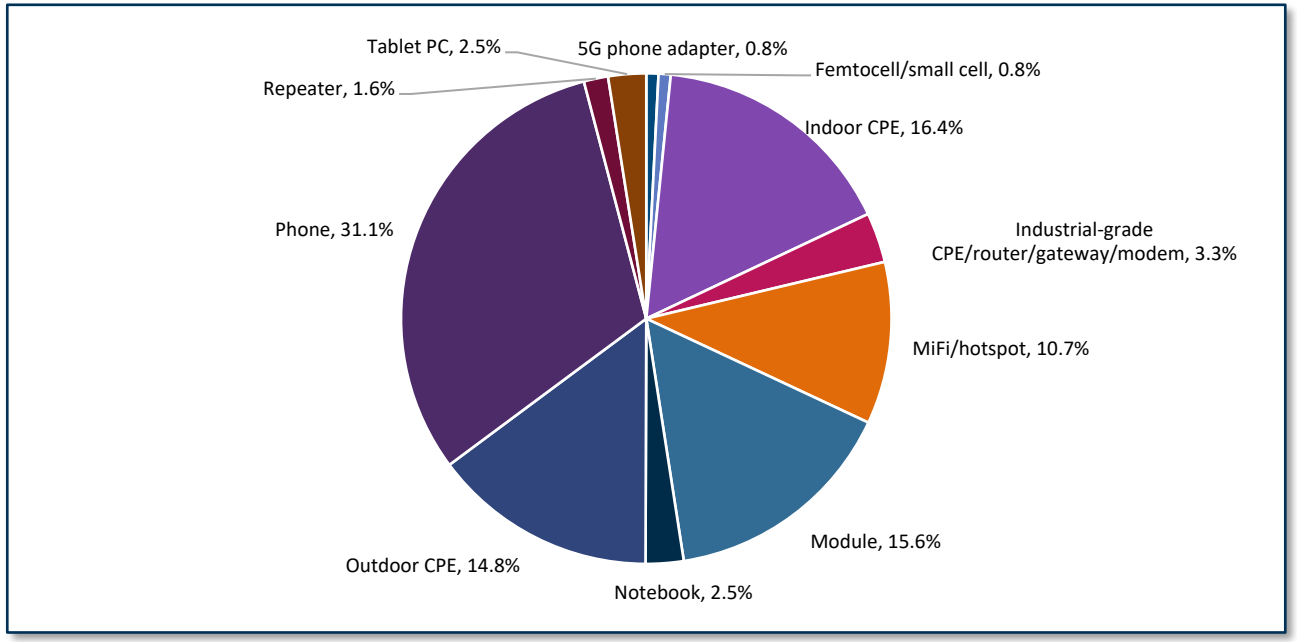
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Strong vendor ecosystem emerging

