Roadmaps for awarding 5G spectrum: A focus on Thailand

July 2022

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Contents

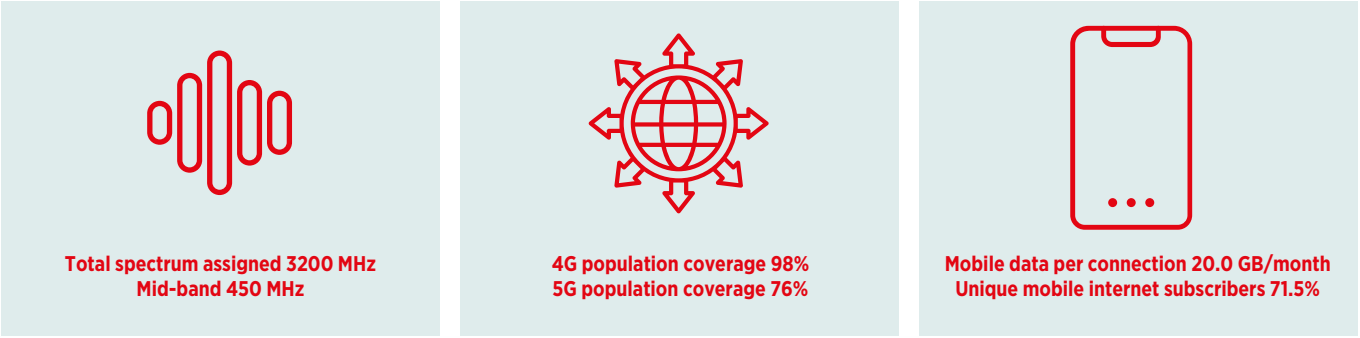
Summary

Broadband connectivity and digital services have played a vital role in the way people live and businesses operate during the COVID-19 outbreak. As the world emerges from the pandemic and social and economic activities begin to recover, mobile connectivity's integration into our day-to-day economic and social activities will continue to grow. Digital transformation is already well underway in many sectors and the 5G era will help accelerate this process and boost economic growth in the years ahead.

In Thailand, 5G is off to an encouraging start thanks to the efforts of the regulator NBTC in releasing a total of 2,820 MHz of spectrum across the 700 MHz, 2600 MHz and 26 GHz bands in February 2020. As of the end of 2021, 5G network coverage has reached 76% of the population and continues to grow. Mobile data traffic per connection in Thailand (20.0 GB per month in 2020, according to ITU) is among the highest in the ASEAN region.

FIGURE 1

THAILAND MOBILE MARKET – KEY INDICATORS



Yet, there is still more work to be done to ensure the adequate supply of spectrum resources to support the next phase of 5G development, especially in the crucial mid-band spectrum (1-7 GHz). The GSMA estimates that mid-band 5G spectrum will drive an increase of more than $610 billion in global GDP in 2030, almost 65% of the overall socio-economic value generated by 5G. In Southeast Asia, 5G mid-bands will boost annual GDP by $35 billion by 2030, with Thailand accounting for 18% of this increment. To secure these benefits, operators will need around 2 GHz of mid-band spectrum during this decade. In Thailand, there is currently 450 MHz of mid-band spectrum assigned for mobile services.

It is thus important for Thailand to keep up the momentum by prioritising the following actions for 5G development:

- Make available at least 300 MHz of spectrum in the globally harmonised 3.5 GHz band by 2023.
- For 3.5 GHz, avoid an unnecessarily large guard band between mobile and FSS. Implement appropriate coexistence measures, such as site shielding and upgrading FSS receiver filters, to allow more spectrum to be assigned for 5G without impacting on other users in adjacent bands.
- Consider a phased approach involving the initial release of the 3.5 GHz band in urban areas where demand is currently higher, if necessary.
- Consider options to assign vacant spectrum in existing 1800 MHz and 2300 MHz bands to support data traffic growth.
- Work towards making available around 2 GHz of mid-band spectrum by developing a spectrum roadmap for 2025-2030, taking into account future IMT spectrum supply including the 4.8 GHz and 6 GHz bands.

1. Introduction

As the world emerges from the pandemic and social and economic activities begin to recover, connectivity will continue to play a vital role in the way people live and businesses operate. Digital services, underpinned by high speed and high performance networks, are set to become more integral to society in a post-pandemic world. With digital transformation already well underway in many sectors, the introduction of 5G will help accelerate this process and boost economic growth in the years ahead.

Increasing smartphone adoption and video usage has driven mobile data traffic growth over the last decade and this trend is set to continue in the 5G era with more immersive media-rich services, new online gaming technologies and extended reality (XR) applications. With more than 180 5G networks across 72 countries as of the end of 2021, 5G is rapidly moving towards mainstream adoption and the total number of connections set to reach 1 billion in 2022.[1]

This report takes a closer look at the state of 5G spectrum planning in Thailand and discusses the key issues and challenges in securing sufficient spectrum resources for 5G, particularly in the mid-bands. It then provides some recommendations on the way forward.

1 Source: GSMA Intelligence

1.1 Overview of the Thailand mobile market

High-bandwidth Internet connectivity is becoming increasingly important for enhancing productivity, social welfare, and wellbeing.

In many emerging markets, where fibre penetration is typically lower or prices higher, there tends to be a greater reliance on wireless technology – both mobile and fixed wireless – to meet growing demand for affordable and expandable connectivity. As of the end of 2020, mobile broadband adoption in Thailand stood at 90.3 per 100 inhabitants compared to 16.6 for fixed broadband.[2] As of 2021 network coverage for both 3G and 4G services was at 98% of national population.

The Thailand mobile market comprises of the following main players as of end of 2021:

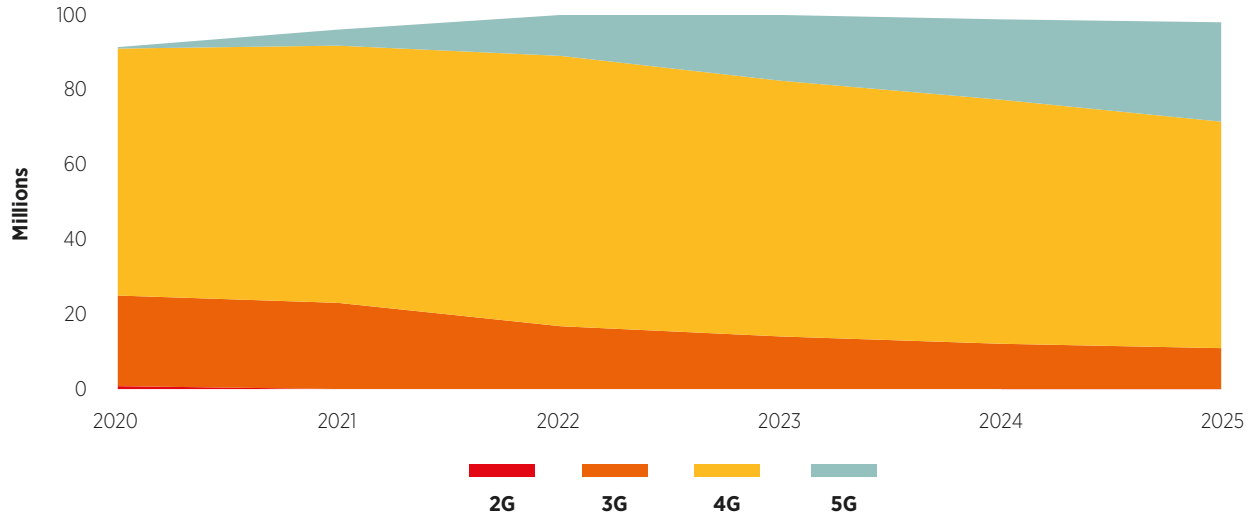
- Advanced Info Service (AIS), the largest mobile operator by subscriber base, has around 46% market share.
- True Corporation (TrueMove H), a multi-play telecoms operator with fixed, mobile and TV services, has a market share of 33%.
- DTAC is the third mobile operator with a market share of 20%. In late 2021, DTAC and TrueMove H announced plans for a merger and this is currently under review by the National Broadcasting and Telecommunications Commission (NBTC).[3]
- National Telecom (NT), formed in 2021 following a merger of state-run firms CAT Telecom and TOT, has significant network infrastructure assets including mobile spectrum and is seeking to expand into 5G provision.[4]

In Thailand, 5G services were launched in early 2020 following the 5G auction in February 2020 (see section 2.2 below). As of the end of 2021, 5G networks covered 76% of Thailand's population and the number of 5G connections reached around 4.3 million.

