GSMA

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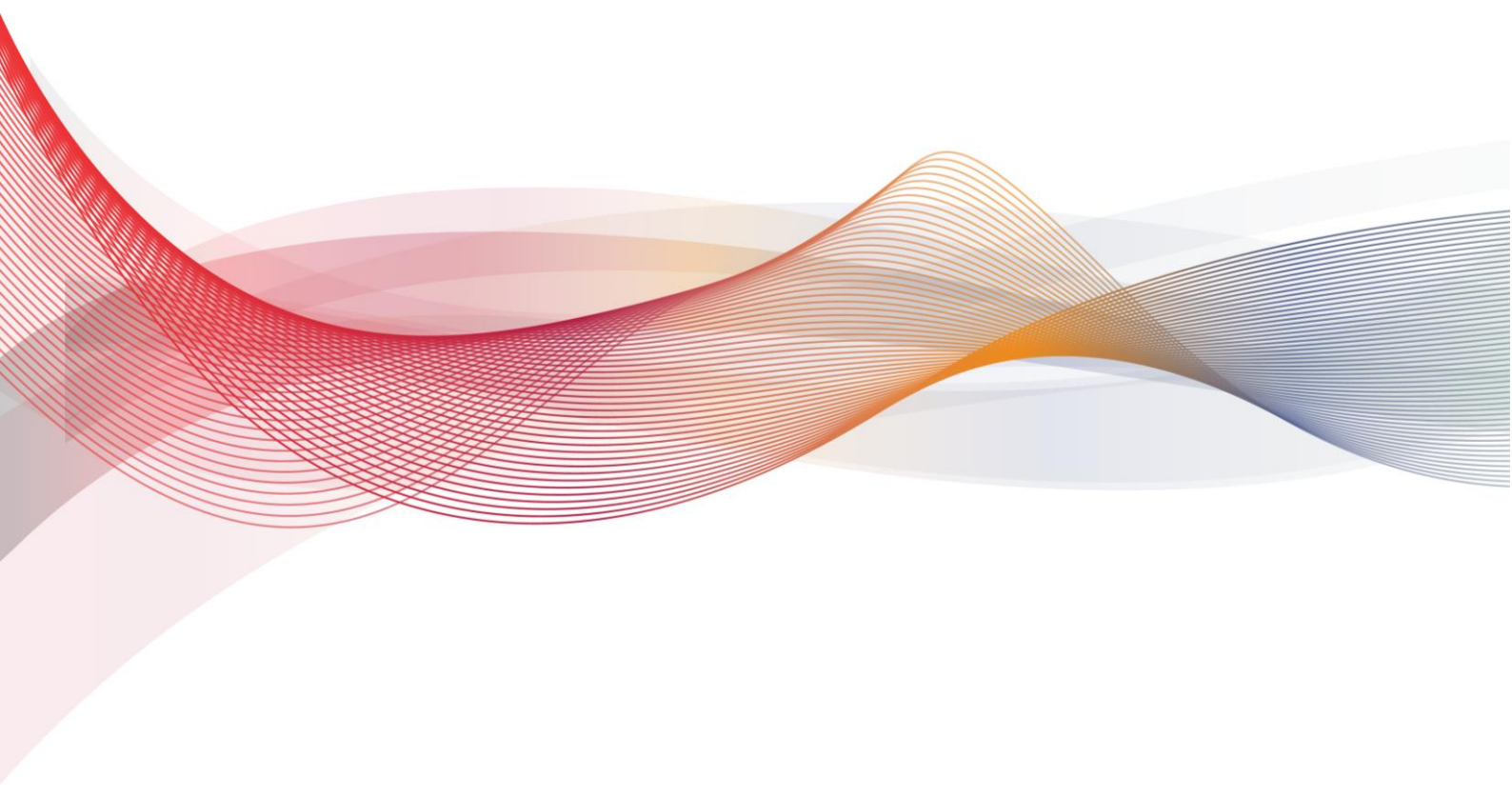
DRIVING GROWTH THROUGH MOBILE

GSMA Public Policy Position

Mobile spectrum requirements and target bands for WRC-15

June 2015



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Executive Summary

At the World Radiocommunication Conference in November 2015 (WRC-15), administrations from around the world will agree on changes to international spectrum allocations and associated regulatory provisions. The outcome will be the single most important factor determining the future availability of affordable, ubiquitous, high-speed mobile broadband services.

