



Today, tomorrow and the future – managing data demand in Asia Pacific



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Executive summary

This is the executive summary of a project carried out by Analysys Mason on behalf of the GSM Association (GSMA) and Huawei, to examine developments in the mobile broadband market in the Asia-Pacific region and estimate the socio-economic benefits of these developments. The report also discusses how these benefits are dependent on sufficient spectrum being available, both to accommodate forecast subscriber and traffic needs, and to enable mobile operators to exploit the latest mobile technologies.

A selection of countries in the region are profiled as case studies in the report - China, Australia, Hong Kong, South Korea, India and Singapore - to demonstrate how the use of mobile networks is evolving in different countries, and how spectrum needs vary based on usage levels and market conditions in different markets. The case studies also highlight the importance of national spectrum assignment being coordinated within a globally harmonised spectrum framework at a regional and international level through the Radiocommunication sector of the International Telecommunications Union (ITU-R).

We would like to thank the GSMA and Huawei for the contributions and guidance that they have provided to us in producing this report.

1.1 Background and context for the study

Many studies conducted in recent years have highlighted the economic impact of decisions made by national governments about the award of mobile spectrum. This impact is substantial, due to the significant reliance on mobile networks – and mobile broadband services in particular – in today's society, both by consumers and businesses.

For example, an increase in both mobile data subscribers in China using 3G and 4G networks and the forecasted traffic per subscriber is expected to result in almost 15 000 Petabytes of data being carried on Chinese mobile networks annually by 2019, approximately 25 per cent of traffic forecasted for the entire Asia Pacific region. This represents a compound annual growth rate of over 55 per cent over the period 2014-2019.

Mobile broadband services today are provided over a combination of 3G and 4G networks. It is now well over a decade since 3G networks were launched in many countries, and those networks continue to prosper, with renewed investment in 3G coverage and improved technology being made by operators in many markets, to increase the speed and quality of their 3G networks.

Operators are also changing the way they use spectrum in various ways, such as deploying newly assigned 4G bands, re-farming 2G or 3G spectrum for 4G, and deploying additional infrastructure layers overlaid on existing networks in the form of smaller cells. Re-farming 900MHz spectrum from 2G to 3G has seen swift market uptake in Asia Pacific region for example with estimates from Huawei that penetration of UMTS900 handsets is reaching 80%.

Alongside this, the number of fully commercial 4G (i.e. LTE and LTE-A) networks in operation around the world has grown considerably. Recent information published by the Global Suppliers Association (GSA) suggests that there are well over 300 LTE networks now operational in 112 countries around the world. Mobile operators in Asia-Pacific are the leading users of the latest releases of the LTE standard (i.e. LTE-A), and a number are undertaking trials and offering commercial LTE-A services. These developments will benefit consumers by making available the significantly better peak download speeds that LTE-A networks can deliver.

Migration of users from 2G and 3G networks to 4G has started, and a key factor that is driving the migration is that most operators do not charge a premium for 4G services over 3G. Despite this migration, 3G (and 2G) networks remain important in many markets, due to the superior coverage that these networks currently deliver compared to 4G, and their ability to support global roaming (particularly for traditional voice use).

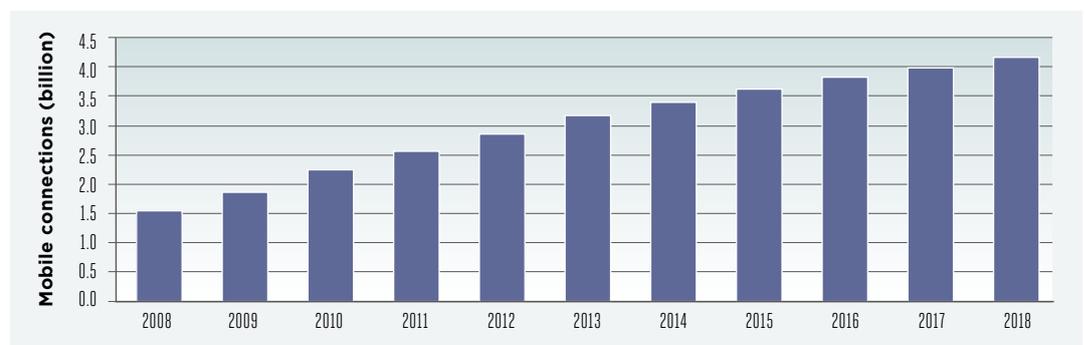
In view of this continued use and growth of mobile services of all types, and in particular due to the further deployment of LTE-A in response to market need, there is immense concern among the mobile industry that sufficient amounts of suitable radio spectrum will be available in the future. The World Radiocommunication Conference in 2015 (WRC-15), organised by the International Telecommunications Union (ITU), will make decisions on the bands that will be assigned for future mobile use, and identify specific portions of these bands for use by International Mobile Telecommunications (IMT). These decisions will be of great importance for the continued development of the mobile market in Asia-Pacific and globally, and are therefore subject to considerable debate in the industry, ahead of WRC-15. A key requirement from the mobile industry's perspective is that, as with previous bands identified for IMT use, additional spectrum needed to support future IMT services must be identified at a global level, to avoid fragmentation between regions. Once identified at a global level, further harmonisation also needs to take place at a regional level so that countries in the Asia Pacific region implement new mobile spectrum bands in a coherent way across different markets. Since the current spectrum landscape for 2G/3G/4G within the region is somewhat fragmented, it is important that policy makers work together to achieve a more consistent framework in future in relation to the way that different mobile bands are deployed and used.