The pace of 5G deployment and adoption is forecast to grow over the next three years – by 2025, the number of 5G connections is also forecast to reach 26.7 million with 5G networks covering 92% of the population.[5] While 4G will continue to account for most of mobile connections, the share of 4G connections is expected to start declining from 2022 onwards.

FIGURE 2

CONNECTIONS BY TECHNOLOGY IN THAILAND



Source: GSMA Intelligence

2 Source: ITU, World Telecommunication/ICT Indicators Database, August 2021
3 www.bangkokpost.com/business/2274991/nbtc-panel-to-follow-up-on-merger
4 www.bangkokpost.com/business/2047367/new-firm-nt-targets-top-three-in-first-year-of-services
5 GSMA Intelligence. July 2022.

In Thailand, monthly mobile data traffic per connection has grown by 2.8 times over the 2017-2020 period, reaching 20.0 GB in 2020.[6] This is already significantly higher than neighbouring countries in Southeast Asia. According to Ericsson estimates, mobile data traffic per smartphone in Southeast Asia will grow by 5.8 times over the 2021-2027 period from 8.0 GB to 46.0 GB per month.[7]

At the same time 5G enterprise use cases are also emerging across different industrial verticals which will drive growth in cellular IoT connections. Across Asia Pacific, operators are using the scale and utility of mobile networks and services to facilitate innovative digital solutions for large and small enterprises in line with Industry 4.0 objectives. In particular, 5G and IoT will play key roles in the implementation of digital transformation projects across different industries, which will further drive demand for 5G connectivity and economic growth for the rest of the decade.

While around 3200 MHz of mobile spectrum has been assigned in Thailand, the 26 GHz mmWave band, which is suitable for localised small cell deployment due to its propagation characteristics, comprises the majority of this figure. As shown below, only 450 MHz is currently assigned in the mid-band range, compared to an average of 850 MHz in the Asia Pacific region today. There is thus a clear need for more mid-band spectrum in order to support the development of 5G and delivery of services over wide areas through public macro mobile networks.

FIGURE 3

CURRENT IMT SPECTRUM ASSIGNED IN THAILAND

Type of spectrum	Bandwidth assigned	Notes
Low band (sub-1 GHz)	170 MHz	700, 850, 900 MHz
Mid-band (1-7 GHz)	450 MHz	1800, 2100, 2300, 2600 MHz
High bands (above 24 GHz)	2600 MHz	26 GHz

Source: GSMA, APT

6 ITU. World Telecommunication/ICT Indicators Database. August 2021.

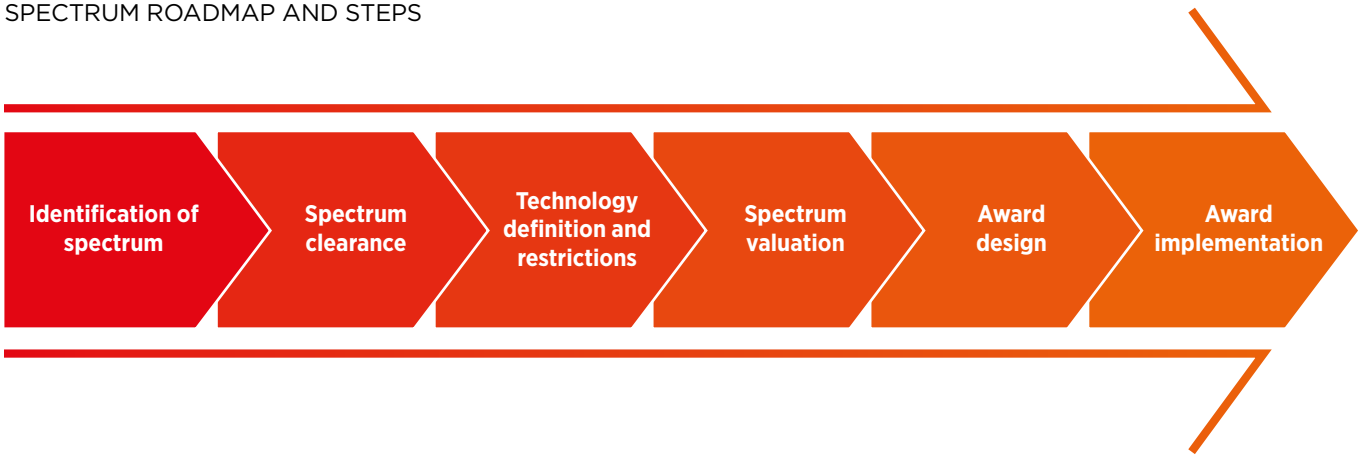
7 GSMA. The Mobile Economy 2022. https://www.gsma.com/mobileeconomy/wp-content/uploads/2022/02/280222-The-Mobile-Economy-2022.pdf

1.2 A roadmap for 5G

As with all previous generations of mobile services, the road to 5G in each country starts with the release of spectrum to support the network rollout. A typical spectrum roadmap, as illustrated below, involves the following steps.[8]

FIGURE 4

SPECTRUM ROADMAP AND STEPS



1.	**Identification of spectrum.** Spectrum is essential for the provision of mobile services and 5G needs significant new harmonised spectrum.[9] Care must be taken to consider the socio-economic benefits that arise from both old and new uses of spectrum and in balancing needs of different users. Consultations provide a forum for the perspectives of different industry stakeholders and allow both governments and industries the opportunity to understand the likely effects of different options. Where competing demands arise, cost-benefit analysis should also be carried out to assess the impacts of proposed changes in spectrum allocation and to ensure efficient use of scarce spectrum and achieve optimal outcomes for society.[10]
2.	**Spectrum clearance.** Approaches for clearing spectrum are dependent on factors such as the density of use; ease of moving incumbents to alternative frequency bands or alternative technologies; and impact on services and users. In some cases geographic sharing with adequate mitigation measures will address interference concerns. For assigned spectrum, it may only be necessary to realign the band assignments to provide contiguous frequencies and maximise spectrum efficiency for 4G and 5G.
3.	**Technology definition and restrictions. T**his should inform the technical licence obligations, conditions of usage and the amount and geographic availability of the spectrum.
4.	**Spectrum valuation and pricing.** This step involves assessing the value of spectrum to guide up-front and annual fees. There are different valuation approaches including benchmarking and modelling analysis, and both methods should be used to improve accuracy and to capture local market factors. Costs relating to licensing obligations should be taken into account when setting prices for spectrum.
5.	**Award design.** There are three main approaches to award spectrum: auctions, beauty contests and direct award.[11] The approach adopted and associated licence obligations will need to take account of policy objectives, available spectrum, and market specifics (for example, the number of operators, or current spectrum holdings). Depending on the timescales for availability of different frequency bands and award design, it may be appropriate to have a single multi-band award or several separate ones.
6.	**Award implementation.** The final step is the actual award. This will normally be underpinned by documentation that provides all the necessary details of the award process, spectrum on offer, licence obligations and other essential information for potential licensees.

8 GSMA. Roadmaps for awarding 5G spectrum in the APAC region. April 2022. www.gsma.com/spectrum/resources/5g-spectrum-in-the-apac-region-roadmaps-for-success/

9 The key frequency bands to prioritise for 5G are outlined in section 1.3.

10 GSMA. Maximising the socio-economic value of spectrum. A best practice guide for the cost-benefit analysis of 5G spectrum assignment. January 2022. www.gsma.com/spectrum/wp-content/uploads/2022/01/mobile-spectrum-maximising-socio-economic-value.pdf

11 For the GSMA auction best practice position see www.gsma.com/spectrum/wp-content/uploads/2021/09/Auction-Best-Practice.pdf

1.3 5G spectrum needs

To get the most out of 5G, spectrum is needed across low-, mid- and high-bands to deliver widespread coverage and support all use cases. In the coming years, growth in user take-up, new 5G applications, and the availability of new devices and applications (e.g. new smartphones, embedded OEM V2X devices, sensors, autonomous vehicles, video, IoT, VR/AR) will further drive demand for mobile data services.