The decisions made at WRC-15 will also have a direct impact on the wealth, well-being and future prospects of all countries and their citizens. For example, the mobile industry (both directly and indirectly) created 3.8% of global GDP (equivalent to $3 trillion) and directly supported 13 million jobs in 2014 – this is expected to rise to 4.2% of GDP and 15 million jobs by 2020.[1]

This document addresses the need for more mobile spectrum, the most appropriate frequency bands and proposes how the needs of incumbent spectrum users can continue to be met. The aim is to inform the policymakers and regulators who are making spectrum allocation decisions and developing national and regional proposals in the lead up to WRC-15.

The tremendous growth in mobile data means that, on average, an additional 600-800MHz of spectrum should be made available for International Mobile Telecommunications* (IMT) at WRC-15 so it is ready for potential use by 2020. This will allow national administrations to continue to support existing services while also giving them the flexibility to make new mobile spectrum available, when needed, to avoid a degraded consumer experience.

The GSMA proposes four frequency ranges within which the 600-800MHz could be satisfied most suitably:

- **Sub-700MHz UHF (470-694/8MHz)** can deliver high quality, wide area coverage for mobile broadband services including in rural areas and deep inside buildings. The band is used for terrestrial broadcasting services which provide a vital public role. However these services could be maintained in a smaller amount of spectrum using the latest broadcast technology and coding solutions without negatively impacting programme choice or public service broadcasting obligations. Also mobile networks could help meet consumer demand for streamed TV content.
- **L-band (1350-1400MHz & 1427-1518MHz)** is capable of delivering additional capacity and coverage over relatively large areas, including inside buildings. A portion is already allocated to the mobile service worldwide and another is reserved for digital radio broadcasting, but is largely unused, creating an ideal basis for a wider mobile allocation. There is also now major support from administrations globally for a significant IMT/mobile broadband identification at WRC-15.
- **2.7-2.9GHz** would provide important extra mobile capacity, and deployments would be cost-effective because existing cell sites could be used. It is primarily used for important civilian and military radars as well as some meteorological radars. However, research shows that the band is not used efficiently so all existing radar requirements could be met in half the band leaving the other half to be used for mobile broadband. Furthermore, the financial benefits of mobile services amount to over 10 times the costs of relocating existing radars into the smaller portion.
- **C-band (3.4-3.8GHz & 3.8-4.2GHz)** can deliver the best possible mobile broadband experience and support busy urban areas where mobile traffic is growing fastest. The band is largely used for fixed satellite services which play a crucial role in tropical areas where rainfall has hindered the use of other bands. However, in the vast majority of countries, higher frequency satellite bands (e.g. Ka and Ku) are becoming the preferred means of delivering satellite services due to lower costs and better performance - which means spectrum is being made available in the band for mobile services. In the few countries heavily impacted by rain fade, the majority of the band, or even the entirety, can remain exclusively used for satellite services.

Separately, the GSMA notes the positive progress being made towards meeting the conditions necessary for the release of the 700MHz band for mobile use in Region 1 (i.e. Europe, the Middle East and Africa) which will be addressed at WRC-15 under Agenda Item 1.2. There is already widespread agreement on a band plan that includes suitable provisions to protect broadcasters. The timely release of this band is essential in order to ensure LTE services can cost-effectively scale to meet growing demand, especially in rural areas, inside buildings and in emerging markets.

* An IMT identification refers to a specific frequency range in a band that is designated for potential use by compatible mobile broadband technologies, including all 3G and 4G networks.

Future Mobile Spectrum Requirements

Mobile services are undergoing a period of dramatic growth causing a tremendous increase in data traffic which in turn is making new technologies and mobile spectrum essential. The rising data demand is being driven by the growing number of mobile subscribers, and particularly smartphone users, who are connecting to faster networks and consuming higher-bandwidth content such as video.

