Welcome

5G Connectivity – Meeting IMT Mid-band Spectrum Needs

8 July 2021

Introduction

Laurent Bodusseau
Spectrum Senior Director, GSMA

Agenda

Introduction	**Laurent Bodusseau** Spectrum Senior Director, GSMA
IMT Spectrum Demand Estimating mid-band spectrum needs 2025-2030	**Stefan Zehle**, CEO **David Tanner**, Associate Consultant Coleago Consulting
The GSMA Insights	**Laurent Bodusseau** Spectrum Senior Director, GSMA
Panel discussion and Q&A	**Moderator: Luciana Camargos** Future Spectrum Senior Director, GSMA
Closing remarks	**Luciana Camargos** Future Spectrum Senior Director, 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

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

Stefan Zehle
CEO, Coleago Consulting Ltd
+44 7974 356258
stefan.zehle@coleago.com

David Tanner
Managing Consultant, Coleago Consulting Ltd
+44 7976 415250
david.tanner@coleago.com

www.coleago.com

coleagoconsulting

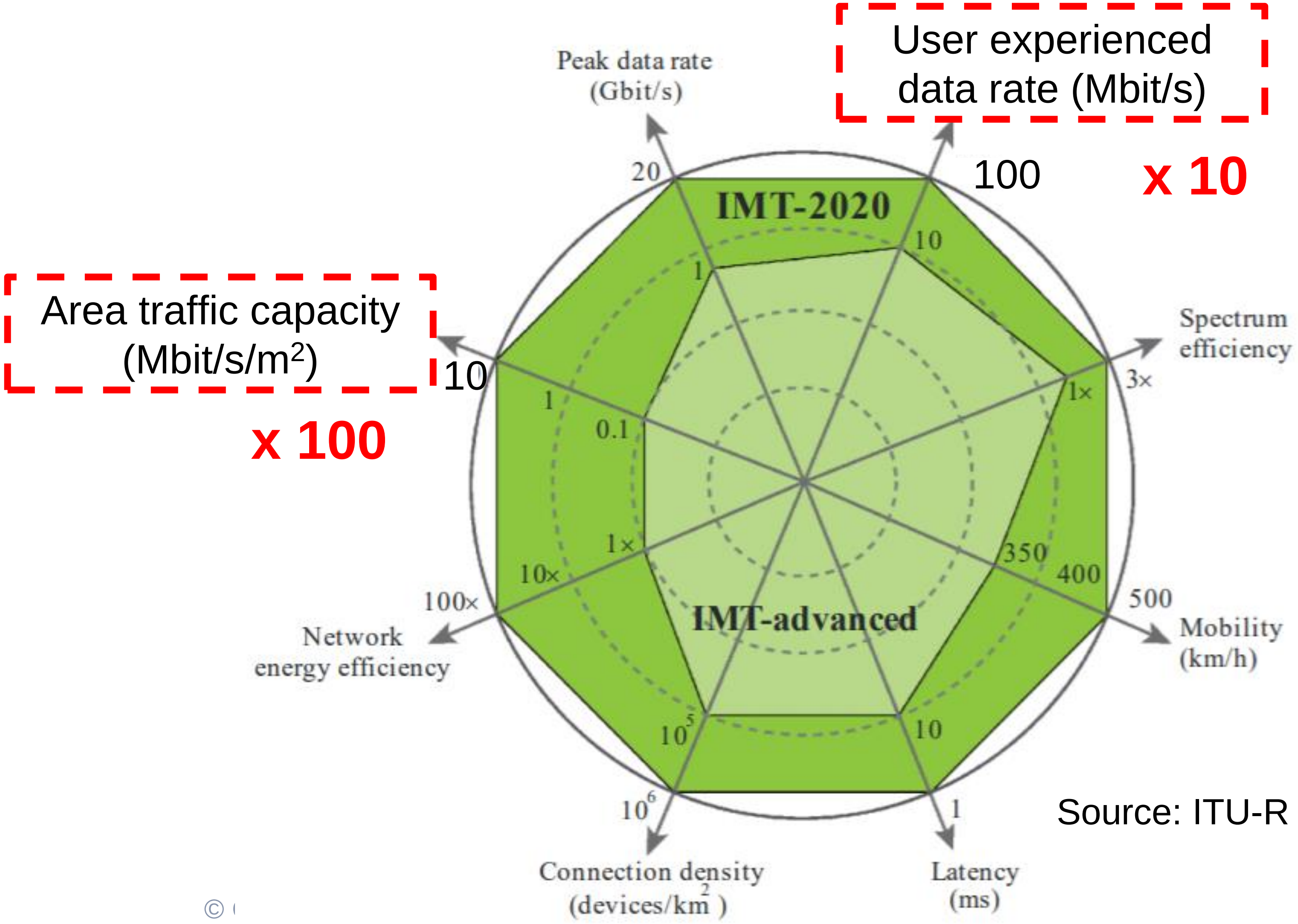
IMT 2020 requirements drive the need for spectrum

Enhancement of capabilities from IMT-Advanced to IMT-2020

One of the pillars in the vision for 5G is to provide 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 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.