1.2 Growth in demand for mobile services

Mobile devices are increasingly viewed as an essential part of modern life. Recent years have seen a surge in mobile data traffic, with rates of growth in use of mobile data services significantly exceeding those of fixed networks in many markets. Forecasts suggest that mobile data will continue to grow, according to Analysys Mason. Although the rate of subscriber growth is reducing in some markets, the amount of traffic carried by networks is increasing as subscribers consume more data.

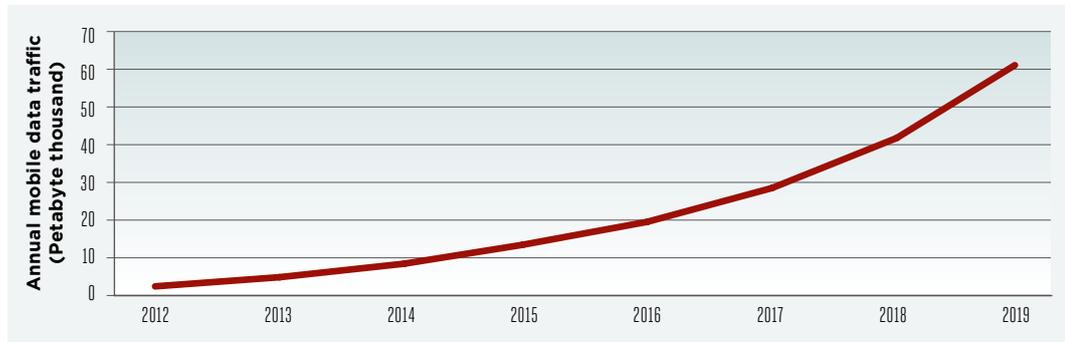
As a result, for the Asia Pacific region, Analysys Mason forecast that mobile connections will grow at a CAGR of 6% while data traffic will grow at 46% over a period from 2013 to 2018, as illustrated below.