The number of mobile connections is predicted to increase from 7.3 billion in 2014 to 10 billion by 2020[2], of which 69% are expected to be data-hungry mobile broadband connections. A growing proportion of users will be connecting to 4G networks which are having a transformative effect on consumer behaviour. Mobile operators in mature markets, such as KT in South Korea, report that the average 4G user consumes double the data of their 3G counterpart.[3]

These faster connections are being exploited by a rising number of smartphones that are tasked with increasingly bandwidth-heavy applications. The smartphone installed base is expected to grow from 2.6 billion in 2014 to almost 6 billion in 2020[4] resulting in a surge of traffic as these devices generate on average 37 times more mobile data than a basic feature phone.[5] Their larger screens make them especially suited to high-bandwidth on-demand video services which made up 55% of mobile data traffic in 2014 and should reach 72% by 2019.[6]

The ITU's official spectrum demand model assumes that mobile traffic will increase between 44 and 80-fold between 2010 and 2020.[7] By comparison, global mobile data traffic grew 76-fold between 2008 and 2014.[8] In response, mobile operators are investing heavily in new technologies (e.g. LTE and LTE-Advanced) and new network architectures (e.g. small cells). However, such is the speed of data growth that operators will require access to significant additional spectrum in future to efficiently meet widespread demand. Taking into account all other capacity enhancing measures, the ITU predicts that an average total of 1340-1960MHz will be required for IMT/mobile broadband by 2020 (the variation reflects the upper and lower data demand estimates).[9]

The ITU predictions are in line with GSMA research which finds that 1600-1800MHz will be required by 2020. Given around 1GHz has already been identified for IMT/mobile broadband, the GSMA recommends that, on average, an additional 600-800MHz should be sought at WRC-15 worldwide. The amount needed for each national market will vary depending on differing levels of data demand and national priorities. It is important to recognise that administrations will not license new mobile spectrum to operators until local demands require it, so incumbents will not be moved unnecessarily.

The new mobile spectrum should comprise a mixture of coverage (i.e. lower frequency) and capacity (i.e. higher frequency) bands to ensure that networks can provide high speed, cost-effective services in rural and metropolitan areas as well as deep inside buildings. It must also be harmonised globally, or at least regionally, to drive the economies of scale required for low cost consumer devices and to enable roaming and minimise cross-border interference.

What's at Stake?

By allocating sufficient additional mobile spectrum at WRC-15, administrations can continue to support existing services for as long as necessary, but will also have greater flexibility to make more spectrum available for mobile services when required. In the absence of new allocations, their ability to make new mobile spectrum available as data traffic rises will be limited resulting in a poorer user experience and potentially more expensive mobile services. As it takes about eight to ten years to re-allocate, re-assign and re-license spectrum, it is essential that administrations act now rather than reacting when it is too late to meet growing consumer demand.

Due to differing market conditions, some administrations may not see the need for new mobile allocations based on the belief there is insufficient national data demand. However, beyond the fact that additional spectrum will only be licensed to mobile operators when there is necessary demand, there are other important reasons for supporting new mobile bands at WRC-15.

First, new mobile bands support all markets regardless of their different near-term spectrum requirements. Growing numbers of early adopters drive the economies of scale that bring down the cost of network equipment and devices for later deployments. This is especially important for developing markets which benefit most from the low-cost smartphones and network equipment that were mass-manufactured for other countries.

Second, it is possible that data demand projections may underestimate growth. In 2010, mobile data traffic was five times greater than some of the estimates made in an ITU report from 2005, and had already exceeded some estimates made for 2020.[10] It is possible this could happen again especially given that research into 5G is accelerating and smartphone costs are dropping sharply,[11] making them viable for mass adoption in emerging markets. At the same time, the 'Internet of Things' and 'big data' – which both depend on telecom networks – are routinely predicted to be two of the most transformative technology trends of the modern age.

Over the coming years mobile services could transform society more than at any other time in its history. Faster and more ubiquitous mobile networks are set to create a more connected world where billions of wirelessly-enabled devices will create data feeds that drive new smart cities, industries and whole countries. But the capacity and reach of these networks will always be determined by spectrum. By ensuring sufficient spectrum is allocated to the mobile service at WRC-15, national administrations will have the flexibility to assign the amount they choose rather than having their future confined by existing allocations.

Agenda Item 1.1 – Suitable New Mobile Bands

At WRC-15, Agenda Item 1.1 addresses additional spectrum allocations to the mobile service and the identification of frequency bands for IMT/mobile broadband all around the world. The GSMA has identified four frequency ranges within which the spectrum requirement for future mobile broadband could be best satisfied. These bands have also been carefully chosen to ensure that the impact on incumbent services is minimised as there is sufficient spectrum for them to continue to operate in parts of the bands through coordination and spectrum planning. These are based on detailed studies which assess how different services can share the frequency bands and the economic benefits of change.