Source: ITU-R

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

Lte → 5G

Extremely high data rates, very high traffic volumes, high traffic density, rapid mobility, city wide coverage

Enhanced Mobile Broadband
Smartphone, 8k 250fps video, AR/VR, cloud based gaming, venues, body cams

Fibre like data rates, extremely high traffic volumes

Fixed Wireless Access
Home, business, retail, nomadic, cameras

Very large number of devices, very low device cost, low energy, high density, country wide coverage

Massive Machine Type Communications
Sensors, meters, tracking, fleet management

Very low latency, very high availability and reliability

Critical Machine Type Communications
Self-driving car, industrial applications, manufacturing

The 5G vision is for a 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-band 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

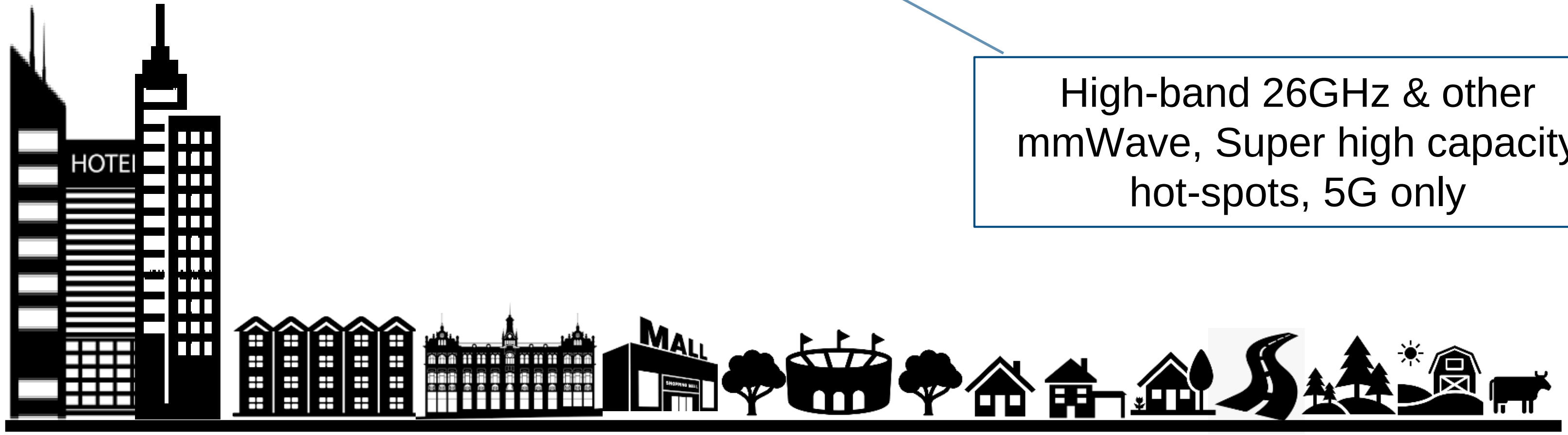
Upper mid-band 3.3-4.2, 4.5-4.99, 6GHz
city-wide speed coverage layer, 5G only

