Releasing Spectrum for Mobile Broadband in Egypt

A report for the GSMA

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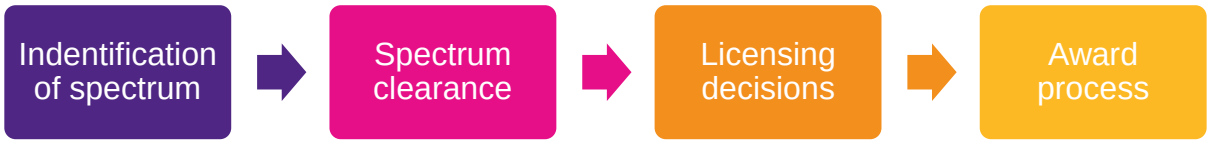
1 Introduction

This report has been commissioned by the GSMA to examine the spectrum which could be used to provide Egypt's citizens with mobile broadband, enabling economic growth and facilitating the creation of jobs. Plum and the GSMA have previously carried out an economic impact study of mobile broadband in Egypt, which is summarised in Section 2; this study found that releasing spectrum to enable mobile broadband to reach its full potential would increase productivity by a net present value of EGP310bn over the next fifteen years.

Given this potential benefit, it is crucial that the regulator and the Government in Egypt work together to ensure that spectrum can be released in a timely and organised manner. The GSMA has asked Plum to investigate which spectrum bands are suitable for use by mobile broadband in Egypt, and to consider the steps needed for these bands to be made available. Figure 1-1 provides an overview of the process that must be followed.

Figure 1-1: Spectrum release roadmap



In order to achieve this, Plum has discussed the current situation and future needs with both mobile operators and the National Telecommunication Regulatory Authority (NTRA), and has drawn on international experience when making recommendations.

Structure of this report

The remainder of this report is structured as follows:

- Section 2 summarises the findings of Plum's previous report which analysed the potential benefits of mobile broadband spectrum release in Egypt.
- Section 3 details the key frequency bands for mobile and which of these have been released for mobile in Egypt. It draws on the NTRA's input to identify four priority bands which the NTRA should release.
- Section 4 discusses the clearance of spectrum for mobile in principle and analyses likely clearance issues in the four priority bands in Egypt.
- Section 5 explores decisions that the NTRA will need to make when licensing spectrum for mobile and makes recommendations according to international best practice.
- Section 6 outlines the process the NTRA will need to go through to award spectrum to mobile operators and discusses key issues the NTRA will need to decide.

2 The benefits of awarding spectrum to mobile

The Egyptian telecommunications industry has seen rapid growth over the past ten years, driven by the uptake of mobiles. Mobile penetration now exceeds 100%, and over half of those with mobiles use them to access the Internet in some way. As the population becomes increasingly connected, the Government would ordinarily expect to be able to see substantial benefits both in economic growth and in social and cultural terms. However, these benefits will not be realised unless the Government acts now to enable the mobile broadband industry to grow with demand. Moreover, the policies that the Government chooses to follow will have a direct impact on the size of the benefit.

In 2011, the National Broadband Plan set a target for 2015 of 22% of households to be connected to fixed broadband, while 10% of citizens (approximately 8 million) should be subscribed to mobile broadband. However, since the publication of the Plan, it is clear these targets are no longer relevant. Fixed line penetration (for all lines, not just broadband) has fallen to 8% of homes, while as of December 2013 it was estimated that 18% of Egyptians (14.5 million people) accessed mobile broadband, well ahead of the target; in fact, this surpasses even the target set for 2021.

Therefore, it is increasingly evident that for the Egyptian Government to fully realise the potential benefits of broadband, it must focus its policies on ensuring that mobile broadband supply is not constrained. The potential benefits are very large. In a previous paper for the GSMA[1] which was presented to the Government of Egypt and the NTRA in 2014, Plum estimated that the productivity gain to 2030 driven by an **unconstrained** mobile broadband market is worth around **EGP310bn** in net present value, when compared to how the economy is set to grow with current market limitations. The key messages of the study are presented in Figure 2-1.

This growth in GDP of EGP310bn would be able to support the creation of up to 1.2 million jobs across the economy by 2030. On top of this pure economic impact, there will be further social and cultural benefits arising from the increase in penetration, and consumer surplus will also rise significantly. Currently, however, mobile operators are suffering from a shortage of suitable spectrum, meaning that the size of the market is constrained by capacity.

The previous study estimates that there could be a capacity crunch in the mobile networks from as early as 2019 if more spectrum is not released. Even where capacity constraints are forecast for a number of years from the present, operators must have certainty around the amount of spectrum they will have at the time, and preferably have access to the spectrum ahead of this point so that they may have fully tested and operational networks ahead of any capacity shortage.

The economic benefit of EGP310bn is based the 700 MHz and 800 MHz bands being used in 2020 and the remainder of 1800 MHz and 2.1 GHz bands being made available in 2018. If there is a delay to this then the net present value of the benefits to the Egyptian economy will be reduced. In order to meet this schedule of spectrum release the Government and regulator will need to urgently begin assignment and clearance processes.

The exact policies implemented by the Government will have a direct impact on the size of the benefit that can be realised. Plum's previous study looked at a further scenario, where the Government reserves certain new spectrum for new mobile network operators, and found that the total economic benefit (and, subsequently the total social and cultural benefits) is significantly reduced. This finding- which shows what policies must be put in place to maximise benefits-should be incorporated in a new national broadband plan.

[1] http://plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

Figure 2-1: Key messages

- This growth in GDP of EGP310bn would be able to support the creation of up to 1.2 million jobs across the economy by 2030. Currently, however, mobile operators are suffering from a shortage of suitable spectrum, meaning that the size of the market is constrained by capacity.
- The previous study estimates that there could be a capacity crunch in the mobile networks from as early as 2019 if more spectrum is not released.
- The economic benefit of EGP310bn is based the 700 MHz and 800 MHz bands being used in 2020 and the remainder of 1800 MHz and 2.1 GHz bands being made available in 2018.

This report comes at a critical time in the cycle of international spectrum allocation decisions. The ITU's World Radiocommunication Conference, which occurs every three or four years, will happen in Geneva in November. WRC-15 will allocate new spectrum bands for mobile services (IMT), thus allowing countries across the world to expand and encourage mobile broadband. The NTRA should be ready to rapidly respond to the decisions which will come out of WRC-15 in order to maximise the economic and social benefits of mobile broadband in Egypt. WRC-15 will also set the agenda for the next World Radiocommunication Conference (WRC-19): by the end of this year the NTRA will be in a position to know all the spectrum bands which are likely to be allocated for mobile by 2020.

Thus the decisions that the NTRA takes in the next couple of years will be the difference between whether Egypt is able to harness the decisions of WRC-15 and WRC-19 or not. It is vital that the NTRA has a clear, transparent and realistic roadmap for spectrum release for the next five years. This is in line with the objective that the NTRA states on its website, that it

> "*intends to blaze the trail for other countries within the Arab and African regions, to set an example for partner states equally serious about the notion of development"*

A recent Plum report highlighted the potential for countries in the Middle East and North Africa region to release spectrum for mobile[2]. Accomplishing the swift release of spectrum across a number of frequency bands for mobile broadband will both stimulate the Egyptian economy and cement the NTRA's reputation as a regional leader.

2.1 Challenges for operators

As the number of mobile subscribers has grown, from around 7 million in 2004 to 100 million in 2014[3], operators have found that they are increasingly constrained by both the capacity of their networks and the profitability of the service. This, combined with an element of regulatory uncertainty over the use and release of other spectrum bands, makes it difficult for operators to invest in providing their subscribers with better quality of service through sufficient bandwidth.

Further, operators are unable to significantly increase profitability through changes to the cost base, as many wholesale prices are kept at a high level by monopoly provision of core networks and international links, even if such monopolies are shifted or rebranded. If mobile operators are prevented from laying their own cables or buying wholesale at reasonable terms and conditions from multiple sources, they may be unable to access capacity where it is needed. It is also important that administrative and approval processes at both the local and national levels, such as getting planning

[2] http://plumconsulting.co.uk/pdfs/Plum_Aug_2015_GSMA_Terrestrial_broadcasting_and_spectrum_use_in_the_Arab_states.pdf

[3] ITU Yearbook

permission, do not delay or prevent operators from making the necessary investment in infrastructure. The Government must act to ensure that the overall telecommunications market is structured to support the provision of new and innovative services to end consumers.

In general, there is a need for a lower-cost alternative to investing in more and more sites to boost the network capacity, such as access to more spectrum under the existing market structure – without this, there is no business case for operators to expand the footprint of their network or invest in new technology, meaning that many Egyptian citizens will not be able to benefit from access to mobile broadband. Since operators must make long-term business plans for meeting capacity and demand, and as a result must be aware of when spectrum will be available a long time in advance, it is crucial that decisions on the award process and timing for releases of spectrum are made now.

2.2 Previous recommendations

It is clear from the outcome of Plum's previous study[4] that a new national broadband plan is required, taking into account the growth of mobile (and mobile broadband) in Egypt and revising objectives, targets and policies based on international best practice and experience. A clear, practical resource management plan will enable strong broadband growth. Trends in the industry demonstrate that the most efficient way of increasing internet connectivity across the society will be to facilitate the growth of mobile broadband. This will be best achieved by releasing more spectrum to Egyptian operators, without reserving this for new mobile network operators (including Telecom Egypt) but also without preventing any interested company from bidding if they are able to offer a competitive package to consumers. Through having access to more spectrum mobile operators are able to offer new services and build their networks at lower cost. Therefore more spectrum means lower consumer prices and greater consumer access to mobile broadband and thus the huge economic benefits it brings.

Given this, Plum made the following overall recommendations to the GSMA and the NTRA:

- The previous national broadband plan must be replaced. A new national broadband plan must be drafted, in consultation with industry and users, to overcome obstacles and set targets and policies for the markets for the next ten years. This study, and the work of the Kayan working committee, could be used as a basis to develop this new plan.
- The regulator must make as much spectrum available as possible for mobile broadband usage, as quickly as possible, particularly in the 700 MHz and 800 MHz bands. This must be awarded through a fair and transparent process with no bands reserved for any particular use or company.
- It is also important that the steps and milestones in the release process are clearly mapped out and effectively communicated to industry stakeholders to create a predictable environment for investment, which will ensure timely use of the spectrum.
- Access to infrastructure that is necessary for mobile broadband deployment-such as fibre duct, international gateway, landing stations and tower sites-must be made simpler and more cost-effective, and be closely monitored to ensure that neither price nor availability of the mobile broadband to consumers inhibits the take-up of service.

[4] http://plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

- Penetration of mobile broadband must be encouraged as the most efficient way of promulgating e-health, e-education and other Internet services that will improve the day-to-day lives of ordinary Egyptians, including in their dealings with public authorities.
- Consumers and businesses must be given the freedom to innovate in the use of Internet services that are demanded to increase business productivity (and thus GDP). Government services must also look to improve their usage of online services to make the public sector more efficient.
- The new national broadband plan should set reasonable targets set for fixed and mobile broadband penetration and quality of user experience to reflect the increased importance of mobile telecommunications in the economy. These revised targets will be particularly important in any discussion over the implementation of universal service.

3 Determining the bands for award

There are a number of frequency bands that have been identified for mobile and in many cases for IMT[5]. These are identified in the ITU Radio Regulations for Regions 1, 2 and 3 and also in the 3GPP standards. In addition there are a significant number of potential bands that are being considered as part of the forthcoming World Radio Conference (WRC-15) although at this stage it is difficult to predict the likely outcome because of the difference in views between the different regional positions prior to the conference.

It is important to recognise that operators require access to a mix of frequency bands that can provide coverage, in-building penetration and capacity. Frequency bands below 1 GHz are ideal for coverage and in-building penetration and bands above 2 GHz to support smaller cells and capacity hot spots. Another important consideration is the technologies that can be supported in the different frequency bands and the potential for operators to refarm their licensed spectrum to maximise spectrum efficiency.

Table 3-1 identifies the key frequency bands that have already been identified in Region 1, their typical deployment and associated technologies and the corresponding 3GPP band number, where applicable.

Table 3-1: Key mobile frequency bands

3GPP Band	Frequencies (MHz)	Comment
28 (700 MHz)	703-733 / 758-788	4G band (LTE and LTE-A). Sub-set of APT Band 28. Ideal band to provide coverage.
20 (800 MHz)	832-862 / 791-821	4G band (LTE and LTE-A). Ideal band to provide coverage.
8 (900 MHz)	880-915 / 925-960	Originally licensed for 2G but has been refarmed for 3G and 4G
3 (1800 MHz)	1710-1780 / 1805-1880	Originally licensed for 2G but now key band for 4G
1 (2GHz)	1920-1980 / 2110-2170	Supports 3G (UMTS, HSPA and HSPA+). Being refarmed for 4G
7 (2.6 GHz)[6]	2500-2570 / 2620-2690	4G band (LTE and LTE-A). Ideal band to provide capacity in urban areas
38 (2.6 GHz)	2570-2620	TDD band. Ideal band to provide additional downlink capacity in urban areas

In addition, spectrum was identified for IMT at WRC-12 in the 694-790 MHz band which is to be effective immediately after WRC-15 on a co-primary basis with broadcasting and is covered under agenda item 1.2[7] of the forthcoming World Radio Conference. There are indications that this

[5] IMT is an ITU designation for a specific subset of mobile services.

[6] The 2.6 GHz band is also known as the 2.5 GHz band in some parts of the world.

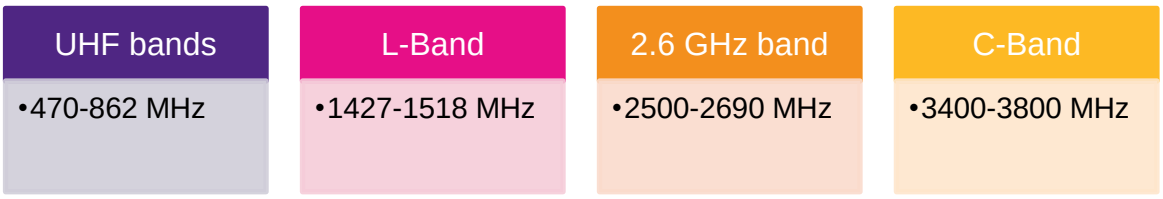
[7] Agenda item 1.2 of WRC-15: "*to examine the results of ITU R studies, in accordance with Resolution 232 [COM5/10] (WRC 12), on the use of the frequency band 694-790 MHz by the mobile, except aeronautical mobile, service in Region 1 and take the appropriate measures*."

spectrum will be awarded for mobile broadband in a significant number of European countries[8] with the main question being the likely timescales for spectrum availability and network deployment taking into account the need to "replan" current broadcasting usage to release the spectrum.