Although some administrations may pursue other bands based on their individual circumstances, the likelihood of establishing a globally harmonised allocation at WRC-15 may be reduced if there is little international consensus. The following frequency ranges represent credible options because they could be used in most markets across all three ITU Regions creating globally or regionally harmonised spectrum. This will lower the cost of equipment, enable roaming and reduce international interference.

- Sub-700MHz UHF (470-694/8MHz)
- L-band (1350-1400MHz & 1427-1518MHz)
- 2.7-2.9GHz
- C-band (3.4-3.8GHz & 3.8-4.2GHz)

These four bands have been included as official candidate bands for consideration at WRC-15 under Agenda Item 1.1. The 'final CPM report', which helps administrations to develop their positions for WRC-15, includes options for mobile allocations and/or IMT identifications in the four bands. The report also references sharing studies which show that mobile broadband can operate in the bands under reasonable conditions without causing harmful interference to existing services.

1. Sub-700MHz UHF (470-694/8MHz)

The GSMA recommends that the 470-694/8MHz band be allocated[12] on a primary basis to the mobile service worldwide, alongside broadcasting, and that a significant portion be identified[13] for IMT/mobile broadband in ITU Regions 2 and 3 (i.e. the Americas and Asia Pacific). The band has the right qualities for delivering widespread mobile broadband, and existing broadcast services could be maintained in a smaller amount of spectrum without being adversely affected in most, if not all, cases.

The band would provide a vital means of delivering high quality, wide area mobile broadband services including in rural areas and deep inside buildings. It would augment the existing 700MHz and 800MHz bands, which are proving instrumental in delivering widespread LTE services and narrowing the digital divide, but which could approach full capacity in the coming years leading to a deteriorating experience for consumers, especially in rural areas.

Furthermore, the sub-700MHz band could use existing 700MHz and/or 800MHz cell sites, providing vital additional capacity across wide areas without major additional deployment costs. Higher frequency bands, such as 2.1GHz, cannot deliver the same nationwide coverage without a prohibitively high investment in infrastructure, making sub-1GHz bands a unique means of delivering virtually ubiquitous, affordable mobile broadband services.[14]

There is also considerable potential for global or near-global harmonisation which would drive low cost equipment and widespread roaming. The entire band is allocated to the mobile service alongside broadcasting in Asia-Pacific and a significant portion is allocated to the mobile service in select countries in the Americas. Canada, Colombia, Mexico and the US support making the 600MHz band available for mobile broadband use - the US is already planning to auction the band in near future.

The sub-700MHz band is currently mainly used for traditional free-to-air broadcast delivery which will remain essential in the future and can be protected. However, the amount of spectrum required for broadcast television in the UHF band varies significantly from market to market due to the different number of channels offered. Therefore, it is in the interests of administrations that there is greater flexibility in how the sub-700MHz band can be used in order to meet evolving consumer demands for the delivery of video content. The band is able to support significant terrestrial broadcast television services as well as mobile broadband, so an IMT identification in this band is not a choice between the two alternatives, but rather a choice about how to best meet current and future demand for services.

For example, Canada, Colombia, Mexico and the United States are already making choices about how much broadcast spectrum they may be able to clear and the domestic and international provisions that will be required to protect the remaining broadcasters in the band. The United States is planning an incentive auction that means incumbent broadcasters will be offered financial incentives to voluntarily relinquish some or all of their spectrum usage rights in order to clear channels in the upper portion of the sub-700 MHz band for IMT use while allowing broadcasters to continue to operate in lower channels in the UHF band, and continue operations in the VHF band. Canada, Colombia and Mexico are currently exploring options for coordinating along their shared borders, including the option of aligning their bands with the post-Incentive Auction U.S. band plan.

