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FINAL REPORT FOR CTIA

COMPARISON OF TOTAL MOBILE SPECTRUM IN DIFFERENT MARKETS

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Overall findings

Whilst mid-band spectrum continues to be the focus of initial 5G deployment around the world, mobile carriers are also expected to wish to refarm licensed mobile spectrum between 600MHz and 3GHz for 5G use, as 5G penetration grows.

This paper references previous papers prepared by Analysys Mason for CTIA on 5G plans, and assesses the total mobile spectrum available in different world markets. It captures licensed and unlicensed spectrum availability in low bands (below 2.6GHz), mid bands (between 3GHz and 7GHz) and high bands (in the millimeter-wave (mmWave) region), and contrasts total spectrum in the US with that available in other markets. The following countries are considered: Australia, Canada, China, France, Germany, Hong Kong, Italy, Japan, Qatar, South Korea, Spain, Sweden, the UK, and the US.

We have estimated the total spectrum in each market currently, and that expected to be available in the future. Expected availability takes account of proposals published by regulators in each market in relation to making additional mobile spectrum (licensed and/or unlicensed) available.

A summary of our key findings is as follows:

Low band

- A key pillar of the US 4G decade was the large amount of licensed low-band spectrum made available to wireless providers. Analysys Mason's research shows that the US is the leading benchmark country in this regard, with a total of 752MHz available.
- Several countries are planning to make further licensed low-band spectrum available: future low-band assignments for these countries, on average, will total 90MHz. This means that commercial access to the 1.3GHz and 1.7GHz bands will be an important element of continued US low-band leadership.

Mid band

- With 1860MHz of unlicensed mid-band spectrum available, the US is a significant outlier, as this is 3.2 times more than the next closest countries (Hong Kong, Qatar, and the UK, each with 580MHz of unlicensed mid-band spectrum). The recent US addition of 1200MHz of unlicensed spectrum in the 6GHz band is 2.4 times more than the average amount of additional unlicensed mid-band spectrum other countries are considering making available in the next few years.
- In a key range of global 5G spectrum (3.3–3.6GHz), the US today has no licensed spectrum available, while other benchmark countries that have made these airwaves available average nearly 200MHz. However, the US would become one of the leading benchmark countries if it made 250MHz (or more) of spectrum available in the lower 3GHz band, as some have proposed, and the FCC and NTIA are exploring with commercial providers.

Mid/high band

- Across the mid and high bands, the US today has made available 15 860MHz of unlicensed spectrum and just 5550MHz of licensed spectrum, meaning

policymakers have made around three times as much unlicensed spectrum as licensed spectrum available. Over the next few years, the share of available licensed spectrum is expected to increase to roughly 55% (8900MHz of licensed vs. 15 905MHz of unlicensed spectrum).

High band

- The US currently leads the world in terms of the amount of licensed high-band spectrum, though China may catch up. In the next few years, China could make 8250MHz of licensed high-band spectrum available, just below the 8300MHz the US could make available.

Summary of spectrum released

The tables in the following sections show the amount of spectrum (total MHz) currently assigned, or being investigated for potential assignment in the future, for mobile use. Unlicensed spectrum that is suitable for mobile use, such as in the 2.4GHz, 5GHz, 6GHz and 57–66GHz bands, as well as licensed spectrum, has been included.

Approach

Spectrum has been split into three categories:

- low bands (below 2.6GHz)
- mid bands (between 3GHz and 7GHz)
- high bands (in the mmWave region).

Separate tables for each category show the current and (potential) future assignments.

Potential future assignments generally include all spectrum that has been specifically consulted on in recent years, and which is likely to be assigned within the next five years. In some cases, particularly the mmWave bands, it is unclear how much spectrum will be made available. In these cases the entire band under consideration has generally been included in the table.

Where spectrum has been considered, discussed or identified for mobile broadband use internationally, but there is no indication of likely future assignment within the next five years by a national regulatory authority (NRA), it has not been included in our totals. For example, a band identified for IMT at WRC-19 (or scheduled to be discussed at future WRCs) has not been included unless an NRA has confirmed plans to assign the band in the coming years.