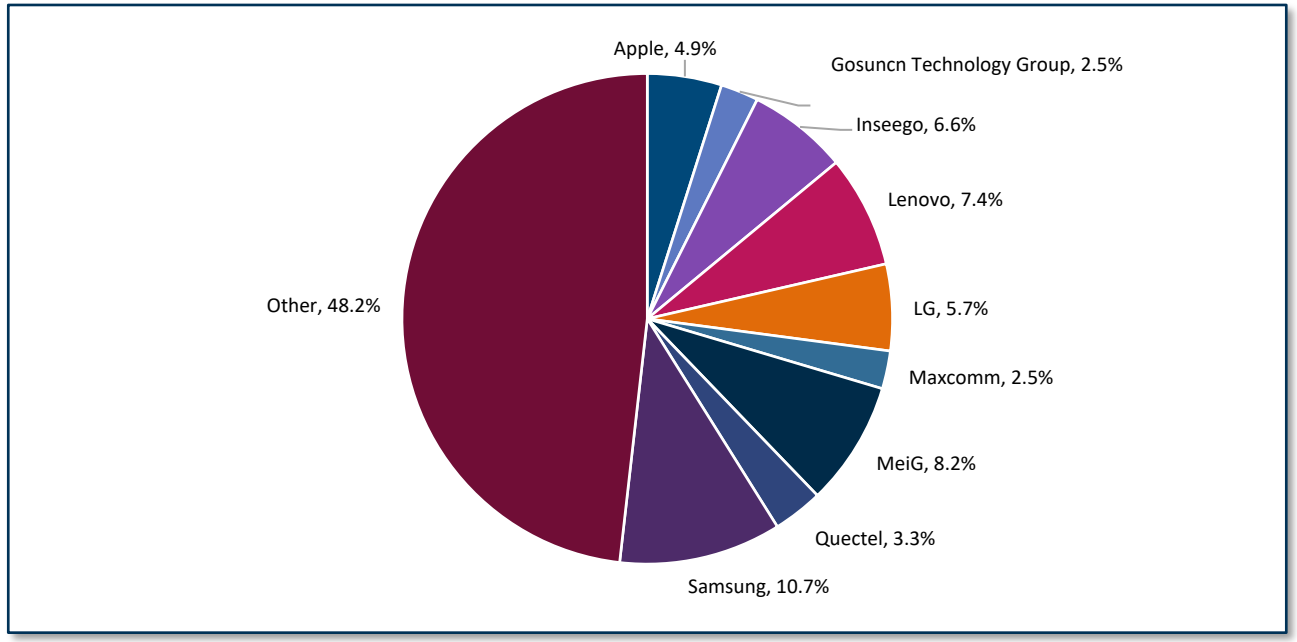
- 50 vendors have announced mmWave devices
- Announced / available
  - Any mmWave: 122 (up by 10 in 2021) / 77
  - n257 (26.5-29.5 GHz): 23 / 20
  - n258 (24.25-27.5 GHz): 10 / 9
  - n261(27.5-28.35 GHz): 45 / 42
  - n260 (37-40 GHz) : 45 / 42
- Supported by mmWave chips from five vendors
- Indoor and outdoor CPE >30% of all announced devices
- Phones nearly a third of all announced models
- Commercially available: 77 devices (up by 13 in 2021)
  - 36 of which are phones
  - mmWave devices 15% of all commercial devices.

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Announced 5G mmWave devices by form factor



