

Final report for CTIA

Mid-band spectrum global update

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1 Executive summary

In April 2018, Analysys Mason published a report (the ‘5G readiness report’¹), describing 5G spectrum and infrastructure policies in leading markets around the world. We benchmarked the situation in the US to that in nine other countries, specifically: Canada, China, France, Germany, Japan, Russia, Singapore, South Korea, and the UK.

The past few months have highlighted the continued push towards mid-band 5G, with auctions taking place in several markets. The next 12–18 months are likely to prove to be critical, with assignment confirmed or expected to take place in each of our remaining benchmark countries over that timescale.

This latest report provides an update to the earlier 5G readiness report, exclusively focusing on mid-band² spectrum plans for 5G. In this report, we have extended our benchmark countries to include Australia, Spain and Sweden, as well as the original list of countries.

Key Finding: Since April 2018, four of our benchmark countries (Japan, South Korea, Spain and the UK) have auctioned or assigned mid-band spectrum. Several countries have also confirmed that mid-band spectrum will be assigned by June 2019 (e.g. Australia, Germany and Japan).

Key Finding: Among the benchmark countries, nearly 200MHz of mid-band spectrum per country is expected to be available by June 2019. By the end of 2020, an average of nearly 300MHz of mid-band spectrum will be available per country.

Key Finding: 5G trials using mid-band spectrum have continued or expanded in all our benchmark countries since our previous report. Since April 2018, mobile network operators (MNOs) have completed or announced over 20 independent 5G trials (based on Analysys Mason research³) in these markets using mid-band spectrum.

Section 2 provides further details and analysis for each of our benchmark countries.

¹ ‘Global race to 5G – spectrum and infrastructure plans and priorities’. We refer to this report as the ‘5G readiness report’. See https://api.ctia.org/wp-content/uploads/2018/04/Analysys-Mason-Global-Race-To-5G_2018.pdf

² Mid-band spectrum is defined as spectrum in the 3-24GHz range. We therefore exclude lower frequency spectrum (e.g. the 2.6GHz band) which may be relevant to 5G.

³ We further note that, in August 2018, the Global mobile Suppliers Association (GSA) “identified 154 operators in 66 countries that have demonstrated, are testing or trialling, or have been licensed to conduct, field trials of 5G-enabling and candidate technologies (up from 134 operators in April 2018)”. See GSA report ‘Evolution from LTE to 5G: Global Market Status’.

1.1 Update: mid-band 5G spectrum release

Around the world, mid-band 5G spectrum plans are being developed, with several countries at an advanced stage with their plans. A summary of the plans in each of our benchmark countries is shown in Figure 1.1 below:

Figure 1.1: Mid-band spectrum release plans in benchmark countries [Source: Analysys Mason, 2018]

Country	Details
Australia	<ul style="list-style-type: none"> 3425-3492.5MHz and 3542.5–3575MHz ranges (a total of 100MHz) have been licensed in specific areas of Australia An auction of spectrum in the 3575-3700MHz range (a total of 125MHz) is planned for November 2018.
Canada	<ul style="list-style-type: none"> In June 2018, Canada published 'Spectrum Outlook 2018-2022' as well as a specific consultation on the 3450-3650 MHz band, with an auction for that band planned for late 2020 The regulator is also seeking preliminary comments on use of the 3400–3450MHz and 3650–4200MHz bands for 5G.
China	<ul style="list-style-type: none"> 500MHz of spectrum (within 3.3–3.6GHz and 4.8–5.0GHz) will be released in China, with the 3.3-3.4GHz range subject to indoor use Details are hard to source in the public domain, but in June 2018 the MIIT indicated that spectrum assignment is likely to take place between H2 2019 and H1 2020 Reports also indicate that China is likely to assign the 3.6-4.2GHz range to 5G use in the future, subject to coordination with existing satellite use.
France	<ul style="list-style-type: none"> 40MHz of spectrum at 3420–3460MHz is to be reserved for fixed wireless access (FWA) use in currently underserved areas (with an additional 10MHz (3410–3420MHz) in certain areas) An auction of the remaining spectrum in the 3410–3800MHz range for mobile use is expected in 2019/20. ARCEP expects 300MHz of contiguous spectrum to be available for 5G by 2020, and 340MHz (390MHz in areas with no FWA) by 2026 In June 2018, ARCEP published a notice providing for the gradual release of the 3.4-3.6GHz band (by region) by March 2020, at the latest.
Germany	<ul style="list-style-type: none"> 126MHz (3410-3473/3510-3573MHz) is currently assigned to MNOs on a national basis Germany plans to award the entire 3.4-3.8GHz band to mobile in early 2019. The 3.4-3.7GHz range (for nationwide use) will be auctioned; the 3.7-3.8GHz will be for regional/local use.
Japan	<ul style="list-style-type: none"> The 3.4-3.6GHz band is currently assigned to MNOs on a national basis The regulator has stated aims to release up to 500MHz of spectrum within the 3.6–4.2GHz and 4.4–4.9GHz ranges by March 2019.
Russia	<ul style="list-style-type: none"> 5G spectrum assignment plans are unclear, with the government's 5G roadmap scheduling a formal decision regarding spectrum to be made in 2018 However, the SCRF has allocated test licenses in the 3.4–3.8GHz range to some operators.
Singapore	<ul style="list-style-type: none"> The IMDA's 2017 5G consultation states that the regulator is 'exploring the possibility' of assigning spectrum from the 3.4–3.6GHz band for mobile use.
South Korea	<ul style="list-style-type: none"> In June 2018, South Korea auctioned 280MHz of spectrum in the 3420-3700MHz range on a national basis, raising a total of ~USD2.89 billion.
Spain	<ul style="list-style-type: none"> In June and July 2018, MNO Mas Movil privately acquired two 2×20MHz national licenses in the 3.4-3.6GHz band; two of Spain's other MNOs (Orange and Telefónica) already own 2×20MHz national licenses in this band Later in July 2018, Spain auctioned 200MHz of spectrum in the 3.6-3.8GHz range.

Country	Details
Sweden	<ul style="list-style-type: none"> 80MHz (3600-3640/3700-3740MHz) has been assigned to MNOs on a national basis; (technology neutral) regional licenses have also been assigned in the 3.4-3.8GHz band Sweden plans to award the entire 3.4-3.8GHz band to mobile. The 3.4-3.7GHz range (for nationwide use) is scheduled for auction in late 2019 or early 2020; the 3.7-3.8GHz will be for regional/local use.
UK	<ul style="list-style-type: none"> UK MNO Three already holds national licenses in the 3480–3500MHz, 3580–3600MHz, 3605–3689MHz and 3925–4009MHz ranges, originally awarded for FWA use⁴ In April 2018, the UK auctioned 150MHz of spectrum from the 3.4–3.6GHz band, which was awarded to four operators, raising a total of ~USD1.50 billion The UK anticipates awarding spectrum in the 3.6–3.8GHz band in 2019; the spectrum is expected to 'be deployed in many areas from around 2020, and nationwide by 2022'. The 3.8–4.2GHz range is 'a candidate band for enhanced spectrum sharing'.
US	<ul style="list-style-type: none"> The US is making 150MHz in the 3550-3700MHz (CBRS) band available, with 70MHz to be auctioned (potentially in 2019) and the remaining 80MHz to be available on a shared or unlicensed basis (in early 2019) The FCC is exploring the 3.7-4.2GHz, adopting an NPRM in July 2018, a move that could open up large additional blocks of mid-band spectrum The US is also studying the 3.45-3.55GHz band, but there is no specific timing on the study or the availability of spectrum.

The amount of mid-band spectrum currently assigned to mobile in our benchmark countries, and the amount expected to be assigned or auctioned by June 2019, and by end-2020, is shown in Figure 1.2 below.

Figure 1.2: Mid-band spectrum assignments for mobile⁵ [Source: Analysys Mason, 2018]

Country	Current assignment (MHz)	Additional assignment expected by June 2019 (MHz)	Total assignment expected by June 2019 (MHz)	Total assignment expected by end-2020 (MHz)
Australia	100 ⁶	125	225	225
Canada ⁷	-	-	-	200
China	-	-	-	500 ⁸
France ⁹	-	-	-	300

⁴ Three has requested to shift its 3605–3689MHz license to 3600-3680MHz (thereby giving the MNO 100MHz of contiguous 5G-suitable spectrum). In August 2018 Ofcom concluded a consultation on Three's request, which it is expected to grant.

⁵ Spectrum assigned explicitly for FWA is excluded. However, spectrum intended/used for FWA but licensed under technology neutral terms is included.

⁶ Licensed in certain areas of Australia

⁷ Regional FWA licenses are assigned in the 3475-3625MHz range

⁸ 100MHz of which (3300-3400MHz) for indoor use only

⁹ Regional FWA licenses are assigned (and currently available) in the 3410-3460MHz range

Country	Current assignment (MHz)	Additional assignment expected by June 2019 (MHz)	Total assignment expected by June 2019 (MHz)	Total assignment expected by end-2020 (MHz)
Germany ¹⁰	126	274 ¹¹	400 ¹²	400 ¹³
Japan	200	500 ¹⁴	700	700
Russia ¹⁵	N/d	-	-	N/d
Singapore ¹⁶	-	-	-	N/d
South Korea	280	-	280	280
Spain	360	-	360	360
Sweden	80 + regional assignments	-	80 + regional assignments	300 ¹⁷
UK ¹⁸	358	-	358	474
US	-	80	80	150

¹⁰ There are also mid-band regional FWA assignments in Germany; it is not clear if licenses can be used for mobile

¹¹ The entire 3.4-3.8GHz band will be assigned in early 2019, though not all the spectrum will be available until 2022 (when existing licenses expire).

¹² See above

¹³ See above

¹⁴ Up to 500MHz to be released across the 3.6-4.2GHz and 4.4-4.9GHz ranges.

¹⁵ It is likely that Russia will have assigned spectrum by end-2020, however we are not aware of official details published by the NRA

¹⁶ It is likely that Singapore will have assigned spectrum by end-2020, however we are not aware of official details published by the NRA

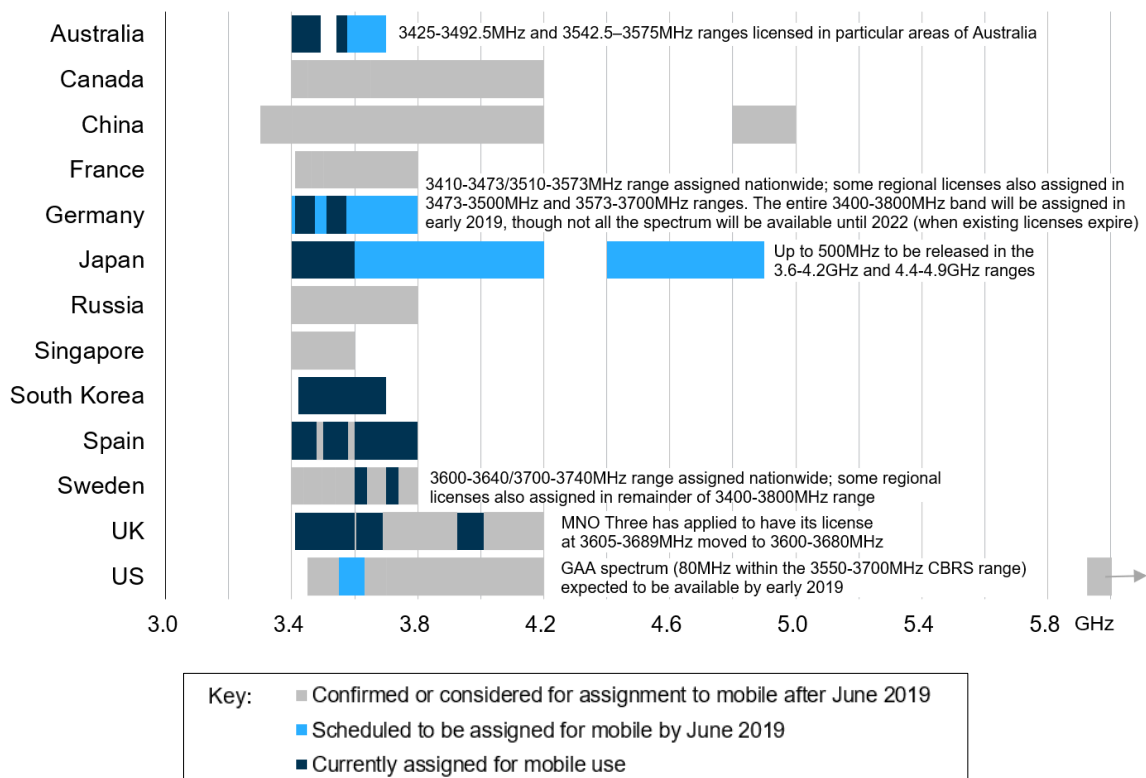
¹⁷ 3400-3700MHz to be assigned in late 2019 or early 2020; date of access depends on expiry of incumbent licenses. 3700-3800MHz to be assigned regionally from 2023

¹⁸ Figures include Three's spectrum licenses at 3605-3689MHz and 3925-4009MHz

It should be emphasised that several other countries, not included in our benchmark, have either already assigned mid-band spectrum (e.g. Ireland¹⁹, Italy²⁰) or committed to doing so by June 2019 (e.g. Hong-Kong²¹, Austria²²).