FIGURE 1.1: ASIA-PACIFIC MOBILE CONNECTIONS



Source: Analysys Mason, 2014

FIGURE 1.2: HISTORIC AND FORECAST ASIA-PACIFIC ANNUAL DATA TRAFFIC

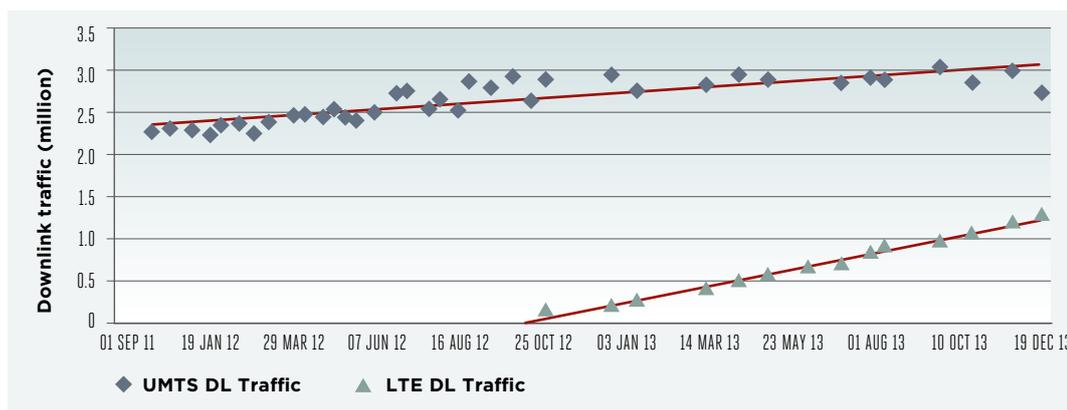


Source: Analysys Mason, 2014

In terms of how traffic carried by 4G networks will evolve compared to 3G, estimations from Huawei are that LTE traffic typically exceeds UMTS traffic when LTE device penetration in a given network or country reaches 30%, which typically occurs two years after LTE deployment. However, although 3G to 4G migration is already underway in many countries, network statistics collected by Huawei suggest that total 3G traffic levels appear to be remaining at a stable level. This indicates that users remaining on 3G networks are increasing their data consumption.

Within one mobile network, Huawei has estimated there has been an increase of more than 22% in UMTS downlink traffic per 3G subscriber, one year after the operator launched LTE. In the same network, downlink speed has improved by over 25% (average per user). The trend in UMTS downlink traffic, compared to LTE downlink traffic, within one mobile operator’s 3G and 4G networks supported by Huawei is illustrated below.

FIGURE 1.3: UMTS AND LTE TRAFFIC TREND WITHIN ONE NETWORK IN ASIA PACIFIC



Source: Huawei, 2014

As well as growth in consumers’ use of mobile broadband services, market trends suggest an increased growth in particular types of mobile data in the medium to long term, such as machine to machine (M2M) communications used by various industries (e.g. in the automotive, healthcare and transport sectors). With substantial growth in M2M connections being predicted, it follows that the number of device types connecting to mobile networks will increase substantially, and device types and traffic loads will become increasingly varied. These trends are leading towards the realisation of an internet of things (IoT) that can exploit the increasing intelligence of devices, and respond to changing social and industrial trends.

1.3 Socio-economic benefits of mobile broadband

A number of scientific studies support the conclusion that broadband services delivered over networks of all types – including wireless and mobile – can have a substantial positive impact on socio-economic development. Furthermore, as operators invest in deploying more infrastructure, this also tends to exhibit spill-over effects, and thus the impact on the wider economy can be far-reaching, improving productivity, fuelling innovation and driving the creation of new businesses.

As few scientific papers exist investigating the socio-economic impact of *mobile* broadband specifically, we have estimated the impact of *total broadband* penetration on economic prosperity. We define ‘broadband’ to include both fixed and mobile broadband connections, including the use of smartphones for data, but excluding basic mobile phones.¹

Using a multiplier approach, we have estimated that a 10 percentage point increase in broadband connections penetration leads to between 0.26% and 0.92% increase in gross domestic product (GDP). It is reasonable to assume that in more developed countries more people are connected so the marginal impact of increased connectivity diminishes, which indeed is reflected in the GDP multipliers derived from previous scientific studies for developed and developing economies.² In short the former tend to experience a lower impact of increased connectivity than the latter as the dramatic shift of bridging the broadband divide has already happened. It may be noted, however, that further expansion of broadband can still bring significant value to advanced economies, should suitably accommodating policies be adopted by governments.

In terms of jobs created, and based on consensus data points from published studies, our estimations indicate that the addition of 1000 new broadband connections results in the creation of up to 33 new jobs. Initially new jobs are created as a result of *direct* effects related, for example, to the construction of new infrastructure. As these direct effects diminish, jobs are created as a result of *indirect* and *induced* effects, mainly in other industries (for example, industries that make use of broadband networks).

Within the Asia-Pacific region³, this potentially gives rise to the impacts summarised in Figure 1.4 below, based on Analysys Mason’s calculation.⁴ Cumulatively, by 2020, increasing penetration of broadband could potentially lead to an increment of USD 1.2 trillion in total **to the output of the countries studied**. Cumulative new jobs added to the regional economy could reach up to 35 million. Note once again that these estimates represent the predicted effect of *broadband adoption of all types*, including mobile broadband.