Finally, there are a number of other frequency bands that appear to be gaining traction in terms of preparation for WRC15 (agenda item 1.1 is where further frequency bands are being identified for IMT). These include the 1.5 GHz band ('L-Band') and also the 3.4-3.6 GHz and possibly 3.6-3.8 GHz bands (collectively known as 'C-Band'). The latter two bands are already identified as 3GPP bands (Bands 42 and 43 for TDD, respectively) and are already being awarded in Europe for mobile broadband.

Against this international background, the NTRA has indicated its priorities for the bands it will release for mobile broadband in the next few years; these are set out in Figure 3-1 below. No rationale was provided with this information and it is assumed that it relates to the ease with which spectrum can be reallocated.

Figure 3-1: Priority bands for the NTRA



In the following sections each of the priority bands for the NTRA are considered individually. However, the NTRA has not indicated that it intends to expand the award of the 1800 MHz or 2.1 GHz bands, or look at whether the 900 MHz band is allocated efficiently. As expansions of existing spectrum holdings, these may be the easiest for mobile operators to include in their current networks. These currently-awarded mobile bands are examined first.

3.1 Currently awarded mobile bands

In addition to the spectrum bands listed in Figure 3-1, the NTRA must make sure that any additional capacity that can be made available in the 900 MHz, 1800 MHz and 2.1 GHz bands is explored. This additional spectrum would also provide the opportunity to support migration to 3G and 4G technologies.

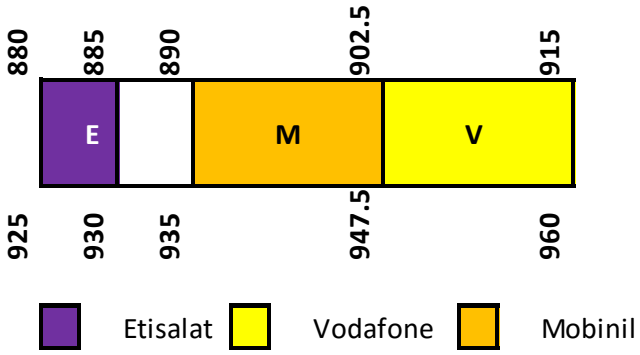
If unconstrained by other use or inefficient band planning, the 900 MHz band has the potential to provide a total of 2×35 MHz, the 1800 MHz band 2×75 MHz and the 2.1 GHz band 2×60 MHz respectively. Information provided by the mobile operators indicates the current frequency arrangements in each of these bands.

[8] The UK, France, Sweden, the Netherlands and Finland have already expressed their intention to use the 700 MHz band. Germany auctioned the band in June.

3.1.1 900 MHz

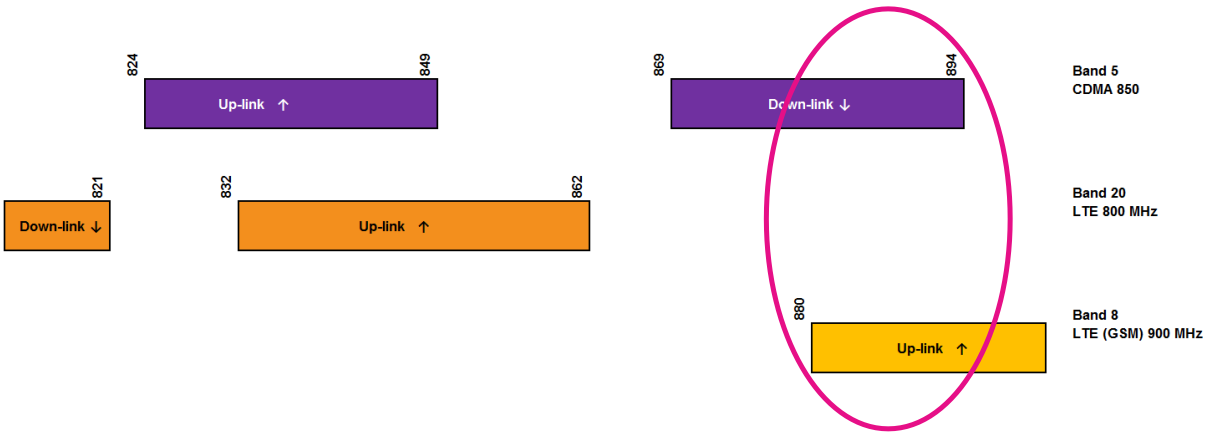
The majority of the 900 MHz band is licensed to the mobile operators including 2×5 MHz in the E-GSM band as shown below:

Figure 3-2: Arrangement in the 900 MHz band



It is understood that there may be the potential to award the remaining 2×5 MHz in the E-GSM band (885-890 / 930-935 MHz). Whilst access to the remaining portion of the 900 MHz band is attractive it does raise concerns about the potential for interference with the use of CDMA 850 in Egypt and also neighbouring countries. It is understood from Etisalat that they have experienced problems with interference in the lower portion of the E-GSM band. This may be because CDMA 850 networks use a reverse duplex – the CDMA 850 base station transmitters have the potential to interfere with the Etisalat base station receivers operating in the E-GSM part of the 900 MHz band, as shown in Figure 3-3, and highlighted by the pink ellipse. Therefore use of the E-GSM frequencies will be limited to regional geographic areas where CDMA 850 has not been deployed and there is sufficient geographic separation to avoid interference into the base station receivers. However, separation distances are unlikely to be sufficient in the case of anomalous propagation – there will be instances where the quality of service is impacted. Cross-border interference implications of CDMA 850 are considered in section 5.2.6.

Figure 3-3: Implications of CDMA 850 network deployments on use of other 3GPP bands

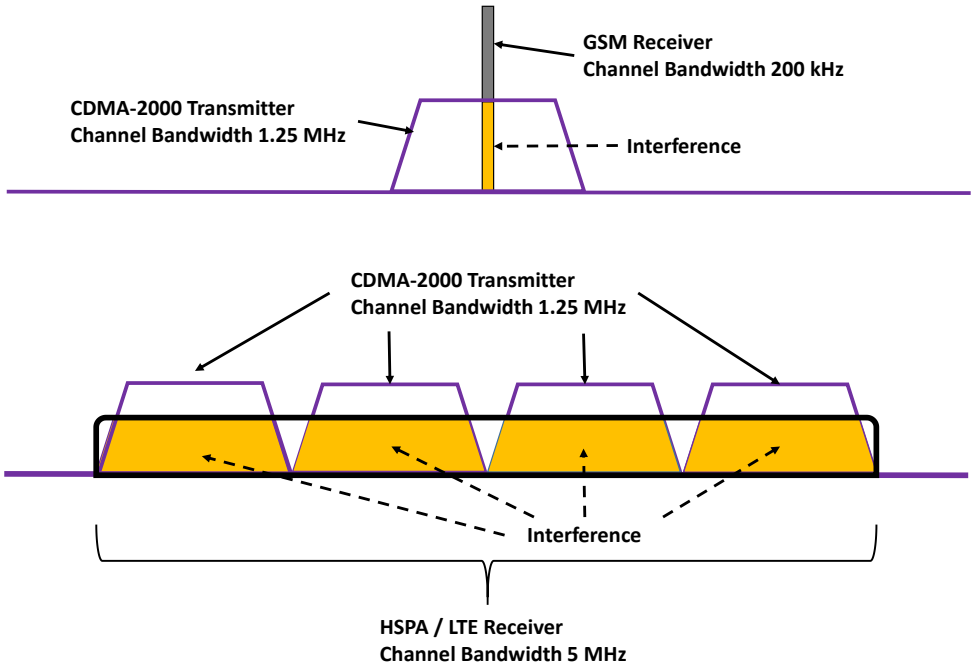


Source: Plum Consulting

The figure below demonstrates the potential for wideband interference assuming use of CDMA 2000 technology and shows that whilst the impact might be limited for GSM receivers operating in the band the situation may be significantly worse if the spectrum is used for HSPA (UMTS) or LTE technologies. This interference will cause a degradation in capacity of the networks and might even block the receivers depending on the signal strength of the CDMA 850 and the relative geographic location of the base stations.

It is highly likely that the interference issues are co-channel so the use of filters in both the CDMA base station transmitters to limit out of band (spurious) transmissions and improve the filtering in the receivers operating in the lower part of the 900 MHz band will not be an option.

Figure 3-4: CDMA interference into GSM and HSPA or LTE



Studies have been undertaken in the APT (Asia Pacific Community)[9] as there are countries where a mix of technologies are deployed. Recommendations based on testing in Indonesia in the 1900 MHz band, where there is a similar interference scenario, conclude that a guard band of 5 MHz is required between the allocations to CDMA 2000 and W-CDMA and that the sites will need to be co-ordinated. PT Indosat also considered the guard band requirements between CDMA 2000 systems with a downlink of 869–894 MHz and GSM or WCDMA systems with uplinks in the band 880–915 MHz and concluded that the guard band can be optimised to a value of 685 kHz with a careful choice of equipment. However, the new allocation scheme decision meant that a sole operator, Indosat, was responsible for managing the interference between the networks which makes it considerably easier.

Given this experience, it is clear that there will be interference issues between CDMA 850 systems and GSM and this situation will be worse if the E-GSM band is redeployed for HSLA or LTE. Whilst in Indonesia it was possible to minimise the guard band as both networks were managed by Indosat that

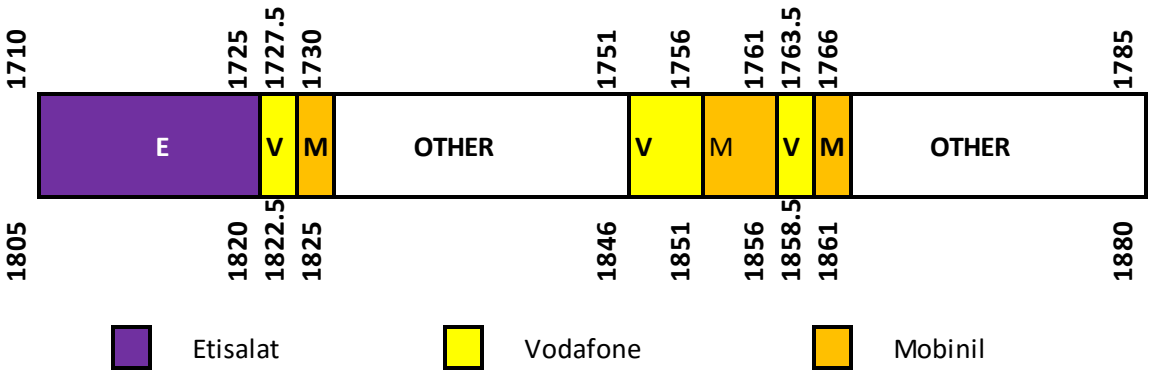
[9] See APT (Asia Pacific Community) Working Document AWG-14/TMP- 34 (20 march 2013) that addresses "Studies on the co-existence between IMT-2000 technologies and between IMT-2000 technologies and other wireless access", Attachments 1 and 3.

is not the situation in Egypt. Even if the CDMA 850 networks are ceased in Egypt there still remains the potential for cross border interference from CDMA 850 networks operating in neighbouring countries and this will limit the use of these E-GSM frequencies near the border. This does mean that the remaining 2×5 MHz of spectrum in the 900 MHz band may not have the potential to provide complete national geographic coverage.

3.1.2 1800 MHz

Figure 3-5 shows the current situation in the 1800 MHz band.

Figure 3-5: Arrangement in the 1800 MHz band



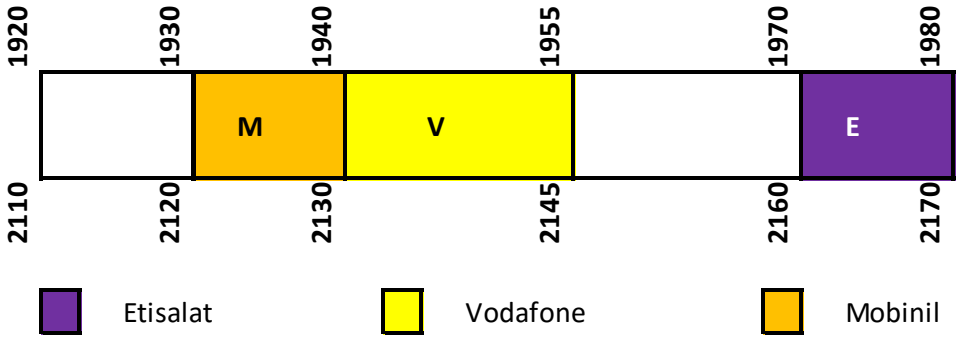
It can be seen from Figure 3-5 that over 50% of the 1800 MHz band is not used by mobile operators; this spectrum is currently used for other services by other users. The 1800 MHz is a prime LTE band, as will be shown in Figure 3-8, and in addition to identifying the potential to release further spectrum in the band the NTRA is advised to allow the operators to use the spectrum on a technology neutral basis. This would require the NTRA to update the operator's service licences which define the technologies that may be used to deliver services.

It can be seen from the arrangement in the 1800 MHz band and the frequencies that are currently assigned to the three operators, Etisalat, Vodafone Egypt and Mobinil, make it very difficult for Vodafone and Mobinil to migrate to LTE technology which ideally requires 2×10 MHz contiguous blocks. This could be achieved, for example, by releasing (refarming) further spectrum below Vodafone's and above Mobinil's currently licensed spectrum. In addition NTRA would be advised to discuss with the operators the possibility of re-arranging the band to provide contiguous spectrum for all operators in the longer term.

3.1.3 2.1 GHz band

Finally, the current 2.1 GHz band arrangement is shown in Figure 3-6.

Figure 3-6: Arrangement in the 2.1 GHz band



It is understood that in 2006 and 2007[10] a total of 2×30 MHz of spectrum was licensed with each of the three operators having 2×10 MHz each. Since then a further 2×5 MHz has been licensed to Vodafone. The current arrangement in the band provides an ideal opportunity to increase the spectrum available, on a contiguous basis, to all the operators if they wish to increase their current holdings of 2×10 MHz or 2×15 MHz. This would require the NTRA to clear the other users from the band.

3.1.4 Conclusion on way forward

The NTRA should investigate, on an urgent basis, the potential to release further spectrum in the 1800 MHz and 2.1 GHz bands. They should also ideally update the service licences to allow the operators to deploy 4G technologies to support more spectrally efficient use of the available frequencies and match with the growing market demand.

3.2 UHF Bands

This section addresses the frequency range 470-862 MHz; known collectively as the UHF bands. These lower frequencies are ideal to provide coverage due to their excellent propagation properties (they travel further than high frequencies) and ability to provide indoor coverage.