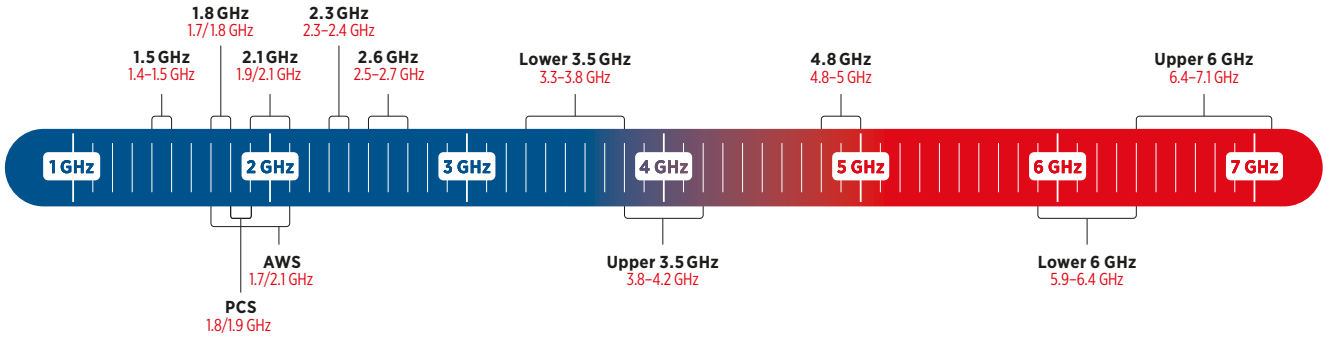
Low-band spectrum is important for covering less-populated areas, delivering deep in-building penetration and lowering the urban / rural digital divide. mmWave will be used for the highest capacity, lowest latency applications.

Mid-band spectrum, which lies in the 1-7 GHz range, is necessary for the increases in bandwidth and capacity that 5G applications will require for city-wide coverage. New mobile broadband use cases such as enhanced mobile broadband (eMBB), fixed wireless access (FWA), IoT and Industry 4.0 depend on mid-band spectrum. These use cases will greatly enhance the impact of mobile services on society and economies.

Mid-band spectrum resources include both lower mid-bands (i.e. 1500 MHz, 1800 MHz, 2100 MHz, 2300 MHz and 2600 MHz) and upper mid-bands (i.e. 3.3–4.2 GHz, 4.5–5.0 GHz and 5.925–7.125 GHz). To deliver 5G services that are consistent with the ITU's IMT-2020 requirements,[12] each operator needs access to 100 MHz of contiguous mid-band spectrum in the short-term.

FIGURE 5

MID-BAND SPECTRUM OPTIONS



However, as 5G matures countries will need an average of 2 GHz of mid-band spectrum to deliver the full range of 5G services.[13] The latest research by GSMA on the socio-economic benefits of mid-band 5G services indicates that mid-band 5G spectrum will drive an increase of more than $610 billion in global GDP in 2030, accounting for almost 65% of the overall socio-economic value generated by 5G.[14] In Southeast Asia, 5G mid-band services will generate additional GDP contribution of $35 billion (which represents 0.64% of GDP), with Thailand accounting for 18% of this increment.

12 User experience of 100 Mbps DL, 50 Mbps UL rates.

13 www.gsma.com/spectrum/resources/5g-mid-band-spectrum-needs-vision-2030/

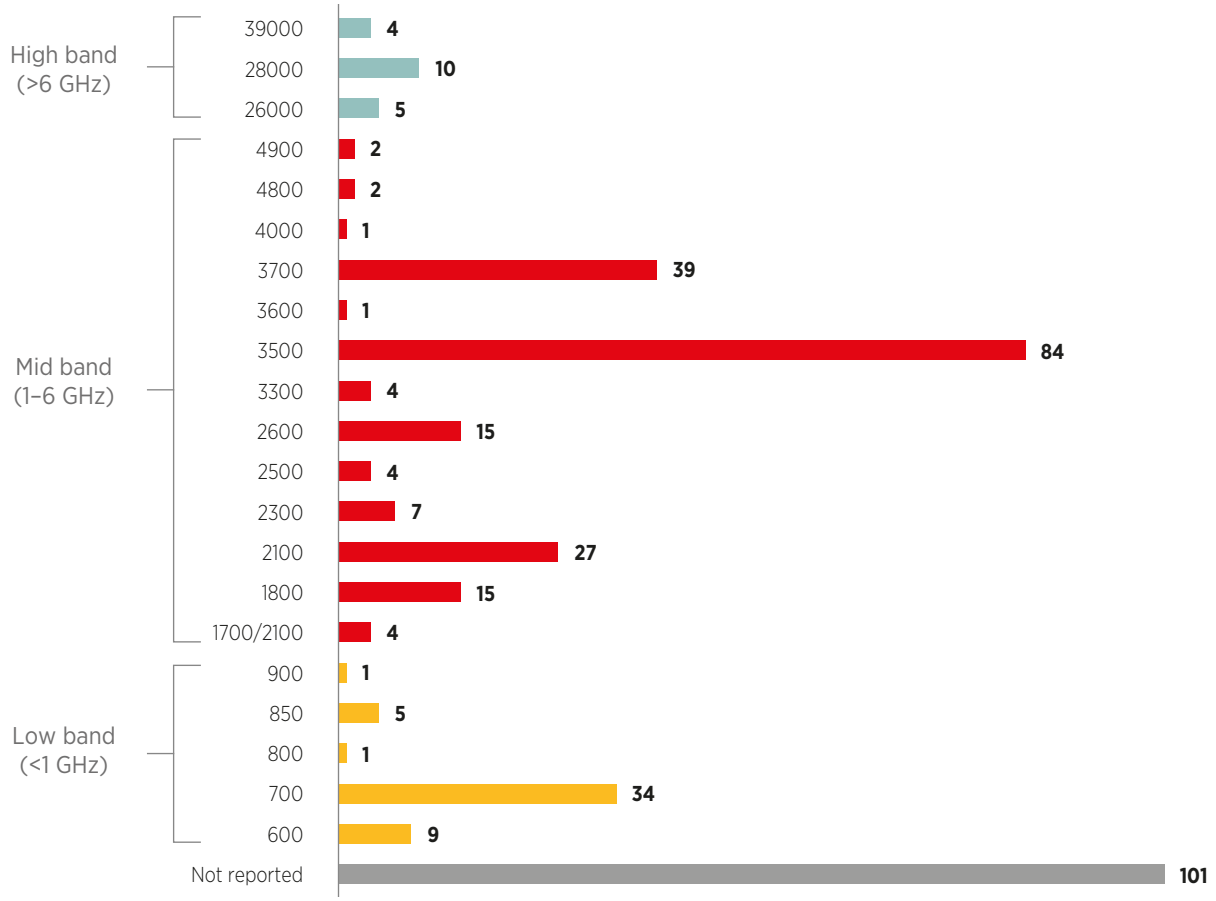
14 GSMA. The Socio-Economic Benefits of Mid-Band 5G Services. February 2022.

Why is 3.5 GHz key for 5G?

The 3.5 GHz band (3.3-4.2 GHz), which is widely harmonised for mobile, has been the basis for the first phase of 5G rollouts in many markets. To date, 3.5 GHz accounts for the majority of 5G network launches,[15] driving the wider ecosystem, device diversity and competition. It has been deployed for eMBB enabling faster data speeds and greater capacity required in urban, densely populated areas, as well as for FWA in sub-urban and rural areas where the availability of fixed broadband tends to be more limited.

FIGURE 6

5G NETWORK LAUNCHES BY SPECTRUM FREQUENCY (UP TO Q1 2022)



Note: These figures refer to trials, assignments and launches not individual operators. A range of operators have trialled or launched their 5G networks on more than one frequency.

Source: GSMA Intelligence.

In markets where 5G spectrum has yet to be assigned or where there is insufficient spectrum supply, some operators are using Dynamic Spectrum Sharing (DSS) technology and refarming existing spectrum bands, mainly in 1800, 2100 and 2600 MHz, to support 5G deployments. While these approaches enable more flexible and efficient use of spectrum, capacity in 4G bands is limited and they do not substitute additional licensed spectrum. Further supply, especially in the mid-bands, will be needed to sustain 5G developments for the rest of the 2020s and beyond.

15 Excluding frequencies not reported.

2. Progress on Thailand's spectrum plan for 5G

2.1 Making 5G spectrum available in Thailand

The Ministry of Digital Economy and Society ('MDES'),through its Office of the National Digital Economy and Society Commission (ONDE), is responsible for telecommunications policy in the Kingdom of Thailand. In accordance with *Act on the Organization to Assign Radio Frequency and to Regulate Broadcasting and Telecommunications Services* (2010) *(as amended)*, the National Broadcasting and Telecommunications Commission (NBTC) regulates frequency spectrum and licensing in Thailand.