The mid-band spectrum ranges for each of our benchmark countries (highlighting the expected assignments by June 2019) are shown in Figure 1.3 below.

Figure 1.3: Mid-band spectrum for mobile use in benchmark countries [Source: Analysys Mason, 2018]



¹⁹ Ireland conducted a regional auction of 350MHz in the 3.4-3.8GHz range in May 2017. In each of nine regions, there was one 25MHz 'A' lot available (3410-3435MHz) and sixty-five 5MHz 'B' lots available (3475-3800MHz). Five different operators won spectrum. See <https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/3-6ghz-band-spectrum-award/>

²⁰ Italy completed its multi-band 5G auction on 2 October 2018. Two 80MHz blocks and two 20MHz blocks were auctioned in the 3.6-3.8GHz range (with a spectrum cap of 100MHz per operator). Final results can be found here: <http://www.sviluppoeconomico.gov.it/index.php/it/per-i-media/comunicati-stampa/it/194-comunicati-stampa/2038666-gara-5g>

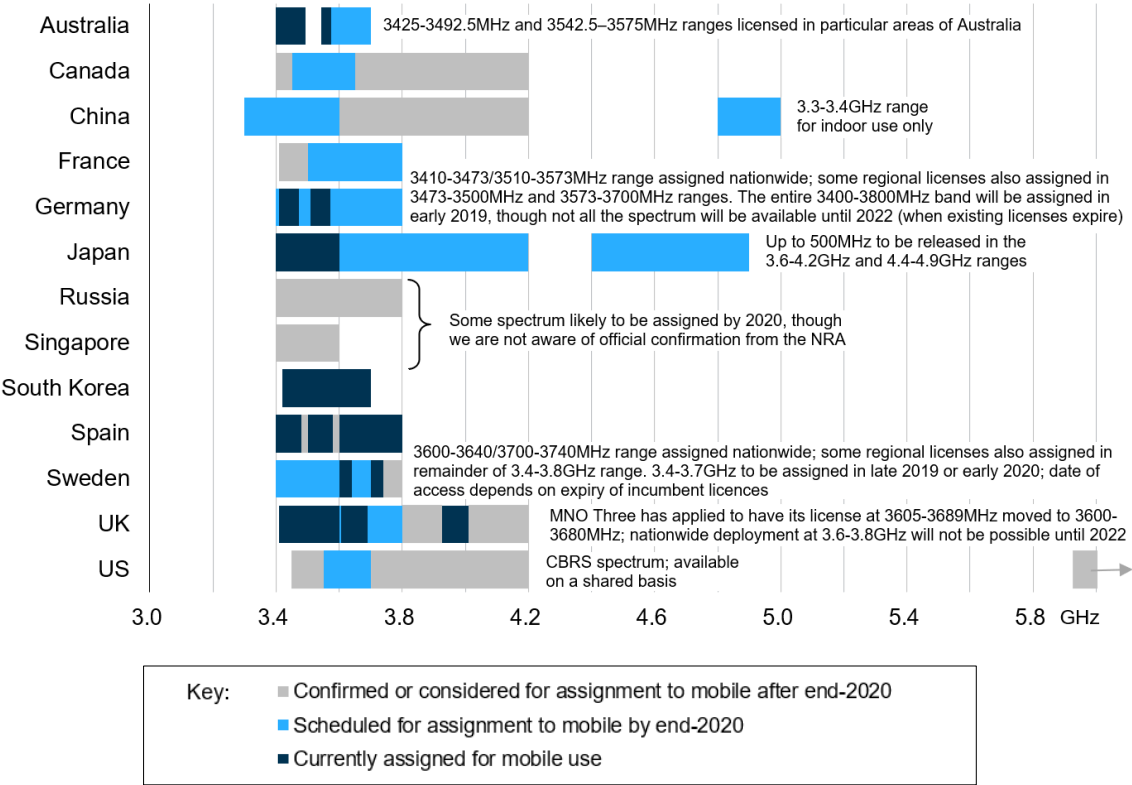
²¹ On 2 May 2018, the CA published a consultation entitled "Arrangements for Assignment of the Spectrum in the 3.4-3.6GHz Band [i.e. 200MHz] for the Provision of Public Mobile Services and the Related Spectrum Utilisation Fee". The assignment is scheduled for H2-2019/ See: [https://www.ofca.gov.hk/filemanager/ofca/listarticle/en/upload/1688/OFCA%20Presentation%20\(12%20Jun%202018\)%20-%20Mr%20Chaucer%20Leung%20\(Eng\).pdf](https://www.ofca.gov.hk/filemanager/ofca/listarticle/en/upload/1688/OFCA%20Presentation%20(12%20Jun%202018)%20-%20Mr%20Chaucer%20Leung%20(Eng).pdf)

On 28 August 2018, the Secretary for Commerce and Economic Development (SCED) and the Communications Authority (CA) jointly launched a public consultation on the assignment of a total of 200MHz in the 3.3-3.4GHz band (for indoor use) and the 4.83-4.93GHz band (for nationwide use). The CA proposes that the spectrum is assigned via auction, planned for mid-2019. See https://www.coms-auth.hk/en/media_focus/press_releases/index_id_1762.html

²² On 19 September 2018, the RTR published a tender for the auction of 190MHz of spectrum in the 3410MHz-3600MHz range and 200MHz in the 3600MHz-3800MHz range, scheduled to take place in Q1 2019. See <https://www.rtr.at/en/pr/PI19092018TK> and <https://www.rtr.at/en/tk/5G-Auction-Tender-Documents>

The mid-band spectrum ranges for each of our benchmark countries (highlighting the expected assignments by end-2020) are shown in Figure 1.3 below.

Figure 1.4: Mid-band spectrum for mobile use in benchmark countries [Source: Analysys Mason, 2018]



2 Country profiles

The following section provides details of the expected release of mid-band spectrum for 5G in each of our benchmark countries. For each country we provide:

- An overview of the mid-band 5G spectrum situation
- An update covering any relevant developments since the publication of the 5G readiness report in April 2018
- Information regarding the expected date for mid-band spectrum release and auction details

2.1 Australia

Current assignment: 3425-3492.5MHz and 3542.5–3575MHz ranges (a total of 100MHz) have been licensed in specific areas of Australia.

Future assignment: Australia plans to hold an auction of the 3575-3700MHz range in November 2018. Licenses will be available in a total of 14 regions.

Overview of mid-band 5G spectrum

MNOs Optus and Telstra own various regional blocks of spectrum in the 3425-3492.5MHz and 3542.5–3575MHz ranges.²³ The spectrum is suitable for LTE or 5G use.

In October 2016, the ACMA released²⁴ a discussion paper on the future use of the 3575-3700MHz range. After various consultations and decisions²⁵, the ACMA published²⁶ its final auction rules on

²³ In April 2000, the relevant government minister made the Radiocommunications (Spectrum Reallocation) Declaration 2000 (the 3.4GHz reallocation declaration) that allowed the introduction of spectrum licensing in the 3425-3492.5MHz and 3542.5–3575MHz ranges (the 3.4GHz band) in particular areas of Australia.

The majority of spectrum licenses were allocated at auction in October 2000. Of the available 482 lots, 22 went unsold. These 22 lots were re-offered in 2002; however, they again remained unsold. These lots were offered for assignment on a quarterly basis from 2004 to 2008.

The original spectrum licenses reached their expiry in December 2015. The majority of spectrum licenses were re-issued to the same licensees, with a new expiry date of 13 December 2030.

In December 2017 the ACMA's 'residual auction' made available 3.4GHz spectrum, consisting of a combination of the spectrum that was not reissued in 2015 and unsold lots from the preceding 3.4GHz assignments.

See https://www.acma.gov.au/-/media/Spectrum-Licensing-Policy/Information/Multiband-auction/Multiband-residual-lots_Auction-guide-pdf.pdf

See Table 3 of the ACMA's December 2016 consultation: https://www.acma.gov.au/theACMA/spectrum-licensing-2ghz-and-3_4ghz

Current holdings in the 3.4GHz band are shown in Table 9 of the August 2018 auction guide (see below)

²⁴ See https://www.acma.gov.au/theACMA/future-use-of-the-1_5-ghz-and-3_6-ghz-bands-2

²⁵ An index of relevant documentation is available at <https://www.acma.gov.au/Industry/Spectrum/Spectrum-projects/3-6-GHz-band>

²⁶ See <https://www.acma.gov.au/theACMA/applicant-information-package-3-6-ghz-band-auction>

August 6, 2018. A total of 125MHz (the entire 3575-3700MHz range) is scheduled to be auctioned in late November 2018, with licenses being made available on a regional basis in 14 different areas; further details are provided below.

Some Australian operators have conducted 5G trials using mid-band spectrum. For example:

- On April 10, 2018, NBN Co. announced²⁷ plans to conduct 5G FWA trials in Melbourne using 100MHz of spectrum in the 3.5GHz band
- On July 16, 2018, Telstra, Ericsson and Intel announced²⁸ that they had conducted an end-to-end 5G commercial network data call over licensed 3.5GHz spectrum

Developments since 5G readiness report

Not applicable (country not included in 5G readiness report)

Expected date for mid-band spectrum release and auction details

Figure 2.1: Details of 5G mid-band spectrum assignment in Australia [Source: ACMA, 2018]

Category	Details
Spectrum to be released	125MHz (3575–3700MHz)
Expected date	Late November 2018. The August 2018 auction guide outlines an indicative timeline with an application deadline of 31 August 2018 and estimated auction commencement of late November 2018.
Lot sizes	25 unpaired 5MHz blocks per region ²⁹
Geographic area	Spectrum will be auctioned in 14 regions: 6 'metropolitan areas' and 8 'regional areas'. Details of these regions are provided below*
License length	Spectrum licenses in all regions will commence on 30 March 2020 (i.e. the end of the two-year reallocation period for metropolitan areas – see below). Licensees are able to apply for 'early access' licenses in the intervening period in any unencumbered areas. The expiry date will be 13 December 2030, to align with the expiry date for current spectrum licenses in the adjacent 3.4GHz band. The license duration will therefore be approximately 10 years, 8 months.