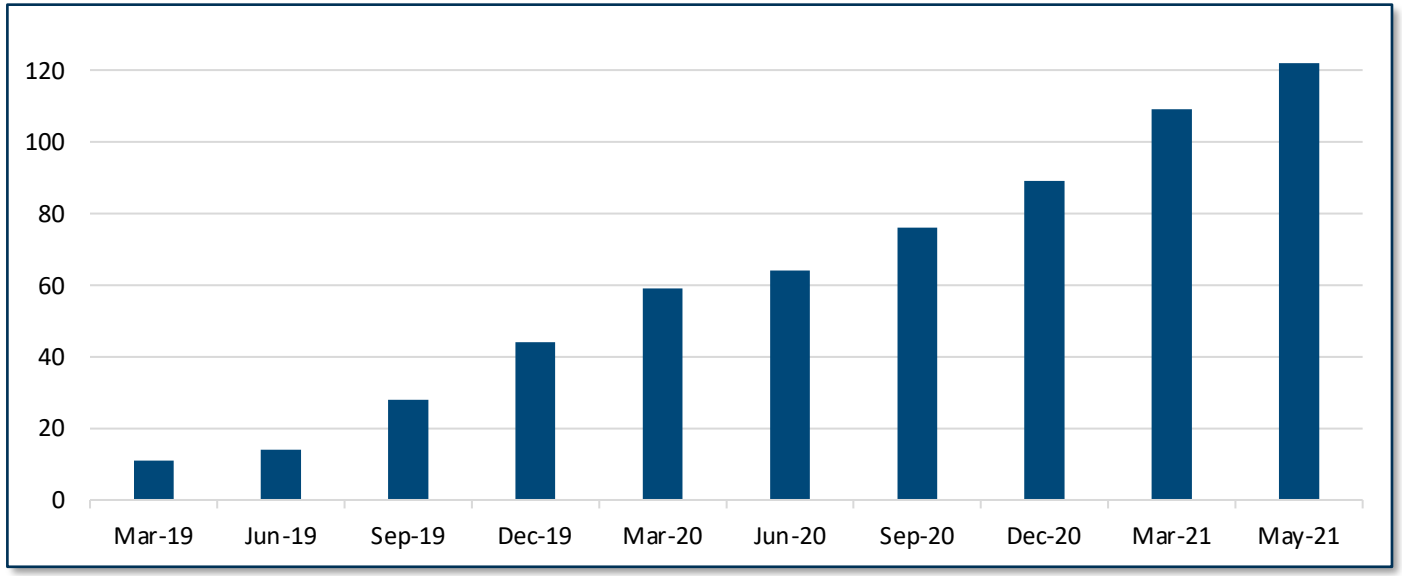
Announced 5G mmWave devices by vendor



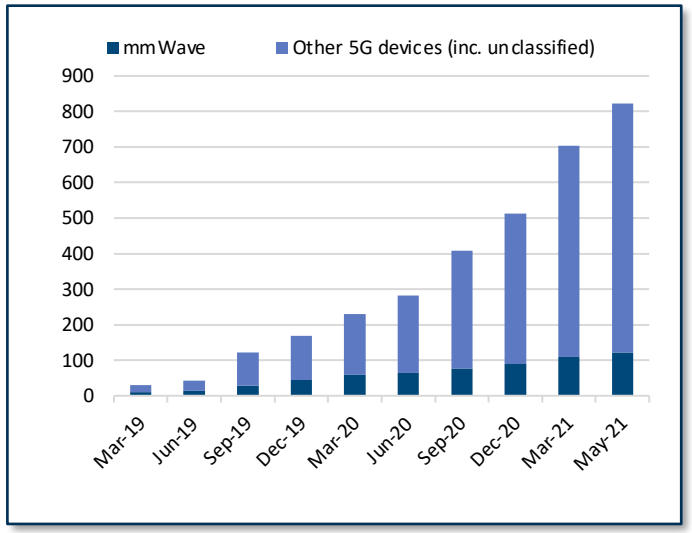
The mmWave device range is growing

- Announced 5G mmWave devices
  - Any mmWave: 122 (up by 10 in 2021)
  - n257 (26.5-29.5 GHz): 23
  - n258 (24.25-27.5 GHz): 10
  - n261(27.5-28.35 GHz): 45
  - n260 (37-40 GHz) : 45
- 15% of all announced 5G devices
- Commercially available: 77 devices (up by 13 in 2021)