FIGURE 1.4: CUMULATIVE GDP AND JOBS IMPACT RESULTING FROM BROADBAND CONNECTIONS PENETRATION INCREASE IN SELECTED COUNTRIES IN ASIA-PACIFIC

	ICT Index	Delta broadband connections penetration (2013-2020) (pp)	Cumulative GDP increment (USD billion)	Cumulative new jobs added (thousand)
Australia	7.9	37	11	287
China	4.18	43	855	19 321
Hong Kong	7.92	61	7	146
India	2.21	35	290	14 722
Singapore	7.65	43	5	80
South Korea	8.57	36	17	593

Source: Analysys Mason, 2014

¹ Previous studies investigating the impact of broadband on the economy may not be comparable with the current study due to differences in the definition of broadband penetration (e.g. the difference between broadband penetration and broadband connections penetration, the latter exhibiting diminishing returns as users get more than one broadband connection), differences in technology mix, as well as differences in penetration forecasts.

² We have distinguished between developed and developing nations for our calculation based on their ICT index.

³ We refer only to the following specific countries – Australia, China, Hong Kong, India, Singapore and South Korea.

⁴ Since the level of benefits occurring depends on the level of penetration and ICT development within the country, we have considered ICT maturity based the published ICT index for different countries.

The role and impact of mobile broadband compared to broadband as a whole varies within different markets, depending on the level of fixed-network investment and different consumer preferences (e.g. the extent to which substitution occurs between fixed and mobile services). We believe a significant proportion of the benefits stated above will be coming from mobile broadband within the studied countries. This impact is maximised if sufficient spectrum is available to enable mobile networks to be deployed with the best speeds and coverage achievable for the given market.⁵

1.4 How mobile technology is evolving

With substantial increases in the number of mobile connections – and traffic per connection – likely in the future, mobile technology and the way that mobile operators use spectrum are continually evolving.

Operators are investing to improve the speed and coverage of their 3G networks and to relieve congestion in UMTS2100 networks – for example, through deployment of UMTS900 and the addition of various UMTS capability-enhancing features such as dual-carrier UMTS for improved data carriage, and adaptive multi-rate (AMR) technology for improved voice quality. UMTS900 in particular has seen swift adoption, and is a key technology to relieve congestion within UMTS2100 networks as well as being used to improve coverage of 3G services through use of lower frequency spectrum. Huawei has estimated that the penetration of UMTS900 terminals has reached 80% in many Asia-Pacific markets, and also that around 25% of 3G devices used in Singapore support dual-carrier UMTS. Operators in the Asia Pacific region are world leaders in terms of UMTS900 deployment with re-farmed 900MHz spectrum playing a key role in improving 3G capacity and coverage in countries such as Hong Kong, where mobile operator Hutchison successfully bid for 900MHz spectrum through an auction of mobile spectrum, in order to deploy UMTS900 in urban areas to relieve congestion within its UMTS2100 network, absorb heavy 3G data traffic and improve the customer experience from 3G services.

With the technological advances now being implemented in 4G through the deployment of LTE-A, average download speeds within 4G networks are continually increasing, which is expected to further drive the take-up of mobile broadband services as consumers obtain a mobile service with faster speeds and better quality.

The most recent releases of the LTE standard that incorporate LTE-A (i.e. releases 10, 11 and 12) are starting to have a significant impact on the way that operators use and manage 4G spectrum, since these incorporate both intra- and inter-band carrier aggregation (CA), as well as advanced antenna technology (i.e. multiple in, multiple out, or MIMO).⁶ Initial LTE-A CA deployments have used two carriers (e.g. 20+20MHz) to improve peak download speeds, but the extension to three or more carriers is ongoing, across a wider range of bands, using higher orders of MIMO. Release 12 of the standard additionally supports FDD-TDD⁷ carrier aggregation. This is a major change to the way that operators have previously used spectrum, and enables multiple bands to be used in combination to benefit consumers by offering higher network throughputs. The benefits of this are therefore highest in markets where operators have multiple spectrum bands assigned to them, giving them the flexibility and the physical bandwidth required to implement advanced CA technologies.