²⁷ See <https://www.itnews.com.au/news/nbn-co-to-run-5g-tests-in-melbourne-488643>

²⁸ See <https://www.ericsson.com/es/en/press-releases/2018/7/ericsson-telstra-and-intel-achieve-first-end-to-end-multi-vendor-5g-commercial-network-data-call-over-licenced-3.5ghz-spectrum>

²⁹ In Perth, the spectrum will be configured into two categories, due to usage of the lower 16 lots (80MHz) by an existing 3.6GHz licensee during the five-year reallocation period, that is, until 30 March 2023: (1) 16 x 5MHz lots (3575–3655MHz, and (2) 9 x 5MHz lots (3655–3700MHz). See August 2018 auction guide for details.

2.2 Canada

Current assignment: no mid-band spectrum is currently assigned for mobile.

Future assignment: an auction of the 3450-3650MHz range is expected in late 2020. The geographical licensing arrangements have not yet been specified, but radio spectrum has always been licensed on a regional basis in Canada.

Overview of mid-band 5G spectrum

The 3475-3650MHz had been auctioned on a regional basis for FWA use³⁰.

In October 2017, ISED launched its ‘Spectrum Outlook’ consultation,³¹ intended to ‘inform ISED’s overall approach and planning related to potential spectrum releases in the 2018 to 2022 timeframe’. Recognizing the importance of mid-band spectrum for 5G, the consultation resolves to expand the band for review (beyond the original 3.4-3.8GHz band) to include the full 3.4–4.2GHz range.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued:
 - On May 3, 2018, Shaw announced³² the successful completion of 5G technical trials involving the 3.5GHz band
 - On July 25, 2018, Xplornet (a rural FWA provider) announced³³ a CAD36 million (USD28 million) project to boost internet speeds in Ontario. The project involves deploying small cells in the 3.5GHz band
- In June 2018, ISED published³⁴ its ‘Spectrum Outlook 2018 to 2022’
 - The document states that ISED “is anticipating [that] 3500MHz spectrum will be released for flexible use in late 2020”

³⁰ See http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf09434.html and <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09311.html>

³¹ See <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11333.html#s6.1>. Comments on the consultation were due by January 9, 2018, and replies to the comments were due by February 8, 2018.

³² See <http://newsroom.shaw.ca/materialDetail.aspx?MaterialID=6442452113>

³³ See <https://www.xplornet.com/about/news/xplornet-bringing-faster-internet-speeds-and-5g-ready-services-to-eastern-ontario/>

³⁴ See <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11403.html>

- All comments which were submitted as part of the consultation have been published³⁵
- ISED also published³⁶ a new consultation on the 3450–3650MHz band. The consultation:
 - Proposes revisions to the 3450–3650MHz band to accommodate flexible use for fixed and mobile services
 - Includes a decision to issue a moratorium on new applications for first-come first-served spectrum licensing in the 3475-3650MHz band
 - Seeks comments on a number of issues related to the 3450–3650MHz band (e.g. provision for incumbents, transition of incumbents, co-existence issues, etc.). The consultation also seeks preliminary comments on the 3400–3450MHz and 3650–4200MHz bands

Expected date for mid-band spectrum release and auction details

Figure 2.2: Details of 5G mid-band spectrum assignment in Canada [Source: ISED, 2018]

Category	Details
Spectrum to be released	200MHz (3450-3650MHz) scheduled for assignment 600MHz (3400-3450MHz, 3650-4200MHz) for initial consultation
Expected date	3450-3650MHz, late 2020 3400–3450MHz and 3650–4200MHz, no date provided
Lot sizes	20 unpaired 10MHz blocks
Geographic area	<p>Details of the regions have not yet been provided, however we note that Tier 4 service areas (see below) were used³⁷ by ISED for the 3475-3650MHz auction in 2004.</p> <p>Four³⁸ types of regions ('service areas') have been defined by ISED for spectrum auctions in Canada:</p> <ul style="list-style-type: none"> • Tier 1 – nationwide • Tier 2 – 14 provincial and large regional service areas³⁹ (subdivisions of Tier 1) • Tier 3 – 59 smaller regional service areas (subdivisions of Tier 2) • Tier 4 – 172 localised service areas⁴⁰ (subdivisions of Tier 3)

³⁵ See <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11377.html> and <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11385.html>

³⁶ See <http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11401.html>

³⁷ See http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf05472.html

³⁸ An additional group of service areas was developed to accommodate the transition of non-auctioned Cellular and Personal Communications Services (PCS) licenses from apparatus-based licenses to spectrum licenses and generally corresponding to the wireline services areas of the telephone companies operating in Quebec, Ontario and British Columbia. These service areas are known as Local Telephone Service Areas (TEL).

³⁹ Two additional Tier 2 areas, created for the Province of Alberta and the Province of Saskatchewan, generally adhere to the Alberta-Saskatchewan interprovincial border and maintain the territorial integrity of each province. These two Tier 2 service areas do not have associated Tier 3 and Tier 4 service areas. These were created for the 700MHz auction held in 2014.

⁴⁰ The Tier 4 localized service area boundaries were initially developed using contiguous groupings of Statistics Canada's 1996 census subdivisions. During development, service area borderlines were placed through lesser populated and more remote areas, wherever possible, in order to minimize potential interference problems.

Category	Details
	All previous spectrum auctions in Canada have been regional (i.e. used Tier 2, 3 or 4 service areas). As of 2011, the population of Canada was 33.5 million. The average population of Tier 2, 3 and 4 service areas in 2011 was therefore 2.1 million, 567 thousand, and 195 thousand respectively. Full details are available ⁴¹ from the ISED website.
License length	N/d

⁴¹ See http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/h_sf01627.html

2.3 China

Current assignment: no mid-band spectrum is currently assigned for mobile.

Future assignment: 500MHz (3.3–3.6GHz and 4.8–5.0GHz) will be released in China. Details have not been specified, but assignment is expected in 2019/20 to meet commercial launch timelines. We are not aware of plans indicating a geographic licensing approach; we note that current mobile licenses are nationwide and hence we assume a similar approach will apply here.

Overview of mid-band 5G spectrum

A presentation released⁴² in November 2016 states that ‘to enable business success of 5G eMBB [enhanced mobile broadband] deployment’, the Ministry of Industry and Information Technology (MIIT) intend to make more than 100MHz of additional mid-band spectrum available per operator.

In June 2017, the MIIT released⁴³ a consultation on using spectrum in the 3.3–3.6GHz and 4.8–5.0GHz ranges for 5G technologies, with the 3.3–3.4GHz range limited to indoor use. These ranges were confirmed in a subsequent announcement⁴⁴ in November 2017, with the MIIT adding that it would not approve any further fixed or satellite licenses in these bands. Reports further stated⁴⁵ that China is likely to assign the 3.6-4.2GHz range to 5G in the future.

We are not aware of an official timeline for the spectrum release, however we understand that license awards are expected to take place in 2019/20, in line with announced commercial launch timelines.⁴⁶ We are not aware of any public documentation indicating a geographic licensing approach; current mobile licenses are nationwide.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued

⁴² See https://5g-ppp.eu/wp-content/uploads/2016/11/03_9-Nov_Session-2_Chang-Ruoting-1.pdf. The presentation also references the 4.4–4.5GHz range for 5G. See also ‘Radio Spectrum Management in China’, Bureau of Radio Regulation, MIIT, September 11, 2017

⁴³ See <https://www.fiercewireless.com/wireless/china-reserves-spectrum-for-5g-says-more-low-band-frequencies-coming-report>. We understand that the MIIT also sought comment on non-exclusive use of the 24.75-27.5GHz and 37-42.5GHz bands in June 2017; see <https://www.qualcomm.com/media/documents/spectrum-4g-and-5g>

⁴⁴ See <http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757020/c5907905/content.html>, <http://www.miit.gov.cn/n1146290/n4388791/c5906943/content.html>, http://www.caict.ac.cn/xwdt/hywx/201711/t20171115_2214806.htm and <http://www.srrc.org.cn/en/news3434.aspx>

⁴⁵ See <http://www.atimes.com/article/china-reserves-spectrum-5g-services/>

⁴⁶ See <http://www.scmp.com/tech/china-tech/article/2075179/china-mobile-targets-steady-build-out-5g-infrastructure-2018>. Note that this source also references spectrum allocation in the 4.5GHz band.

- On July 10, 2018, China Mobile, Huawei and Intel announced⁴⁷ that they had completed “interoperability and development testing (IODT)” of the 5G New Radio (NR) standard using C-band spectrum
- On July 18, 2018, the China Academy of Information and Communications Technology (CAICT) reported⁴⁸ that most of its members had begun pre-commercial 5G testing in the 3.3-3.6GHz band⁴⁹
- On June 22, 2018, the MIIT confirmed⁵⁰ that policies would be rolled out to “accelerate the commercialization of 5G” and ensure the timely assignment of 5G spectrum licenses. The MIIT said that 5G license would “most likely [be issued] between the second half of 2019 and the first half of 2020.”

Expected date for mid-band spectrum release and auction details

Figure 2.3: Details of 5G mid-band spectrum assignment in China [Source: MIIT, CAICT, 2018]

Category	Details
Spectrum to be released	500MHz (3.3–3.6GHz and 4.8–5.0GHz). Reports indicate that China is likely to assign the 3.6-4.2GHz range to 5G in the future.
Expected date	No official auction date published, however a date of 2019/20 is likely for initial spectrum release, in line with announced commercial launch timelines.
Lot sizes	No specific consultation/details released. (3.3-3.4GHz range to be restricted to indoor use).
Geographic area	
License length	

⁴⁷ See <https://www.huawei.com/en/press-events/news/2018/7/ChinaMobile-Intel-Huawei-5G-NR-IODT>

⁴⁸ See http://www.caict.ac.cn/email/hydt/201807/t20180718_180465.html

⁴⁹ We understand the “3.5GHz band” (referred to by the CAICT) to mean the 3.3-3.6GHz range

⁵⁰ See <http://www.chinadaily.com.cn/a/201806/22/WS5b2c2e08a3103349141dda52.html>

2.4 France

Current assignment: no mid-band spectrum is currently assigned for mobile use.

Future assignment: 300MHz of contiguous C-band spectrum is planned to be released for 5G by 2020, and 340MHz (3460–3800MHz) by 2026. Further details have not been specified, though if using a similar approach to previous mobile spectrum awards in France, we consider it likely that spectrum will be licensed on a nationwide basis, although current FWA assignments are regional.

Overview of mid-band 5G spectrum

ARCEP ran a public consultation⁵¹ on new spectrum for 5G from January to March 2017. On June 22, 2017, ARCEP published responses to the consultation⁵² and preliminary decisions⁵³ regarding the future allocation of spectrum. The NRA confirmed its intention to allocate:

- 40MHz at 3420–3460MHz⁵⁴ to FWA in specific geographical areas^{55, 56} (with an additional 10MHz at 3410–3420MHz in certain areas, depending on coexistence constraints). This spectrum is technology-neutral, though it is expected to be used for LTE
- 300MHz of contiguous C-band spectrum for 5G by 2020, and 340MHz⁵⁷ (3460–3800MHz) by 2026

ARCEP's announcement also encouraged industry players to conduct 5G pilots. It nominated 80MHz (3600–3680MHz) of spectrum for that purpose, and identified six cities where pilot projects could be carried out (Lyon, Nantes, Lille, Le Havre, Saint-Etienne and Grenoble)⁵⁸. On January 16,

⁵¹ See https://www.arcep.fr/uploads/tx_gspublication/consult-frequences-terr-entreprises-5G-innov.pdf

⁵² See https://www.arcep.fr/uploads/tx_gspublication/synth-consult-frequences-5g-entreprises-juin2017.pdf

⁵³ See [https://www.arcep.fr/index.php?id=8571&no_cache=0&L=0&no_cache=0&tx_gsactualite_pi1\[uid\]=2063&tx_gsactualite_pi1\[annee\]=&tx_gsactualite_pi1\[theme\]=&tx_gsactualite_pi1\[motscle\]=&tx_gsactualite_pi1\[backID\]=26&cHash=0b883993e79c11e684d43c456e864432](https://www.arcep.fr/index.php?id=8571&no_cache=0&L=0&no_cache=0&tx_gsactualite_pi1[uid]=2063&tx_gsactualite_pi1[annee]=&tx_gsactualite_pi1[theme]=&tx_gsactualite_pi1[motscle]=&tx_gsactualite_pi1[backID]=26&cHash=0b883993e79c11e684d43c456e864432)

⁵⁴ The entire 3420–3460MHz range is not available in all departments. See <https://www.arcep.fr/index.php?id=13756>.