3.2.1 Current use in Egypt

Historically, the 470-862 MHz band has been allocated to analogue broadcasting and its use is coordinated with neighbouring countries. The aim was to undertake switchover from analogue to digital terrestrial broadcasting by June 2015[11] and Egypt has started the DSO process, but according to the NTRA "*the exact timing for fully moving to digital has not yet been determined*" and there is currently no information on the progress of frequency or network planning, deployment of digital

[10] Plum database information obtained from publicly available documents

[11] The deadline for the switchover from analogue to Digital Terrestrial Television (DTT) was set by ITU Member States at RRC-06. There have been later dates agreed since 2006 for individual countries and frequency bands.

terrestrial broadcasting transmitters and the readiness of the market to switch to digital in terms of set top boxes or similar. However, the NTRA has finalised DSO frequency coordination with neighbouring countries with respect to the transition process from analogue to digital and is in discussions with equipment manufacturers to deploy set-top boxes. It is important that Egypt completes the digital switchover in the near future; especially given that as of June 2015 no protection is provided to analogue broadcasting from interference and the need to release spectrum for mobile.

The 470-790 MHz band has been licensed for digital terrestrial TV (DVB-T2) on a national basis. The licences are for an indefinite period (no fixed expiry date). It is understood that there are plans to reallocate the broadcasting service to below 614 MHz which means the spectrum available to broadcasting will be 470-614 MHz, but this may require further frequency coordination.

3.2.2 ITU allocation

The frequency bands 694-790 MHz and 790-862 MHz are already allocated to mobile in the Radio Regulations for Region 1[12]. The 470-694 MHz band is allocated to broadcasting and there is no mobile allocation.

At WRC-15 the 694-790 MHz band, agenda item 1.2, will be made available for mobile but it is unlikely that there will be agreement to identify the 470-694 MHz band as co-primary with broadcast based on the recent Regional positions. However, this band might be identified for mobile through footnotes on a country-specific basis.

3.2.3 Regional experience

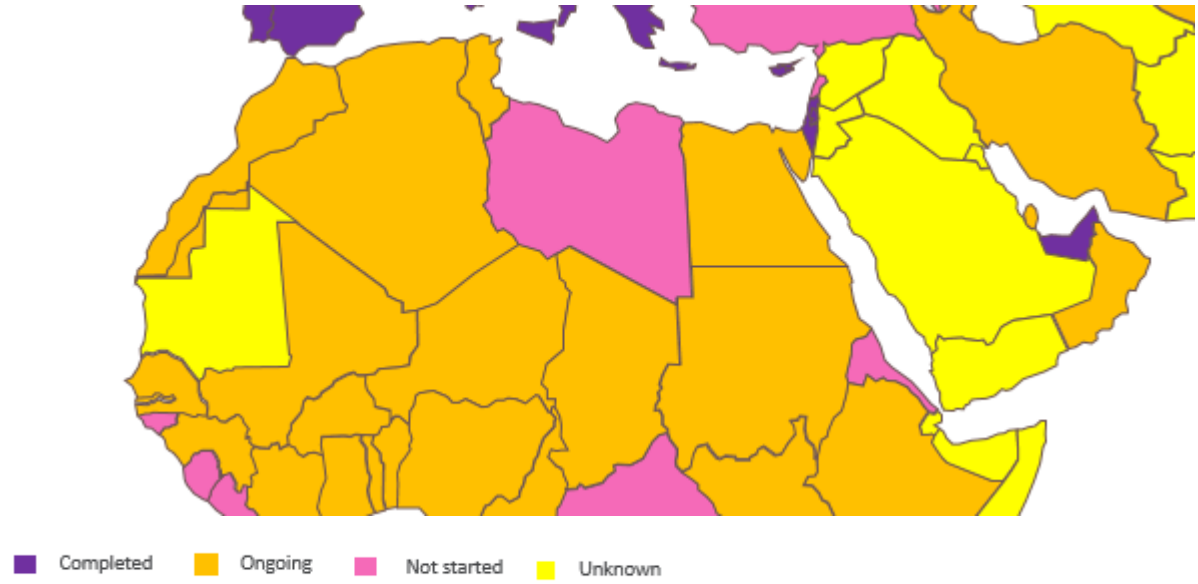
There is currently no licensing of the 790-862 MHz band for mobile broadband in the Region, with the exception of the UAE[13], due to delays in terrestrial switchover to digital technology and the consequential impact on the release of spectrum for mobile. Figure 3-7 is based on a Questionnaire undertaken by ITU-D[14] and shows that even if Egypt completes the switchover there is still the potential for interference from neighbouring countries that have not completed or possibly even started the process.

12 According to Footnote 5.316B the allocation to mobile shall come into effect from 17 June 2015. For countries party to the GE06 Agreement, the use of stations of the mobile service is also subject to the successful application of the procedures of that Agreement. Resolution 224 (Rev.WRC-12) and Resolution 749 (Rev.WRC-07) shall apply as appropriate. (WRC-12)

13 See http://www.gsma.com/spectrum/uae-gives-go-ahead-to-800mhz-lte-launch/

14 See http://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Pages/DSO/default.aspx

Figure 3-7: Status of digital switchover in the MENA Region



Source: ITU-D and Plum Consulting

There is clearly the potential for interference into mobile networks from broadcast transmitters operating in the same frequency band in neighbouring countries, especially if they are high sites with high transmitter powers and located near the national borders.

There is also use of CDMA 850 in the Region which makes the 700 MHz band more attractive for the award of mobile broadband based on the 3GPP band plan 28. However, access to the 700 MHz band, 694-790 MHz, is less clear and depends on the outcome of the recent re-planning exercises of the broadcast spectrum below 694 MHz based on four multiplexes per country and the implementation of any new digital broadcasting plan[15].

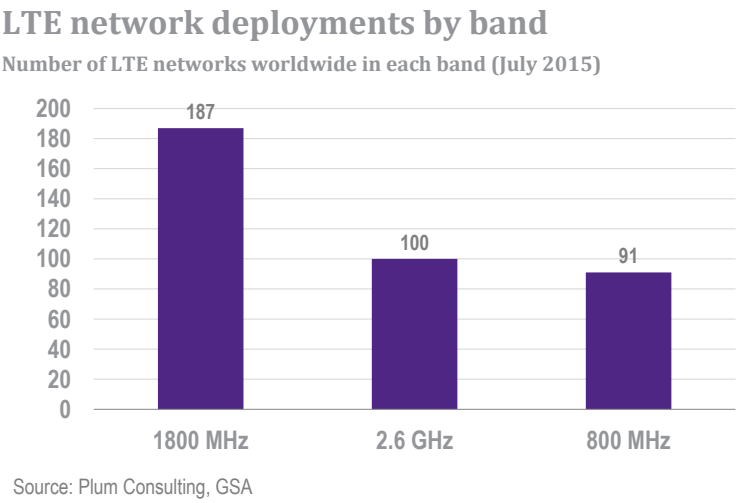
3.2.4 Conclusion on way forward

The NTRA is currently planning on only releasing the 700 MHz band for mobile broadband in Egypt. This band is ideal to provide coverage, including indoor from base stations located outdoors. However the 800 MHz band provides similar properties and it is the third most used band for LTE network deployment, after the 1800 MHz and 2.5 GHz bands, with 91 networks deployed worldwide[16].

[15] See http://www.itu.int/en/ITU-R/terrestrial/broadcast/ASMG/Pages/default.aspx

[16] See http://www.gsacom.com/news/gsa_430.php

Figure 3-8: LTE network deployments by band



Source: Plum Consulting, GSA

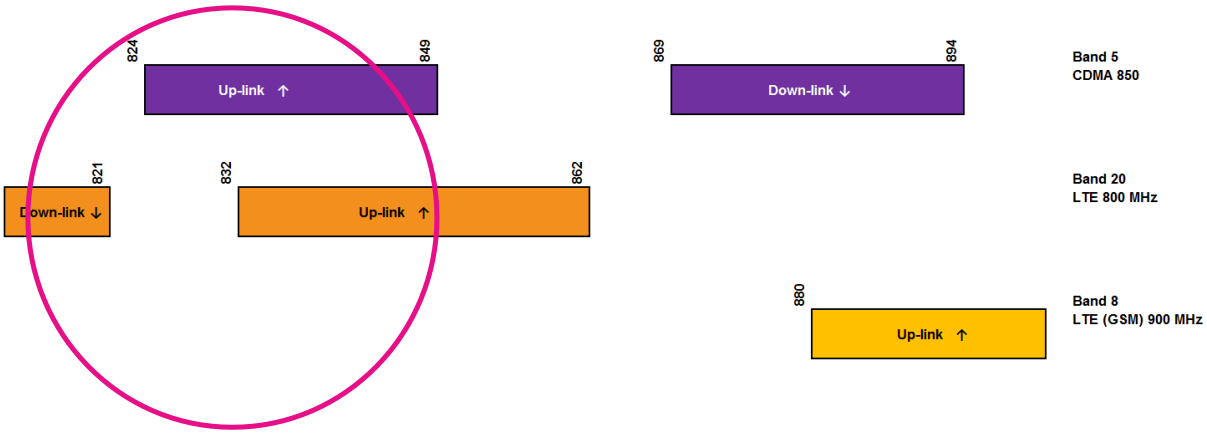
The priority for NTRA should be to complete the DSO so that spectrum can be reallocated and licensed for mobile broadband. Egypt has fallen behind other countries in Region 1 in the digital switchover process and it will bring huge benefits when completed. It will be essential as part of the licensing process to identify any potential for interference from neighbouring countries that may not have completed switchover. Most countries to date have first licensed the 800 MHz band[17] as there is an established eco-system with terminals readily available.

The 800 MHz band is used by Telecom Egypt as wireless local loop (WLL) using CDMA 2000 1X in the geographic areas of Cairo and Sinai. The licences are for 4.5×2 MHz and were issued in January 2005[18]. The NTRA has no current plan to allow this spectrum to be refarmed for LTE services. It can be seen from Figure 3-9 that the CDMA 850 base station receiver will suffer from interference from the LTE 800 downlink. This will require LTE base station transmitters to have more stringent roll-off and for the CDMA 850 receivers to include extra filters for protection against overload. In the range 832 – 849 MHz there is the potential for severe interference between the mobile terminals. Therefore access to the band may be limited until the CDMA 850 licence expires or agreement can be reached to refarm and relicense the spectrum according to the Band 20 band plan.

[17] Often referred to as the first digital dividend

[18] See https://www.cdg.org/technology/product_pavilion/operator_detail_cdmaone.asp?operatorid=97

Figure 3-9: Implications of CDMA 850 network deployments on use of other 3GPP bands



Source: Plum Consulting

Due to the current deployment of CDMA 850 it might prove easier for the NTRA to release the 700 MHz band first and we understand that is their intention. A number of countries in Europe[19] have already adopted the Band 28 plan but limited to 703-733 / 758-788 MHz. The UAE has also confirmed adoption of the APT700 lower 2×30 MHz duplex plan[20]. According to the GSA[21] there are 76 APT700 (band 28) devices available from 13 manufacturers and 10 commercially launched networks. It is therefore anticipated that suitable devices for the limited Band 28 plan should be available once the frequencies are released.

The spectrum below 694 MHz will most likely take longer to be identified as a harmonised band and much will depend on the outcome at WRC-15. A staged approach to releasing the UHF spectrum will mean that the 800 MHz band can be released for mobile as soon as possible.

3.3 L-Band

This section addresses the frequency range 1427-1518 MHz, known as the L-Band. These frequencies are very attractive for IMT services because they offer a significant amount of spectrum which could be used as a supplementary downlink (SDL) to provide additional capacity to support asymmetric traffic (typically, there is more downlink than uplink traffic). The propagation characteristics of the band are such that they can provide good coverage and in building penetration.

3.3.1 Current use in Egypt

The frequency bands 1427-1452 MHz, 1452-1492 MHz and 1492-1518 MHz are licensed for fixed links. The licences are for individual links and are renewed automatically on an annual basis. The links in these bands are typically low capacity based on the ITU-R channel plan recommendations

[19] For example Finland, France, Germany, Sweden and the UK have already adopted the APT700 band plan 28 (703-748 / 758-803 MHz) but limited to the lower 2 x 30 MHz duplex (703-733 / 758-788 MHz).

[20] See http://www.gsacom.com/downloads/pdf/APT700_zone_Snapshot_APT700_extract_GSA_Evolution_to_LTE_report_090415.php4

[21] A report from the GSA (Global mobile Suppliers Association) on the "Status of the LTE Ecosystem", 16 February 2015

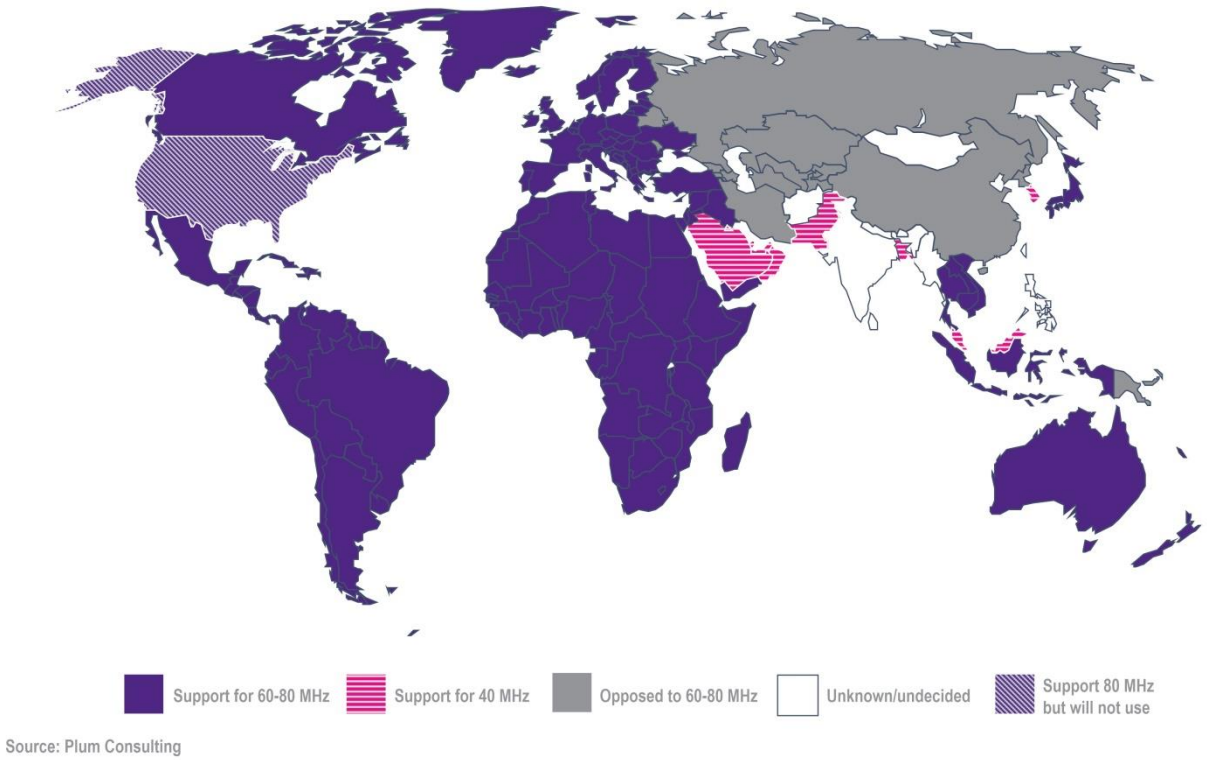
which support narrower bandwidths. According to the NTRA, all the spectrum has been assigned at different locations in Egypt.