Broadcasting services could be maintained in a smaller amount of spectrum using the latest technologies leaving a portion of the sub-700MHz band available for mobile broadband. This is possible by moving from analogue to digital TV, then to more efficient digital transmission technologies (e.g. the move from DVB-T to DVB-T2[15] improves spectral efficiencies by 50-60%[16]), and by employing state-of-the-art video codecs which are currently able to reduce the bandwidth requirement for a given quality of content by around 10% per year.[17] For example, DVB-T2 combined with the MPEG4 codec can support 14 standard definition (SD) channels in an 8MHz multiplexer. A more recent codec, PERSEUS, which has been endorsed by the European Broadcasting Union, could support three times the number of SD and HD channels as MPEG4 in the same 8MHz multiplexer.[18]

The revolution in broadband access and smartphone adoption, which has been most pronounced to date in developed markets, has also highlighted a major transformation in how TV services will be accessed in future. Two of Europe's leading state broadcasters recently declared the need to adopt an 'Internet-first' and 'mobile-first' content delivery platform[19] as fewer people are watching terrestrial broadcast services.[20] The ability to use mobile broadband networks to deliver TV content to more people in more places on more screens presents endless opportunities for broadcasters and content developers, but it is contingent on mobile services with access to sufficient spectrum.

Governments will be better placed to improve mobile broadband, broadcast and on-demand TV services by supporting greater flexibility in the sub-700MHz band at WRC-15. Such a change does not require the immediate re-planning of broadcasting services, however it will allow governments to control the evolution of broadband and TV services based on their own preferred timeframe and in coordination with their neighbours. Protection to support the long-term future of broadcast services can be secured through appropriate regulatory and technical provisions.

2. L-band (1350-1400MHz & 1427-1518MHz)

The GSMA recommends that a significant portion of the L-band is allocated to the mobile service (where not already allocated) and identified for IMT/mobile broadband. There is currently near global support for an IMT identification in most, or all, of the upper portion (1427-1518MHz) at WRC-15 (see fig 1). Numerous administrations are also considering supporting mobile use of the lower portion (1350-1400MHz) to serve as an uplink band with the entire upper portion used for downlink.

The band is able to deliver widespread mobile broadband services because it offers a good balance of capacity and coverage over relatively large areas, including inside buildings. Crucially, a significant portion of the band is already allocated to the mobile service worldwide (i.e. 1427-1525MHz) creating a major opportunity to quickly identify a harmonised band. The existing allocation contains a portion that is currently reserved for digital radio broadcasting (1452-1492MHz), which is effectively unused, and has already made available for mobile broadband in Europe.

The band currently supports a variety of applications including aeronautical telemetry, military and civilian radar systems, and fixed link transmission systems. The adjacent bands contain mobile satellite

allocations in 1518-1525 MHz and an earth observation satellite allocation in 1400-1427 MHz. Studies show that compatibility between the services in adjacent bands and mobile broadband can be achieved through appropriate technical conditions and operational measures.

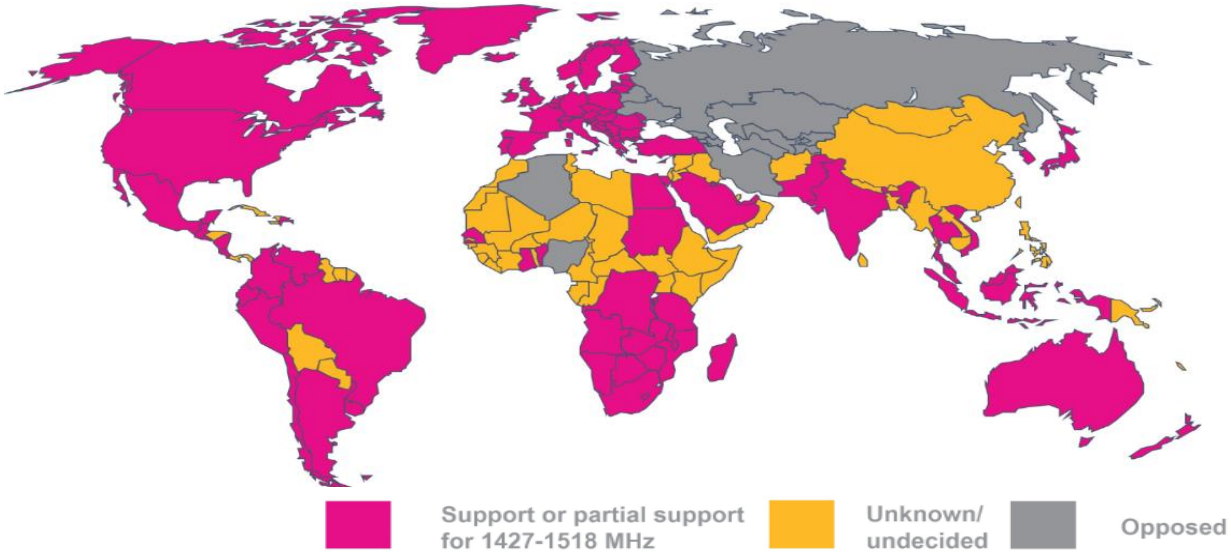

Figure 1. The status of support for 1427-1518MHz worldwide (March 2015)