⁵⁵ I.e. areas not covered by FTTH deployments (the purpose of assigning the spectrum for FWA is to boost high-speed connectivity in France). Operators can apply for a license within a particular department, but coverage is only permitted in areas not covered by FTTH. For example, in the Seine-et-Marne department, operator Sem@for77 is licensed to cover 142 communes representing 33% of the total area of the department.

See https://www.arcep.fr/fileadmin/reprise/dossiers/thd-radio/FichesSynthese/Fiche_77__Semafor77.pdf

⁵⁶ A consultation on FWA spectrum was published on July 13, 2017, and a document outlining the assignment approach on December 11, 2017. As of March 2018, players are able to request regional FWA licenses from the regulator. See: https://www.arcep.fr/uploads/tx_gspublication/consult-attribution-THD_radio-juil2017.pdf
https://www.arcep.fr/uploads/tx_gspublication/modalites_attribution_THD_radio-dec2017.pdf
<https://www.arcep.fr/?id=7108>

⁵⁷ 390MHz in areas where 3410–3460MHz has not been assigned for FWA. ARCEP will reorganize the current 3.4–3.6GHz users towards the bottom of the band to achieve this. ARCEP states that it will contact existing licensees in the 3.4–3.6GHz band 'without delay', aiming to complete the required reorganization by YE 2017.

⁵⁸ The announcement notes that 3.4–3.8GHz spectrum is already available for 5G pilots in the six cities mentioned above, but that those cities are 'not exhaustive and may change'. The interview with ARCEP's president (link below) states that there are nine pilot cities – Bordeaux, Douai and Montpellier, in addition to the six mentioned above.

2018, ARCEP formally opened a ‘5G pilot window’.⁵⁹ The first pilot licenses were issued by ARCEP (in the 3.4-3.8GHz band) to Orange and Bouygues in February 2018⁶⁰.

ARCEP has not indicated what geographic licensing approach it will adopt for the 3.4-3.8GHz band. However, we consider it likely that spectrum will (predominately) be awarded on a nationwide basis (as has been the case historically for mobile licenses in France).

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued:
 - On May 7, 2018, Nokia and SFR announced⁶¹ the successful completion of a 5G NR call using 3.4-3.8GHz spectrum⁶²
 - On May 24, 2018, SFR reported⁶³ achieving bitrates of 1.6Gbit/s in a 5G NR trial using the 3.4-3.8GHz band⁶⁴ and massive MIMO; equipment was provided by Huawei
 - On July 3, 2018, Bouygues reported⁶⁵ it had conducted 5G trials in Bordeaux (using the 3645-3745MHz trial license issued by ARCEP in February 2018)
 - On July 4, 2018, SFR and Orange made separate announcements⁶⁶ stating that ARCEP had approved the expansion of their mid-band 5G tests to additional locations
 - On July 16, 2018, ARCEP published a 5G roadmap (see below), which states that 22 trial licenses have been granted in the 3.4-3.8GHz band

⁵⁹ See [https://www.arcep.fr/index.php?id=8571&no_cache=0&tx_gsactualite_pi1\[uid\]=2119&tx_gsactualite_pi1\[annee\]=&tx_gsactualite_pi1\[theme\]=&tx_gsactualite_pi1\[motscle\]=&tx_gsactualite_pi1\[backID\]=26&cHash=7a322a2c0239bb9c53b8f95be9d7e7e2](https://www.arcep.fr/index.php?id=8571&no_cache=0&tx_gsactualite_pi1[uid]=2119&tx_gsactualite_pi1[annee]=&tx_gsactualite_pi1[theme]=&tx_gsactualite_pi1[motscle]=&tx_gsactualite_pi1[backID]=26&cHash=7a322a2c0239bb9c53b8f95be9d7e7e2)

⁶⁰ See <https://www.telegeography.com/products/commsupdate/articles/2018/03/02/arcep-issues-two-5g-trial-licences-assigns-3-5ghz-spectrum-in-saint-martin>

⁶¹ See https://www.nokia.com/en_int/news/releases/2018/05/07/nokia-and-sfr-first-in-france-to-conduct-a-5g-new-radio-call-using-35-ghz-spectrum

⁶² Details of the exact spectrum range have not been published in the public domain

⁶³ See <https://www.telegeography.com/products/commsupdate/articles/2018/05/24/sfr-achieves-1-6gbps-speeds-in-a-5g-trial/index.html>

⁶⁴ Details of the exact spectrum range have not been published in the public domain

⁶⁵ See <https://www.telecompaper.com/news/bouygues-telecom-reaches-speed-of-23-gbps-in-live-5g-test-in-bordeaux--1251173>

⁶⁶ See <https://www.mobileworldlive.com/featured-content/top-three/operators-tussle-for-france-5g-leadership/>

- On May 25, 2018, ARCEP announced⁶⁷ that Covage subsidiary Sem@for77 became the first operator to be allocated spectrum in the 3410-3460MHz band for regional FWA (in the Seine-et-Marne region)
- On June 9, 2018, ARCEP published⁶⁸ an official notice regarding the release schedule for the 3.4-3.6GHz band. The notice states that the band will be progressively vacated (by department) of incumbent wireless backhaul links (used by the Ministry of Internal Affairs' PPDR network) by March 1, 2020, at the latest
- On July 16, 2018, ARCEP published a 5G roadmap⁶⁹. The roadmap outlines a schedule in which a consultation on spectrum assignment is held in October 2018, and a call for applications in mid-2019

Expected date for mid-band spectrum release and auction details

Figure 2.4: Details of 5G mid-band spectrum assignment in France [Source: ARCEP, 2018]

Category	Details
Spectrum to be released	300MHz of contiguous spectrum by 2020, and 340MHz (3460–3800MHz) by 2026 (390MHz in areas where 3410–3460MHz has not been allocated for FWA)
Expected date	Assignment likely in 2019/20
Lot sizes	
Geographic area	No specific consultation/details released
License length	

⁶⁷ See <https://www.arcep.fr/index.php?id=13756>

⁶⁸ See https://www.arcep.fr/uploads/tx_gsavis/18-0538.pdf

⁶⁹ See https://www.arcep.fr/index.php?id=8571&no_cache=1&no_cache=1&tx_gsactualite_pi1%5Buid%5D=2161&tx_gsactualite_pi1%5Bannee%5D=&tx_gsactualite_pi1%5Btheme%5D=&tx_gsactualite_pi1%5Bmotscle%5D=&tx_gsactualite_pi1%5BbackID%5D=26&cHash=d2b75603f42a5369ce848acb5c207816&L=1

2.5 Germany

Current assignment: 126MHz (3410-3473/3510-3573MHz) assigned to MNOs on a national basis.

Future assignment: 300MHz (3.4-3.7GHz) to be awarded nationwide and 100MHz (3.7-3.8GHz) to be awarded on a regional/local basis in early 2019.

Overview of mid-band 5G spectrum

Each of the three MNOs in Germany currently owns 2×21MHz of spectrum in the 3410-3473/3510-3573MHz range on a nationwide basis^{70, 71}; licenses expire in December 2021. We are not aware of services being offered using this spectrum, though the GSA indicates that Telefónica has been trialing an LTE TDD network using its spectrum. Various regional FWA licenses have also been assigned in the 3473-3500MHz and 3573-3700MHz ranges, expiring between 2020 and 2022⁷².

BNetzA's 'framework' document issued^{73,74} on June 27, 2017 identified 400MHz in the 3.4–3.8GHz range for 5G⁷⁵. On January 31, 2018, BNetzA published a draft decision⁷⁶, confirming its intention to auction 300MHz in the 3400–3700MHz range (for nationwide use), and 100MHz in the 3700-3800MHz range on a regional/local basis.

⁷⁰ Four 2×21MHz lots (3410-3494/3510-3594MHz) were made available for FWA in each of 28 regions at an auction in 2006. The first lot was won by Clearwire (subsequently WiMee-Connect) in all regions. The second lot was won by Inquam (subsequently WiMee Plus) in all regions. Telefónica subsequently acquired both operators. The third lot was won by DBD in all regions. We understand that T-Mobile subsequently acquired DBD. See https://www.bundesnetzagentur.de/EN/Areas/Telecommunications/Companies/FrequencyManagement/BroadbandWirelessAccess/broadbandwirelessaccess_node.html

We note that BNetzA's recent consultation states that one assignment holder holds licenses in the third lot in 27 out of the 28 regions (as well as the fourth lot in the remaining region).

⁷¹ See https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/Mobilfunk/DrahtloserNetzzugang/Projekt2016/Frequenzen700bis1800_pdf.pdf?__blob=publicationFile&v=3.

On February 21, 2018, Telefonica announced that it had sold half of its spectrum in the 3410-3452/3510-3552MHz range (i.e. 2×21MHz) to Vodafone. See <https://www.telefonica.de/fixed/news/6094/more-high-speed-for-germany-vodafone-and-telefonica-deutschland-to-cooperate-over-fast-fibre-optic-connections-for-mobile-networks.html>

⁷² These licenses were assigned on an individual basis. There are currently around 80 regional FWA assignments; licensees are generally SMEs. The latest expiry date of these licenses is December 2022.

⁷³ See https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2017/27062017_Frequenzen.html?nn=26577. The '5G Strategy in Germany' paper was published in September but reiterates previous BNetzA documentation.

⁷⁴ This follows the 'Frequency Compass' and 'Points of Orientation' documents published in 2016; see https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/Mobilfunknetze/mobilfunknetze-node.html

⁷⁵ Both the 2.1GHz and C-band spectrum will be awarded technology-neutral, with licenses expiring on December 31, 2040.

⁷⁶ See https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/Mobilfunknetze/mobilfunknetze-node.html

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued. For example, on May 3, 2018, Deutsche Telekom announced⁷⁷ that it was operating 5G antennae in Berlin using 3.7GHz spectrum⁷⁸
- BNetzA published⁷⁹ responses to its 5G consultation and issued⁸⁰ an ‘auction decisions’ document
- On September 17, 2018, BNetzA published⁸¹ draft rules for the 3.4-3.7GHz auction. The proposed rules will be reviewed by the regulator’s Advisory Council on September 24, 2018; a final decision is scheduled to be made in November 2018, with the auction planned for Q1 2019
- BNetzA published⁸² a separate consultation on its proposed approach for the assignment of the 3700-3800MHz range. The proposed licensing arrangement is as follows:
 - Individual assignments; no right to national roaming on national networks in the 3400-3700MHz range
 - To be eligible for a license, and applicant cannot hold nationwide licenses in the 700MHz or 3.4-3.7GHz bands
 - For outdoor use, up to 80MHz (3700-3780MHz) will be available for regional use, and 20MHz (3780-3800MHz) for local use
 - For (local) indoor use, up to 100MHz is to be made available using a simplified assignment procedure. Local indoor use is to co-exist with regional outdoor use
- A number of industrial manufacturing companies (including Daimler, Volkswagen, Audi, BASF and Siemens) have signalled interest⁸³ in obtaining local or regional licenses for 5G

⁷⁷ See <https://www.telekom.com/en/media/media-information/archive/5g-rollout-in-germany-523636>

⁷⁸ Details of the exact spectrum range have not been published in the public domain

⁷⁹ See https://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/Mobilfunknetze/mobilfunknetze-node.html

⁸⁰ Ibid.