Consistent with the *Thailand Digital Economy and Society Development Plan* (2018 - 2037), *5-Year Action Plan for Digital Economy and Society* (2018 – 2022), NBTC's *Telecommunications Master Plan No. 2* (2019 – 2023), the NBTC issued a *Spectrum Management Master Plan* in 2019.[16]

Importantly, from the *2-Year Action Plan for Promoting the Adoption of 5G Technology in Thailand* (2021-2022), the 5G infrastructure development strategy has adopted the following targets *inter alia*:[17]

- 5G network coverage over the key strategic areas with average download speed at least 50 Mbps everywhere and 100 Mbps in Urban areas including:
  - (i) Covering 50% of defined areas in the Special Economic Promotional Zones within Eastern Economic Corridor (EEC);[18]
  - (ii) Covering 50% of the residents in each Smart City; and
  - (iii) Covering at least 500 Tambon Health Promoting Hospitals and 100 Community ICT Learning Centres/ Digital Community Centres.
- The amount of spectrum proposed in all bands is enough to serve all 5G mobile service providers and is in line with the market conditions and competitive situation; and
- The mobile service providers are able to refarm the existing spectrum for providing 5G services.

16 NBTC, Spectrum Allocation Plan for the International Mobile Telecommunication business of Thailand, the 5-year period (2019 - 2023), revised edition (in Thai)

17 ONDE, Action Plan for Promoting the Adoption of 5G Technology in Thailand Phase 1, released February 2022, page 76

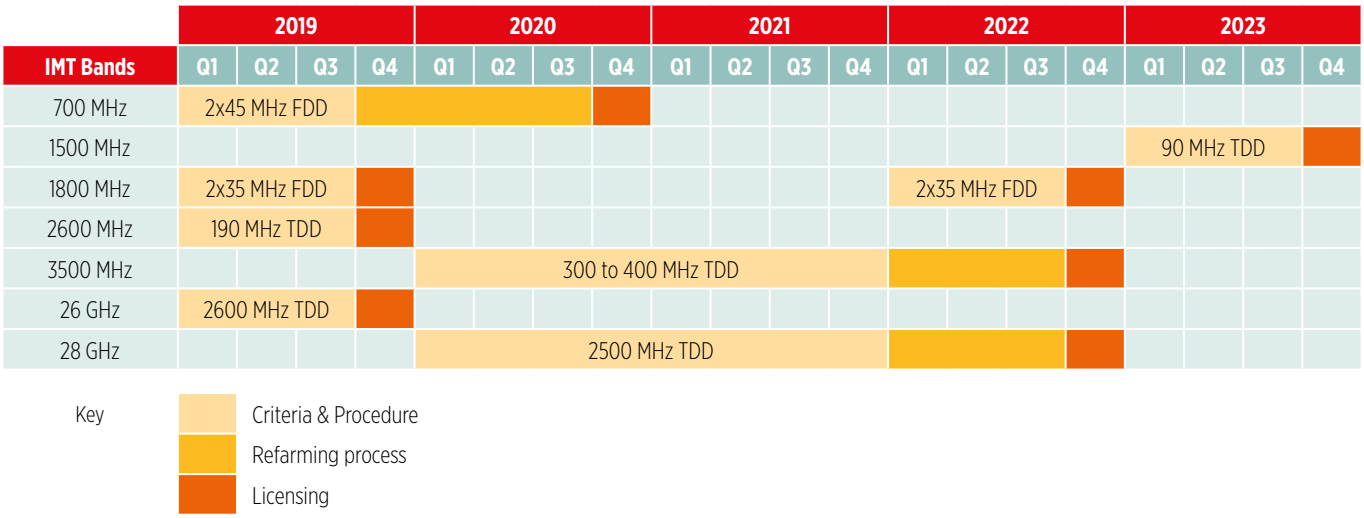
18 Refer to www.eeco.or.th/en

The *Spectrum Management Master Plan* sets out the criteria for the allocation and regulation of efficient spectrum management to sufficiently meet the demand, keep pace with the dynamic changes of technology and comply with international standards.

Following the successful auction and assignment of the 700 MHz, 2.6 GHz and 26 GHz bands in February 2020, the NBTC updated and revised the plan. The spectrum masterplan specified additional bands to support 5G technology which included 3.4-3.7 GHz, 24.25-27.5 GHz and 27.5-29.5 GHz as shown in Figure 7 below.

FIGURE 7

THAILAND SPECTRUM PLANNING AND TARGETS



Source: Adapted from NBTC, 5G Roadmap and Spectrum Presentation in Thailand, based on Spectrum Allocation Plan for the International Mobile Telecommunication business of Thailand, the 5-year period (2019 - 2023), 21 October 2021

It is important to highlight Thailand's successful assignment of a total of 3,220 MHz of IMT spectrum (including 2,600 MHz in 26 GHz band). Subject to the resolution of the issues in relation to the 3.5 GHz band, which are discussed in section 3, there could be an additional 410 MHz of IMT spectrum which could also be assigned.

FIGURE 8

THAILAND'S TOTAL IMT SPECTRUM ASSIGNMENTS (AS OF JULY 2022)

Band	Current IMT allocations	Current assignment	Vacant or potentially vacant Spectrum
700 MHz	703-748/758-803 MHz	2x45 MHz	
850 MHz	824-839/869-884 MHz	2x15 MHz	
900 MHz	890-915/935-960 MHz	2x25 MHz	
1800 MHz	1710-1750/ 1805-1845 MHz	2x40 MHz	2 x 35 MHz
2100 MHz	1920-1980/ 2110-2170 MHz	2x60 MHz	
2300 MHz	2310-2370 MHz	60 MHz	40 MHz
2600 MHz	2500-2690 MHz	190 MHz	
3500 MHz	None	None	>300 MHz (under study)
26 GHz	24.30 - 25.10 GHz and 25.20 - 27.00 GHz	2600 MHz	
Total		3220 MHz	Up to 410 MHz or more

Source: ONDE, Action Plan for Promoting the Adoption of 5G Technology in Thailand Phase 1, released February 2022, page 34 with amendments in relation to 3.5 GHz and vacant spectrum from WPC, March 2022

2.2 Thailand's 5G spectrum auction

The Kingdom of Thailand held its first 5G spectrum auction in February 2020 involving frequencies in 700 MHz, 2.6 GHz and 26 GHz bands. See a more complete summary in Figure 9 below.

FIGURE 9

SUMMARY OF THE THAI 5G SPECTRUM AUCTION IN FEBRUARY 2020

The NBTC held Thailand's first 5G spectrum auction in February 2020, raising THB100.52 billion (USD3.2 billion) as licensed operators secured 48 lots ahead of the 5G commercial rollout.

Thailand's largest mobile operator Advanced Info Service (AIS) acquired the most lots: 23 across all three spectrum bands. The operator secured one lot for the 700 MHz band, 10 for the 2600 MHz band and 12 for the 26 GHz band. True Corporation (TrueMove H) the second-largest operator secured 17 lots—nine in 2600 MHz band and the rest from 26 GHz band—while Total Access Communication (DTAC), the third largest operator, secured two lots, both in the 26 GHz band.[19]

New to spectrum auctions, state-run firms CAT Telecom and TOT, which have recently merged to become National Telecom company (NT), participated for the first time, winning a combined six lots, with TOT securing four and CAT winning two. All of TOT's lots are in the 26 GHz band, while CAT's are both from the 700 MHz band.

700 MHz band	2.6 GHz TDD band	mmWave 26 GHz
CAT: 2 x 10 MHz AIS: 2 x 5 MHz	AIS: 100 MHz TrueMove H: 90 MHz	AIS: bought maximum 1200 MHz TrueMove H: 800 MHz TOT: 400 MHz DTAC: 200MHz

Source: NBTC, 2020

700 MHz price	2.6 GHz price	26 GHz price	Total
THB 51,462 Million (USD1.6 billion)	THB 37,164 Million (USD1.2 billion)	THB 11,570 Million (USD373 Million)	THB 100,196 Million (USD3.23 billion)

Source: NBTC, 2020

Auction Terms

It is worth highlighting that the NBTC had set relatively conservation spectrum reserve price to motivate 5G investment. For example, the reserve price for the key 2.6 GHz band was 15% percent that of the 1800 MHz which was auctioned in 2018. The following payment structure for the 15-year licence was adopted:

- 1st Year: 10% of auction price
- 2nd-4th Year: Grace Period (no payment)
- 5th – 10th Year: 15% of auction price per annum

The winners of the 2.6 GHz spectrum were required to provide 5G network coverage for at least 50 percent of the Eastern Economic Corridor (EEC) one year after the auction, by February 2021.