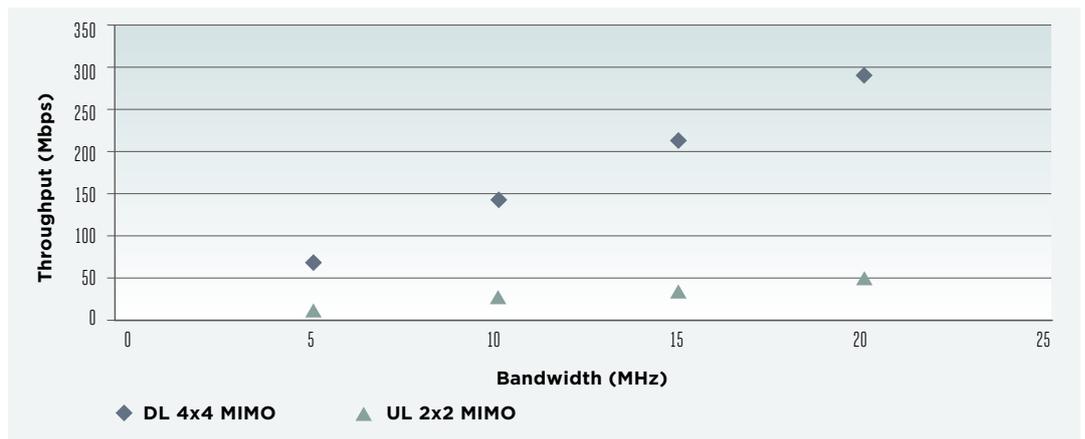
⁵ The order of magnitude of these estimates is broadly consistent with other studies that the GSMA have published on the impact of mobile broadband services, where other studies have used a similar approach. Differences between Analysys Mason's estimates and other published GSMA study results are primarily due to different fixed and mobile penetration estimates being used to estimate the impact. It was not within the scope of this study to validate the penetration forecasts used in other published work.

⁶ The initial standard supported CA in specific bands only; subsequent releases (i.e. release 11 and release 12) have expanded the range of bands that are supported by inter-band CA as well as extending the scope for intra-band CA (e.g. from two 20MHz carriers, to three or more).

⁷ i.e. carrier aggregation between Frequency Division Duplex (FDD) and Time Division Duplex (TDD) deployment (using a combination of paired and unpaired spectrum).

As shown in Figure 1.5 below, there is a strong correlation between the carrier size used for the provision of LTE-A services and the peak throughput achieved on these.

FIGURE 1.5: PEAK THROUGHPUT ACHIEVED IN LAB TESTS FOR DIFFERENT CARRIER SIZES FOR LTE-A TECHNOLOGIES



Source: Analysys Mason, Huawei, 2014

Operators in Asia-Pacific are at the forefront of LTE-A CA developments, and there are a range of networks across the region where LTE-A CA technology of various forms is deployed, providing data speeds of 250–300Mbit/s and beyond.⁸ In laboratory trials one operator – NTT DoCoMo – has achieved peak download speeds of over 1Gbit/s using LTE-A (by aggregating five 20MHz carriers). Future iterations of LTE-A (once these are supported in devices) will potentially enable peak downlink speeds up to 3Gbit/s to be provided, also by aggregating five 20MHz carriers, along with 8×8MIMO⁹.

As well as supporting aggregation of multiple carriers, LTE networks in Asia-Pacific are also at the forefront of other 4G developments, such as voice-over-LTE (VoLTE). Although VoLTE technology has not been widely deployed around the world to date, a number of Asia-Pacific operators have launched VoLTE, including in Hong Kong, Japan, Singapore and South Korea.

Technological evolution is also enabling mobile networks to provide services such as high-quality streaming video. As the world has become increasingly mobile, this is leading to demand for access to services and content (including Internet, social media and TV content) from any location, at any time.

Implementation of LTE broadcast technology (eMBMS or Enhanced Multimedia Broadcast Multicast Service) is an example of how mobile networks are evolving to support a wider range of video services. For example, Huawei and China Telecom have deployed LTE-based eMBMS to distribute TV channels in Nanjing. Starting with the International Exhibition Centre used to host the 2014 Youth Olympic Games, coverage has been extended to over 30 base stations in Nanjing, including university and college campuses as well as the freeway between the International Exhibition Centre and the airport.

⁸ LTE-A with carrier aggregation typically refers to technology based on 3GPP Release 10 and beyond

⁹ Source: Huawei

The vast amount of video and multimedia content available on the fixed internet is driving similar expectations for access to on-line video services through mobile networks. More and more video content is being made available for on-demand streaming, including user-generated content through various services and sites such as YouTube. This directly leads to increasing demands to use mobile devices to access this content, and also to upload user-generated content whilst on the move, as well as to view live streamed content at sports events, concerts and other entertainment venues.