3. 2.7-2.9GHz

The GSMA recommends that the 2.7-2.9GHz band be allocated to the mobile service and a substantial portion identified for IMT/mobile broadband. It could deliver crucial extra mobile capacity in busy urban areas where data traffic is rising quickly and deployments would be relatively low-cost because existing 2.6GHz cell sites could be used. There is also clear evidence that all existing radar requirements could be met in a portion of the band allowing mobile services to occupy the other portion.

The band is used for important civil and military radars, which are mainly located at airports, as well as some meteorological radars. However, some countries have no radars at all, in many others there are only one or two, while almost all of the remainder have no more than a few tens of radars operating in the band. Given the small number of radars in most countries, and their use of spectrum at fixed locations, there is a clear opportunity to examine using a portion of the band for mobile services.

There is growing interest and support for an IMT identification in the band from various countries in Europe, Africa and Asia. The UK's interest is especially notable because it is one of the heaviest users of radars in the band worldwide yet believes that the spectrum could be used more efficiently. A GSMA study[21] using real-world data showed that it is possible to relocate all existing radar requirements in the south-east of England, where radars are most densely used, into the 2.8-2.9GHz portion of the band thus making the 2.7-2.8GHz part available for mobile broadband. The study even showed there would still be spare capacity in the 2.8-2.9GHz portion to support more radars in future.

In the past, studies have shown that radar services cannot operate alongside mobile without prohibitively large exclusion zones. However, these conclusions are no longer valid as they were based on less spectrum efficient radar technology and use of the same, rather than adjacent, radio channels for both services.[22]

There is also a compelling economic argument for allowing mobile services to occupy a portion of the band. Research from Aetha Consulting shows that the estimated financial benefit of using the band for the mobile service in Western Europe would be over 10 times greater than the costs associated with relocating existing radar services.[23] Studies in a wide variety of other show similar economic benefits.[24][25]

4. C-band (3.4-3.8 & 3.8-4.2GHz)

The GSMA recommends that the C-band be allocated to the mobile service alongside existing satellite services and that a significant portion be identified for IMT/mobile broadband. The size of this band provides a unique opportunity to deliver very fast mobile broadband services in hotspots like coffee shops and train stations where mobile networks are under pressure from rapidly growing data usage. There is also now evidence from live LTE and satellite networks[26] that both services can successfully operate in the band in different portions when deployments are planned.

The potential for a globally harmonised mobile broadband identification is strong because a portion of the band (i.e. 3.4-3.6GHz) has already been identified for IMT/mobile broadband in 90 countries including much of Europe, the Middle East and Africa as well as a small number of countries in Asia and Oceania. Further, most of the C-band is allocated to the mobile service on a co-primary basis (i.e. 3.5-4.2GHz) alongside fixed satellite services (FSS) in the Americas and in the Asia Pacific.

There is also strong global support for expanding existing C-band IMT/mobile broadband identifications at WRC-15. There is a common European proposal for an IMT identification in the 3.4-3.8GHz band. In the Americas, there is widespread support for an IMT identification in the 3.4-3.6GHz portion and in North America this extends up to 3.7GHz. Similarly, in the Middle East and Africa there is support for widening the existing 3.4-3.6GHz IMT identification and some countries support extending it up to 3.8GHz. A number of countries around the world also support extending the IMT identification from 3.8 up to 4.2GHz to provide the flexibility to support long-term mobile capacity and performance requirements – these countries include Finland Japan, Korea, Sweden and the UK.