Sources

Data is based on the most recently published information available from NRAs and relevant government agencies. This has been supplemented by other sources where appropriate, e.g. WRC and ITU documentation, information provided by regional spectrum organisations (such as APT and CEPT), standards organizations (ETSI and 3GPP), and press reports.

Low band: current assignments (total MHz)[1]

	450	EU 700	800	900	EU 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600	Total licensed	Total unlicensed
France		60	60	70		150		120		84	180[2]	640	84
Germany		60	60	70	40	150		120		84	190	690	84
Italy		60	60	70	40	140		120		84	150	640	84
Qatar			40	44		80		60		84	80	304	84
Spain			60	70		150		120		84	180	580	84
Sweden	10	40	60	70		140		120		84	190	630	84
UK			60	70	40	150[3]		120	40	84	175[4]	655	84
	600	NAM 700	850	900	ATC spectrum[5]	PCS	AWS-1/ AWS-2	AWS-3/ AWS-4	2300 (WCS)	2400 unlicensed	2600		
US	70	70	64[6]	6	30	130	100	105	20	84	156.5[7]	752	84
Canada	70	68	50			130	90	90	30	84	190	718	84
	600	APT 700	850	900	Japan 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600		
Australia		90	40	50		150		120	100	84	140	690	84
China		80	20	52		140	50	90	70	84	160	662	84
Hong Kong			25	60		150		118	90	84	140	583	84
Japan		60	60	30	70	150	31[8]	120		84	80[9]	601	84
S. Korea			60	20		120		120	57	84	100	477	84

Currently assigned spectrum

1 Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. PPDR spectrum has generally been excluded, as have temporary spectrum assignments. Spectrum is assigned on a regional basis in Canada and the US (and Australia in certain bands); in these cases, the amount shown may not have been made available or assigned in all regions.

[1] 3GPP bands 33 and 34; where spectrum has been assigned in these bands in ITU Region 1 it has been excluded, since it is not used. [2] Includes 40MHz for local/private use in the 2.6GHz unpaired band. [3] The DECT guard band (1.7817–1.785/1.8767–1.88GHz) is a "shared access band" which is available for local licensing in certain locations. [4] The full 2.6GHz unpaired band has been assigned, but 15MHz is restricted. [5] In April 2020, the FCC authorized Ligado Networks to deploy a low-power nationwide terrestrial network in the 1526–1536MHz, 1627.5–1637.5MHz and 1646.5–1656.5MHz bands. [6] Includes 14MHz of SMR spectrum. [7] Includes only 67.5MHz of BRS spectrum (out of 73.5MHz) and 89MHz of EBS spectrum (out of 112.5MHz) – the amounts estimated to be licensed to mobile players (on a population-weighted basis). [8] PHS spectrum. [9] Spectrum used by AXGP and WiMAX2+ standards (TD-LTE compliant); regional WiMAX spectrum has been excluded.

Low band: current + potential future assignments (total MHz)[2]

	450	EU 700	800	900	EU 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600	Total licensed	Total unlicensed
France		85	60	70	90	150		120		84	180[2]	755	84
Germany		75	60	70	40	150		120		84	190	705	84
Italy		60	60	70	40	140		120		84	150	640	84
Qatar		60	40	44		80		60		84	80	364	84
Spain		60	60	70	40	150		120		84	180	680	84
Sweden	10	60	60	70	90	140		120	80	84	190	820	84
UK		80	60	70	40	150[3]		120	40	84	175[4]	735	84
	600	NAM 700	850	900	ATC spectrum[5]	PCS	AWS-1/ AWS-2	AWS-3/ AWS-4	2300 (WCS)	2400 unlicensed	2600		
US	70	70	64[6]	6	30	130	100	105	20	84	180[7]	775	84
Canada	70	68	50			130	90	90	30	84	190	718	84
	600	APT 700	850	900	Japan 1500	1800	1900 and 2000[1]	2100	2300	2400 unlicensed	2600		
Australia		90	70	50		150		120	100	84	140	720	84
China		80	20	52		140	50	90	70	84	160	662	84
Hong Kong	70**	90**	25	60		150		118	90	84	140	743	84
Japan		60	60	30	70	150	31[8]	120		84	80[9]	601	84
S. Korea		40	60	20		120		120	80	84	160	600	84

Currently assigned spectrum Spectrum being investigated for potential future use

2 Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. PPDR spectrum has generally been excluded, as have temporary spectrum assignments. Spectrum is assigned on a regional basis in Canada and the US (and Australia in certain bands); in these cases, the amount shown may not have been made available or assigned in all regions. ** Indoor only.