19 RCR Wireless News, (February 2020), available at www.rcrwireless.com/20200217/5g/thailand-raises-3-2-billion-in-5g-spectrum-auctions-48-licenses-sold

Both AIS[20] and TrueMove H[21] have deployed their 5G networks after the spectrum auction in early 2020, using their newly purchased 2.6 GHz spectrum. DTAC launched 5G services utilising its 700 MHz spectrum holdings in February 2021.[22]

There are substantial differences in the IMT spectrum holdings between the three main Thai operators: AIS holds 1,420 MHz (1200 MHz in 26 GHz), TrueMove H has 990 MHz (800 MHz in 26 GHz), while DTAC only has 270 MHz (200 in 26 GHz band).

20 Refer to www.gsma.com/membership/resources/ais-is-the-first-operator-in-thailand-to-launch-5g-network-nationwide/

21 Refer to www.bangkokpost.com/business/1880365/true-move-debuts-5g-on-newly-bought-bandwidth

22 Refer to www.telecompaper.com/news/dtac-launches-5g-service-on-700-mhz-spectrum--1373369

3. Key issues and challenges to secure sufficient spectrum for 5G services in Thailand

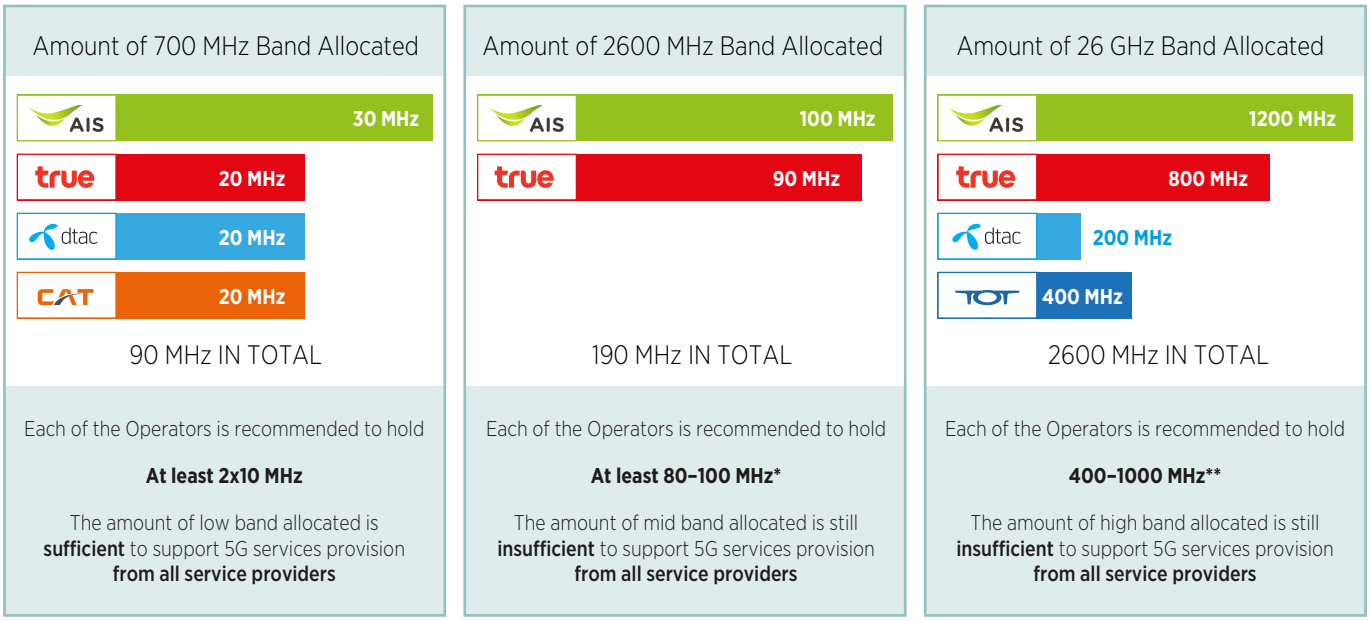
3.1 Key spectrum challenges

Thailand has made available a significant amount of spectrum for 5G services. However, as detailed in Figure 10, while the total spectrum bandwidth currently assigned is one of the highest in the ASEAN region, much of this is in the mmWave range. In the mid-band range, there is still insufficient mid-band spectrum to address growing demand for 5G across the whole country.

FIGURE 10

CURRENT 5G SPECTRUM ASSIGNMENTS IN THAILAND, EXCLUDING LEGACY IMT BANDS (AS OF JULY 2022)

Infrastructure – Spectrum >> Total spectrum bandwidth allocated for 5G services is 2880 MHz



Source: ONDE, *Action Plan for Promoting the Adoption of 5G Technology in Thailand Phase 1, released February 2022,* page 36 – *GSMA, **GSMA and Huawei

The importance of mid-band frequencies is well recognised. As indicated by ONDE, *"The mid band allocation is still insufficient for the 5G service to support all service providers in the future in terms of the network capacity and coverage. Therefore, the regulatory agencies should allocate additional mid band in the future."*[23]

North America, Japan, China and many European markets have assigned considerably more mid-band spectrum for 5G/IMT, including 400 MHz or more in the 3.5 GHz band, there is an acknowledged need to address this shortfall.[24]

The current proposal in Thailand is to refarm an additional 200-300 MHz[25] of mid band spectrum from the 3.4-3.7 GHz range (in addition to the 190 MHz currently assigned in 2.6 GHz) for 5G services.

The key challenge is the current use of the extended C-band (3.4-3.7 GHz) and standard C-band (3.7-4.2 GHz) frequencies for satellite services in Thailand with an estimated more than 10 million TVRO services in operation.[26] This challenge is explored more in section 3.2 below.

The other challenge is how much mmWave band spectrum to make available. While Thailand successfully auctioned the 26 GHz band in 2020, it is still undertaking tests and trials in relation to the 28 GHz band. There are ongoing discussions between MDES and Thaicom concerning the reallocation of the 28 GHz spectrum for 5G.[27]

23 ONDE, Action Plan for Promoting the Adoption of 5G Technology in Thailand Phase 1, released February 2022, page 36

24 In another regional example, Australia is also trying to increase the current 225 MHz of 3.5 GHz band allocated for 5G/IMT services. Refer to www.acma.gov.au/consultations/2022-03/proposed-spectrum-re-allocation-declaration-34-ghz-and-37-ghz-bands

25 ONDE highlights that the volume of 3.4 - 3.7 GHz band to be allocated will depend on the specified Guard Band.

26 Source: NBTC.

27 ONDE, Action Plan for Promoting the Adoption of 5G Technology in Thailand Phase 1, page 37

3.2 Securing the 3.5 GHz band for 5G services

Given satellite usage in Thailand, a considerable amount of time and effort may be needed to optimize the use of the 3.5 GHz band for 5G. While there is only one national satellite – namely Thaicom6 operating on the C-band[28] there are other regional satellites including from Lao PDR.[29]

To address these issues and make spectrum available in the 3.5 GHz band (above 3.4 GHz) for IMT services, Thailand has undertaken a number of trials since early 2019 including trials to explore the possibility of coexistence between the 5G networks and the Fixed Satellite Service (FSS) as used in the 3.5 GHz band.

In the latest trials which commenced in 2021, Thailand undertook a further frequency co-ordination study between Satellite Communications and 5G IMT in C-Band. This study project funded by NBTC has been conducted by two Thai universities, namely King Mongkut's University of Technology North Bangkok (KMUTNB) and Chulalongkorn University (CU). The project is still on-going and is scheduled to be concluded and finished in 2022. The 3.4-3.7 GHz is being planned for IMT services. Currently, 3.7-4.2 GHz is allocated for satellite services and used for TVRO.

The scope of the study and its preliminary conclusions are summarised in Figure 11 below.