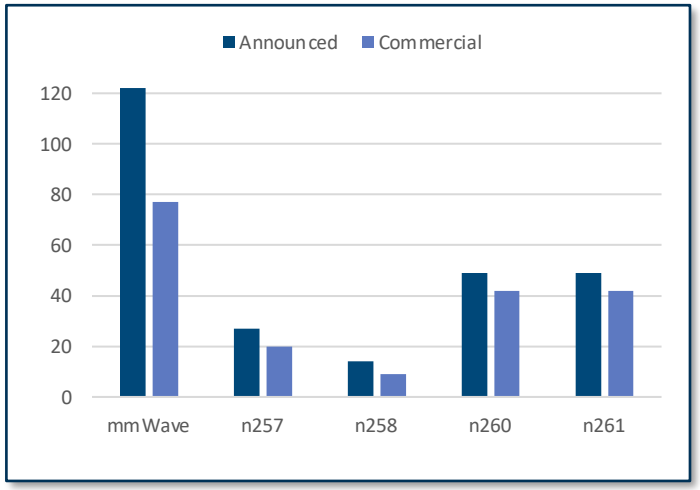
Announced 5G mmWave devices



Announced mmWave and other 5G devices



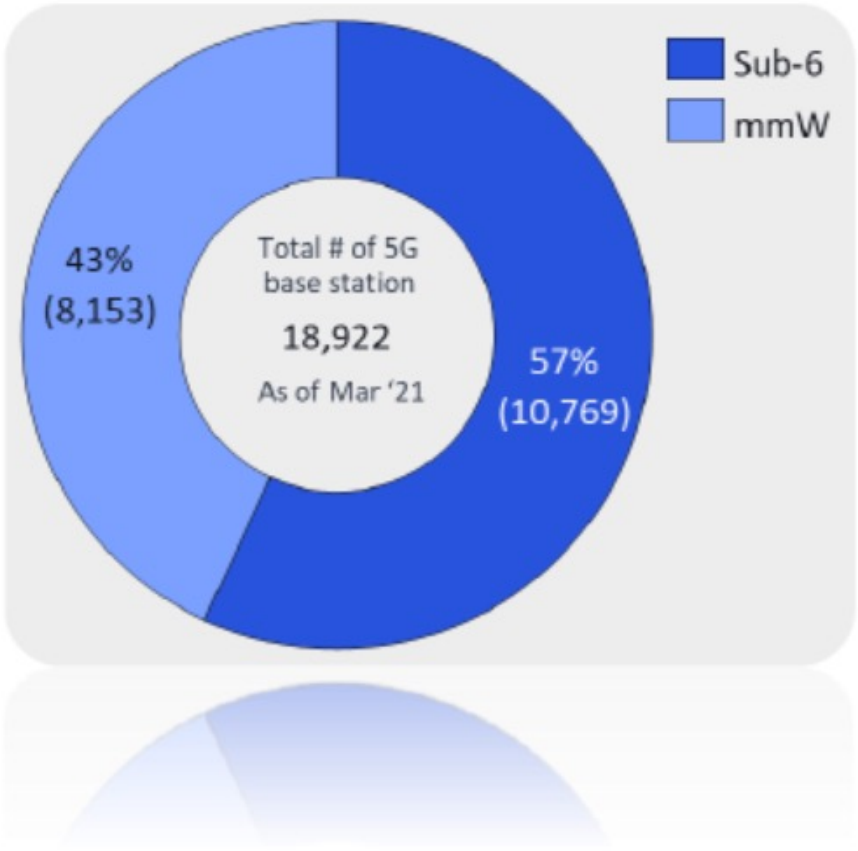
Known support for 5G spectrum bands above 24 GHz in announced 5G devices



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Example – Japan Operators

All operators expanding mmWave coverage – 8.1K base stations 1-1.5yrs ahead of initial plan



mm Wave		Mar-20	Jun-20	Sep-20	Dec-20	Mar-21	Mar-22	Mar-23	Mar-24
JP total	Plan	0	0	0	0	1,094	4,011	10,361	29,560
JP total	Actual	436	901	2,337	3,901	8,153	0	0	0