Although the C-band is starting to be used for LTE services, it is predominantly used for FSS, such as broadcast TV, VSATs and satellite broadband. In tropical countries, where the effect of rainfall has historically limited the use of other bands, C-band satellite services can be essential so mobile broadband services may often not be feasible. However, in most countries satellite operators[27] are increasingly using higher frequency bands (e.g. Ka and Ku) to deliver improved performance and better value services. This means that a portion of the C-band could start to be made available for mobile broadband, and this could accelerate as mobile data traffic rises further and more mobile devices support this frequency band.

Identifying a portion of the band for IMT/mobile broadband will still allow administrations to use the entire band for FSS services where required. However, it will also allow other administrations to gradually make parts of the IMT identified band available for mobile broadband when needed. This would give national regulators greater flexibility to use the band as they see fit and prepare for the long-term demand of all services. Options include retaining full FSS use in the band in rural areas where it is most needed, while allowing *part* of the band to be used for mobile broadband in urban areas where the mobile capacity challenge is greatest. [28]

Some satellite providers argue that interference studies show that the two services cannot co-exist in the C-band. However, this argument is based on sharing studies conducted for WRC-07 using assumptions that were not realistic. More recent sharing studies show that large exclusion zones are not necessary making mobile broadband use possible.[29] In fact, portions of the 3.4–3.8GHz band are already being successfully shared between mobile operators and satellite providers with no known cases of cross-border interference. The UK already operates FSS and LTE services in the C-band without interference problems. In the US, the FCC recently approved plans to allow mobile broadband services to operate in the 3.5GHz band in areas where radar and satellite services do not operate. Furthermore, incumbent services can continue to be protected from interference through international coordination between neighbouring countries and the use of appropriate technical and regulatory conditions.

Finally, the economic case for change is strong, as research shows the financial benefits of allocating a portion of the band to mobile services – even in areas where FSS is highly used – would surpass the costs of moving existing services elsewhere in the C-band or into different satellite frequencies. A study of the Asia-Pacific market by Frontier Economics shows the benefits exceed costs by approximately eight times, would increase government revenue by $52 billion, and create in excess of 100,000 new jobs.[30] Studies in other regions show similar economic benefits[31].

Agenda Item 1.2 – 700MHz in Region 1

At WRC-15, Agenda Item 1.2 will specifically assess the conditions for use of the 700MHz band (i.e. 694–790MHz) for the mobile service in Region 1 (i.e. Europe, the Middle East and Africa).

The band was allocated to the mobile service and identified for IMT/mobile broadband in Region 1 (i.e. Europe, the Middle East and Africa) at WRC-12 but only for use after WRC-15 when technical and regulatory conditions would be established to protect the broadcasting services in the adjacent band. The timely release of the band is essential in order to ensure LTE services can cost-effectively scale to meet growing demand, especially in rural areas, inside buildings and in emerging markets.

The technical and regulatory conditions should ensure regulators have agreed a band plan and emission levels so that mobile broadband services can be rolled out widely and cost-effectively without interfering with each other or broadcasters.

The GSMA has proposed and received widespread support for a band plan for Region 1 that is compatible with the Asia Pacific Telecommunity's (APT) 700MHz approach[32], which has already gained traction in Asia and Latin America. By adopting this compatible approach, it will be possible for operators and consumers to benefit from a wide range of lower cost equipment, including smartphones, ensuring LTE services can benefit people on all budgets regardless of whether they live in urban centres or rural areas.