⁸¹ See https://www.bundesnetzagentur.de/DE/Allgemeines/Presse/Reden/5GVergabebedingungen.pdf?__blob=publicationFile&v=2

⁸² See https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/RegionaleNetze/Entwurf%20Antragsverfahren%203,7%20-%203,8%20GHz.pdf?__blob=publicationFile&v=2

⁸³ On 18 May 2018, Telecom paper (citing business publication *WirtschaftsWoche*) reported that fifteen industrial manufacturing companies had signalled an interest in obtaining licenses for 5G. "The interested companies... want to use 5G in their production plants to connect machines"

*Expected date for mid-band spectrum release and auction details**Figure 2.5: Details of 5G mid-band spectrum assignment in Germany [Source: BNetzA, 2018]*

Category	Details
Spectrum to be released	300MHz (3.4-3.7GHz) to be auctioned for nationwide use 100MHz (3.7-3.8GHz) awarded on an individual basis for regional/local use ⁸⁴
Expected date	Early 2019
Lot sizes	Thirty unpaired 10MHz blocks (for nationwide use)
Geographic area	National and regional/local (see above). Details of the region size for licenses in the 3.7-3.8GHz range have not been provided; all previous spectrum assignments for mobile use have been on a nationwide basis. We note that in the previous ⁸⁵ 3.6-3.8GHz (BWA) auction in 2006, Germany was divided into 28 regions ⁸⁶ .
License length	3.4-3.7GHz spectrum will be assigned until December 31, 2040 at the latest. Most of 3.4-3.7GHz spectrum will become available in 2022 when current licenses expire. 3.7-3.8GHz licenses will be valid for up to 10 years (not exceeding December 31, 2040).

⁸⁴ Any guard bands necessary between the nationwide and regional networks are to be implemented by the regional network operators. Therefore, the full 100MHz of spectrum will not always be available for regional assignments.

⁸⁵ See https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OffentlicheNetze/Mobilfunk/DrahtloserNetzzugang/Mobilfunk2020/20180514_5GAuktion_EntscheidungI&II.pdf?__blob=publicationFile&v=2

⁸⁶ For further details, see https://www.bundesnetzagentur.de/EN/Areas/Telecommunications/Companies/FrequencyManagement/BroadbandWirelessAccess/broadbandwirelessaccess_node.html

2.6 Japan

Current assignment: 3.4-3.6GHz range assigned to MNOs on a national basis.

Future assignment: Up to 500MHz within the 3.6–4.2GHz and 4.4–4.9GHz ranges to be released by March 2019. Further details have not been specified, though we consider it likely that spectrum will be licensed on a nationwide basis based on historical mobile licenses.

Overview of mid-band 5G spectrum

Each of the three MNOs in Japan were licensed to use 40MHz of spectrum in the 3.48–3.6GHz range in 2014 on a national basis⁸⁷. The exact status of the usage of this spectrum is unclear, though we understand that licenses permit mobile LTE services to be offered. We understand that the 3.4-3.48GHz range was assigned to NTT DOCOMO and Softbank in April 2018 (see below).

The MIC published a 5G roadmap⁸⁸ on June 28, 2016, which outlines its aim ‘to realize 5G in 2020’ in time for the Tokyo Olympics. A 5G consultation⁸⁹ was subsequently published by the MIC in July 2017, providing further details on the expected bands and timeline for assignments. An updated roadmap was published⁹⁰ by the MIC on June 28, 2018. We are not aware of any public documentation indicating a geographic licensing approach; current mobile licenses are nationwide.

The MIC is proposing to authorize 5G use in several bands⁹¹, including 3.6–4.2GHz and 4.4–4.9GHz. The MIC aims to allocate these to mobile by March 2019, sharing with existing systems. Given sharing constraints, a maximum of 500MHz is expected to be allocated to mobile.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued. For example:
 - On May 31, 2018, NTT DOCOMO and NEC reported⁹² trials in the 4.4-4.9GHz band⁹³

⁸⁷ See <http://www.gtigroup.org/news/ind/2014-12-25/5208.html>

⁸⁸ See https://www.gsma.com/spectrum/wp-content/uploads/2016/08/MIC_Spectrum-for-5G-MIC-Kuniko-OGAWA.pdf. The MIC has since published a number of similar iterations of the presentation; see https://5g-ppp.eu/wp-content/uploads/2016/11/Opening-1_Yuji-Nakamura.pdf (November 9, 2016), https://5g-ppp.eu/wp-content/uploads/2016/11/04_9-Nov_Session-2_Yuji-Nakamura.pdf (November 9, 2016) and http://5gmf.jp/wp/wp-content/uploads/2017/06/02-Opening-Session-1_Isao-Sugino.pdf (May 24, 2017).

⁸⁹ ‘Draft report from New generation mobile communication system committee’, July 28, 2017 (in Japanese); see http://www.soumu.go.jp/main_content/000499652.pdf. See also section 9 of the 5GMF white paper version 1.1.

⁹⁰ See https://www.gsma.com/spectrum/wp-content/uploads/2018/07/Kohei-Satoh-MWC-Shanghai_MIC-Japan-1.pdf

⁹¹ The June 2016 roadmap indicated that the MIC also aimed to share the 5.15–5.35GHz band with 5G; however, this band is not mentioned in subsequent documentation.

⁹² See <https://www.rcrwireless.com/20180531/5g/nec-ntt-docomo-carry-out-5g-trial-multiple-base-stations-japan-tag23>

⁹³ We understand the “4.5GHz band” (referred to in the report) to mean the 4.4-4.9GHz range

- On August 17, 2018, NTT DOCOMO and Huawei announced⁹⁴ that they had conducted a wide-scale 5G field-trial using the C-band
 - The roadmap published⁹⁵ by the MIC in June 2018 provides details of a number of ongoing 5G field-trials in Japan using mid-band spectrum
- Progress towards 5G commercialisation has continued. For example, on June 29, 2018, NTT DOCOMO announced⁹⁶ plans to launch 5G technology ‘within 800 days.’
 - On April 6, 2018, the MIC approved⁹⁷ a bid from internet retailer Rakuten to become Japan’s fourth MNO, assigning the company 1.7GHz (1730-1750/1825-1845MHz) spectrum⁹⁸. On May 10, 2018, Rakuten published⁹⁹ its Q1 financial results for FY2018, indicating its intention to launch services in October 2019 using the 1.7GHz band
 - We understand that Rakuten had previously submitted¹⁰⁰ an application to the MIC for 4G suitable spectrum in both the 1.7GHz and 3.4GHz bands (3400-3480MHz), however the 3.4GHz spectrum was awarded¹⁰¹ to Softbank (3400-3440MHz) and NTT DOCOMO (3440-3480MHz)

Expected date for mid-band spectrum release and auction details

Figure 2.6: Details of 5G mid-band spectrum assignment in Japan [Source: MIC, 2018]

Category	Details
Spectrum to be released	Up to 500MHz within the 3.6–4.2GHz and 4.4–4.9GHz ranges
Expected date	March 2019
Lot sizes	No specific consultation/details released. Historically, mobile licenses in Japan have been assigned on a national basis via beauty contest rather than auctioned.
Geographic area	However, an article published ¹⁰² by the Asia Nikkei review on November 28, 2017, stated that the MIC is planning to conduct a competitive auction process for assigning 5G spectrum.
License length	

⁹⁴ See <https://www.telegeography.com/products/commsupdate/articles/2018/08/17/huawei-and-ntt-docomo-carry-out-large-scale-5g-field-trial-in-japan/>

⁹⁵ See https://www.gsma.com/spectrum/wp-content/uploads/2018/07/Kohei-Sato-MWC-Shanghai_MIC-Japan-1.pdf

⁹⁶ See <https://www.mobileworldlive.com/featured-content/top-three/docomo-starts-countdown-to-5g/>

⁹⁷ See <https://www.telegeography.com/products/commsupdate/articles/2018/04/09/mic-advisory-panel-gives-green-light-to-rakutens-mobile-bid/>

⁹⁸ A consultation released by the MIC in December 2017 proposed draft rules for releasing this band. See http://www.soumu.go.jp/main_content/000517622.pdf. We understand that the MIC also allocated the 1710-1750/1805-1825MHz range to KDDI, and the 1765–1785/1860–1880MHz range (which was previously shared) to NTT DOCOMO in the Tokyo, Nagoya and Osaka areas.

⁹⁹ See https://global.rakuten.com/corp/investors/assets/doc/documents/18Q1PPT_E.pdf

¹⁰⁰ See <https://www.telegeography.com/products/commsupdate/articles/2018/02/27/japanese-e-tailer-rakuten-submits-application-for-mobile-frequencies/>

¹⁰¹ See http://www.soumu.go.jp/menu_news/s-news/01kiban14_02000333.html

¹⁰² See <https://asia.nikkei.com/Politics-Economy/Policy-Politics/Japan-to-invite-new-faces-to-5G-party>. See also <https://www.mckinsey.com/industries/telecommunications/our-insights/japan-at-a-crossroads-the-4g-to-5g-revolution>

2.7 Russia

Current assignment: limited data available. We are not aware of any mid-band spectrum currently assigned for mobile in Russia.

Future assignment: details have not been specified. We understand that current mobile authorizations in Russia are a mixture of regional and national licenses.

Overview of mid-band 5G spectrum

The government's 5G roadmap¹⁰³ schedules a formal decision on 5G spectrum allocation¹⁰⁴ for 2018. At the time of publication of this report, we understand that no decision has been announced.

However, on July 4, 2017, the SCRF announced¹⁰⁵ a decision to allocate 3.4–3.8GHz to MegaFon for 5G network testing ahead of the 2018 World Cup¹⁰⁶. Fixed incumbent Rostelecom has also received a test license in the 3.4-3.8GHz band,¹⁰⁷ while Beeline's request for a test license (submitted to the SCRF in September 2017) was declined on interference grounds.¹⁰⁸

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued. For example, Rostelecom and Ericsson launched¹⁰⁹ a 5G trial network in St Petersburg using the 3.4-3.8GHz band¹¹⁰
- MegaFon acquired Neosprint (an operator that owns 24MHz of spectrum in the 3.4-3.6GHz band in Moscow) for RUB720 million (USD12 million)¹¹¹. We understand that MegaFon used

¹⁰³ On July 28, 2017, the Russian government published its 'Digital economy of the Russian Federation' plan, which includes a 5G roadmap. See <http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf>

¹⁰⁴ Some sources claim that the Russian Digital Economy plan indicates 5G networks will be built in the 694–790MHz, 3.4–3.8GHz, 4.4–4.99GHz, 5.9GHz, 24.25–29, 5GHz, 30–55GHz, 66–76GHz and 81–86GHz bands. However, we are not aware of this explicitly stated in the public documentation; see <http://www.tadviser.ru>. An article published on TDaily.ru in March 2018 states that 5G spectrum will not be approved until 2019. See <http://www.tdaily.ru/news/novosti-korotkoi-stroki/44151>

¹⁰⁵ See <http://minsvyaz.ru/ru/events/37119/>

¹⁰⁶ In March 2018 reports emerged that the Russian regulator had started issuing licenses for the 2018 FIFA World Cup. See <https://www.telecompaper.com/news/russia-issues-spectrum-permits-for-world-cup--1235619>

¹⁰⁷ See <https://www.kommersant.ru/doc/3521675>. The link includes a list of regions covered by the licenses.