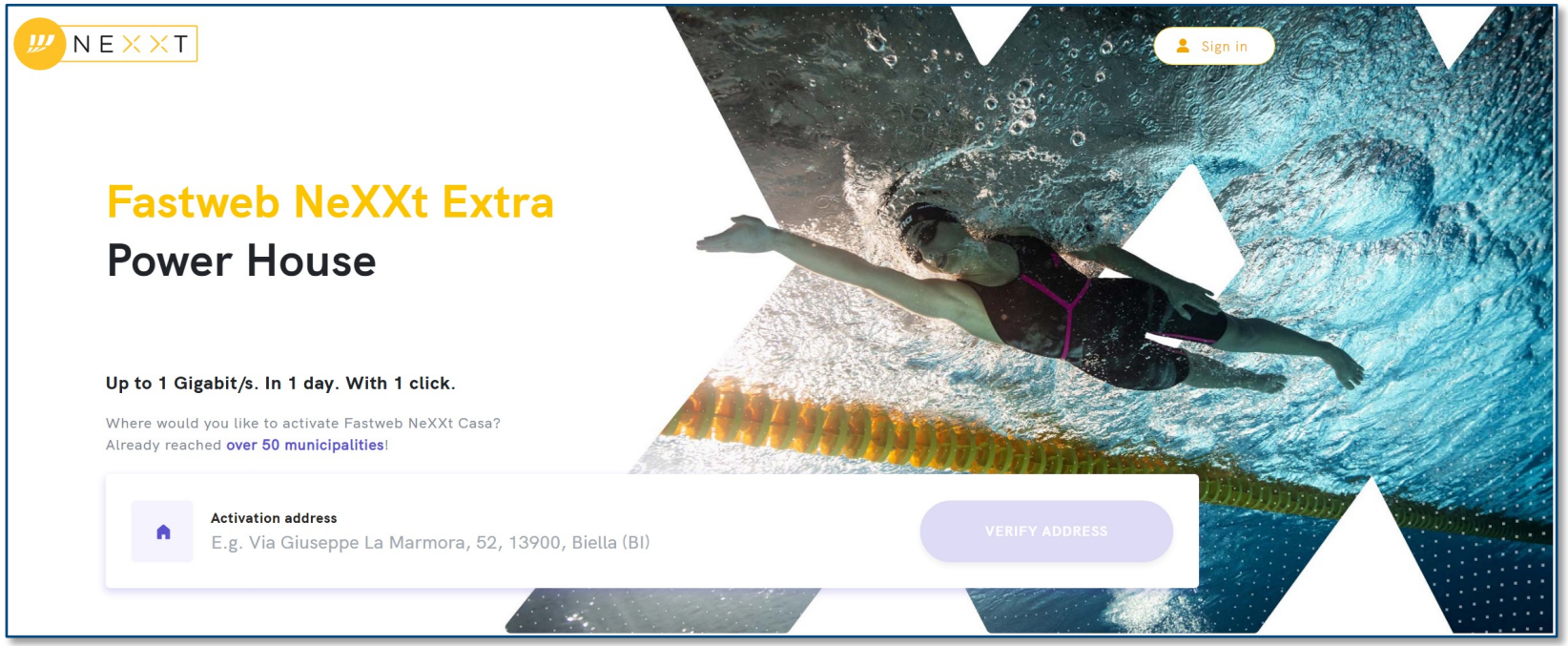
Source: Qualcomm

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Example – Italy Fastweb

- **Fastweb** “a new generation network that allows access to many services through the use of the mobile broadband network; it is able to support connections at very high speed, up to 1 Gb/s, and with very low latency”
- **Stated goal:** Broadband ‘fibre-like’ connections to 12 million homes (i.e 45% pop coverage) with speeds of up to 1 Gbps within 2024 with the aim to close the digital divide in disadvantaged areas of the country.
- **At launch:** 50 cities growing to 500 in 2021