3.3.2 ITU allocation

The 1427-1452 MHz, 1452-1492 MHz and 1492-1518 MHz bands are already allocated to mobile (except aeronautical mobile) on a primary basis in ITU Region 1 (as well as to fixed links). The 1452-1492 MHz band has also been allocated to broadcasting and broadcasting satellite.

Figure 3-10 provides an indication from earlier in 2015 of the support for the use of some or all of the 1427-1518 MHz band for mobile broadband (IMT), including Egypt[22]. Indications are that the frequencies could be harmonised on a global basis thereby offering significant scale economy benefits.

Figure 3-10: Status of commitment to 1427-1518 MHz for IMT services



Source: Plum Consulting

3.3.3 Regional experience

There is currently no spectrum available as the precise frequency bands depend on the outcome of WRC-15 and therefore there is no relevant regional experience in the Middle East.

[22] See http://plumconsulting.co.uk/pdfs/Plum_October_2015_Global_Economic_Impact_1.4_1.5_GHz_for_mobile.pdf

3.3.4 Conclusion on way forward

The way forward will depend on the outcome at WRC-15. The band is not currently identified within 3GPP (the standards body) for LTE and there may be some further work required depending on the band plans that are adopted. Availability of equipment and terminals will depend on the degree of harmonisation that is achieved across the ITU Regions.

In Egypt it will be important to consider the options for reallocation of the band from fixed links to mobile broadband. It may be possible to replace some of the fixed links with wired solutions but for those links in rural areas a wireless solution, operating in alternative spectrum is likely to be the only option.

3.4 2.6 GHz band

The 2.6 GHz spectrum can be divided into paired (2500-2570 / 2620-2690 MHz) and unpaired (2570-2620 MHz) bands. The paired band is harmonised on a global basis excluding North America. The frequencies are ideally suited to provide additional capacity especially in urban and sub-urban geographic areas. It is an attractive band because of the potential to support wide bandwidths (2×20 MHz) which will allow the deployment of higher speed data services.

3.4.1 Current use in Egypt

According to the NTRA, the 2.6 GHz band is currently used by "*legacy fixed links and the public sector*".

3.4.2 ITU allocation

The 2500-2690 MHz bands are already allocated in ITU Region 1 to fixed and mobile (except aeronautical mobile) on a co-primary basis. In addition 2520-2670 MHz is allocated to the broadcasting satellite service on a primary basis. Also footnote 5.384A of the Radio Regulations identifies the 2.6 GHz band for use by administrations wishing to implement IMT.

As noted in Figure 3-8 the 2.6 GHz band is already an important LTE band with 100 networks using the paired spectrum. The use of this band for mobile broadband is not dependent on the outcome of WRC-15 as it was allocated by the World Radio Communication Conference (WRC) in 2000 for terrestrial mobile communications services. It has been licensed in a number of European countries in combination with the 800 MHz band where the networks are mature and there is no further spectrum available in the 900 MHz, 1800 MHz and 2.1 GHz bands.

3.4.3 Regional experience

There have been no spectrum awards of the 2.6 GHz bands in the Middle East (although Turkey auctioned both in August 2015).

3.4.4 Conclusion on way forward

This band is already well established for the deployment of LTE and the band is ideal to provide additional capacity in urban and possibly sub-urban geographic areas.

It is understood that the implications of refarming the spectrum have already been considered and that there is now a need to formally start the process and undertake the necessary coordination and negotiation. The actual removal of existing users from the band has been estimated to last around one year but there are no indications how long the preparations and associated agreements will take.

There could be merit in concentrating on the release of the spectrum on a phased geographic basis if possible. This will provide much needed spectrum to those locations where there are capacity constraints. However, this spectrum is less attractive to the operators than access to the other bands such as 1800 MHz, 2.1 GHz and 800 MHz (as well as 700 MHz) as it is most suited to provide additional capacity at hot spots and not significant geographic rollout.

3.5 C-Band

The C-Band considered here is 3400-3800 MHz. It provides a significant amount of bandwidth suitable for mobile broadband for the provision of additional capacity.

3.5.1 Current use in Egypt

In the 3400-3800 MHz bands there are existing regional and national WiMAX licences which have no set expiry date. It may, however, be possible to share the bands between the two technologies on an adjacent or even regional co-channel basis depending on the market demand for fixed wireless access services. Such considerations are currently being consulted on by the Irish Regulator, ComReg[23].

3.5.2 ITU allocation

The 3400-3800 MHz spectrum is currently allocated, in ITU Region 1, on a co-primary basis to fixed and fixed satellite (Space-Earth) services and to mobile on a secondary basis.

The 3.6 GHz band was identified at the World Radio Conference 2007 (WRC-07) for IMT (International Mobile Telecommunication) by certain countries[24] and despite it not becoming a global allocation it was accepted by many countries for mobile services subject to some specific obligations (cross-border deployments and power limitations). The 3.6 GHz band[25] has since been identified in September 2012 by 3GPP for deployment of LTE-TDD and is considered suitable for the deployment of small cells to support higher data rates using LTE-Advanced.

It is unlikely that a world-wide harmonised allocation will be identified at WRC-15 because of the use of the band for fixed satellite services in a number of countries-in Asia there is opposition to allowing

[23] See http://www.comreg.ie/publications/consultation_on_proposed_3_6_ghz_band_spectrum_award.583.104900.p.html

[24] See footnote 5.430A of the Radio Regulations

[25] Identified as bands 42 (3400-3600 MHz) and 43 (3600-3800 MHz).

mobile broadband above 3600 MHz and APT opposes release of 3400-4200 MHz for IMT. In Europe there are already moves to licence the band 3400-3800 MHz and there are EC Decisions that relate to this spectrum.

3.5.3 Regional experience

There is currently no experience of allocating C-Band to mobile in the Middle East or North Africa. C-Band presents an opportunity for the NTRA to be in the vanguard of regulators authorising mobile use of the band.

3.5.4 Conclusion on way forward

It is unlikely that the 3400-3800 MHz band will become mainstream for mobile broadband until 2020[26]; further, there are views being currently expressed that the band might be suited for continued provision of fixed wireless using WiMAX or LTE and other more spectrally efficient technologies, although the band has been identified for heterogeneous networks where the band can be used to deploy small cells for offloading traffic from the wide area coverage layers. The release and licensing of this band for mobile broadband might be a longer-term option if the 2.6 GHz band can be refarmed as they are potentially substitutes for each other in terms of providing additional capacity in urban areas, and there is a far greater and more advanced ecosystem for the 2.6 GHz band.

However, it would be sensible for the NTRA to start exploring the potential ongoing demand for fixed wireless and the possible options to migrate existing licensees from all or part of the band, including studying the associated costs and timescales. Also the existing users should be made aware that their licences are not likely to be renewed after a date to be decided (such as 2020).

3.6 Backhaul spectrum

It is important to ensure suitable spectrum is also available to provide the necessary fixed links between base stations and the core network where fibre is not an option. These links typically require access to spectrum ranging from 6 GHz to 38 GHz, depending on the required link lengths, in frequency bands allocated to fixed services.

3.7 Overall conclusions

The NTRA should prioritise the identification of further spectrum that can be awarded in the 1800 MHz and 2.1 GHz frequency bands. In the 900 MHz band it is recommended that the NTRA should consider the ceasing of CDMA 850 to avoid the interference into the E-GSM band. In addition we would encourage the NTRA to adopt a technology neutral approach and allow the operators to refarm their spectrum for 4G technologies which will improve spectrum efficiency and ensure a market-led approach to service and capacity network planning.

[26] See http://www.plumconsulting.co.uk/pdfs/Plum_Jun_2015_ComReg_Technical_advice_3.6_GHz_band_Report_2_Rollout_considerations.pdf.pdf

Access to the 700 MHz and 800 MHz bands is also a priority to the mobile operators, and it is essential that the NTRA progress the rollout of the digital terrestrial TV network and the consequent switch off of analogue TV.

Finally, in respect of the 1452-1492 MHz, 2600 MHz and 3400-3800 MHz bands are a lower priority than the other bands. However, this does not mean the NTRA should not be monitoring developments in the Region and elsewhere and preparing existing users to migrate from the bands. It is important for the NTRA to indicate timescales they are currently targeting for award of these bands to provide certainty to the mobile operators.

4 Spectrum clearance

The analysis in Section 3 discusses the clearance of spectrum for mobile broadband use, looking at each band individually. This section first sets out an overview on how clearance should take place, and then highlights the obstacles that must be overcome for each of the identified bands.

4.1 The clearance process

When the NTRA allocates spectrum to mobile communications which had previously had a different use, then the NTRA must oversee the clearance of the spectrum. Clearance is the process of ceasing or moving the use of spectrum by other services so that frequencies can be made available for mobile use.

The first step has to be to identify those services that cannot co-exist with the planned new spectrum use on a co-channel, adjacent channel or geographic basis. It may be necessary to undertake interference modelling to inform decisions on which services need to be cleared from the spectrum and what are the implications of this does not occur. It is important to recognise that there may be limited potential to manage interference by reducing transmitter powers or defining block edge masks.

Clearance involves the refarming or reallocation of spectrum and the potential approaches are well defined ranging from release of spectrum at the end of licence duration or equipment lifetime to forced migration. Whilst the option of waiting until licence expiry has obvious attractions this might not be the preferred economic outcome or even feasible depending on the licensing regime and it is often necessary for the regulator to put in place the means to clear the spectrum.

There are three tasks that regulators need to complete in order to clear spectrum (and ensure it stays available for mobile usage):

i. Clear incumbents from the spectrum, potentially by allocating other spectrum for them to use or offering financial incentives for early release.
ii. Set in place technical standards and guard bands that ensure that mobile broadband and other users at lower and higher frequencies do not interfere with each other. Despite the presence of the guard bands, coordination between spectrum users may still be necessary.
iii. Create a system of monitoring and reporting to allow for feedback on interference.

This section details specific tasks that the NTRA will need to undertake in clearing spectrum for mobile. Section 4.2 is then a detailed discussion about clearing the priority bands in Egypt.

4.1.1 Moving incumbent users

In order to clear spectrum, existing users must move their operations elsewhere. There are three options available depending on the spectrum needs of incumbent holders.

- If incumbent users require the amount of spectrum they initially hold in order to operate, then the NTRA may need to make alternative spectrum available. This may require further clearance processes and studies.
- If incumbent users can compress their spectrum demand by making more effective use of the spectrum, or implementing compression technologies, then no reallocation is necessary.

However, the incumbents may need some financial compensation if transitioning to the new technology is costly.

- If there are wired alternatives then it might be appropriate for the existing users to take advantage of such options. For example, this might apply to fixed links or access networks where fibre is available as an alternative.

The option to be used will vary by the band studied, the ongoing demand and market size for the services being offered and whether there may be alternative delivery mechanisms such as wired solutions.

For the UHF bands, which are currently used by television broadcasting, the second option is the obvious option with digital terrestrial broadcasting technologies requiring significantly less spectrum than analogue to deliver the same services. As outlined in a recent study[27], once digital switchover is completed the amount of spectrum required for television broadcasting in Egypt, even after taking into account international interference and harmonisation plans, is likely to be less than 470-582 MHz which is significantly less than the current 470 -862 MHz[28] allocated to broadcasting. In addition the timescales for switch over and release of analogue spectrum have also been agreed as part of the Regional replanning of the broadcasting bands and although there is a clear indication that the 2015 will not be met in many countries in the Middle East there is the expectation that the spectrum will be released in the short term.

On the other hand, the use of L-Band by fixed links, where the licences are automatically renewed on an annual basis and there are no Regional imperatives to release spectrum by a set date, it will be necessary to discuss and set dates for migration from the band with the licensees and where necessary provide assignments in alternative fixed link bands. It is likely that the alternative bands will be at higher frequencies so it will be necessary for users to replace equipment and antennas. However, in the case of legacy fixed links in the 2.6 GHz band it is expected that they will generally be analogue and at the end of their life time and due for replacement anyway.

A detailed examination of the each of the bands is set out in Section 4.2.

4.1.2 Defining acceptable interference levels

All radio transmission equipment in addition to transmitting in band also transmits out of band which causes interference. The higher the power, the greater the chance of interference with other blocks and bands[29]. To combat this, regulators tend to define power limits, and regularly monitor interference levels. Interference levels are commonly defined using the terms ‘block-edge masks’ (BEMs) and ‘spectrum emission masks’ (SEMs).

[27] http://plumconsulting.co.uk/pdfs/Plum_Aug_2015_GSMA_Terrestrial_broadcasting_and_spectrum_use_in_the_Arab_states.pdf . It is understood that the study assumes more analogue programmes in Egypt than is currently the situation so the number of multiplexes may be an over statement.

[28] Due to cross border considerations and the use of multi frequency systems analogue TV broadcasting does not use all the 470 – 862 MHz band across all of Egypt.

[29] Interference is also a function of the quality of equipment; lower quality equipment or poorly installed and maintained equipment increase interference.

"A block-edge mask specifies permitted power levels over the block of spectrum of interest and its neighbouring blocks. The spectrum emission mask on the other hand describes the actual emission profile of a device." [30]

The NTRA will need to set BEMs in four categories:

- In-block: The in-block area is the frequency space that mobile operators are assigned to use for mobile broadband. The in-block power limit is set according to how much interference in other blocks and bands is acceptable. Lower power results in less interference.
- Out-of-block (Transition): The transition power limit is an intermediate level of power that is allowed between the in-block frequencies and the baseline out-of-block frequencies. There is a need for a transition frequency space because signals drop off in strength gradually rather than instantly.
- Out-of-block (Baseline level): The baseline power limit is the strength of signal that is allowed in frequencies that are far away from the licensed block.
- Out-of-block between bands: The NTRA needs to set a different baseline level for areas where the spectrum is allocated to a different usage. The baseline level of power for mobile transmissions is lower for frequencies which are allocated to broadcasting than frequencies which are also allocated to mobile.

4.1.3 Setting guard bands and duplex gaps

To ensure that transmissions between different spectrum uses, such as mobile and broadcasting, do not interfere with each other, the NTRA will need to set guard bands – unused blocks of spectrum positioned in-between allocated spectrum. Their size varies according to the amount of likely interference, which in turn depends on the power of transmission. Depending on the services, the relevant guard bands may already be determined[31].