¹⁰⁸ Beeline's request was postponed until the SCRF's next meeting, see <https://www.telegeography.com/products/commsupdate/articles/2017/09/22/beeline-mts-make-5g-frequency-applications/> and <https://www.telegeography.com/products/commsupdate/articles/2018/01/04/scrf-declines-to-issue-spectrum-for-russian-5g-testing/>

¹⁰⁹ See <https://www.ericsson.com/en/news/2018/5/5g-zone-at-the-hermitage>

¹¹⁰ Details of the exact spectrum range have not been published in the public domain

¹¹¹ See <https://corp.megaфон.com/press/news/20180427-2006.html>

the spectrum in June 2018 to deploy test 5G networks in stadiums hosting the 2018 World Cup in Russia

- Beeline had a second request for a 5G test license denied by the SCRF¹¹²
- On September 5, 2018, the Russian deputy prime minister was reported¹¹³ as saying that 5G mobile services should be launched commercially in major cities across Russia by the end of 2021 (one year later than the 2020 target set out in previous government announcements)
- On October 3, 2018, reports emerged¹¹⁴ that the SCRF will consider allocating additional spectrum for 5G testing in the 3.4-4.2GHz and 4.4-4.99GHz ranges to MTS, Beeline and Tele2. Separately, the SCRF is also considering a request from Beeline to conduct 5G testing in the 3.4-3.8GHz and 4.4-4.5GHz ranges in Moscow city, the Moscow region, St. Petersburg, the Novosibirsk region, the Republic of Tatarstan and the Krasnodar region

Expected date for mid-band spectrum release and auction details

Figure 2.7: Details of 5G mid-band spectrum assignment in Russia [Source: Analysys Mason, 2018]

Category	Details
Spectrum to be released date	No specific details/consultation released
Expected	
Lot sizes	
Geographic area	
License length	

¹¹² See <https://www.telegeography.com/products/commsupdate/articles/2018/04/09/vimpelcoms-application-to-test-5g-frequencies-denied/>

¹¹³ See <https://www.kommersant.ru/doc/3732337>

¹¹⁴ See <http://www.tdaily.ru/news/all/95/47473>

2.8 Singapore

Current assignment: we are not aware of any mid-band spectrum currently assigned for mobile in Singapore.

Future assignment: Singapore is exploring the possibility of assigning the 3.4-3.6GHz range in 2019. Further details have not been specified, though we expect licenses to be national (as has historically been the case for Singapore mobile licensing).

Overview of mid-band 5G spectrum

The IMDA ran a public consultation¹¹⁵ ‘5G mobile services and networks’ from May to July 2017. The document states that the IMDA is ‘exploring the possibility’ of allocating the 3.4–3.6GHz range for IMT services (including 5G)¹¹⁶. In the consultation’s model of future spectrum supply, the 3.4–3.6GHz range is released in 2019.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued
 - On June 21, 2018, M1 and Huawei announced¹¹⁷ plans to conduct “the first 3.5GHz with Non-Standalone (NSA) standards compliance field trial in Southeast Asia by end 2018, as well as the first 28GHz and 3.5GHz with Standalone (SA) standards compliance field trial in South East Asia by mid-2019”
 - On July 23, 2018, Singtel and Ericsson announced¹¹⁸ plans to conduct a trial of 5G services in Q4 2018, using trial spectrum¹¹⁹ awarded by the IMDA

¹¹⁵ See <https://www.imda.gov.sg/regulations-licensing-and-consultations/consultations/consultation-papers/2017/public-consultation-on-5g-mobile-services-and-networks>

¹¹⁶ The consultation notes that, based on the current users and assignments, although the 3.4-3.6GHz range is generally under-utilised, there is still a lack of contiguous spectrum to support the deployment of new services. Considering the geographical size of Singapore, co-channel operations of both IMT and FSS (downlink) services may not be possible. In the event that IMDA makes available the extended C-band for IMT services, IMDA will have to consider either: i) A full migration, which involves moving all satellite users out of the extended C-band and making available approximately 200MHz of spectrum for IMT; or ii) A partial migration, which involves moving part of the users to the upper ranges of the extended C-band and making available part of the 200MHz spectrum for IMT.

¹¹⁷ See <https://www.m1.com.sg/AboutM1/NewsReleases/2018/M1%20and%20Huawei%20embark%20on%20first%20end-to-end%205G%20live%20tests%20in%20Singapore.aspx>

¹¹⁸ See <https://www.ericsson.com/en/press-releases/2018/7/singtel-and-ericsson-to-launch-singapores-first-5g-pilot-network>

¹¹⁹ In May 2017, the IMDA announced that it would waive the frequency fees associated with 5G trials until December 2019, intending to encourage 5G R&D within the industry. See <https://www.imda.gov.sg/-/media/imda/files/regulation-licensing-and-consultations/frameworks-and-policies/spectrum-management-and-coordination/spectrum-planning/5g-technology-annex-a.pdf?la=en>

*Expected date for mid-band spectrum release and auction details**Figure 2.8: Details of 5G mid-band spectrum assignment in Singapore [Source: IMDA, 2018]*

Category	Details
Spectrum to be released	200MHz (3400-3600MHz)
Expected date	2019
Lot sizes	
Geographic area	No specific consultation/details released
License length	

2.9 Spain

Current assignment: Spain completed an auction of spectrum in the 3600-3800MHz range in July 2018. Spectrum was made available on a national basis.

Future assignment: none scheduled

Overview of mid-band 5G spectrum

Three of Spain's MNOs own national licenses in the 3.4-3.6GHz band¹²⁰: Orange (2×20MHz), Telefónica (2×20MHz) and Mas Movil (2×40MHz).

The remaining 2×20MHz of the 3.4-3.6GHz band is used by the military for radiolocation services; a consultation issued by the Ministry of Energy, Tourism and Digital Agenda (MINTEAD) in July 2017 indicates that this block is not expected to be reallocated¹²¹.

MINTEAD completed an auction of the 3.6-3.8GHz range in July 2018:

- Forty 5MHz blocks were available in the 3600-3800MHz band
- Licenses are national, technology-neutral and without coverage obligations; license duration is twenty years
- The spectrum won is shown in Figure 2.9 below:

Figure 2.9: Outcome of the Spain's 3.6-3.8GHz auction in July 2018 [Source: MINTEAD, 2018]

Operator	Spectrum won	Spectrum range (MHz) ¹²²
Vodafone	90MHz	N/d
Telefónica	50MHz	N/d
Orange	60MHz	N/d
Mas Movil	-	-
Total	200MHz	-

A number of operators have conducted 5G trials (or announced plans for the launch of 5G services) using mid-band spectrum. For example:

¹²⁰ The exact assignments are as follows: Mas Movil (3400-3440/3500-3540MHz), Telefónica (3440-3460/3540-3560MHz), Orange (3460-3480/3560-3580MHz). See https://sedeaplicaciones.minetur.gob.es/setsi_regconcesiones/default.aspx

¹²¹ See <http://www.mincotur.gob.es/telecomunicaciones/es-ES/Participacion/Documents/Plan-Nacional-5G.pdf>

¹²² The spectrum was awarded as generic blocks; we understand that exact assignments are yet to be confirmed

- On March 1, 2018, Orange announced¹²³ that it is in the process of selecting cities in which to launch commercial 5G services in 2019 using its spectrum in the 3460-3480/3560-3580MHz range
- On Jul 30, 2018, Vodafone confirmed¹²⁴ that it had deployed pre-commercial 5G antenna across several cities using Huawei equipment operating in the 3.6-3.8GHz band

Developments since 5G readiness report

Not applicable (country not included in 5G readiness report)

Expected date for mid-band spectrum release and auction details

The 3400-3600MHz range was awarded in July 2018. Spain has not indicated that further mid-band spectrum is planned for release.

¹²³ See <https://www.telegeography.com/products/commsupdate/articles/2018/03/01/orange-espana-earmarks-3-5ghz-band-for-5g-eyes-four-city-launch-in-2019/>

¹²⁴ See <https://www.telegeography.com/products/commsupdate/articles/2018/07/30/vodafone-tests-5g-in-madrid-barcelona-seville-malaga-bilbao-and-valencia/>

2.10 South Korea

Current assignment: South Korea auctioned the 3420-3700MHz range on a national basis in June 2018 for 5G use, raising a total of USD2.69 billion.

Future assignment: none scheduled

Overview of mid-band 5G spectrum

In early 2017, MSIT released¹²⁵⁻¹²⁶ a national broadband/spectrum plan ('K-ICT'), indicating that it planned to allocate 300MHz in the 3.4–3.7GHz¹²⁷ band to 5G by 2018. The 3.4–3.7GHz band (along with spectrum in the 28GHz band) was auctioned in June 2018 (see below).

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- MSIT confirmed¹²⁸ the details and date of the auction (see Figure 2.10 below). The auction was held as scheduled. MSIT announced¹²⁹ results on June 18, 2018 (see Figure 2.10 below)
 - Twenty-eight 10MHz blocks were available in the 3420-3700MHz range
 - Licenses start on 1 December 2018 and last 10 years; licenses are national

Figure 2.10: Outcome of South Korea's 3420-3700MHz auction in June 2018 [Source: MSIT¹³⁰, 2018]

Operator	Spectrum won	Spectrum range (MHz)
LGU+	80MHz	3420-3500MHz
KT	100MHz	3500-3600MHz
SKT	100MHz	3600-3700MHz
Total	280MHz	3420-3700MHz

Expected date for mid-band spectrum release and auction details

The 3420-3700MHz range was awarded in June 2018. South Korea have not indicated that further mid-band spectrum is planned for release.

¹²⁵ See https://blog.naver.com/with_msip/220917986508.

¹²⁶ See also a notice released by MSIT in July 2017 indicating that the government may be reserving 3.1–3.735GHz for 5G; see <http://www.msit.go.kr/web/msipContents/contentsView.do?catelId=mssw352&artId=1364893>

¹²⁷ See https://www.ituaj.jp/wp-content/uploads/2017/05/nb29-2_web.pdf

¹²⁸ See <http://www.msit.go.kr/web/msipContents/contentsView.do?catelId=mssw311&artId=1381784>

¹²⁹ See <http://www.msit.go.kr/web/msipContents/contentsView.do?catelId=mssw311&artId=1386500>

¹³⁰ Ibid.

2.11 Sweden

Current assignment: 80MHz (3600-3640/3700-3740MHz) assigned to MNOs on a national basis; some (technology neutral) regional licenses assigned in the 3.4-3.8GHz band.

Future assignment: 300MHz (3.4-3.7GHz) to be awarded nationwide by late 2019 or early 2020 and 100MHz (3.7-3.8GHz) to be awarded on a regional basis from 2023 onwards.

Overview of mid-band 5G spectrum

Two MNOs in Sweden own national¹³¹ 2×20MHz licenses in the 3.6-3.8GHz band: TDC Sverige (owned by Tele2) (3600-3620MHz, 3700-3720MHz) and B2 Bredband (owned by Telenor) (3620-3640MHz, 3720-3740MHz). These licenses are technology and service neutral and expire in December 2022. The remaining spectrum in the 3.6-3.8GHz range was auctioned on a regional basis, though most of the licenses have not been assigned.

Until recently, two MNOs in Sweden also owned national licenses in the 3.4-3.6GHz band: Telia-Sonera (3438-3466MHz, 3538-3566MHz) and Tele2 (3466-3494MHz, 3566-3594MHz). However, these licenses expired in December 2017. The 3410-3438MHz and 3510-3538MHz ranges are currently allocated to several local operators with regional¹³² based technology-neutral licenses which expire in March 2023.

The PTS issued¹³³ a consultation on the August 30, 2016, analysing the need for the award of spectrum in the 3438-3510MHz and 3538-3600MHz ranges. The consultation proposed that the two bands be handled together, and therefore that the PTS would hold off on a new assignment “until the [entire] 3.4-3.8GHz band can be reassigned”. This approach was confirmed in a statement^{134, 135} released by the PTS on October 14, 2016.

On February 3, 2017 the PTS published¹³⁶ a spectrum plan for 5G tests in the 3.4-3.6GHz band from 2017, with comments to be submitted by February 24, 2017. On March 31, 2017, the PTS announced

¹³¹ In 2007, PTS auctioned four 40MHz blocks (two FDD and two TDD) in the 3.6-3.8GHz band in each of Sweden's 290 municipalities. B2 Bredband won one FDD block in every municipality, meaning that it effectively holds a national license of 2×20MHz. Of the remaining 870 licenses, the majority (758) remained unsold and were re-auctioned in 2009. 265 of these licenses are now assigned; these licenses are spread out geographically across the country (most assigned licenses are in the more northerly municipalities). The 2009 auction also made available a national 2×20MHz block, which was won by TDC Sverige. All licenses expire in December 2022. See February 2018 consultation.