References

[1] GSMA Mobile Economy Report 2015
[2] GSMA Mobile Economy Report 2015
[3] KT reveals huge data growth – 31st October 2013
[4] GSMA Mobile Economy Report 2015
[5] Cisco VNI Mobile, 2015
[6] Cisco VNI Mobile, 2015
[7] Report ITU-R M.2290-0
[8] Mobile data grew from 33PB per month in 2008 (Cisco VNI 2009) to 2.5EB per month in 2014 (Cisco CNI 2015)
[9] This factors in an element for Wi-Fi offload. See report ITU-R M.2290-0
[10] ITU-R M.2243
[11] $25 Smartphones on Firefox OS to Rock MWC
[12] The goal is to achieve a 'primary' allocation for mobile in each of the target bands. This means that mobile services would have the same rights to operate in the band as other services with 'primary' status. However, the mobile service would be prioritized over other services allowed in the band that have 'secondary' allocations and must therefore accept interference from 'primary' services
[13] An 'identification' for International Mobile Telecommunications (IMT) means that a specific frequency range in the band is dedicated for use by compatible mobile broadband technologies, including all 3G and 4G networks. The practical effect is to improve harmonization by providing clarity to equipment manufacturers and encouraging governments to align the use of the spectrum specifically for mobile broadband services
[14] E.G. 2.1GHz networks require around four times the number of base stations and three times the CAPEX to deliver the same coverage as 700MHz networks
[15] The evolution from DVB (Digital Video Broadcasting — Terrestrial) to DVB-T2 (Digital Video Broadcasting – Terrestrial 2nd generation) technology provides improved spectrum efficiency allowing more data to be carried
[16] Plum 2014
[17] Plum 2014
[18] V-Nova consortium launches ground breaking video compression [Press release] & Sky and EBU endorse novel compression technology with claims to double HEVC performance [news story]
[19] See 'BBC aims to go 'internet first' to attract younger audiences':http://www.theguardian.com/media/2015/apr/09/bbc-internet-first-bbc3-matthew-postgate. Also 'TV industry faces its 'ketchup' moment: 'Mobile is now the first screen':http://www.theguardian.com/technology/2015/apr/13/tv-industry-ketchup-moment-mobile-first-screen
[20] According to the EC Special Eurobarometer: e-Communications Household Survey March 2014 (p59) terrestrial broadcast made up 53% of EU TV owning households in Feb/Mar 2011 (i.e. 23% analogue + 30% DTT) and fell to 43% in Jan 2014 (i.e. 6% analogue + 37% DTT)
[21] CEPT document CPG-PTD(15)043, "2.7-2.9 GHz band segmentation, radar spectrum efficiency, and compatibility between IMT and radars", April 2015
[22] Numerous studies for the ITU show radars can share the 2.7–2.9GHz band using adjacent channels including:-
- JTG4567/353-E: Sharing between IMT systems and radars in the 2700–2900 MHz band
- JTG4567/541-E: Analysis of required mitigation for IMT systems and radars to share the 2700–2900 MHz band

[23] The findings from the study are discussed in JTG4567/193-E: Consideration of the 2.7–2.9GHz band and economic benefits that would arise from making this band available for IMT
[24] The findings of these studies are summarised in a GSMA paper entitled,'The suitability of an IMT identification in the 2.7-2.9GHz band at WRC-15'
[25] In Africa, the benefits were found to be range from approximately PPP$10 billion to PPP$22 billion, while costs are estimated between PPP $0.3 billion and PPP $1.1 billion. In the Arab States the benefits were found to range from approximately PPP US$5 billion to PPP US$11 billion, while costs are estimated between PPP US$0.1 billion and PPP US$0.6 billion
[26] For example, UK Broadband operates a live LTE service called Relish in the UK in the lower half of the C-band while satellite services continue to operate elsewhere in the band
[27] Companies which offer higher frequency (Ka and Ku) satellite services include SES, o3B and Avanti. Some are even offering services in tropical areas and can overcome the challenge of rain fade (e.g. see JTG4567/550-E: A study of rain fade depth on FSS frequency bands)
[28] Studies comparing coexistence between IMT/ and VSAT in Malaysia, South Africa and Colombia found that, 'under realistic but conservative assumptions, a separation distance of less than 5 km would typically be required. This is in contrast with the much larger separation distances that have been calculated in JTG 4-5-6-7'
[29] Numerous studies for the ITU show FSS services can share the C-band with mobile services without prohibitively large exclusion zones including:
- JTG4567/354-E: Studies relating to compatibility/sharing between IMT and FSS in 3.4–4.GHz
- JTG4567/355-E: Study into adjacent channel compatibility sharing between IMT and ubiquitous FSS earth stations in 3.4–4.2GHz

[30] The findings from the study are discussed in JTG4567/343-E: Consideration of the 3.4–4.2GHz band and the economic benefits that would arise from making part of this band available for IMT
[31] In Africa, the benefits were found to be range from approximately PPP$10 billion to PPP$22 billion, while costs are estimated between PPP $0.3 billion and PPP $1.1 billion. In the Arab States the benefits were found to range from approximately PPP US$5 billion to PPP US$11 billion, while costs are estimated between PPP US$0.1 billion and PPP US$0.6 billion
[32] This involves using 2x30MHz based on the lower duplexer of the standard APT band plan which uses 2x45MHz

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