The sizes of guard bands are set according to a trade-off: Larger guard bands reduce interference but also reduce the spectrum that can be allocated. The guard band between the uplink and downlink frequencies is called the 'duplex gap' and is often allocated to low power applications (such as PMSE). The size of the duplex gap is informed by technical factors, and below 1 GHz is usually at least 10 MHz. In the case of the paired LTE band plans the channel plans are harmonised on a Regional basis to ensure economies of scale for equipment and devices. As TDD allocation does not require separate uplink and downlink bands, TDD band plans do not have a duplex gap.

4.1.4 Setting reasonable timetables for clearance

Some incumbent users of spectrum will be able to clear bands in a quick and efficient way. For example, where incumbents operate few transmitters and receivers it can be possible to reconfigure each piece of equipment and test and monitor it within a matter of months. This would be the case, for example, for government-operated microwave fixed links between defined sites. Factors which are likely to lengthen the clearance process include:

[30] Forde, T.K., Doyle, L.E., B. Ozgul (2010) "Dynamic Block-Edge Masks (BEMs) for Dynamic Spectrum Emission Masks (SEMs), IEEE Symposium on New Frontiers in Dynamic Spectrum p.1-10.

[31] For example there is a guard band of 1 MHz between DTT broadcasting and the 800 MHz mobile broadband channel plan

- Multiple users of spectrum that have to be moved.
- Relatively large number of transmission or reception sites.
- Difficult reconfiguration of transmission or reception equipment. For example, if satellite uplink frequencies were changed, satellites and ground earth stations would need to be reconfigured.
- Lengthy procurement or installation process of new equipment.
- Lengthy decommissioning of old equipment.

The NTRA should be aware that there can be a loss of credibility if it sets unrealistic timetables or repeatedly misses deadlines. This can lead to uncertainty which would discourage investment in Egypt's telecommunications infrastructure. However, regulatory urgency will help Egypt realise the benefits of mobile broadband as soon as possible. Additionally, consultations with stakeholders are a powerful tool for the NTRA to assess how quickly change can occur and what issues will need to be dealt with.

4.2 Issues in clearing specific spectrum

As described in Section 3, the NTRA has identified four key spectrum bands which are to be allocated to mobile communications; the current uses for each of these bands are set out in Section 3. For each of these bands, this section describes the issues that the NTRA will face in clearing the bands and provides a methodology for achieving this.

4.2.1 UHF bands

The NTRA has identified that it wishes to allocate the 700 MHz band to mobile spectrum, and it should also consider refarming the 800 MHz band as well. This will require the spectrum above 614 MHz to be cleared of terrestrial television use. This approach is similar to the replanning and reallocation of spectrum that is underway across Europe and Africa. It has supported the award of the 800 MHz band to mobile broadband in many countries and also the 700 MHz band to mobile operators in Germany and France, with South African and Kenyan governments making statements on the future use of the band. However, in the majority of the countries it is the spectrum above 694 MHz that is currently being cleared and currently there is limited or even no consideration of potential channel plans for mobile spectrum below 694 MHz. Therefore the potential to utilise the spectrum between 614 MHz and 694 MHz is likely to be limited unless other countries adopt a similar approach to Egypt and there is the potential for equipment economies of scale through harmonised bands.

Currently, the entirety of the (470-864 MHz) UHF band is used by television broadcasting in Egypt and the national broadcasting licence that has been issued has no expiry date. However, with the move to digital transmission and the prevalence of alternative broadcasting platforms, it is likely that significant parts of the UHF spectrum will not be required for television[32] and the NTRA has indicated they do not see broadcasting requiring access to spectrum beyond 470-614 MHz.

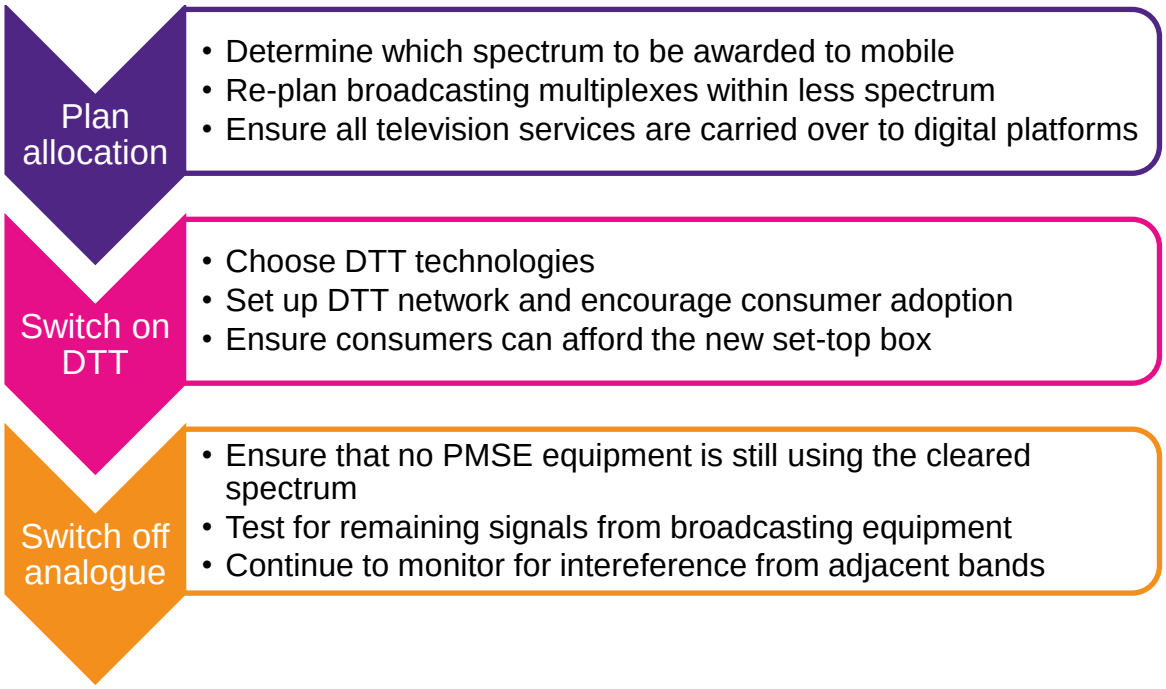
[32] Further discussion on this question can be found in the report "Terrestrial broadcasting and spectrum use in the Arab states", available from http://www.gsma.com/spectrum/terrestrial-broadcasting-and-spectrum-use-in-the-arab-states/

In order to clear this spectrum for mobile use, the regulator must follow the steps described in Figure 4-1. The NTRA has already started down the path towards clearing this band. DTT was launched in Egypt in September 2013[33] and Associate Professor Dr El Sayed Azzouz has stated that:

> "*Current programmes could all be accommodated in the spectrum below 694 MHz with room for introducing a larger number of programmes*"[34]

A large amount of UHF spectrum could therefore potentially be allocated to mobile[35].

Figure 4-1: Clearance of UHF spectrum



In Egypt there are a few issues that will need to be dealt with as the NTRA continues to undertake the digital switch over (DSO) process.

Firstly, the national broadcasting licence of the Egyptian Radio and Television Union (ERTU) does not expire, meaning that there is no natural date at which ERTU's spectrum rights over certain frequencies would cease. The NTRA will need to consider how it will reclaim the relevant spectrum rights. The fact that there is only one licensee and that there are not regional licences will ease this process.

Secondly, the NTRA will need to investigate whether there is any illegal use of spectrum in Egypt which would interfere with mobile. There may be unregistered broadcasting in the UHF band or unregistered use of PMSE devices, such as short range microphones. Such use will need to be acted upon depending on the powers available to the NTRA to remove illegally operating equipment.

[33] http://al-shorfa.com/en_GB/articles/meii/features/2014/01/16/feature-03

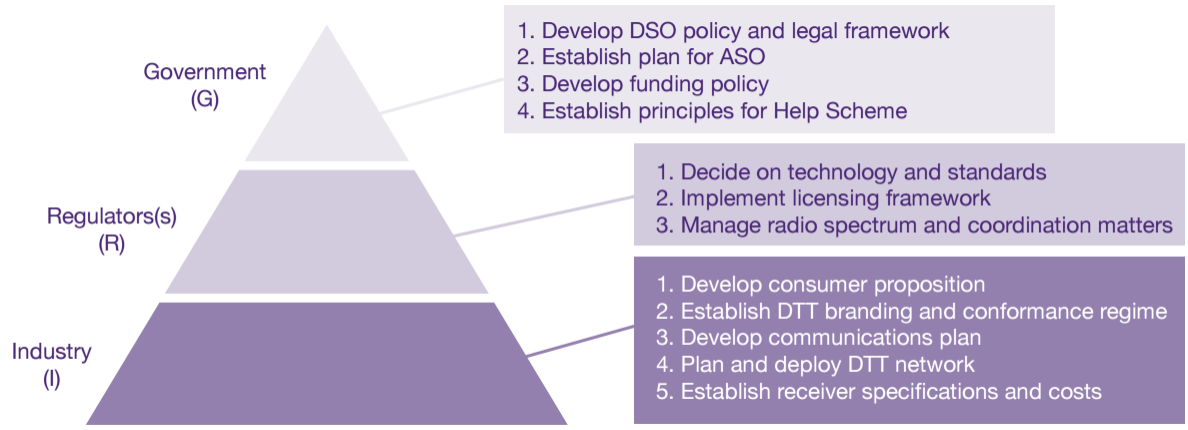
[34] Assoc. Prof. Dr. El Sayed Azzouz, Head of Spectrum Management, NTRA Egypt, 'Practical Aspects of Digital Switchover: The Egyptian Experience'.

[35] See Plum Consulting "Terrestrial broadcasting and spectrum use in the Arab states", April 2015, http://plumconsulting.co.uk/pdfs/Plum_Aug_2015_GSMA_Terrestrial_broadcasting_and_spectrum_use_in_the_Arab_states.pdf

Thirdly, the legacy CDMA technology used for wireless local loop by Telecom Egypt in Cairo and Sinai would complicate clearance. It is understood that there are a significant number of users of the service and therefore there could be a considerable impact if the networks were closed down in the short term. It is unlikely that alternative suitable spectrum can be identified that provides a comparable coverage possibility and CDMA technology is spectrally efficient therefore if it is not feasible to turn off these networks it may be necessary to consider the possibility of geographic sharing in the short to medium timescales. It would, however, be appropriate for the NTRA to start considering and discussing with Telecom Egypt how these services may be delivered by alternative networks such as wired options or alternative wireless solutions[36]. The impact of interference from CDMA 850 into the 900 MHz band allocations, specifically the E-GSM frequencies, indicates that the preferred option should be to clear the spectrum.

Practical recommendations for the DSO can be found in a previous Plum report[37] which summarises international best practice across the full range of DSO actions as shown in Figure 4-2[38].

Figure 4-2: DSO actions



UHF case studies

Below are some case studies around the release of UHF spectrum, some of which are taken from the GSMA Mobile Broadband Toolkit. They illustrate the difficulties that have been faced in transitioning to digital terrestrial TV and the importance of a transparent process and informed viewers to facilitate the process. In Kenya although switch over has been completed there are viewers that can no longer access terrestrial TV and in Nigeria the process has been delayed.

[36] The alternative wireless solutions cannot be specifically defined without understanding in detail the services provided by WLL using CDMA 850 and coverage areas served by a single base station and requirements for non line of sight operation. There are solutions being provided by, for example, LTE-A in the 3.5 GHz band that can supply fixed broadband solutions. Migration of users to other operators' wireless networks may also be a possible solution.

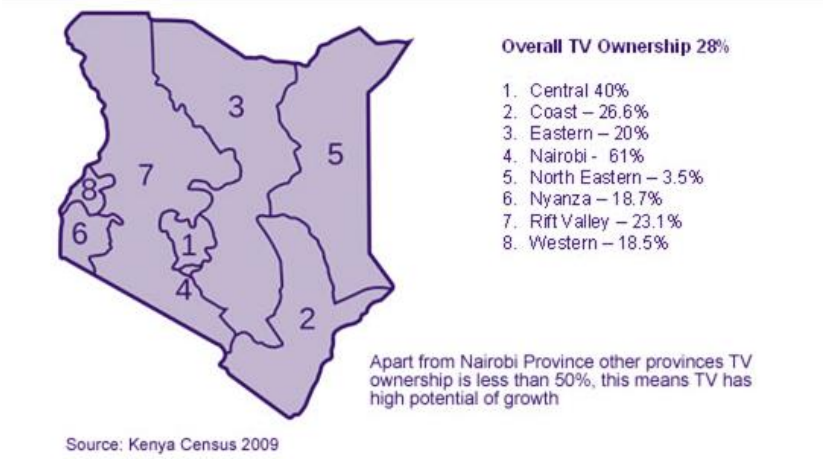
[37] Plum and Farncombe, 'Practical recommendations for digital switch over: Supporting information to ITU's guidelines for the transition from analogue to digital broadcasting', February 2013
http://plumconsulting.co.uk/pdfs/GSMA_AnalystReport_Plum_A4%20%28Online%20Version%29.pdf

[38] See also ITU, 2010, 'Guidelines for the transition from analogue to digital broadcasting'.
http://www.itu.int/pub/D-HDB-GUIDELINES.01

Kenya

Kenya started the DSO process in 2008 when the Government created the Digital Television Committee to oversee it. DVB-T transmissions started in 2009. In 2010 the Government decided to upgrade to DVB-T2 which was first broadcast in 2012. Also in 2012, the DVB-T transmissions were ceased. In 2012 the consumer awareness campaign was initiated: Digital TV Kenya[39]. The Government waived several fees and taxes on set-top boxes to aid consumer take-up[40]. Figure 4-3 gives TV ownership in Kenya.

Figure 4-3: TV ownership by province in Kenya



There are two authorised broadcaster distributors of DTT: Kenya Broadcasting Corporation which received its licence in 2009 and first broadcast using DVB-T in 2009 (before upgrading to DVB-T2 in 2012). And Pan Africa Network Group which received its licence in 2011 and first broadcast using DVB-T2 in 2012. Both firms initially focussed their rollouts on major cities[41].