[1] 3GPP bands 33 and 34; where spectrum has been assigned in these bands in ITU Region 1 it has been excluded, since it is not used. [2] Includes 40MHz for local/private use in the 2.6GHz unpaired band. [3] The DECT guard band (1.7817–1.785/1.8767–1.88GHz) is a "shared access band" which is available for local licensing in certain locations. [4] The full 2.6GHz unpaired band has been assigned, but 15MHz is restricted. [5] In April 2020, the FCC authorized Ligado Networks to deploy a low-power nationwide terrestrial network in the 1526–1536MHz, 1627.5–1637.5MHz and 1646.5–1656.5MHz bands. [6] Includes 14MHz of SMR spectrum. [7] Assumes that all 112.5MHz of EBS spectrum is assigned, in addition to the currently assigned 67.5MHz of BRS spectrum. [8] PHS spectrum. [9] Spectrum used by AXGP and WiMAX2+ standards (TD-LTE compliant); regional WiMAX spectrum has been excluded.

Mid band: current assignments (total MHz)[3]

	3.3–3.4GHz	3.4–3.6GHz	3.6–3.8GHz	3.8–4.2GHz	4.2–4.5GHz	4.5–5GHz	5.15–5.895GHz unlicensed	5.925–6.425GHz unlicensed	6.425–7.125GHz	Total licensed	Total unlicensed
France							455			-	455
Germany		200	100+100*				455			400	455
Italy		126	200				455			326	455
Qatar		200					580			200	580
Spain		160	200				455			360	455
Sweden			80				455			80	455
UK		190	80	400*			580			670	580
US			80[1]				580	500	700[2]	-	1860
Canada							530			-	530
Australia		125	100				430			225	430
China	100**	200				160	260			460	260
Hong Kong	100**	200				80	580			380	580
Japan		200	200	300		100	560[3]			800	560
S. Korea		180	100				440			280	440

Currently assigned spectrum

3 Temporary spectrum assignments have been excluded. Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. * Local/private licenses. ** Indoor only.

[1] CBRS spectrum consists of three tiers. The GAA tier (Tier 3) is licensed-by-rule to permit open, flexible access to the entire 3.55–3.7GHz range. However, GAA users must not cause harmful interference to Tier 1 incumbents (operating across the band) or to Tier 2 Priority Access Licensees (PALs) (who will operate in up to 70MHz within the bottom 100MHz of the band). GAA operation is currently possible, while an auction to determine PALs is scheduled to take place later in 2020. The table displays 80MHz of GAA (unlicensed) spectrum in the 3.6–3.8GHz block. We note, however, that the amount of GAA spectrum may be higher than 80MHz in certain areas. [2] Available for unlicensed use in the US. [3] Includes the 4.9–5GHz range.

Mid band: current + potential future assignments (total MHz)[4]

	3.3–3.4GHz	3.4–3.6GHz	3.6–3.8GHz	3.8–4.2GHz	4.2–4.5GHz	4.5–5GHz	5.15–5.895GHz unlicensed	5.925–6.425GHz unlicensed	6.425–7.125GHz	Total licensed	Total unlicensed
France		110	200				455	500		310	955
Germany		200	100+100*				455	500		400	955
Italy		126	200				455	500		326	955
Qatar		200	200				580			400	580
Spain		160	200				455	500		360	955
Sweden		190	120+80*				455	500		390	955
UK		190	200	400*			580	500		790	1080
US	100[1]	200[1, 2]	200[2]	180			625	500	700[3]	600	1905
Canada		150[4]	150[4, 5]	180[5]			530			480	530
Australia		200	200	400[6]			430			700	430
China	100**	200				160	260			460	260
Hong Kong	100**	200				160	580			460	580
Japan		200	200	300		100+200*	560[7]			1000	560
S. Korea		200	200	200			440			600	440

Currently assigned spectrum Spectrum being investigated for potential future use

4 Temporary spectrum assignments have been excluded. Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. * Local/private licenses. ** Indoor only.