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

IMT 2020 Requirements

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

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



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

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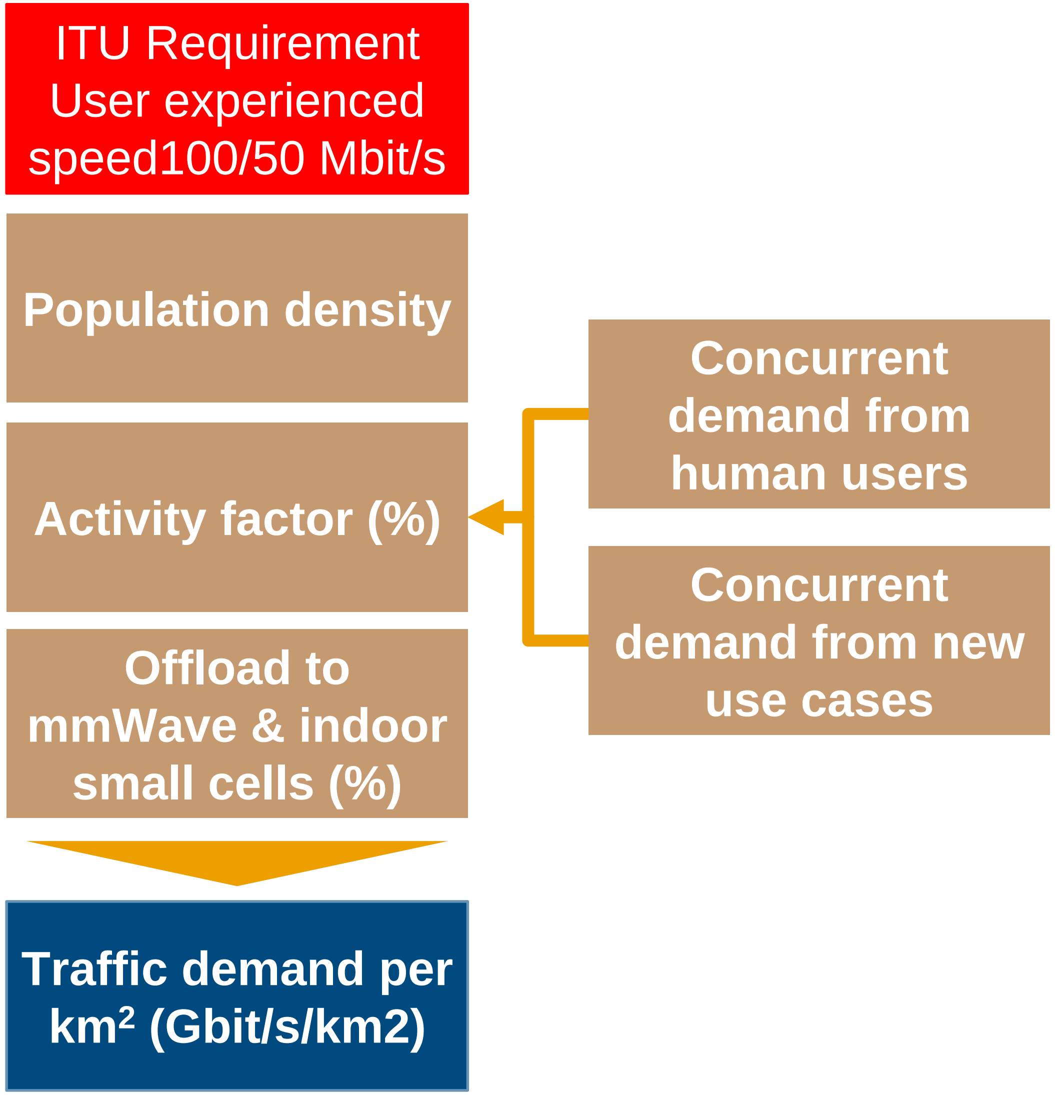
The required 100 Mbit/s DL and 50 Mbit/s UL user experienced data rate is the key driver to for additional mid-band spectrum