The analogue switch-off (ASO) was beset by delays and litigation by broadcasters. The litigation centred around the granting of the second broadcast distribution licence and the timing of the ASO[42]. The ASO eventually began earlier this year[43], having been originally planned for 2012. The deadline of February 2015 met with controversy when the broadcasters turned off their DTT transmissions in protest, and the regulator has used the police to enforce the cessation of analogue transmissions[44]. The broadcasters claimed that 90% of their customers had not got access to DTT and that the ASO was premature, while the regulator claimed that 60% of houses were able to receive DTT[4546]. The last

[39] See http://www.digitalkenya.go.ke/ and https://www.facebook.com/DigitalTVKenya

[40] http://www.cto.int/media/events/pst-ev/2015/DBSF%202015/Presentations/5.7%20Daniel%20Obam.pdf

[41] http://www.digitalkenya.go.ke/what-s-digital-transition/signal-availability-in-kenya

[42] See http://digitalkenya.go.ke/news-updates

[43] http://digitalkenya.go.ke/images/content/PRESS31_12_2014.pdf
http://www.digitalkenya.go.ke/images/content/Dig_2_12_2014.pdf

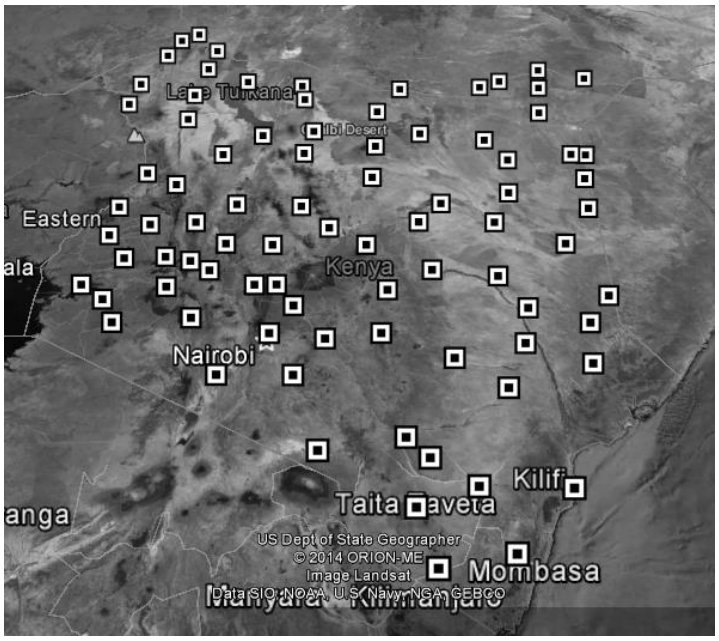
[44] http://nairobinews.nation.co.ke/ca-switches-off-analogue-tv/

[45] http://www.bbc.co.uk/news/world-africa-31485671

[46] Media coverage of the DSO was criticised by the regulator http://digitalkenya.go.ke/images/content/MCK.pdf

analogue signals ceased in June 2015, with the regulator admitting that not all households were able to receive DTT[47].

Figure 4-4: Location of analogue transmitters in Kenya



Source: GE-06

Tanzania

Tanzania was one of the first African countries to complete the DSO and is often held up a model example of how to achieve the DSO[4849]. The process began in 2005 when the TRCA issued the first consultation which set out the roadmap and key decisions[50]. The second consultation on 2006 was around multiplex licensing[51]. Thus, through transparent stakeholder engagement the TRCA was able to plan a successful DSO[52].

The process of awarding multiplex licences took two years in Tanzania, delaying the DSO. The first tender of 2008 was abandoned after all expressions of interest were rejected. The second tender of 2010 was able to award the three licences.

The public education campaign began in 2011 and enjoyed the high profile backing of the President of Tanzania throughout. The Government reduced taxes on set-top boxes to encourage consumer adoption. The ASO began at the end of 2012 with Dar es Salaam (the most populous city). By mid-

[47] http://www.ca.go.ke/index.php/archive-news/94-news/338-kenya-meets-global-digital-migration-deadline
http://asokoinsight.com/news/digital-switch-off-leaves-1-3-million-homes-in-tv-blackout-kenya/

[48] See https://www.itu.int/en/ITU-R/GE06-Symposium-2015/Session2/209%20%20Digital%20Migration%20-%20GENEVA.pdf

[49] See http://www.analysysmason.com/About-Us/News/Insight/Case-study-of-digital-TV-switchover-in-Tanzania/

[50] https://www.tcra.go.tz/images/documents/digital%20broadcasting/1stConsultativeDocDigitalSwitchOver.pdf
https://www.tcra.go.tz/images/documents/digital%20broadcasting/roadmap.pdf

[51] https://www.tcra.go.tz/images/documents/digital%20broadcasting/2ndConsultativeDocDigitalSwitchOver.pdf

[52] https://www.tcra.go.tz/images/documents/digital%20broadcasting/digitalMigrationStatusMay2014.pdf

2012 half of the analogue transmitters had been switched off[53], but political pressure meant that the remaining ones were switched off on a slower timescale to allow more households to buy set-top boxes. The 2015 deadline was still met with ease though. The downside of being in the vanguard of countries is that Tanzania now faces a decision over whether to upgrade to DVB-T2 and replace the set-top boxes again.

Nigeria

Nigeria has not yet completed the DSO, thus missing the ITU 2015 deadline which the regulator attributed to a lack of government funding[54]. The Presidential Advisory Committee on Digital Broadcasting was set up in 2008, but didn't generate the necessary political willpower to meet its roadmap[55]. Nigeria had aimed to complete the ASO in 2012, but is now expected to finish the DSO by December 2017. The government has begun to use early spectrum awards to fund the DSO[56].

DTT penetration in the country is 22%[57], having been deployed with a mix of DVB-T[58] and DVB-T2[59] in 2010 and 2011, respectively. DTT coverage is focussed on the main cities. The analogue transmitters in Nigeria are shown in Figure 4-5.

Figure 4-5: Location of analogue transmitters in Nigeria

Source: GE-06

[53] https://www.tcra.go.tz/images/documents/digital%20broadcasting/digitalTerrestrialTelevisionCoverageMap.pdf

[54] http://www.nta.ng/2015/06/21/digital-switchover-funding-poor-planning-frustrate-nigeria/

[55] https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CDMQFjADahUKEwiqlpWa_4DIAhXGuhoKHeUGBkQ&url=http%3A%2F%2Fwww.apc.org%2Fen%2Fsystem%2Ffiles%2Fcountries%2Fapcpublicationdigitalmigrationnigeriaen_v2.pdf&usg=AFQjCNEWRb1UfEVn9Y34oBCNhUMAVy1_ag&bvm=bv.102829193,d.d24

[56] http://allafrica.com/stories/201509170191.html

[57] http://www.ngrguardiannews.com/2015/03/78-of-nigerians-may-miss-out-in-digital-tv-switchover/

[58] https://www.dvb.org/news/commercial-dvb-t-services-available/country/nigeria

[59] https://www.dvb.org/news/nigeria-enjoys-dvb-t2-services/country/nigeria

In order to complete the DSO, the coverage and penetration of DTT will have to increase. This may involve government subsidies for set-top boxes. After which the ASO can be completed.

We have also included a further two case studies – the one from Finland shows how the issue of cross-border interference may be treated and the other for Namibia shows the approach adopted to remove CDMA 850 networks.

Finland

Finland had to overcome significant cross-border issues in order to enable mobile broadband. Having completed ASO in 2007, it had hopes of launching mobile broadband services swiftly. However, it was 2011 before successful coordination with a neighbour's military systems could be finalised.

Finland has a long border with Russia, and Russia uses the 790-862 MHz band for aeronautical radio navigation services (ARNS) and military communications. Coordination on mobile use of the band has not been previously possible for political reasons, so neighbouring countries tended to use the band for their own ARNS and military communications. One option for Finland was to wait until Russia had completed ASO, but the likely timetable for this was uncertain.

Therefore, to generate momentum for an agreement the Finnish Ministry of Communications hosted a summit, with the GSMA, which led to regular meetings between Finnish and Russian regulators from 2010. Russia started testing interference between mobile and ARNS in 2011, and both countries jointly announced during the second half of 2011 that mobile would be allowed to be deployed in the 800 MHz band.

Within Finland full mobile coverage would be allowed up to 55km from the Russian border, and in the best case scenario base stations could be built 12km from the border. Therefore, customer handsets could work 4km from the border. This agreement was a watershed moment as it enabled mobile broadband in Finland. It was initially expected that mobile operators or neighbouring countries may have to compensate the Russian military for the move, but no such financial compensation was needed because Russia recognised the benefits from speeding up its own ASO.

Namibia

Telecom Namibia operates its mobile network in the 800 MHz band and has refarmed the band from 2G to 4G, thus enabling mobile broadband. In February 2013 Telecom Namibia announced it was going to introduce LTE, with a planned operation date of November 2013.[60] One obstacle to this process was the existing CDMA customers using the 800 MHz band. Telecom Namibia did not publish the number of CDMA 800 customers, but it was understood to be a small proportion of the market.

Moving these customers required Telecom Namibia to switch CDMA 800 customers to other (higher) frequencies, operated by Telecom's recent acquisition Leo. Then each customer required a new handset. The redundant CDMA 800 network was decommissioned whilst the LTE network was built.

[60] Telecom Namibia ,2013, 'Telecom Namibia appoints ZTE to deploy LTE-ready network' http://www.telecom.na/index.php/media/news/786-telecom-namibia-appoints-zte-to-deploy-lte-ready-network

4.2.2 L-Band

The L-Band (1427-1518 MHz) is currently used in Egypt for providing fixed links, as set out in Section 3.3. The whole band is licensed for fixed link services on a geographic basis (each link is licensed to a specific location). However, these are limited to specific locations and the NTRA has identified that there is potential for this spectrum to be used for mobile communications, either:

- In addition to existing fixed links, therefore sharing on a geographic basis if there are only a limited number of links and there is the potential to migrate these as the mobile networks are rolled out, or
- Nationally, with existing users of the spectrum moving to other spectrum bands.

The fixed links users of L-Band have licences which are renewed annually. This means that the NTRA should be able to easily reclaim spectrum rights over the band should it want to do so but this might have significant implications for existing users of the frequencies if alternative delivery mechanisms are not readily available. Therefore the NTRA may choose to give more than one year's notice for the incumbents to move. In this, the NTRA will need to consider:

- How to set the deadline date for moving? The sooner the date the earlier mobile can utilise the band, but an early date will cost the incumbents more and it may be worth waiting until there is a global mobile ecosystem for L-Band.
- What alternative frequency bands might be made available to existing licensees?
- Will the incumbents need to be compensated for replacing or scrapping equipment?
- Is it possible for the existing fixed links assignments to be rearranged in a more spectrally efficient way?

The NTRA may also need to investigate whether there is any unauthorised use of the 1400 MHz band that would interfere with mobile.

4.2.3 2.6 GHz

The 2.6 GHz band, divided into paired (2500-2570 / 2620-2690 MHz) and unpaired (2570-2620 MHz) sections, is currently used by legacy fixed links and public sector users in Egypt. According to the NTRA the process of refarming the incumbents to other spectrum bands should take a year but that it is unclear when this process would start. In the case of the 2.6 GHz legacy fixed links it is assumed that this should be a reasonably simple process with licences being renewed annually and the likelihood that the users already have access to alternative means of providing the required services.

In the case of the public sector users it is far less clear what the approach may be as this very much depends on the actual services and whether they are formally licensed to use the spectrum. It is often the case with the public sector that release of the spectrum can be agreed through the identification of alternative spectrum or by making improvements to equipment, such as filtering, that allow the two services to share with mobile. For example, in the UK changes were made to the radars to allow them to continue operation in the 2.6 GHz band. This report proposes that the process of moving or upgrading current spectrum users should be started.

Checks may have to be made to ensure that there is no illegal usage of the band.

Given that the 2.6 GHz band already has a well-established global mobile ecosystem and that refarming should be swift, allocating the band for mobile could be an 'easy win' for the NTRA.

4.2.4 C-Band

The C-Band (3400-3800 MHz) is generally used internationally by satellite earth stations and in some countries for fixed links. However, in Egypt 2×24.5 MHz is used for WiMAX operation, running on an indefinite licence. This raises the issue of how and when the NTRA would be able to reclaim the spectrum rights to C-Band if it wanted to do so. There are a few options the NTRA could follow in relation to C-Band:

- Reclaim spectrum rights over the whole band and assign it to mobile.
- Keep existing WiMAX assignments and assign the rest of the band to mobile.
- Convert the existing WiMAX licences to technology neutral licences (so that they could be used for mobile should the licence owners wish) and assign the rest of the band to mobile.

The approach adopted may be informed by the current market served by the WiMAX operators as these services may be an important means of delivering fixed services to rural areas where wired infrastructure is not available. The NTRA may find it quicker to make the WiMAX licences technology neutral rather than reclaiming them from the incumbents. The mix of national and regional licences will need to be taken into consideration with possibly the need to allow spectrum trading allowing the use of the frequencies in urban areas for mobile and in rural areas for fixed wireless access. Checks for illegal use of the band may also have to be undertaken by the NTRA.

5 Spectrum licensing issues

The way in which spectrum is licensed to mobile operators will affect the efficiency with which the spectrum is used and the benefit to the Egyptian economy. This section discusses the NTRA's objectives and the following section details different decisions that the NTRA will have to make regarding the licensing of spectrum to mobile.

5.1 Background analysis

Spectrum licensing decisions will need to be taken by the NTRA in light of its objectives and thorough market analysis in order that it may achieve its objectives.

5.1.1 The NTRA's objectives

The NTRA has a number of stated objectives on its website. The NTRA states on its website that aims to encourage investment in order to:

- "*Ensure that telecommunication services reach all areas of the country.*
- *"Protect national security and higher state interests.*
- *"Ensure optimum use of the frequency spectrum.*
- *"Assuring the compliance with the State-approved provisions of international agreements and the issued resolutions by regional and international organizations.*
- *"Monitor technical and economic efficiency programs for all telecommunications services."*

The NTRA also has a detailed scope of work; it is with these in mind that the NTRA will make licensing decisions.

Figure 5-1: NTRA Scope of Work

Policy and Licensing

- Setting detailed regulatory policy in harmony with the national telecommunications plan to ensure that high-quality, up-to-date telecommunication networks and services are provided at affordable prices for all citizens.
- Working to bring about the total liberalization of the telecom services market by the end of 2005 in line with WTO and BTA commitments.
- Forming a licensing framework for liberalized services to create a transparent, healthy and predictable sector and to stimulate growth.
- Developing a licensing process for networks and services covering individual licenses and class licenses for all telecommunication applications.

Competition Safeguards

- The NTRA has prepared the competition policy framework, prohibiting anti-competitive practices such as the misuse of a dominant position, cross-subsidization, refusal to supply essential facilities, vertical price squeezing, dumping, predatory pricing, misuse of information and restrictive agreements.
- The NTRA is working to create a suitable environment for the liberalization of the market, in which there will be free competition and investment on a non-discriminatory basis.

Interconnection Directive

- The NTRA has issued a framework that governs interconnection agreements and provision of services between licensed operators. The framework ensures that all licensees are treated fairly and in a non-discriminatory manner, and identifies the technical, commercial, legal and regulatory rules needed to ensure efficient and fair internetworking practices in the telecommunication market.

5.1.2 Market analysis

A number of policy decisions around upcoming spectrum awards in Egypt will be informed by analysis of the Egyptian mobile market[61]. It is important that the NTRA conducts thorough analysis of the market so that it is in the best situation to make decisions around competition in spectrum awards and obligations in the licences. The NTRA will need to conduct regular analysis of the market especially if spectrum is awarded over a number of years.