[1] Includes the 3.3–3.55GHz band; in December 2019, the FCC announced that it was proposing steps to prepare this band for "advanced commercial services, including 5G". [2] CBRS spectrum in the 3.55–3.7GHz range: 70MHz licensed (PALs) in the 3.55–3.65GHz range, and 80MHz unlicensed (GAA). See footnote 3 of previous table for details. [3] Available for unlicensed use in the US. [4] The 3.45–3.65GHz range is scheduled to be auctioned later in 2020. [5] ISED (the Canadian NRA) has proposed the auction of additional 5G spectrum in the 3.7–4.2GHz band in 2022 and has announced plans for further study of the 3.65–3.7GHz band via a future consultation. For the purposes of the table we assume that Canada will follow the US and assign the lower 280MHz of the 3.7–4.2GHz band to mobile. [6] Maximum amount based on spectrum under consultation – the ACMA (the Australian NRA) launched a discussion paper on reconfiguration options in the 3.7–4.2GHz band in September 2019. [7] Includes the 4.9–5GHz range.

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High band: current (total MHz)[5]

	24.25–27.5GHz	27.5–29.5GHz	37–43.5GHz	45.5–47GHz	47.2–48.2GHz	57–66GHz unlicensed	66–71GHz unlicensed	71–76GHz	81–86GHz	Total licensed	Total unlicensed
France	1000[1]					9000				1000	9000
Germany	3250*					9000				3250	9000
Italy	1000					9000				1000	9000
Qatar						4700				-	4700
Spain						9000				-	9000
Sweden						9000				-	9000
UK	2250*[2]					9000	5000			2250	14 000
US	700	850	3000[3]		1000	9000	5000			5550	14 000
Canada						9000	5000			-	14 000
Australia						9000	5000			-	14 000
China						5000				-	5000
Hong Kong	950	650*				9000				1600	9000
Japan	500	1200*				9000				1700	9000
S. Korea	1000	1400				7000				2400	7000

Currently assigned spectrum

5 Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. * (Includes) local/private licenses.

[1] Trial licenses. [2] Indoor use only. [3] Includes spectrum in the 37–37.6GHz band available on a shared basis.

High band: current + potential future assignments (total MHz)[6]

	24.25–27.5GHz	27.5–29.5GHz	37–43.5GHz	45.5–47GHz	47.2–48.2GHz	57–66GHz unlicensed	66–71GHz unlicensed	71–76GHz	81–86GHz	Total licensed	Total unlicensed
France	3250[1]▯					9000	5000			3250	14 000
Germany	3250*					9000	5000			3250	14 000
Italy	1000					9000	5000			1000	14 000
Qatar	800▯					4700				800	4700
Spain	1400▯					9000	5000			1400	14 000
Sweden	3250*					9000	5000			3250	14 000
UK	3250[2]*▯					9000	5000			3250	14 000
US	2950	850	3500[3]		1000	9000	5000			8300	14 000
Canada	1000	850	3000			9000	5000			4850	14 000
Australia	2400					9000	5000			2400	14 000
China	2750▯		5500▯			5000				8250	5000
Hong Kong	3250	850*				9000				4100	9000
Japan	500	2000*				9000				2500	9000
S. Korea	3000	1400				7000				4400	7000

Currently assigned spectrum Spectrum being investigated for potential future use

6 Different conditions and technical criteria may apply to each of the unlicensed spectrum frequencies. * (Includes) local/private licenses. ▯ Likely maximum amount based on spectrum under consultation.

[1] Currently assigned spectrum is via trial licenses. [2] Currently assigned spectrum is for indoor use only. [3] Includes spectrum in the 37–37.6GHz band available on a shared basis.