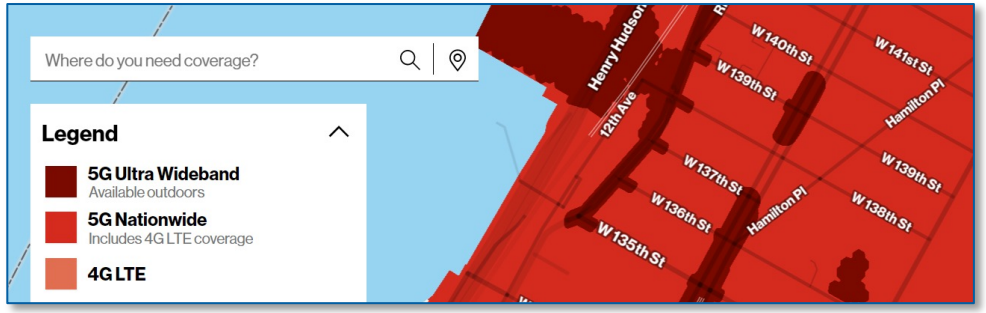
Source: www.fastweb.it

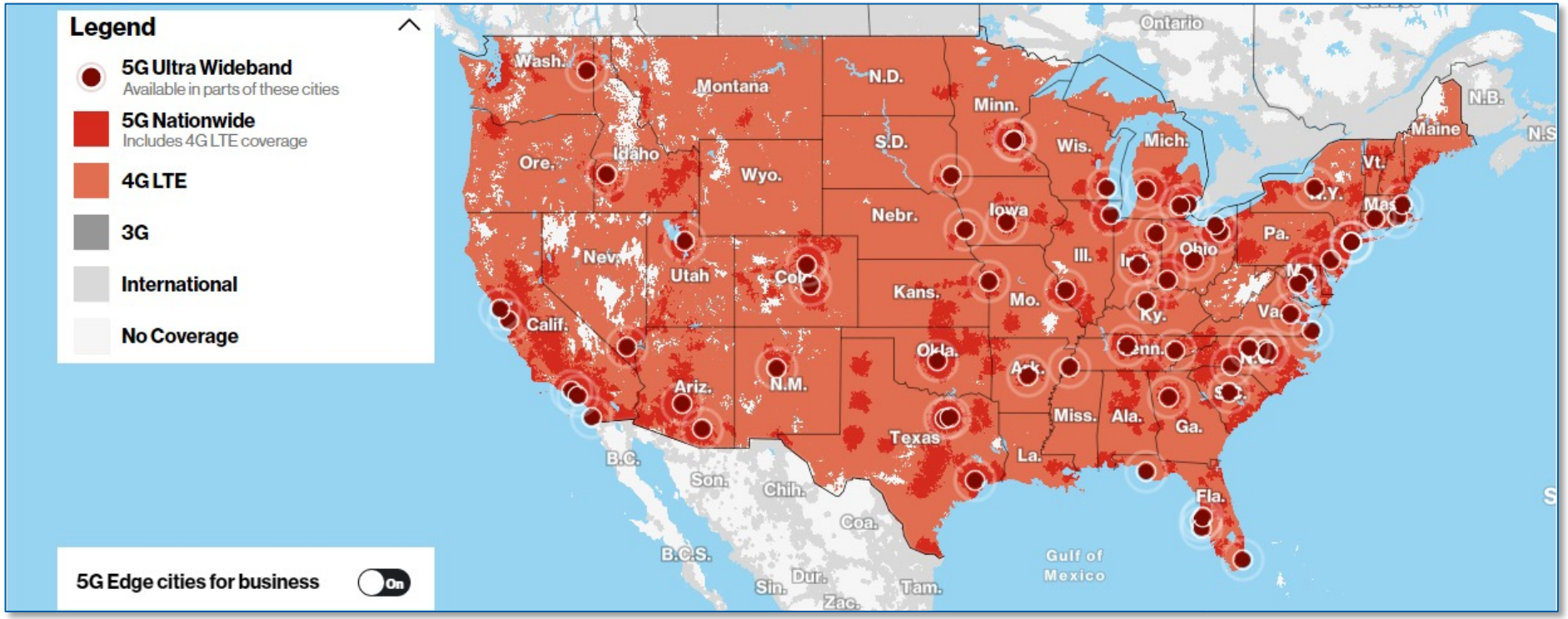
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Example – US Verizon

- $10Bn capital spending over next 3yrs
- Initial C band build on existing infra. 7-8k c-band equipped cell sites in ‘21
- 14k+ additional mmWave cell sites in ‘21; total 30k+ by end ’21
- Over time, 50% urban traffic expected to be on mmWave

Snapshot of New York coverage





Source: www.verizon.com/about/sites/default/files/Verizon-Investor-Day-Infographic-2021.pdf

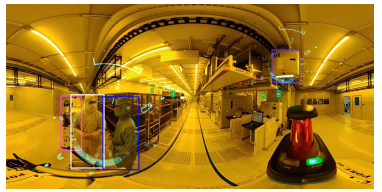
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Verticals mmWave - examples

Chunghwa Telecom

https://ase.aseglobal.com/en/solution/smart_factory_5g

- ASE 5G smart factory 5G 28 GHz mmWave private network service provided by Chunghwa Telecom supported by Qualcomm's suite of mmWave platform
- "These use cases demonstrate the extensive scope and sophistication of 5G technology application that will accelerate the transformation of smart manufacturing and automation" Dec'20



AI + AGV (Artificial Intelligence + Automated Guided Vehicles)



Remote Augmented Reality Assistant



AR Experience "
ASE Green Tech
Education Centre

AT&T

AT&T and Samsung Test 5G Connected "Innovation Zone" (att.com)

- AT&T and Samsung have deployed a 5G testbed at Samsung's Austin manufacturing facility as part of a "5G Innovation Zone"
- The goal of the testbed will be to provide a real-world understanding of how 5G can impact manufacturing and provide insight into the future of a Smart Factory.

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Summary

- 5G ecosystem in place and expanding: Infrastructure and devices available and market growing
- Licensed spectrum from low, mid and high bands enable the full 5G vision
- Commercial deployments & licensing underway are ongoing globally
- GSA supports ASEAN countries to roll out 5G, including mmWave spectrum and recommends to consider individual wide-area/national licensing.