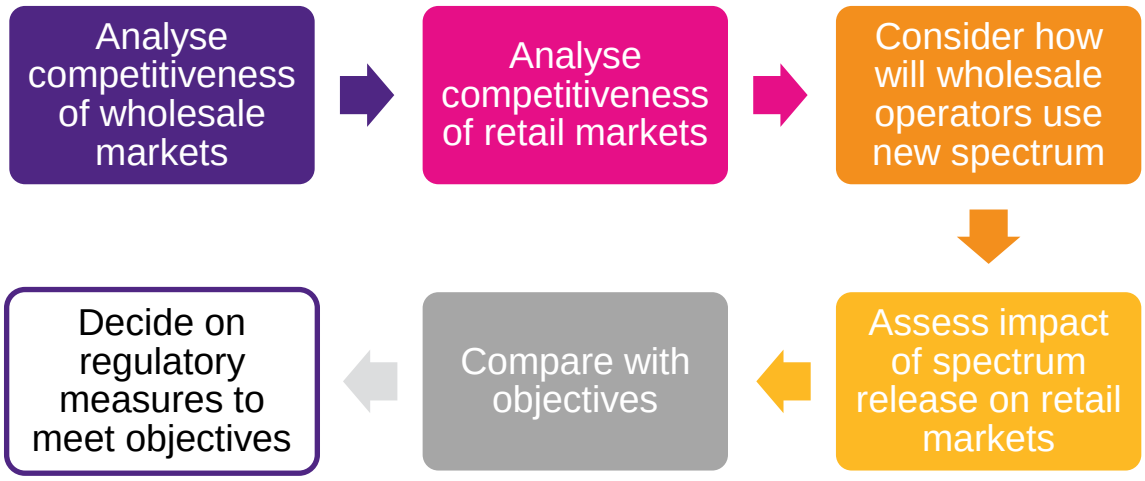
The NTRA will need to analyse the wholesale and retail markets separately. The NTRA will need to answer the following questions when defining relevant markets:

- Are mobile and fixed complements or substitutes?
- Are there separate business and consumer markets?
- Are there separate markets for voice and data services?
- Are there separate markets for low data speeds and high data speeds?
- Are there multiple markets split by geography within Egypt?
- Are there multiple markets by language, culture or people group within Egypt?

Once relevant wholesale and retail markets are defined the NTRA can conduct the market analysis along the lines of Figure 5-2.

[61] For a brief analysis of the Egyptian mobile market see http://plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

Figure 5-2: Competition analysis

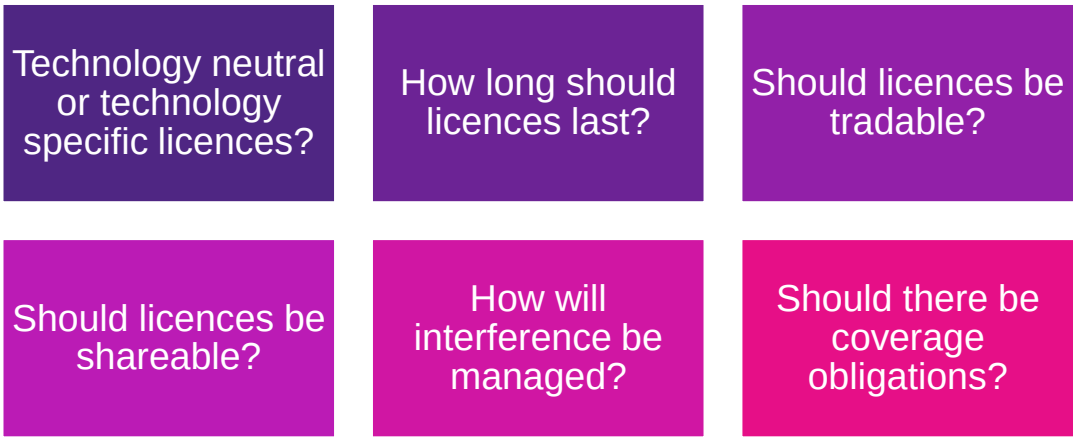


Once the NTRA has undertaken the competition analysis it will be in a position to make a number of decisions regarding spectrum licensing.

5.2 Decisions to be made

The NTRA will have to make the following licensing decisions, as shown in Figure 5-3, which are discussed below.

Figure 5-3: Licensing decisions



5.2.1 Technology neutrality

It is understood that the spectrum licences are technology and service neutral but the operators also require a service licence which defines what services and technologies may be deployed in the associated spectrum. Currently the service licences support the deployment of GSM, Edge and 3G in any of the frequency bands but do not include 4G. We would suggest that the NTRA should consider

updating the service licences to be technology neutral and so also allowing for the deployment of 4G and future mobile technologies, following the example of the majority of regulators around the world. Licences which are technology neutral mean that operators can refarm spectrum without potentially lengthy regulatory delays, thus increasing spectrum efficiency and the dynamism of the Egyptian mobile market. It may reduce the benefits of spectrum release in the long run if operators are tied to limited technologies, rather than being able to use the spectrum with the most efficient technology. As the GSMA states:

> *"Restrictive licence conditions limit operators' ability to use their spectrum resources fully, and risk delaying investment in new services"*[62]

Ideally all the operators should be in a position to upgrade to LTE.

5.2.2 Licence duration

It is useful for regulators to be able to reclaim spectrum easily. When balanced with the need for mobile operators to have certainty to encourage investment the result is that spectrum licences in most countries have expiry dates. There are a number of different approaches to this that the NTRA could take:

- Longer licences of at least 20 years. Such licences encourage investment by operators as there is time for investment to be recouped.
- Shorter licences of 10 years. These give the regulator flexibility, but may not encourage as much investment.
- Indefinite licences. The UK has awarded mobile spectrum with licences that last for at least 20 years and the presumption that they will not expire. If the regulator wishes to reclaim the licences they have to give five years notice to the licensee. Similarly, the USA regulator awards licences for 10 years but with the strong presumption of automatic renewal. This effectively means that the licence is indefinite unless something major occurs.

According to Plum's spectrum auction database of over 400 spectrum awards the most common licence duration is 15 years. The GSMA states that

> *"New licences should be granted for 15 to 20 years, at least, to give investors adequate time to realise a reasonable return on their investment."*[63]

5.2.3 Spectrum trading

The efficient assignment of spectrum rights may change over time and so there should be mechanisms in place in Egypt that allow spectrum rights to be bought and sold as the market will promote allocative efficiency. For example, if one operator is able to use spectrum more efficiently then it might be able to buy spectrum from a less efficient operator. Such changes in efficiency are inevitable in a market characterised by rapid technological change. Also, spectrum trading provides an ongoing mechanism for market entry. As summarised by the GMSA:

[62] GSMA Mobile Policy Handbook 2015 http://mph.gsma.com/publicpolicy/handbook/spectrum-management-and-licensing

[63] GSMA Mobile Policy Handbook 2015 http://mph.gsma.com/publicpolicy/handbook/spectrum-management-and-licensing

"Spectrum trading creates increased flexibility in business planning and ensures that spectrum does not lie fallow, but instead is used to deliver valuable services to citizens. Spectrum trading restrictions should only be applied when competitive or other compelling concerns are present."[64]

In order to allow spectrum trading in Egypt the NTRA would need to insert provision for it into the spectrum licences and clarify the legal and regulatory process any trade would undergo. Spectrum trading could be encouraged by the NTRA ensuring that both regulatory uncertainty and transaction costs are low.

Similarly, the NTRA may wish to include spectrum leasing clauses in the licences, whereby the licence holder has an arrangement with another operator to use the spectrum without transferring the licence.

5.2.4 Sharing mechanisms

Spectrum sharing is another way in which the allocative efficiency of the spectrum in Egypt can be increased, although it does not replace the need for more spectrum to be allocated to mobile. Spectrum sharing should be enabled by spectrum licences.

There are different types of spectrum sharing according to the dynamism of the sharing arrangement, with the two types being most suitable for mobile spectrum shown in Figure 5-4.

Figure 5-4: Sharing mechanisms

Static sharing

- Operators share spectrum by geography or frequency (with no time dimension).
- For example, the sharer may use some frequencies in one area of Egypt with the licence holder using the rest of the frequencies in that area of Egypt and all the frequencies in a different area of Egypt.

Licensed shared access

- Both incumbent and sharer(s) are licensed and their spectrum usage is defined in advance to specific geographic areas and times.
- It is like static sharing with the ability to share with a time dimension.
- For example, the sharer may have access to the frequencies at specific times of day which would be defined in advance. Devices are top-down managed to operate only according to the sharing agreement.

The NTRA may choose to allow multiple sharing approaches to ensure maximum flexibility in the market while potentially retaining control over sharing arrangements from a competition policy perspective. Spectrum sharing has the capability to increase spectrum efficiency and investment when it is initiated by the market; the regulator should not mandate sharing.

[64] GSMA Mobile Policy Handbook 2015 http://mph.gsma.com/publicpolicy/handbook/spectrum-management-and-licensing

5.2.5 Interference management

Spectrum licences need to define responsibilities over interference management. The technical licence conditions should define the necessary limitations that apply to the deployment of equipment and networks to ensure the necessary protection of co-channel and adjacent channel services. These licence conditions might, for example, define maximum transmitter powers, block edge masks and separation distances, and require the new operators to include any necessary guard bands within their frequencies. In addition it may be necessary for co-ordination procedures to be defined to minimise the potential for interference into the incumbent service-this is an approach that may be used where the spectrum is shared on a geographic basis with, for example, the military where before base stations are installed they need to either be outside a co-ordination zone or approved by the military.

The NTRA will also need to include a general licence condition requiring the licence holders to operate according to their licence conditions and avoid the potential for interference with other licensed spectrum users. It is not unusual for administrations to require licensees to resolve between themselves any instances of interference with the regulator, if necessary, being the last option for resolution of any interference problems.

5.2.6 Cross border considerations

The NTRA also needs to consider the impact of spectrum usage in neighbouring countries when identifying and licensing spectrum. It is essential that prospective licensees are aware of any limitations that might limit the use of frequencies on a national basis. For example deployments of CDMA 850 in neighbouring countries may impact on the use of the 800 and 900 MHz bands in Egypt as mentioned in sections 3.1.1 and 3.2.4 around the border. Similarly if neighbouring countries delay digital switch over and do not cease operation in the 700 MHz and 800 MHz bands there is the risk of interference from high power, high tower analogue broadcast transmitters into the mobile networks.

In the case of mobile networks operating either side of the border it is of course possible to require all base stations within a pre-determined distance of the border to be co-ordinated on an individual basis prior to their installation and deployment to avoid interference and the potential for unintended roaming from the home to the foreign network. This would, however, be a major overhead on the mobile operators and would significantly delay the roll-out of networks. To avoid this a number of operators and administrations have instead developed agreements that are based on the operators themselves assessing whether they meet pre-agreed parameters and only where these might be exceeded entering into detailed co-ordination. These agreements will establish preferential frequencies, codes etc. and interference levels that will apply to operators operating either side of the border in the same frequency bands. Of course as networks evolve there is no guarantee that networks on either side of a border will use the same technologies so in such instances it is necessary to depend on signal strength agreements only.

In Africa a cross-border frequency co-ordination agreement providing a harmonised calculation method (HCM4A) has been developed as part of the HIPSSA Project[65]. The agreement covers

[65] The HIPSSA study was undertaken under the global project "ACP-Information and Communications Technologies" programme within the framework of the 9th European Development Fund. This was launched by the ITU and the European Commission to provide "Support for the establishment of harmonised policies for the ICT market in the ACP states".

"*frequencies between 29.7 MHz and 43.5 GHz for the purposes of preventing mutual harmful interference to the Fixed and Land Mobile Service and optimising the use of the frequency spectrum on the basis of mutual agreements*".

The approach is based on the HCM (Harmonised Calculation Model) agreement developed and used in Europe. In Africa there are some countries that have deployed CDMA technology and therefore the agreement has had to take into account both GSM and CDMA and their respective technology evolutions as well as a range of frequency bands and channel plans. In Europe a number of Recommendations, for example, have been developed that address frequency planning (GSM and UMTS/LTE/WiMAX) and code planning (only for UMTS) in border areas.

We propose that the NTRA should implement cross border agreements with their neighbouring countries.

5.2.7 Coverage obligations

Regulators sometimes use 'use it or lose it' clauses in spectrum licences to ensure that spectrum does not lay idle. However, some regulators (such as in the UK) eschew such clauses because they do have disadvantages:

- Measuring the use of spectrum can be costly for regulators.
- Such clauses may increase the cost to operators of holding a licence, thus reducing the value at auction.
- Idle spectrum can be efficient (for example, an operator may decide to leave spectrum unused while it becomes apparent which technology would be most efficient).
- Unless detailed, such clauses do not ensure the heavy use of spectrum, and high levels of detail increase complexity and the risk of inefficiency.

Instead of 'use it or lose it' clauses, many regulators decide to apply coverage obligations to spectrum licences.

Coverage obligations are put on low frequency spectrum such as sub-1 GHz (high frequency spectrum is not suitable for coverage because it travels less far) in countries which tend to have

- Large rural populations;
- Low population density;
- Remote, disconnected rural communities; and
- Limited rural infrastructure.

If the NTRA was to introduce coverage obligations then it would need to consider:

- How will coverage be measured? Would the obligation be a percentage of the Egyptian population or a list of certain towns and cities that need to be covered? What level of service constitutes coverage?
- Over what timescale will the obligations have to be met?
- Which licences to carry them? Would it be enough if one licence included the responsibility to cover certain rural areas?

The NTRA should bear in mind that the more stringent the coverage obligations, the less valuable the spectrum. Less valuable spectrum will get lower prices at auction.

5.3 Recommendations for future licencing

Based on international best practice, in the light of a thorough market analysis the NTRA should consider:

- Licensing mobile spectrum on a national basis to avoid unnecessary complexity and segmentation.
- Ensuring that spectrum licences are technologically neutral so that operators can make the most efficient use of spectrum.
- Setting a licence duration of at least 15 years to encourage certainty and investment.
- Allowing the trading and leasing of spectrum licences and making any trading mechanism transparent.
- Allowing spectrum sharing and establishing a transparent mechanism for encouraging and approving sharing agreements.
- Ensuring that spectrum licences clearly define responsibilities over interference management.

6 Award roadmap

At the start of the spectrum award decision process the NTRA needs to be clear about its objectives, as this will influence what type of award would be most suitable. Different awards favour different outcomes and potential competing objectives include:

- **Efficiency**. Is radio spectrum, a scarce national resource, being used at maximum efficiency?
- **Benefit to the national economy**. Mobile broadband increases productivity and brings a large benefit to the Egyptian economy. This benefit could be hindered by excessive pricing of spectrum.
- **Government revenue**. Is the NTRA receiving a fair price for the use of this national resource?
- **Simplicity and transparency**. Is the award process clear to all stakeholders and simple for the NTRA to run? Is there the potential for it to get bogged down in lawsuits?
- **Speed**. Is the awards process going to get mobile broadband rolled out quickly? The more quickly Egyptian operators can access spectrum the greater the economic benefits of mobile broadband to the economy.