Neither 2G nor 3G networks have been able to support live video streaming economically, or with an acceptable user experience, but 4G networks are beginning to play a major role in making IP-based video streaming and multimedia services available to a large number of users. Various factors are combining to make live video streaming over LTE achievable:

- **technological improvements such as caching third-party content locally on base stations, and video optimisation using innovative technology in the LTE Evolved Packet Core (EPC)**
- **advances in device technologies**
- **improvements in the LTE-A air interface (e.g. carrier aggregation).**

Video-optimisation technologies are already being tested and implemented within networks in Asia-Pacific. For example, Huawei is working with China Mobile to deploy technology to improve video experience through triple optimisation (video caching, transmission control protocol (TCP) optimisation, and smart pacing¹⁰). Other vendors have also recently begun testing products using systems that cache content locally on LTE base stations. One such system has been tested in the Singapore SportsHub, for example.¹¹

The advances in technology that are being implemented through LTE and LTE-A go some way to increasing network capacity and will also significantly improve on network speed and quality. However, despite these advances, it is recognised that operators will require access to significant additional spectrum to fully meet future market demands, both to cater for increasing demand for services, and to deploy higher speed networks, which needs more spectrum to be available per operator to achieve the planned 100MHz (five times 20MHz) LTE-A CA supported by the latest industry standards. Spectrum implications are further described below.

1.5 Spectrum implications

Based on market trends such as those identified in this report, previous research published by GSMA found that on average in each country a total of 1600-1800MHz of spectrum will be required for mobile by 2020.¹² Similarly, the ITU has predicted that an average total of 1340-1960MHz will be required for IMT/mobile broadband services by 2020.¹³ This total amount includes spectrum already assigned for 2G, 3G and 4G which, as discussed in this report, is vital to support existing GSM, CDMA and HSPA services as well as emerging LTE and LTE-A network deployment.

¹⁰ A technique used to reduce traffic carried over mobile networks e.g. through buffering, to reduce the amount of bandwidth used

¹¹ <http://nextvasia.com/broadcast-related-technology/starhub-nokia-demonstrate-mobile-edge-video-delivery/>

¹² See <http://www.gsma.com/spectrum/resources/>, GSMA Public Policy Position: Mobile spectrum requirements and candidate bands for WRC-15

¹³ <http://www.itu.int/en/ITU-R/study-groups/rctp/Pages/default.aspx>

The precise spectrum requirements vary for each nation. In some countries, the population is more concentrated than in others, affecting the type and amount of spectrum needed to achieve mobile broadband coverage. In more densely populated countries, better efficiencies (both in terms of spectrum use and in the cost of rolling out networks) can be achieved using spectrum in higher frequency bands, although sub-1GHz spectrum is still beneficial in these countries to achieve the depth of coverage required for in-building use of mobile broadband services from a user’s handset. However, despite significant national variations, the ITU-R and the GSMA are striving to identify spectrum bands that might be used for IMT at a global level (with the detailed assignment of these bands being left to national regulators to implement based on national demand), in order to foster global economies of scale. The requirement for globally identified bands is as important at WRC-15 as it has been in previous WRCs where spectrum requirements for IMT have been discussed.

To provide an indication of the spectrum requirements in different markets, we have reviewed the spectrum currently used for provision of mobile services in eight Asia-Pacific countries, including developed and developing economies. We have found that the total amount of spectrum assigned – for all mobile operators in a given market, and for all generations of mobile technology – does not exceed 685MHz in any of the countries assessed. In some countries (e.g. China, India, Indonesia and Thailand), the amount of spectrum is significantly below this, despite mobile penetration forecasts and traffic predictions being high. This therefore leaves a significant shortfall between current levels and the GSMA’s forecast requirement of 1600–1800MHz by 2020.

Of the spectrum currently in use for mobile service provision, only a sub-set is used for high-speed 3G and 4G mobile data/broadband services. We have considered how the amount of such spectrum compares to the number of 3G and 4G connections, both in 2014 and forecast for 2018. In combination with the predicted shortfall in spectrum (i.e. the difference between the GSMA’s published requirement, and the spectrum currently assigned per market), we have identified where the future spectrum needs for mobile are most urgent. This is highlighted below.