FIGURE 11

SCOPE OF THE 2021 FREQUENCY CO-ORDINATION STUDY AND ITS PRELIMINARY FINDINGS

The study[30] which includes indoor and outdoor testing assesses:

- the possibility of co-existence between satellite communications and 5G/IMT services in the 3.5 GHz range;
- the necessity of satellite antenna modifications including to the technical specifications of the Low-noise block down converter (LNB);
- the appropriate technical parameters for IMT services including guard bands, bandwidth, transmit power, etc; and
- the appropriate requirements for IMT base station installation including separation distance.

The preliminary findings of the NBTC the 2021 study, which are based on very conservative assumptions and may change in the final report, were presented in November 2021. The NBTC's views are that low power indoor IMT base stations might be able to co-exist with existing TVRO satellite services. However, for the deployment of outdoor Macro IMT base stations:[31]

- Existing standard full band LNB might have to be replaced with 5G protection LNB;
- The guard band needed between IMT and satellite services may be around 100 MHz;
- In the worst case (antennas facing each other),the required separation distance between antennas is around 150 metres; and this required distance may be lower if the antennas are not facing each other.

Coexistence measures need to balance the objectives of protection of existing uses and ensuring maximum availability of scarce mid-band spectrum for 5G. There are alternative approaches that have been adopted other countries to address the issue of FSS coexistence that the NBTC should take into account when finalising its work. These include the migration of TVROs to alternative bands or technologies, the use smaller guard bands and mitigation measures such as FSS receiver upgrades, FSS restrictions zones and reduced base station transmitter power.

28 The Thaicom6 which was launched in 2014 has 18 C-band and 6 Ku-band transponders and has an expected lifetime of 15 years. The Thaicom5, which was expected to be extended post 2020 on 17 December 2019, experienced a technical issue and after several unsuccessful attempts to recover the satellite, it decided to deorbit the satellite on 26 February 2020. Migration of Thaicom5 services to Thaicom6 and other satellites occurred in early 2020. Refer to www.thaicom.net/thaicom-5-satellite-ends-service/

29 Since November 2015, part of the C-band (3.4 – 3.7 GHz) has been used for FSS by the satellite LAOSAT-1. The main business services of LAOSAT-1 are DTH, Television Production Centre (TVPC), VSATs, and the National Emergency Communication Network (NECN). However, in 2020, the Lao PDR regulator assigned via an administrative decision 80 MHz each of 3.5 GHz band to Lao Telecom (3400-3480 MHz) and Star Telecom (3480-3560 MHz).

30 NBTC, Thailand's Frequency Coordination Study between Satellite Communications and 5G IMT in C-Band presentation to the Virtual Workshop on Frequency Harmonization for Implementation of 5G in ASEAN Countries, 26 November 2021

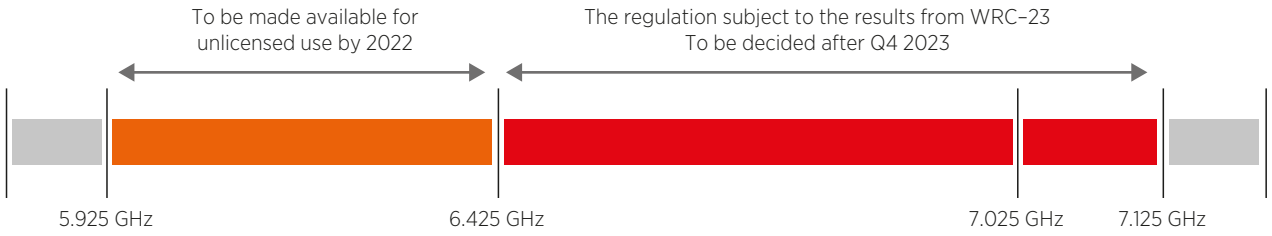
31 ibid

3.3 Additional mid-band spectrum bands

Following work undertaken by the Thai 6 GHz Focus Group, the NBTC announced on 17 February 2022, that 500 MHz from 5925 to 6425 MHz would be available for unlicensed use later in 2022 while the 700 MHz from 6425 to 7125 MHz would be subject to regulation including possible assignment for IMT, subject to the results of WRC-23 (see Figure 12 below).

FIGURE 12

RESULTS FROM REGULATORY STUDIES AND THE NBTC'S DECISION



Source: NBTC, *Regulatory Preparation, 6 GHz spectrum,* February 2022[32]

In general the reasons for the partitioning of the 6 GHz spectrum band between unlicensed (Wi-Fi etc) and licensed (IMT) uses in Thailand include:[33]

- An acute need for additional mid-band spectrum in Thailand given the lack of 3.5 GHz could be partially addressed by assignment of the upper 6 GHz band for licensed 5G. Early field studies show that the 6 GHz band is a very good substitute for the 3.5 GHz band in terms of performance;
- A large allocation to Wi-Fi does not of itself address the digital divide. The allocation of the entire 6 GHz band for unlicensed use does not provide additional coverage and help bridge Thailand's digital divide which the COVID-19 pandemic has highlighted is a key public policy issue and which has increased given the adverse impact on tourism and other parts of the economy;
- Partitioning the 6 GHz band assists in future proofing for 5G advanced and 6G services; and
- Strong FWA growth in Thailand supports an IMT allocation in the 6 GHz band: Growth in 4G and 5G FWA Thailand (which has underdeveloped fixed network infrastructure and especially fibre deployments) would be supported by reservation of additional mid-band spectrum in the 6 GHz band.

32 NBTC, Saneh Saiwong, Regulatory Preparation, 6 GHz spectrum, USA-Thailand 6 GHz Spectrum Virtual Workshop, 17 February 2022

33 Refer to Windsor Place Consulting, Optimising IMT and Wi-Fi mid-band spectrum allocations: The compelling case for 6 GHz band partitioning in Asia-Pacific, October 2021. Available at www.mcmc.gov.my/skmmgovmy/media/Spectrum-File/23b_WPC.pdf

4. Recommended action plan for Thailand

4.1 Near term actions

While Thailand has already taken significant steps to make IMT spectrum available – including auctioning the 700 MHz and 2.6 GHz bands – additional spectrum is needed to support the development of the country's digital economy for the rest of this decade. The following actions, focused on the 3.5 GHz and existing bands, are recommended in order to overcome these challenges:

(i) **3.5 GHz band.** As detailed above, there are significant challenges for Thailand to make the 3.5 GHz band available for 5G services, especially in the quantum needed to address the country's mid-band spectrum shortfall.

a) Supply – At least 300 MHz of 3.5 GHz spectrum in the 3.3 to 3.7 GHz range should be made available for 5G use by 2023. If the full 300 MHz is not possible initially, consistent with the phased approaches in other markets, 200 MHz can be released first. Additional 3.5 GHz spectrum should be released in future subject to clearance and/or the implementation of adequate mitigation measures as discussed below.

If a phased approach is taken all the spectrum released during such a process should be subject to a condition that provides for a reorganisation of the band to create larger contiguous blocks of spectrum. The aim is provide the option for all mobile operators, including the newly merged NT, to secure up to 100 MHz of contiguous spectrum in this band.

b) Clearance and/or mitigation measures – To facilitate the release of 3.5 GHz spectrum Thailand should accelerate clearance or introduce adequate mitigation measures to ensure coexistence with incumbent users in the band. Figure 13 gives the background on how this was achieved in Brazil.

FIGURE 13

BRAZIL CASE STUDY: MIGRATION OF TVRO TO KU-BAND

In November 2021, Brazil successfully ran a multi-band spectrum auction covering the 700 MHz and 2.3, 3.5 and 26 GHz band spectrum bands. The auction which was designed to facilitate the development of 5G, was originally scheduled for March 2020 but was delayed due to potential interference issues with satellite TV broadcasting and the COVID-19 pandemic. The licensees are obliged to provide 5G services to all capital cities by July 2022, as well as about 35,500km of the national highway network.

The successful spectrum assignment process in Brazil focussed on striking a balance between government objectives, operators' requirements and consumer welfare. This process began several years ago with the modernisation of various Brazilian regulatory policies that were designed to support investment. In 2019, an updated telecommunications law was introduced with three crucial aspects:

- Introduction of longer licence terms;
- A secondary spectrum market; and
- Unlimited renewal terms.[34]

These decisions were crucial to support current networks, attract new players and guarantee better services to end users. Certain auction policies also focused on long-term network investment. In particular, new payment terms were introduced including yearly instalments for the duration of the licence, the exchange of the premium for investments and the deduction of obligation costs from reserve prices. The auction conditions also included support of Brazilian policy objectives such as the coverage of motorways, protection of adjacent services, 4G in remote areas and a set timeline for 5G to be introduced.