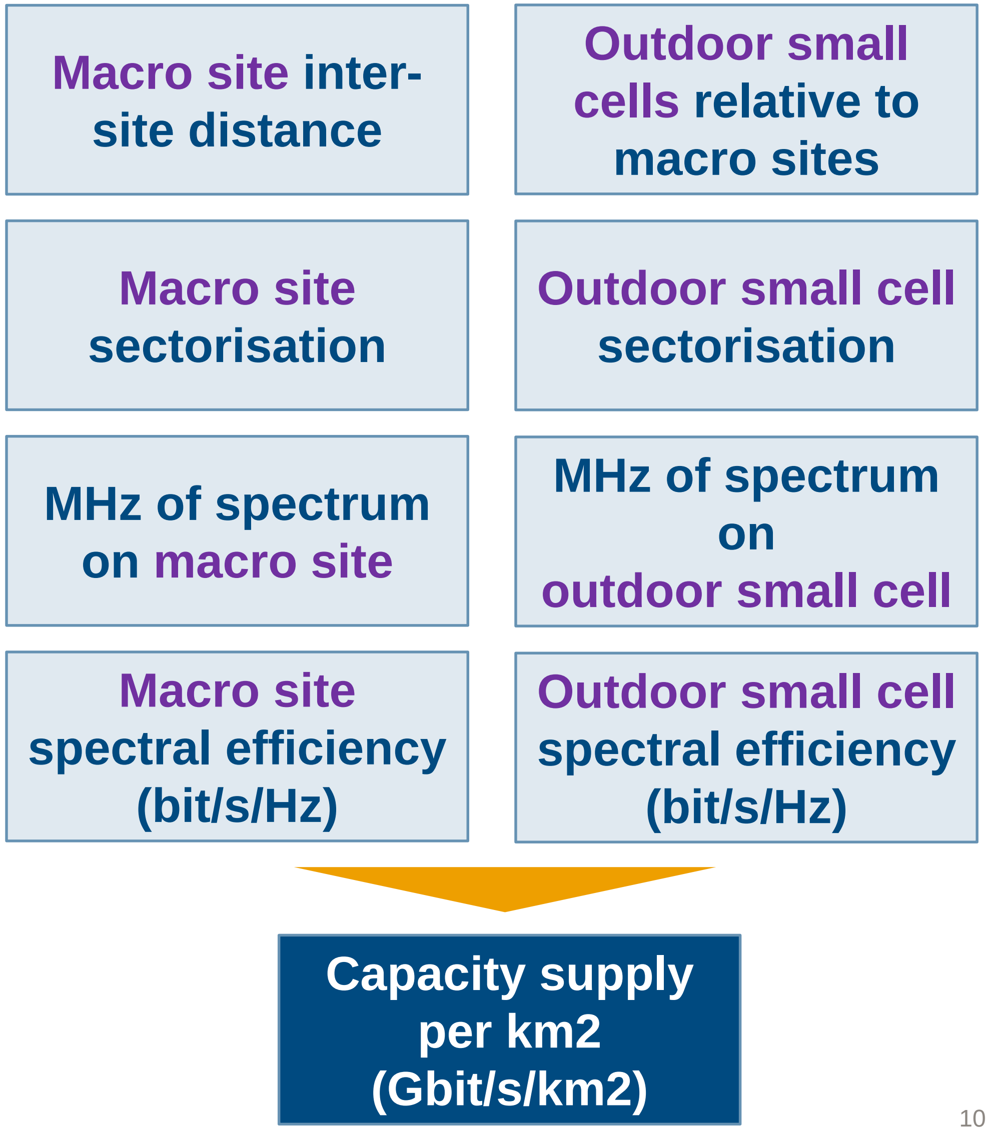
- We use the **population density** in cities as a proxy for mobile area traffic demand density that is triggered by both human and non-human users.
- Concurrent bandwidth demand from both human users and other use cases is presented in the form of an **activity factor** ranging from 10% to 25%. The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



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 36 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 km²

We analysed 36 cities:

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

- Our analysis covers a 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.
- 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.

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

In the 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.

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.

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 is 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 due to the large number of sites

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

Additional upper mid-band spectrum provides a sustainable path to bring fibre-like speeds to additional areas

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

Conclusion: Demand drivers for mid-band spectrum is driven by both cities, as well as small towns and villages

	Urban areas with high population density	Villages and rural small towns
Country with extensive FTTH	City-wide speed coverage	FWA
Country with sparce fixed infrastructure	City-wide speed coverage FWA	FWA

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

Benefits of additional mid-bands for 5G

Benefit of using additional upper mid-band spectrum for IMT	Countries with extensive wired broadband	Countries with limited wired broadband
Economic delivery of a consistent 100 Mbit/s DL and 50 Mbit/s UL user experienced mobile data rate, citywide	✓	✓
Ensures that FWA broadband is a long-term solution	✓	✓
Lower cost for urban FWA overcomes lack of fibre or xDSL broadband access		✓
Improves rural FWA broadband economics to bridge the digital divide	✓	✓
Helps to deliver United Nations Sustainable Development Goals		✓
Economic delivery of a consistent 100 Mbit/s DL and 50 Mbit/s UL user experienced mobile data rate on highways and railways	✓	✓
Contributes to reaching the ITU and UNESCO Broadband Commission 2025 targets		✓

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.
- ✓ The availability of additional mid-band spectrum would enable operators to deliver fibre-like 5G FWA to small towns and villages.
- ✓ In countries with 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 highly populated areas, substantial capacity is required on major transport routes (highways and railways) to serve the connected vehicles and smart road use cases.

The GSMA Insights

Laurent Bodusseau
Spectrum Senior Director, GSMA

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.