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The Industry Voice of the Global Mobile Ecosystem

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Panel and Q&A

How to fulfil the Spectrum needs for this decade?

Moderator: **Joe Guan**, Head of Policy, Greater China, GSMA
Singapore: **Mr. Leng Chye Leck**, Deputy Director, IMDA
Thailand: **Mr. Saneh Saiwong**, Principle Engineering Expert, NBTC
Viet Nam: **Mr. Hoang Le Trung**, Official, MIC

Mr. Leng Chye Leck
Deputy Director, IMDA

Virtual Event

21 October 2021

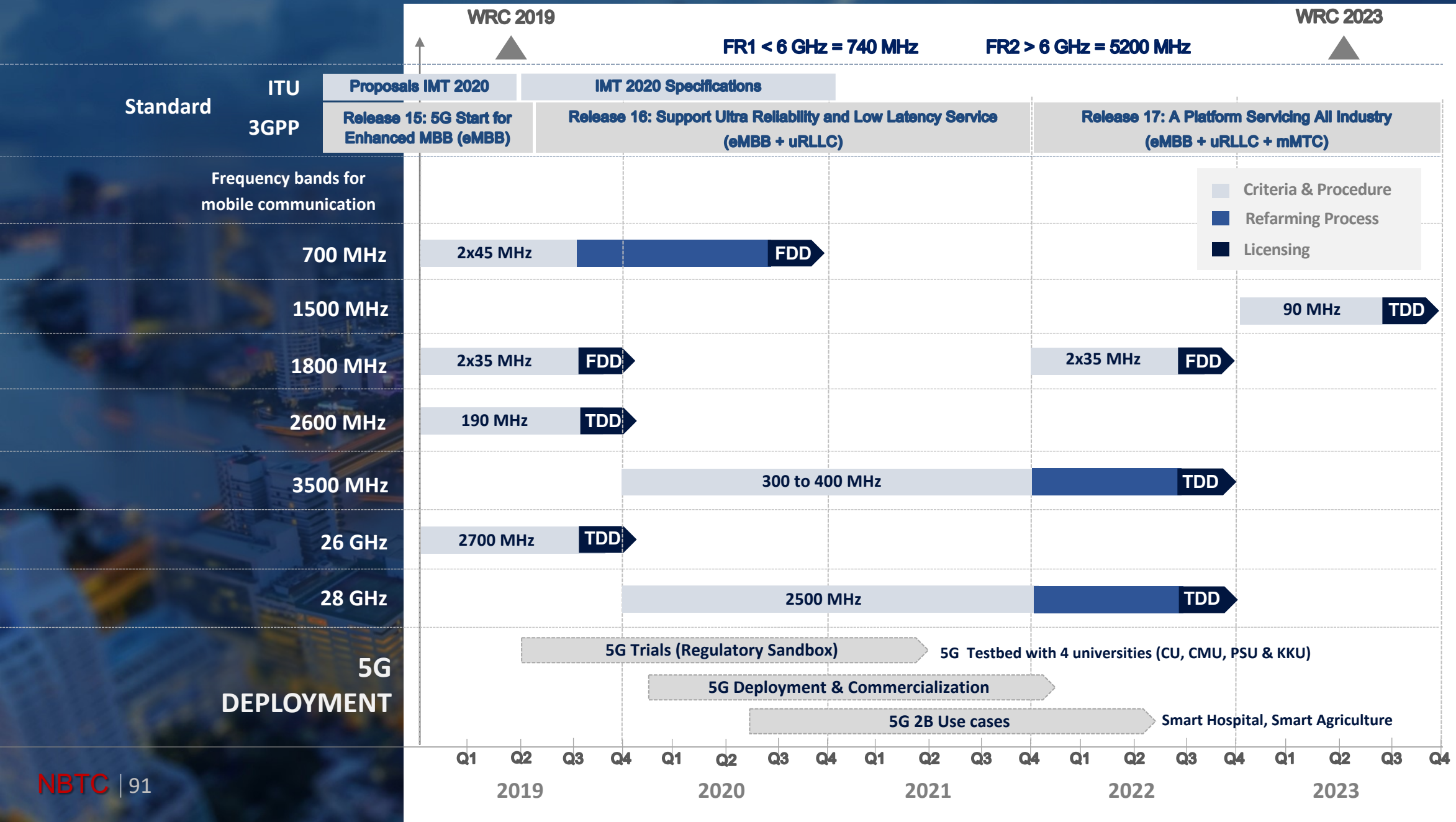


5G Roadmap and Spectrum Preparation in Thailand

Mr. Saneh Saiwong

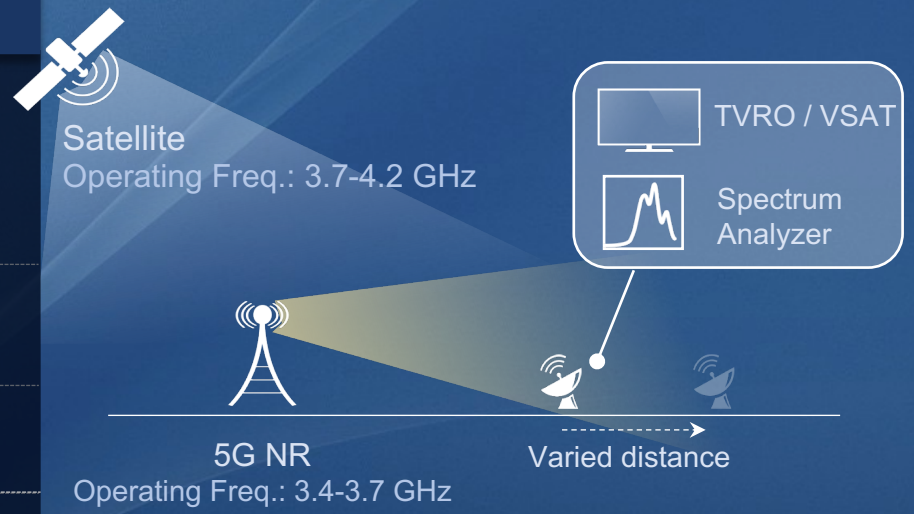
Office of the National Broadcasting and Telecommunications Commission (NBTC)

THAILAND IMT SPECTRUM RELEASE PLAN 2020 - 2023