The most significant long term spectrum management challenge in making sufficient spectrum available in the pioneer 3.5 GHz band was how to accommodate the current Television Receive Only (TVRO) services which utilised the 3.5 GHz band in Brazil. Initial considerations centred around either continuing TVRO services above 3.8 GHz or maintaining them in 3.6 GHz band. To achieve this, the Brazilian regulator Anatel, broadcasters, operators and suppliers worked to develop a bespoke low noise block filter with a performance gain above the previous commercially available devices. The model was finalised, is 100 percent effective and is now commercially available.[35]

However, as the demand in Brazil for mid-band spectrum for 5G and future services became clearer during the band planning process, Brazil decided to go in an alternative direction after engagement with the entire industry. Specifically, Brazil decided that TVRO services would be migrated to the Ku-band. This approach was seen to have several benefits, not least creating a pathway to the future availability of the 3.8-4.2 GHz range for 5G. Fixed Satellite Service, in the band from 3,600 MHz to 3,700 MHz, would therefore start operating on a secondary basis.[36]

Historically, Ku- and Ka-band satellite services have been more susceptible to rain fade and Brazil, which has periods of high rainfall, has previously been an extensive user of C-band satellite services. The approach adopted by Brazil is consistent with a global trend of using higher spectrum bands for satellite services. It highlights the technical advances of the satellite industry which has moved beyond reliance on the C-band with the development of advanced satellite modulation techniques. As such the delivery of services in higher spectrum bands without appreciable rain fade issues is now a common global approach.

34 Refer to www.gsma.com/spectrum/brazil-multi-band-auction-one-of-the-largest-in-mobile-history/

35 Frank Yuan, Huawei, ASEAN Workshop on Frequency Harmonization for Implementation of 5G, 26 November 2021, page 6

36 GSMA, Op cit

c) **Efficient guard band and other mitigation measures.** Thailand should adopt guard bands that maximise spectral efficiency. The heavy use of the 3.5 GHz band for 5G means that there are both studies and real-world regulatory examples of the necessary guard band between 5G and FSS. For example, studies have concluded that a guard band in the range of 18[37] to 25 MHz is needed.[38] In Canada[39] and the US[40], a guard band of 20MHz has been adopted.

Regionally, after originally proposing a guard band of 100 MHz in the 3.5 GHz band between IMT and FSS services, Singapore has successfully instituted a guard band of 50 MHz. Similarly, in India the TRAI opted to reduce the guard band from 100 MHz to 30 MHz.[41]

In addition to guard bands, other possible measures to ensure coexistence between IMT and FSS include:[42]

- Earth station site shielding;
- Restriction zones to protect FSS;
- Improved FSS receivers;
- Addition of filters to FSS receivers;
- IMT base station location limits;
- Reduced base station transmitter power; and
- Detailed coordination.

d) **Phased introduction by geography.** Thailand should consider whether to adopt a policy of geographical separation for VSAT in regional and rural areas while restricting the use of satellite direct to home (DTH) and TVRO in the 3.4-3.7 GHz band spectrum in key urban areas, such as Bangkok and/or the top 10 urban areas of the country.[43] This approach would allow 5G to be introduced in the 3.5 GHz in urban areas where demand is highest while permitting continued access to the band for FSS services in other parts of Thailand where satellite access is more important and fewer alternatives are available. A decision on future deployment of 5G in rural regions can be reviewed and taken at a later stage depending on changes in demand.

As detailed in Figure 14, the ACMA in Australia adopted such an approach by first clearing and auctioning the 3.6 GHz band in key urban areas. The auction of the 3.6 GHz band was successfully completed in December 2018. The ACMA is currently exploring other licensing approaches to make the 3.5 GHz band available in remote Australia.[44]

37 Refer to the Transfinite study in 2019 which concluded that an 18 MHz guard band is sufficient to mitigate co-frequency interference. Available at www.transfinite.com/papers/Report_for_GSMA_on_3.4-3.8_GHz_Compatibility.pdf

38 A guard band of 25 MHz was proposed in Brazil based on studies by Anatel.

39 ISED. Decision on the Technical and Policy Framework for the 3650-4200 MHz Band and Changes to the Frequency Allocation of the 3500-3650 MHz Band. May 2021. Available at https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11699.html

40 FCC. Expanding Flexible Use of the 3.7 to 4.2 GHz Band, 3 March 2020. Available at https://docs.fcc.gov/public/attachments/FCC-20-22A1.pdf

41 TRAI. Recommendations on Auction of Spectrum in frequency bands identified for IMT/5G. April 2022. https://www.trai.gov.in/sites/default/files/Recommendations_11042022_0.pdf

42 GSMA, Roadmap for C-Band Spectrum in ASEAN, August 2019, page 5

43 Including for example Greater Bangkok, Chang Mai, Nakhon Ratchasima, Hat Yai, Udon Thani etc.

44 Refer to www.acma.gov.au/consultations/2022-02/allocation-awls-34-40-ghz-band-remote-australia

FIGURE 14

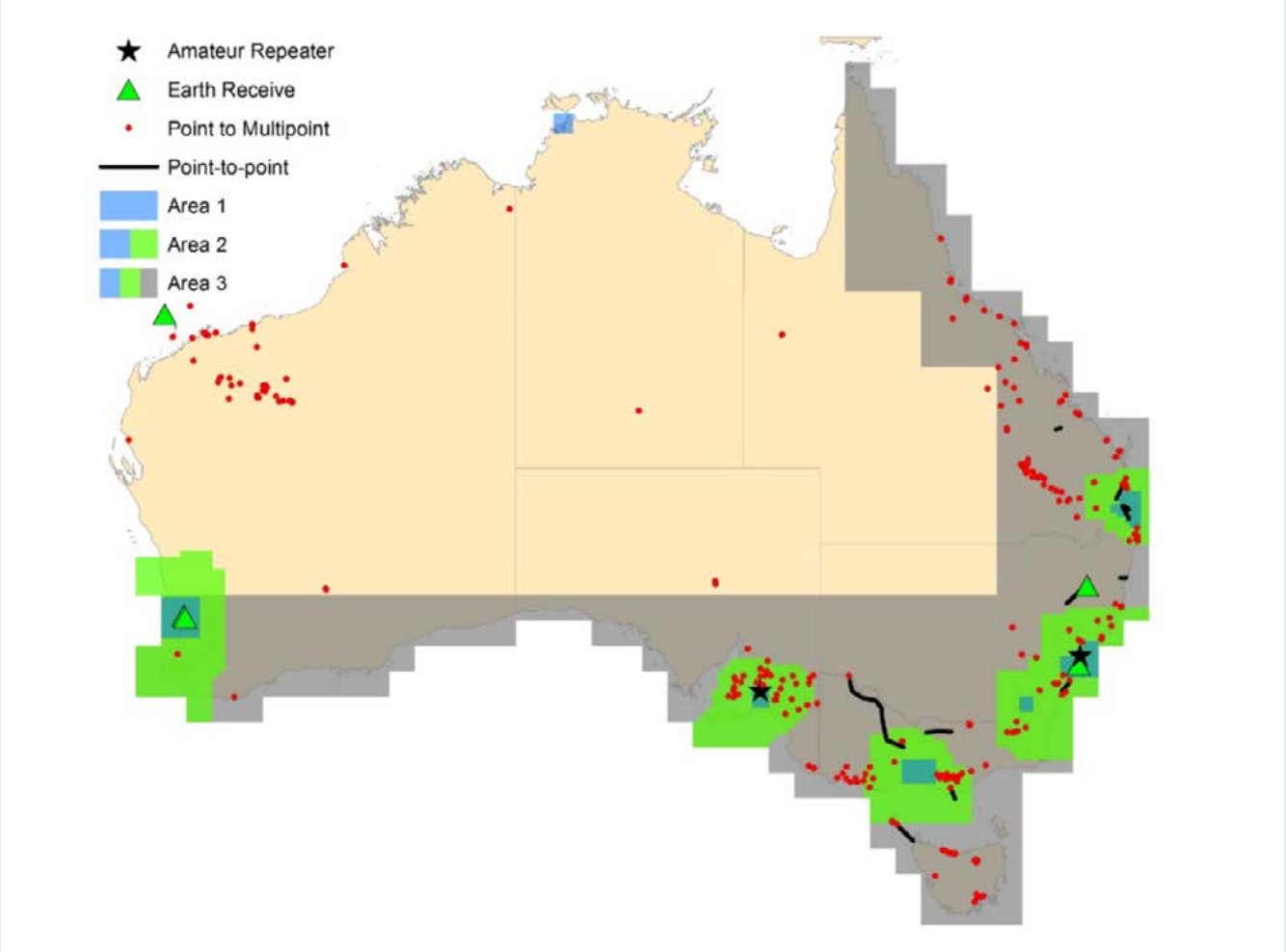
AUSTRALIA CASE STUDY: GEOGRAPHICAL PHASED APPROACH

ACMA undertook an investigation and ultimately refarmed and auctioned the 3.6 GHz band to enable 5G networks in Australia. At the time ACMA began actively considering use of the 3.6 GHz band in October 2016, the band was being considered as a pioneer band for 5G.