¹³² The licenses in the 3.4-3.6GHz band were originally assigned on a county basis, but the charging base for the annual fees is comprised of population by municipality. There are licenses assigned in 98 out of 290 municipalities. We understand that the majority of license holders are not using their licenses (see February 2018 consultation). On October 16, 2018, the PTS announced that it had asked all licensees who were not using (or lightly using) their licenses to return them to the regulator. See <https://www.pts.se/sv/nyheter/radio/2018/pts-vill-att-kommunala-frekvenstillstand-i-35-ghz-bandet-lamnas-tillbaka/>

¹³³ See <http://www.pts.se/upload/Remisser/2016/Spektrum/3-5-GHZ-forstudie-2016-25.pdf>

¹³⁴ See <http://www.pts.se/sv/Dokument/Rapporter/Radio/2016/Analys-av-behov-och-efterfragan-for-en-ny-tilldelning-genom-urvalsfarande-i-frekvensomradena-34383510-och-35383600-MHz/>

¹³⁵ The PTS also re-released the consultation document, with an additional section on stakeholder responses, claiming that all stakeholders who responded to the consultation (Hi3G, Huawei, Tele2, Telenor, TeliaSonera) endorsed its recommendations.

¹³⁶ See <http://www.pts.se/upload/Remisser/2017/Spektrum/5G-tester/forslag-spektrumplan-5G-tester-170203.pdf>

that it received (generally supportive) responses from nine parties. The PTS therefore launched its plans for the 5G tests, making 100-200MHz available in the 3.4-3.6GHz band “from 2017”. The press release also stated that the PTS planned to launch those frequencies for long-term use “from 2020”. On February 28, 2018, the PTS announced that it had made a contiguous 200MHz block of spectrum (3.4-3.6GHz) available for 5G-tests in Stockholm County.

On February 15, 2018, the PTS published¹³⁷ a consultation on releasing the 3.4-3.8GHz for 5G. On May 3, 2018, the PTS published¹³⁸ responses to the consultation and its revised proposals for assigning the spectrum. The PTS has since confirmed¹³⁹ its intention to assign the 3.4-3.7GHz range on a nationwide basis in late 2019 or early 2020, and the 3.7-3.8GHz range on a regional basis from 2023; further details are provided below.

Developments since 5G readiness report

Not applicable (country not included in 5G readiness report)

Expected date for mid-band spectrum release and auction details

Figure 2.11: Details of 5G mid-band spectrum assignment in Sweden [Source: PTS, 2018]

Category	Details
Spectrum to be released	3.4-3.8GHz (400MHz)
Expected date	Assignment of 3.4-3.7GHz band proposed for late 2019 or early 2020 (although the potential date of access differs depending on when existing licenses expire). Assignment of the 3.7-3.8GHz band proposed for 2023
Lot sizes	The February 2018 consultation states that some industry players have requested block sizes of 80-100MHz, but an alternative option (which provides more flexibility) is block sizes of 5-10MHz. The PTS states further consideration will be made before the award. In October 2018 the PTS published ¹⁴⁰ a consultation outlining different options for the 3.7-3.8GHz band; block sizes of 80-100MHz or 40-50MHz are envisaged ¹⁴¹

¹³⁷ See <https://www.pts.se/contentassets/9057a944959742878f4b3ce0e7ade9f7/remiss-av-rapport-infor-framtida-tilldelning-av-frekvenser-for-5g/forstudie-frekvenser-5g-remissrapport.pdf> (English version also available)

¹³⁸ See <https://www.pts.se/contentassets/9057a944959742878f4b3ce0e7ade9f7/inriktning-frekvenser-for-5g-bemotande-remissvar.pdf> (English version also available)

¹³⁹ See <https://pts.se/globalassets/startpage/dokument/listningar-pa-textsidor/35-ghz/infomote-21-sep.pdf>

¹⁴⁰ See <https://pts.se/globalassets/startpage/dokument/icke-legala-dokument/remisser/2018/radio/konsultation-1---23-och-35-ghz/2.-forslag-for-tilldelning-av-lokala-blocktillstand.pdf>

¹⁴¹ Three options are outlined: (1) 3.7-3.8GHz spectrum is exclusively assigned for site-by-site licensees (80-100MHz block size), (2) previous option, but 100MHz blocks of spectrum are also assigned in the 3.8-4.2GHz band for local coverage providers, and (3) 3.7-3.8GHz spectrum is shared between site-by-site licensees and local coverage providers (40-50MHz block size)

Category	Details
Geographic area ¹⁴²	300MHz (3.4-3.7GHz) for nationwide use; spectrum will be assigned using a selection procedure (i.e. some form of competitive bid process ¹⁴³) 100MHz (3.7-3.8GHz) awarded on a regional basis; spectrum will be assigned without a selection procedure (i.e. some form of administrative assignment ¹⁴⁴). The October 2018 3.7-3.8GHz consultation considers an option where spectrum is licensed exclusively on a site-by-site basis, as well as an option where spectrum is shared between local coverage providers and site-by-site licensees. Details of the region size for local coverage licenses have not been provided. We note that in the previous 3.4-3.8GHz auctions lots have been made available in each of Sweden's 290 municipalities. At the time of the 3.6-3.8GHz auction in 2007, the average municipality population was ~33,000 ¹⁴⁵ .
License length	The October 2018 3.7-3.8GHz consultation proposes 10-year licenses

¹⁴² The original consultation had proposed a different arrangement which distinguished between high density/demand areas and other areas. However, given consultation responses, the PTS proposed the national/regional arrangement shown (in line with the approach adopted in Germany).

¹⁴³ See <https://pts.se/sv/bransch/radio/auktioner/>

¹⁴⁴ The PTS state that the issue of how regional licenses will be assigned in situations where demand exceeds supply will be investigated further

¹⁴⁵ Municipality population varies between ~2,400 (Västerbotten – Bjurholm) and ~894,200 (Stockholm – Stockholm)

2.12 UK

Current assignment: the UK completed the auction of 150MHz of 3.4-3.6GHz spectrum in June 2018. MNO Three also holds various mid-band spectrum licenses on a national basis.

Future assignment: the UK is planning to award spectrum from the 3.6-3.8MHz range in 2019. Further details have not been specified, though we consider it likely that the majority of spectrum will be awarded for 5G use on a nationwide basis (as in the recent 3.4-3.6GHz auction). The UK is also considering use of 3.8-4.2GHz for 5G on a shared basis with existing satellite services. Details of the approach to sharing (e.g. national licenses with geographic restrictions on use, or regional licenses) have not yet been confirmed.

Overview of mid-band 5G spectrum

MNOs recently acquired national licenses suitable for 5G in the 3.4-3.6GHz band (see below). Furthermore, FWA operator UK Broadband (owned by MNO Three), owns national licenses in the 3480-3500MHz, 3580-3600MHz, 3605-3689MHz and 3925-4009MHz mid-band ranges.

Ofcom released¹⁴⁶ a consultation on October 6, 2016, to examine whether 3.6–3.8GHz spectrum¹⁴⁷ could be allocated to future 5G enhanced mobile broadband (eMBB) services. On October 26, 2017, Ofcom released¹⁴⁸ a statement confirming the release of this band and beginning the process of vacating existing users. Ofcom stated that it expects the spectrum to ‘be deployed in many areas from around 2020, and nationwide by 2022’¹⁴⁹. This timeline was confirmed in an announcement¹⁵⁰ made on February 2, 2018, which stated that the award was planned for 2019. Ofcom’s proposed annual plan for 2018/19 states that a consultation for the band is due to be published in Q3 2018/19.

In 2016, Ofcom ran a ‘Call for Input’ on the 3.8–4.2GHz range as ‘a candidate band for enhanced spectrum sharing’, and for ‘potential new innovative applications’¹⁵¹. Most recently, Ofcom’s ‘Enabling 5G in the UK’ paper, published in March 2018, confirmed its intention to consider the band for the possibility of shared use. A consultation is expected to be released later in 2018¹⁵².

¹⁴⁶ See <https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz>

¹⁴⁷ This excludes the portion already owned by MNO Three (via subsidiary UK Broadband), i.e. 3605-3689MHz

¹⁴⁸ See https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz?utm_source=updates&utm_medium=email&utm_campaign=3.6-3.8. This followed the statement and consultation which ran from July 28, 2017 to September 22, 2017. See https://www.ofcom.org.uk/__data/assets/pdf_file/0017/103355/3-6-3-8ghz-statement.pdf

¹⁴⁹ Ofcom have said that it will revoke all fixed link licenses in the 3600–3800MHz band in 2022 as well as stop protecting earth station licensees from interference in 2020

¹⁵⁰ See https://www.ofcom.org.uk/__data/assets/pdf_file/0018/110718/3.6GHz-3.8GHz-update-timing-spectrum-availability.pdf

¹⁵¹ See https://www.ofcom.org.uk/__data/assets/pdf_file/0031/79564/3.8-GHz-to-4.2-GHz-band-Opportunities-for-Innovation.pdf.

¹⁵² Ofcom’s ‘Fixed Wireless Spectrum Strategy’ and ‘Review of the authorization regime for spectrum access’ published on December 7, 2017, both stated that the regulator will publish a consultation on further sharing of the 3.8–4.2GHz band in 2018.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G trials using mid-band spectrum have continued:
 - In April 2018, Vodafone announced¹⁵³ it had completed a 3.4GHz 5G trial. On June 20, 2018, Vodafone further announced^{154, 155} that it plans to begin trials (using its 3410-3460MHz spectrum) in seven cities between October and December 2018, and to roll out 5G in certain locations in 2019
 - EE has announced¹⁵⁶ that it will conduct 5G trials in October 2018. The operator also confirmed¹⁵⁷ plans to launch 5G commercially in 2019
- Government initiatives to encourage 5G deployment have been announced/developed:
 - A smart city roadmap for London was published¹⁵⁸ in June 2018, including a number of measures aimed at enabling 5G
 - On July 23, 2018, the Government published its “Future Telecoms Infrastructure Review”
 - On September 4, 2018, the Government selected¹⁵⁹ the West Midlands region to become the UK’s first large-scale 5G testbed
- The 3.4-3.6GHz (and 2.3GHz) auction took place in April 2018¹⁶⁰.
 - Thirty 5MHz blocks were available in the 3410-3480MHz and 3500-3580MHz¹⁶¹ bands at a reserve price of GBP1million (USD1.3 million) per block

¹⁵³ See <https://mediacentre.vodafone.co.uk/pressrelease/first-test-new-5g-spectrum-across-live-network/>

¹⁵⁴ See <https://mediacentre.vodafone.co.uk/pressrelease/5g-trial-seven-cities/>

¹⁵⁵ See <https://mediacentre.vodafone.co.uk/news/vodafone-makes-uks-first-holographic-call-using-5g/>

¹⁵⁶ See <http://newsroom.ee.co.uk/ee-set-to-switch-on-uks-first-5g-trial-network-in-londons-tech-city-east-london/>

¹⁵⁷ See <http://newsroom.ee.co.uk/ee-turns-3g-into-4g-to-boost-smartphone-speeds-and-lay-foundation-for-5g-launch-in-2019/>

¹⁵⁸ See https://www.london.gov.uk/sites/default/files/smarter_london_together_v1.64_-_published.pdf

¹⁵⁹ See <https://www.gov.uk/government/news/west-midlands-to-become-uks-first-large-scale-5g-testbed>

¹⁶⁰ See <https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-archive/2-3-and-3-4-ghz-auction>

¹⁶¹ The spectrum already owned by MNO Three (via subsidiary UK Broadband), i.e. 3480-3500MHz and 3580-3600MHz, was not included in the auction.