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

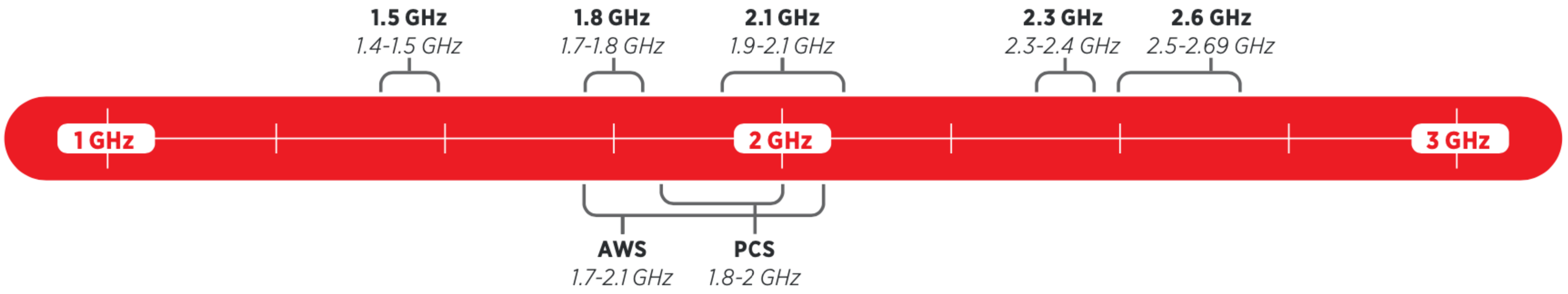
https://www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf

Panel

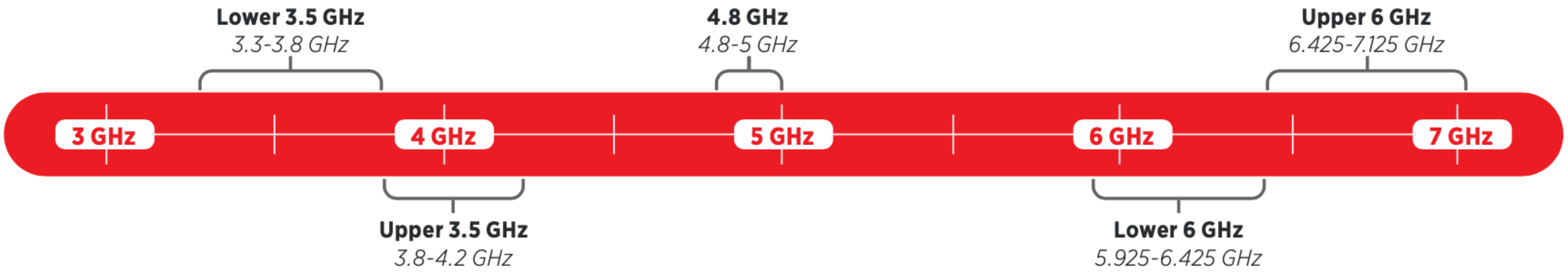
Luciana Camargos
Future Spectrum Senior Director, GSMA

Meeting the mid-band spectrum needs

Lower Mid-Band Spectrum

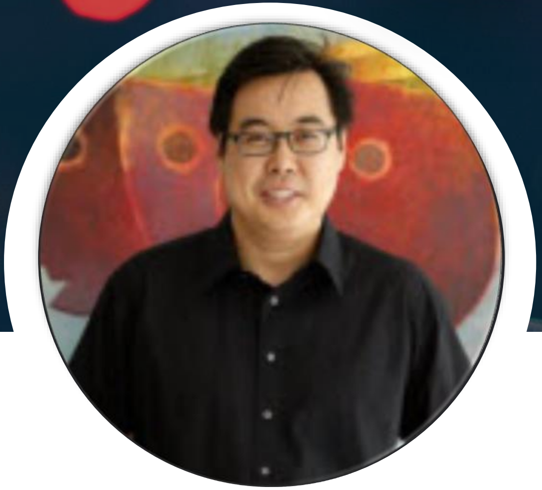


Upper Mid-Band Spectrum



Moderator: Luciana Camargos
Spectrum Senior Director, GSMA

Massimiliano Simoni
Chairman, Spectrum Strategy Management Group, GSMA



Foong Chee Kheong
Group Head of Regulatory Affairs, Group Corporate Office, Axiata

Eric Fournier
Director for Spectrum Planning and International Affairs, ANFR

Mohamed El-Moghazi
Acting Executive Director, National Spectrum Affairs, NTRA

Closing Remarks

Luciana Camargos
Future Spectrum Senior Director, GSMA