ACMA released its first discussion paper in October 2016 regarding the future use of the 3.6 GHz band in Australia titled Future Use of the 1.5 GHz and 3.6 GHz bands. Historically, the 3.6 GHz band was used by the Fixed-Satellite Service (FSS) and point-to-point links. However, in 2005 as part of the ACMA's Strategies for Wireless Access Services consultation process, the band was embargoed Australia-wide. In 2009, the ACMA made the band available for MBB applications in regional and remote areas. The band remains embargoed in capital cities (excluding Hobart) for mobile broadband services and Australia-wide for all other services.

As part of the consultation, ACMA considered the refarming options on a national or regional level. In June 2017, ACMA published the Future Uses of the 3.6 GHz Band: Options Paper, detailing their comprehensive highest value use assessment of the 3.6 GHz band. It was found that the highest value use of the band was in wide-area broadband deployments in metro and regional areas as shown below.

Figure: 3.6 GHz band geographical area refarming options overlaid with incumbent licences



Source: ACMA, Future Use of the 1.5 GHz and 3.6 GHz, page 39

(ii) **Legacy bands.** In addition, there is good reason for NBTC to consider making available spectrum in the 1800 and 2300 MHz bands which is either vacant or likely to be vacant (in the case of the 2300 MHz band) to mobile operators under an adjusted spectrum pricing approach. These will be important to support 4G services which will continue to coexist alongside 5G well into the 2030s. NBTC should consider possible options to structure the award of unassigned spectrum in such a way as to align the licence end date of the entire bands which is ideal from a spectrum management perspective.

4.2 Medium term actions to address future IMT spectrum needs in 2025-2030

It is also important to recognise that the 5G journey is only just starting – for the rest of the decade and beyond, 5G will become central to mobile connectivity and underpin Thailand's digital transformation and economic growth. It is thus important for policymakers and regulators to also take a longer-term view on spectrum supply especially in the mid-band frequencies.

By 2030, countries will need an average of 2 GHz of mid-band spectrum to deliver 5G services at a performance consistent with the ITU's IMT-2020 (5G) requirements.[45] At present, only around 450 MHz of mid-band spectrum has been assigned for IMT in Thailand. Even with the inclusion of the 3.5 GHz bands, the total supply of mid-band spectrum in Thailand will still be significantly below the 2 GHz required for IMT by 2030.

Thus, the following actions are recommended for Thailand:

- Assess options for expanding the supply of spectrum for 5G in the 2025-2030 timeframe, particularly in the mid-bands. These can include the release of unassigned spectrum in existing mid-bands and identification of new spectrum in potential future bands;
- Plan for the use of 4.8 GHz and upper 6 GHz (6425–7125 MHz)[46] to support further development of 5G;
- Gather information on usage trends for FSS in the 3.7-4.2 GHz band and assess possible options for the future introduction of 5G use in this range.

In this context the NBTC should consider the development of a long term Spectrum Roadmap covering at least till 2030. This roadmap which can be updated annually would incorporate NBTC's work on the release of different frequency bands, and information on evolving trends in technology and spectrum use, and harmonisation and standardisation activities.

This information will be critical for businesses to prepare investment plans, secure financing and develop arrangements for deploying particular technologies. In this way, Thailand will be better positioned to support the longer term growth of 5G and to realise its full socio-economic benefits for all citizens and enterprises across all sectors of the economy.

45 Coleago Consulting. Estimating the mid-band spectrum needs in the 2025-2030 time frame, July 2021. Available at www.gsma.com/spectrum/wp-content/uploads/2021/07/Estimating-Mid-Band-Spectrum-Needs.pdf

46 Considerations on the optimal approach for managing spectrum are currently at the forefront of the debate around the 6 GHz band. For example, GSMA Intelligence recently published a cost-benefit analysis for different authorisation models for the 6 GHz in 24 countries. See GSMA Intelligence. The socioeconomic benefits of the 6 GHz band: considering licensed and unlicensed options. June 2022. Available at https://data.gsmaintelligence.com/research/research/research-2022/the-socioeconomic-benefits-of-the-6-ghz-band-considering-licensed-and-unlicensed-options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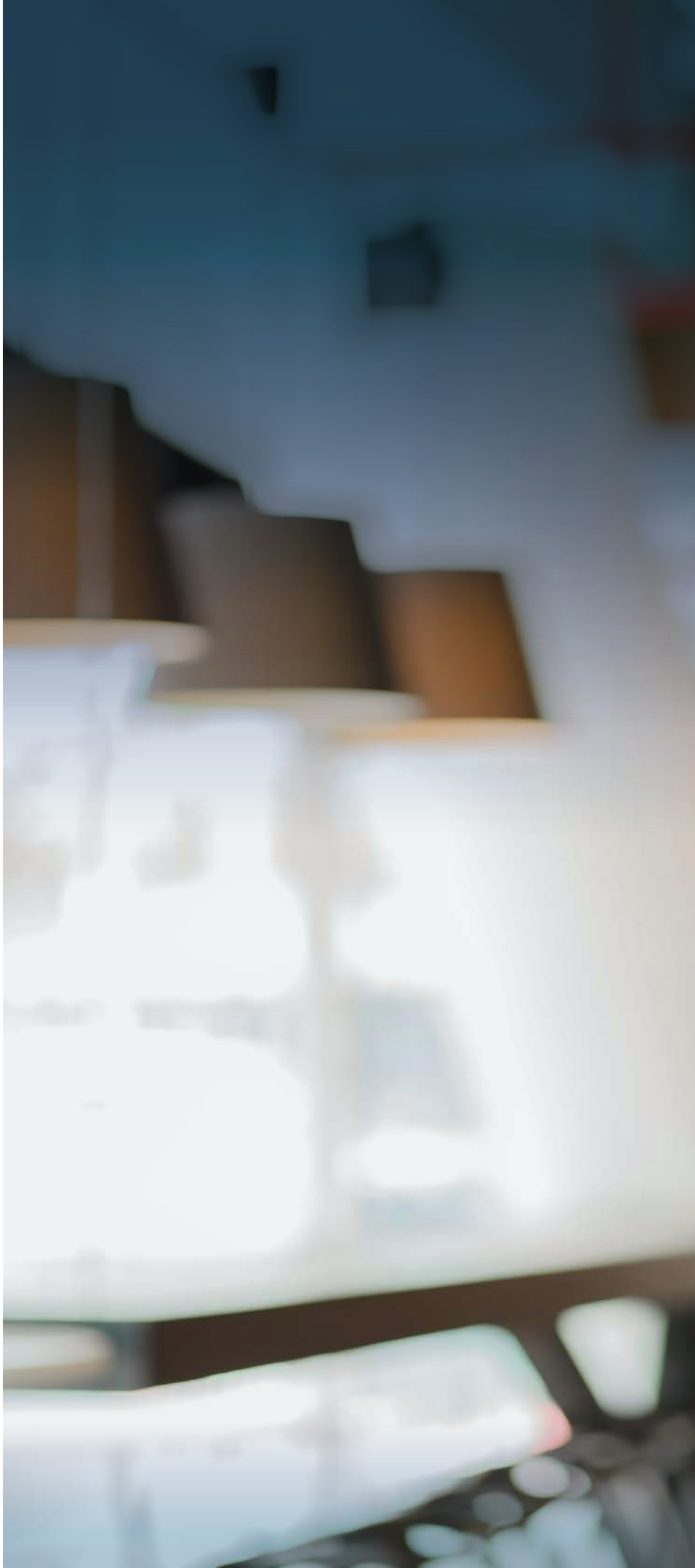

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