FIGURE 1.6: LEVELS OF NEED FOR ADDITIONAL MOBILE SPECTRUM IN BENCHMARK COUNTRIES IN ASIA-PACIFIC

	Shortfall from GSMA 2020 spectrum target	2018 3G and 4G Spectrum per connection (Hz per connection)	Need for additional mobile spectrum
Australia	942 to 1142MHz	14.38	●
China	1123 to 1323MHz	0.33	●●●
India	1220 to 1420MHz	0.33	●●●
Indonesia	1254.25 to 1454.25MHz	0.69	●●●
Japan	1074 to 1274MHz	2.89	●●
South Korea	1240 to 1440MHz	7.79	●●
Thailand	1241 to 1441MHz	1.84	●●
Vietnam	1240 to 1440MHz	2.56	●●

KEY	●	Some need for additional mobile spectrum
	●●	Significant need for additional mobile spectrum
	●●●	Urgent need for additional mobile spectrum

Source: Analysys Mason, 2014

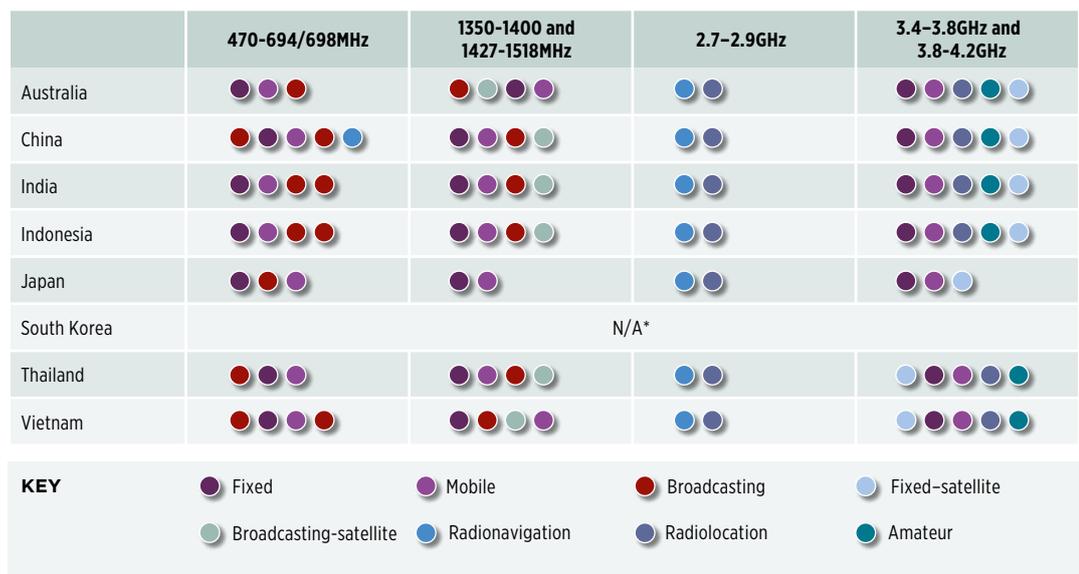
1.6 Conclusions

The GSMA has identified four frequency ranges that the mobile industry considers to be suitable for future use by mobile broadband services:

- Sub 700MHz UHF (470-694/698 MHz)
- L-Band (1350-1400MHz and 1427-1518MHz)
- 2.7-2.9GHz
- C-Band (3.4-3.8GHz and 3.8-4.2GHz)

Our assessment of the current uses of each of these bands within selected countries in the Asia Pacific region suggests that allocations within the bands are broadly similar between countries; however, the actual usage, and how extensively they are used, varies.

FIGURE 1.7: SUMMARY OF CANDIDATE BAND ALLOCATION IN THE BENCHMARK COUNTRIES



Source: Analysys Mason, Frequency allocation tables, 2014
 *Not available

In considering how to meet future mobile spectrum needs, national regulators and policy makers face difficult choices when trying to make spectrum available for mobile use whilst also protecting existing service needs. Various options are open to achieve a better use of spectrum, enabling re-allocation of portions of bands to occur – for example, by concentrating existing services into particular sub-band, deploying new technologies that require less spectrum, making use of alternative bands for existing services. Ultimately these choices should be guided by the benefits from the use of different bands for new mobile use, relative to the costs of alternative options to meet existing users’ needs.

As complement to these approaches, we expect that more advanced options to spectrum sharing will be explored including approaches such Licensed Shared Access (now being considered at a European level); the gradual take up of small cells layers, with their reduced output power and the exploitation of higher frequencies (offering higher radio frequency signal attenuation), which will facilitate future exploitation of sharing opportunities as well as improvement in overall spectrum.



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