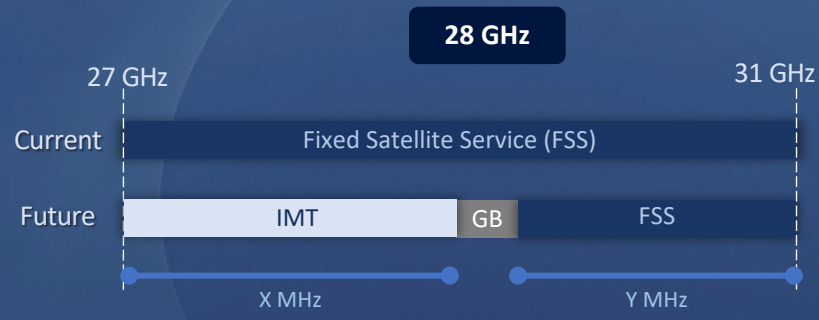


Preparation For Future 5G spectrum

FREQUENCY BANDS for mobile communication	STATUS			
	2021	2022	2023	2024
3500 MHz	Field trial & Related studies			
28 GHz				
1500 MHz (Supplementary Downlink)	Related studies			
6 GHz	Related studies with WRC-23		Consideration for IMT/unlicensed	







Thank you



NBTC
National Broadcasting and Telecommunications Commission

Spectrum Management Bureau
Office of the National Broadcasting and Telecommunications Commission (NBTC)
Email: spectrum@nbtc.go.th

Mr. Hoang Le Trung
Official, MIC

Virtual Event

21 October 2021

Panel and Q&A

How to fulfil the Spectrum needs for this decade?

Vote of Thanks

Mr. Dorany Auk, TRC Commissioner

Closing Remarks

Joe Guan, Head of Policy, Greater China (GSMA)