- Licenses are national, technology-neutral and without coverage obligations. Licenses were awarded in perpetuity (with further payment required after 20 years¹⁶²)
- The spectrum won by the four MNOs is shown in Figure 2.12 below:

Figure 2.12: Outcome of the UK's 3.4-3.6GHz auction in April 2018 [Source: Ofcom, 2018]

Operator	Spectrum won	Spectrum range (MHz)
O2	40MHz	3500-3540
BT/EE	40MHz	3540-3580
Vodafone	50MHz	3410-3460
Three	20MHz	3460-3480
Total	150MHz	-

- On June 27, 2018, Ofcom published¹⁶³ a consultation on varying Three's license¹⁶⁴ in the 3605-3689MHz range
 - UK Broadband (owned by Three) has requested a number of changes to this license, including: shifting it down by 5MHz, surrendering its rights to use 4MHz of spectrum in that block, and changing the applicable technical conditions.
 - The consultation (which closed on August 8, 2018) sets out Ofcom's provisional view that it is "minded to agree" to the requested variation

Expected date for mid-band spectrum release and auction details

Figure 2.13: Details of 5G mid-band spectrum assignment in the UK [Source: Ofcom, 2018]

Category	Details
Spectrum to be released	200MHz (3.6-3.8GHz) 3.8-4.2GHz is a "candidate band for enhanced spectrum sharing"
Expected date	Award planned for 2019. Under the expected timeline for migration of incumbent users of the spectrum, Ofcom expects the 3.6-3.8GHz spectrum to be 'be deployed in many areas from around 2020, and nationwide by 2022'
Lot sizes	
Geographic area	No specific consultation/details released
License length	

¹⁶² See auction documentation for details: <https://www.ofcom.org.uk/spectrum/spectrum-management/spectrum-awards/awards-archive/2-3-and-3-4-ghz-auction>

¹⁶³ See <https://www.ofcom.org.uk/consultations-and-statements/category-2/variation-uk-broadbands-spectrum-access-licence-3.6-ghz>

¹⁶⁴ For details of its existing license, see https://www.ofcom.org.uk/__data/assets/pdf_file/0028/96913/UK-Broadband.pdf

2.13 US

Current assignment: we are not aware of any mid-band spectrum currently assigned for mobile in the US.

Future assignment: the US is making 150MHz in the 3550-3700MHz (CBRS) band available, with 70MHz to be auctioned (potentially in 2019) and the remaining 80MHz to be licensed on a shared basis (in early 2019). The FCC is also exploring the 3.7-4.2GHz band, adopting an NPRM in July 2018 that could open up large additional blocks of mid-band spectrum. The US is also studying the 3.45-3.55GHz band, but there is no specific timing on the study or the availability of spectrum.

Overview of mid-band 5G spectrum

The FCC is in the process of releasing the citizens broadband radio service (CBRS) band (3550–3700MHz) for shared wireless broadband use.¹⁶⁵ The band is governed by a three-tier authorization framework that allows commercial users to share spectrum with existing federal and non-federal users:

- Tier 1 consists of incumbent users¹⁶⁶ (primarily the US military), which have top priority
- Tier 2 consists of priority access licenses (PALs), which will be granted for a fee. A maximum of seven PALs, each 10MHz in size, will be licensed in any given geographical area in the bottom 3550-3650MHz range. Use of these bands can be pre-empted by Tier 1 users
- Tier 3 users have general authorized access (GAA) – opportunistic use of any available block of the 3550–3700MHz band without a defined license term. We understand that use of GAA spectrum can begin as soon as the necessary equipment and spectrum management databases have been certified, which is expected in early 2019

Furthermore, on August 3, 2017, the FCC issued¹⁶⁷ an NOI entitled ‘*Exploring Flexible Use in Mid-Band Spectrum Between 3.7 GHz and 24 GHz*’. The NOI consults on three specific mid-range bands (3.7–4.2GHz, 5.925–6.425GHz and 6.425–7.125GHz) for ‘expanded flexible use’ and seeks comment on further bands between 3.7GHz and 24GHz which might also be suitable. On July 13, 2018, the FCC issued an NPRM on the 3.7-4.2GHz range (see below), and in October 2018, the agency issued an NPRM on the 5.925-6.425GHz and 6.425-7.125 GHz bands¹⁶⁸.

¹⁶⁵ See <https://www.fcc.gov/rulemaking/12-354#block-menu-block-4> for an index of FCC CBRS documentation.

¹⁶⁶ Tier 1 incumbent users mainly use these bands for naval radar applications in coastal areas, so this capacity remains largely unused in inland areas.

¹⁶⁷ See http://transition.fcc.gov/Daily_Releases/Daily_Business/2017/db0713/DOC-345789A1.pdf and <https://commlawmonitor2.lexblogplatformthree.com/wp-content/uploads/sites/512/2017/08/Mid-Band-Spectrum-NOI.pdf>

¹⁶⁸ See <https://transition.fcc.gov/oet/ea/presentations/files/oct18/3.1-Rulemakings-JSP.PDF>

On February 26, 2018, the National Telecommunications and Information Administration (NTIA), in coordination with the Department of Defense (DOD) and other federal agencies, announced¹⁶⁹ that it had identified 100MHz (3450–3550MHz) for ‘potential repurposing to... commercial wireless’. The ‘DOD plans to submit a proposal under the Spectrum Pipeline Act to carry out a comprehensive radio-frequency engineering study to determine the potential for introducing advanced wireless services in this band (which is currently used for military radar) without harming critical government operations’.

Developments since 5G readiness report

The following developments have taken place since the publication of the 5G readiness report:

- 5G/LTE trials using mid-band spectrum have continued. For example:
 - On May 16, 2018, Verizon announced¹⁷⁰ that it has successfully tested LTE using the CBRS band in partnership with Ericsson, Federated Wireless and Qualcomm
 - On July 23, 2018, Boingo (a DAS, small cell and Wi-Fi provider) announced¹⁷¹ that it had successfully deployed a private LTE network using the CBRS band at Dallas Love Field Airport (DAL)
- Developments in the 3.7-4.2GHz band (C-band):
 - On April 19, 2018, the FCC instituted¹⁷² a ‘freeze’ on applications for new receive-only earth stations in the C-band. It also initiated a 90-day window (to July 18, 2018) in which existing earth stations can verify the accuracy of existing registration and license information. The registration window was subsequently extended for another 90-day period (to October 17, 2018)
 - On May 1, 2018, the FCC issued¹⁷³ a public notice seeking comment on an upcoming report that will address the feasibility of allowing commercial wireless services to use or share use of the 3.7-4.2GHz band. The deadline for comments was May 31, 2018, with reply comments due by June 15, 2018

¹⁶⁹ See <https://www.ntia.doc.gov/blog/2018/ntia-identifies-3450-3550-mhz-study-potential-band-wireless-broadband-use>. The ‘DOD plans to submit a proposal under the Spectrum Pipeline Act to carry out a comprehensive radio-frequency engineering study to determine the potential for introducing advanced wireless services in this band [which is currently used for military radar] without harming critical government operations’.

¹⁷⁰ See <https://www.fiercewireless.com/wireless/verizon-touts-commercial-cbrs-deployment-ericsson-federated-wireless-qualcomm>

¹⁷¹ See <http://www.boingo.com/press-releases/boingo-deploys-cbrs-at-dallas-love-field-airport/>

¹⁷² See <https://edit.ses.com/sites/default/files/2018-05/FCC%20Registration%20of%20C-band%20Rx-only%20Earth%20Stations.pdf>

¹⁷³ See https://apps.fcc.gov/edocs_public/attachmatch/DA-18-446A1.pdf

- On July 13, 2018, the FCC unanimously voted to adopt an NPRM, seeking comment on repurposing the 3.7-4.2 GHz band for flexible use, including mobile broadband.¹⁷⁴ Comments were due on October 29, 2018, and reply comments are due on November 27, 2018
- Developments in the CBRS band:
 - On May 8, 2018, the CBRS Alliance¹⁷⁵ launched¹⁷⁶ the ‘OnGo’ brand and certification program
 - On May 10, 2018, six conditionally approved SAS Administrators (Amdocs, CommScope, Federated Wireless, Google, Key Bridge, and Sony) met with regulators to discuss possible SAS field-testing scenarios¹⁷⁷. Nokia has also requested¹⁷⁸ to operate as a SAS Administrator and ESC operator
 - On July 12, 2018, Wireless Innovation Forum announced¹⁷⁹ approved the first six test labs that will bear the “WinnForum CBRS Approved” logo for CBRS Device (CBSD) testing
 - On July 27, 2018, the FCC issued¹⁸⁰ a public notice establishing procedures for filing initial Spectrum Access System (SAS) commercial deployment proposals. The deadline for proposals was September 10, 2018
 - On October 23, 2018, the FCC held its October open meeting¹⁸¹. Proposals to increase the size of PAL license areas from census tracts to counties (and extend the license duration to 10 years with an expectation of renewal) were voted through
- Developments in other mid-band spectrum ranges:
 - FCC Commissioner Michael O’Rielly indicated that the FCC may investigate opening up the 4940-4990MHz band¹⁸²

¹⁷⁴ See <https://www.fcc.gov/document/fcc-expands-flexible-use-mid-band-spectrum>

¹⁷⁵ See <https://www.cbrcalliance.org/about-us/>

¹⁷⁶ See <https://www.cbrcalliance.org/news/cbrc-alliance-launches-ongo-brand-and-ongo-certification-program/>

¹⁷⁷ See [https://ecfsapi.fcc.gov/file/10510250686420/2018-05-10%20Ex%20Parte%20re%20SAS%20Field%20Testing%20\(GN%2015-319\).pdf](https://ecfsapi.fcc.gov/file/10510250686420/2018-05-10%20Ex%20Parte%20re%20SAS%20Field%20Testing%20(GN%2015-319).pdf)

¹⁷⁸ See <https://ecfsapi.fcc.gov/file/1052267429439/Suri%20and%20Corker%20Ex%20Parte%205-18-2018%20FINAL.pdf>

¹⁷⁹ See <https://www.businesswire.com/news/home/20180712005761/en/Wireless-Innovation-Forum-Announces-CBRS-CBSD-Standards>

¹⁸⁰ See <https://docs.fcc.gov/public/attachments/DA-18-783A1.pdf>

¹⁸¹ See <https://www.fcc.gov/document/fcc-announces-tentative-agenda-october-open-meeting-4>

¹⁸² See <https://www.fiercewireless.com/tech/fcc-commissioner-targets-mid-band-spectrum-for-5g-within-2-years>

- At the FCC’s October 2018 open meeting, the agency adopted an NPRM proposing “to allow unlicensed devices to operate under the Commission’s Part 15 rules only in locations and frequencies where they would not cause harmful interference to the licensed services in the band.”¹⁸³

Expected date for mid-band spectrum release and auction details

Figure 2.14: Details of 5G mid-band spectrum assignment in the US [Source: FCC, 2018]

Category	Details
Spectrum to be released	Three-tiered sharing arrangement in the CBRS band (3550–3700MHz range): Tier 1 – protected spectrum for incumbents in certain locations Tier 2 – 70MHz (within the 3550-3650MHz range) to be auctioned Tier 3 – Remaining spectrum (at least 80MHz) to be made available on an unlicensed (GAA) basis 3450-3550MHz and 3700-4200MHz also being considered for release
Expected date	CBRS band: Tier 2 – spectrum potentially auctioned in 2019 Tier 3 – GAA spectrum expected to be available in early 2019
Lot sizes	Tier 2 spectrum will be auctioned in seven blocks of 10MHz. Tier 2 licenses are known as priority access licenses (PALs)
Geographic area	PALs will be assigned by county, with an option in the largest markets to bid for all counties in those markets as a package.
License length	License length is ten years, with expectation of renewal

¹⁸³ See <https://www.fcc.gov/document/promoting-unlicensed-use-6-ghz-band>