The award process is not the only tool by which the NTRA can pursue its objectives, but it should be clear on the key goals before setting the award. The award roadmap is shown in Figure 6-1.

Figure 6-1: Award roadmap

6.1 Single process or multiple contests

There are a number of frequency bands that the NTRA will be looking to release for mobile over the coming years, meaning that the NTRA will need to decide whether to hold separate auctions for each new release of spectrum or whether to hold awards that assign multiple different frequencies. Table 6-1 lists the advantages of both approaches. Additionally, one frequency band may be cleared in stages over a period time: should the NRTA hold one award for such a band or multiple awards each time there is a new release? This decision is a balance between speedy release of spectrum and efficient assignment of spectrum.

Table 6-1: Advantages of running a single award or multiple awards

Advantages of running a single award	Advantages of running multiple awards
• It may be quicker to run a single process. • It reduces uncertainty over licences, therefore helping investment: – Operators know what spectrum will be awarded. – Operators know exactly how the spectrum will be awarded. – Using some types of auction operators can bid for bundles of spectrum, thus increasing efficiency.	• Each award is simpler to run. • The NTRA would be able to learn from one award to the next. • Spectrum can be awarded at the speed of the quickest band to be cleared (rather than wait for multiple bands to be ready to be awarded). • Operators can learn lessons from one award to the next.

A related question is over the optimum length of time between an award and the start date of the frequency licences. Clearly, the start date of the licences should be as soon as the band is cleared, but this date may be unclear in advance. If the award is too far in advance of the spectrum being released investment decisions will be influenced by increased uncertainty over how the market will develop before the spectrum can be used. Equally, if the award is too close to the spectrum being released then operators would not have time to build the infrastructure required to support the extra frequencies. The key factor for operators is certainty: the investment will be less risky if operators have certainty over the start date of the awarded licences and lower risk will increase investment.

6.2 Auction or beauty contest

International best practice reveals that spectrum awards can be divided into two broad categories: auctions and beauty contests. An auction involves operators competing against each other on price, with the operators that bid the highest price winning. A beauty contest involves operators submitting bids to the NTRA who would judge between them on criteria such as price and quality. The NTRA will need to decide which mechanism to award spectrum through.

There are numerous papers that discuss the relative merits of both approaches[66]; this report briefly outlines the major considerations. Crucially, where demand outstrips supply (as is the case for mobile spectrum in Egypt) an auction would maximise efficiency whereas a beauty contest would not.

There are examples of where regulators have awarded spectrum though mechanisms that combine elements of auctions and beauty contests; however, such hybrid processes are not advised as they increase complexity, reduce transparency and can result in strange outcomes[67]. It is important to note that any process which artificially reduces the number of potential bidders may have a negative impact on the efficiency of the auction.

[66] See Binmore, K. and P. Klemperer (2002). 'The biggest auction ever: the sale of the British 3G telecom licenses'. The Economic Journal, 112. http://www.nuff.ox.ac.uk/users/klemperer/biggestpaper.pdf ; and Pratt, A. and T. Valletti (2000) '*Spectrum Auctions Versus Beauty Contests: Costs And Benefits'*. Prepared for the OECD-Working Party on Telecommunications and Information Services Policies. http://istituti.unicatt.it/economia_impresa_lavoro_OECD-draft.pdf

[67] For the ITU position against hybrid formats see ITU (2010) '*Guidelines for the transition from analogue to digital broadcasting'*. http://www.itu.int/pub/D-HDB-GUIDELINES.01

The relative merits of auctions and beauty contests are discussed in Table 6-2, which is based on ITU advice. Ultimately the NTRA's decision will be based on its key objectives.

Table 6-2: Auctions versus beauty contests

	Auction	Beauty contest
Strengths	Results in allocation efficiency (in economic terms). Can be simple for the NTRA to run. Transparent. Returns economic value to the Egyptian government and society. Potential for large revenue generation.	Focus on quality. Thorough procedure. NTRA retains (most) control over the assignment.
Weaknesses	NTRA has less control over end result (depending on the set quality requirements). Auction is an upfront investment and may slow down service investments due to capital market constraints.	Do not necessarily maximise economic efficiency. Time consuming for the NTRA. Not transparent, vulnerable to corruption. Asymmetric information: NTRA knows less about the value of the spectrum than operators. Selection of who should be on the judging panel may unduly influence results.
Risks	Collusion between bidders could result in lower proceeds (although this is uncommon). Errors in the auction design and execution could result in the wrong assignment. Winner's Curse (bid was too high and service has to be terminated).	Risk of appeal procedures. Can result in excessive profits for licence holder (if NTRA sets price too low). Operators may be unable to hold the promises they make. Winners' Curse (most optimistic bidder wins).
Situations in which use is recommended	The number of frequencies to be assigned is less than the demand. Quality requirements can be formulated upfront. There are no market distortions that could jeopardize long term interest of end-users.	The number of licences is limited. Grip on the assignment process is necessary (for example in the case of distorted markets). Supplementary requirements are needed on the basis of social and cultural factors (and need to be compared).

Source: ITU (2010) '*Guidelines for the transition from analogue to digital broadcasting'* with Plum modification

6.3 Estimate value of spectrum

The NTRA will need to estimate the value of spectrum so that it can set expectations around auction or beauty contest revenue. Each frequency band will be valued differently, according to its propagation characteristics, international harmonisation and the technology used. There are different complementary methods for estimating spectrum value which are briefly described below:

- **Benchmark analysis**. Benchmark analysis is the most simple of the approaches to valuing spectrum. It involves looking to awards of spectrum in other countries to see what the price would likely be in Egypt. This involves selecting a suitable sample of countries and frequencies and then adjusting benchmark values for country specifics and normalising the prices to a common

basis. The key advantage of benchmarking is that, unlike the other two approaches, it is does not involve forecasting, but rather relies on what operators have actually paid for the spectrum. Additionally, if there is a large dataset then econometrics can be run to take account of country and specifics.

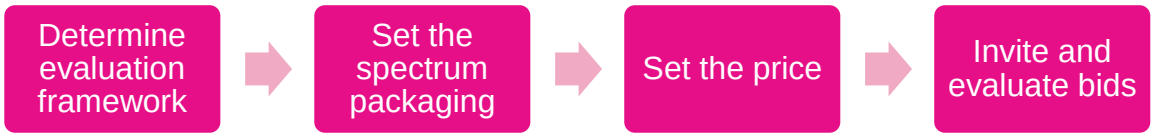
- **Avoided cost model**. The avoided cost model approach estimates the cost to the operators that would have been incurred should they have expanded their network capacity through infrastructure build out rather than additional spectrum. This cost is avoided because the spectrum has been released, and thus presents a lower bound on the value of the spectrum to operators.
- **Discounted cashflow model**. The discounted cashflow model approach estimates the total value of the additional spectrum to the operators by estimating the additional revenue the operators will gain through having the spectrum. Thus the model estimates the additional cashflow to the operator gained from having the additional spectrum. This approach relies on demand forecasts and can be complex to estimate as it requires modelling an operator's entire commercial operation.

The NTRA may decide to use one or more of these approaches in valuing spectrum in Egypt. As more spectrum is awarded the NTRA will gain a better understanding of the operators' willingness to pay for spectrum in Egypt.

6.4 Running a beauty contest

The beauty contest process is shown in Figure 6-2.

Figure 6-2: Beauty contest process



Beauty contests usually contain a two-step evaluation process in which the bidders are first evaluated to see if they are able to fully use the spectrum which they are attempting to gain, followed by evaluation of such bidders' bids being evaluated. If the NTRA were to run a beauty contest it would need to define a process for evaluating bids on price and quality. Measures of quality should be:

- Derived from the NTRA's key objectives.
- Objective (not lead to pre-conceived results).
- Well-defined and unambiguous in meaning and measurement.

Criteria might include coverage plans and roll-out speed[68], which then have to be weighted[69]. The criteria and weighting should be published by the NTRA before the bids are submitted so that operators know what the NTRA is looking for.

The NTRA would also need to set the spectrum packaging. Each successful bidder could be awarded the same amount of spectrum, or the amount of spectrum could vary by bidder. Efficiency is more likely to be achieved if operators who have more use for the spectrum are assigned more of it. The exact size of each package will depend on the likely technology. For example, LTE is usually deployed in blocks of 2×10 MHz, so blocks smaller than this could be an inefficient use of spectrum.

There are three models of setting the price in beauty contests:

- The NTRA would accept the price that operators offer.
- The NTRA would negotiate with operators over the price.
- The NTRA would set the price, with the operators competing on quality alone. This approach is unusual as it would require the NTRA to be able to accurately estimate the value of the spectrum without direct input from the operators (who have more information about its value).

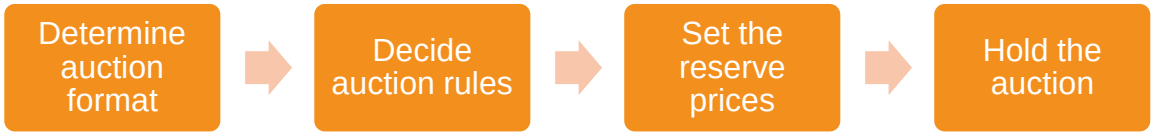
It is worth remembering that high prices may be passed onto consumers and delay the uptake of mobile broadband in Egypt which would stifle the economic benefits it can bring.

After deciding the above, the NTRA would then need to publish an invitation to tender which would make the whole process transparent and thus reduce investment uncertainty.

6.5 Running an auction

The first task of the NTRA if it decides to hold an auction is to determine the auction format. After this, the NTRA would need to set the auction rules and also, potentially, the reserve prices. The auction process is shown in Figure 6-3.

Figure 6-3: Auction process



In setting the auction format the NTRA will need to balance complex auctions which may lead to greater allocative efficiency versus simpler auctions which may be faster to run, be cheaper for the

[68] For an example list of beauty contest criteria see CEPT (2005) Auctions And Beauty Contests In CEPT Administration. ECC Report 65. https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&ved=0CGEQFjAH&url=http%3A%2F%2Fwww.erodocdb.dk%2Fdocs%2Fdoc98%2Fofficial%2Fword%2FECCRep065.doc&ei=UxXyUqWYDbHH7Aa16YHYDw&usg=AFQjCNGTrAV2ToOnRok8c8uMzgOVDWTN0w&bvm=bv.60799247,d.ZGU

[69] For a discussion of criteria, weighting and decision rules see Janssen et al (2002) 'Auctions and beauty contests: A policy perspective'. SEOR-ECRI. http://www.bmg.eur.nl/fileadmin/ASSETS/bmg/ECRI/Maasland/Auctions_and_Beauty_Contests.pdf

NTRA, and have greater bidder understanding which itself helps efficiency. International best practice illustrates that there are good principle to follow in designing an auction, but that, as stated by the GSMA:

> *"There is no 'one size fits all' design for spectrum auctions. Each auction needs to be designed to meet the market circumstances and to achieve the specific objectives set by government."*[70]

Auction formats can be divided into two types, based on whether the different lots in the auction are auctioned one after the other or at the same time:

- **Sequential auction formats**. Each lot is auctioned in turn. This is simple to run, but may be less efficient because bidders are bidding on individual lots rather than bundles of lots. This is important because the lots are complementary-the value to an operator of owning a block of spectrum is highly dependent on what other spectrum they hold.
- **Simultaneous auction formats**. Lots are auctioned simultaneously: operators bid for multiple lots at once. This is more complex and costly to run than sequential auctions, but may lead to greater allocative efficiency. This is because operators are bidding for multiple lots of spectrum and because different spectrum bands are complementary to each other. A complex auction, however, can lead to mistakes and thus inefficiency.

Some common spectrum auction formats are listed in Table 6-3.

Table 6-3: Common spectrum auction formats

Sequential auction formats	Simultaneous auction formats
• First-price sealed bid. • Second-price sealed bid. • Open ascending (English) sequential auction. • Open descending (Dutch) sequential auction.	• Anglo-Dutch auction. • Simultaneous multi-round auction (SMRA). • Combinatorial clock auction (CCA).

After deciding upon the auction format the NTRA would then have to set a number of other auction rules, including:

- Pre-qualification rules. The NTRA may set in place rules that disqualify non-serious bidders from joining the auction.
- Spectrum packaging. See discussion above.
- Spectrum caps. These are sometimes used by regulators to meet competition policy objectives; however, they can cause inefficiency and should be used carefully.
- Deposit. What size deposit should the bidders give the NTRA?
- Penalties for disobeying auction rules. There needs to be a credible threat of punishment if the rules are broken.
- Security. The auction process needs to be secure, especially if done in an electronic format.

[70] GSMA (2015) Mobile Policy Handbook http://mph.gsma.com/publicpolicy/handbook/spectrum-management-and-licensing

- Stopping corruption. Measures should be taken so that there is no opportunity for corrupt behaviour.
- Transparency. The more transparent the award process the more it will generate confidence in the process and encourage investment by bidders.

Prices paid in an efficient auction will reflect the value of an incremental spectrum lot to the marginal bidder. Bidders should not pay more than the net present value of future cashflows from use of the spectrum, but should pay more than the avoided cost value.

In some cases, regulators set a reserve price for the auction. The rationale behind a reserve price is that the auction might result in an inefficient outcome and may be awarded at too low a price, particularly if spectrum lots are poorly defined, there is low competition in the market, or the market demand is not fully understood. If this were the case, the NTRA might still want the winners to pay prices that reflect a reasonable value for the spectrum. However, high prices may delay the take-up mobile broadband and thus its economic benefits. The factors impacting reserve prices are described in Table 6-4.

Table 6-4: Furthering regulatory aims through reserve prices

Objective	Impact on reserve price	Comments
Maintaining competition	▼	This means setting reserve prices on the low side to encourage bidding from weaker market players.
Fostering broadband	▼	This means setting reserve prices on the low side so that spectrum is not left unsold.
Raising revenues that reflect the commercial value of spectrum	▲	This means setting non-trivial reserve prices so that government is assured of a minimum level of revenues.
Avoid collusion in auction	▲	Set reserve prices at non-trivial levels so operators do not have an incentive to not compete in the auction so as to keep prices low (and trade after).

Source: Plum Consulting, GSMA's Mobile Broadband Toolkit

Once setting the reserve prices the NTRA would then be able to run the auction. After the auction the NTRA may want to allow a process of re-stacking whereby the winners switch which lots they won so that they have more efficient contiguous blocks of spectrum.

7 Recommendations

To enable Egypt to benefit from the potential growth in GDP of EGP310bn it is essential that the NTRA release further spectrum from 2019 or as a minimum identify the timescales for release of spectrum to provide operator certainty. It is noted that achieving such economic benefit is based on the 700 MHz and 800 MHz bands being used in 2020 and the remainder of the 1800 MHz and 2.1 GHz bands being made available in 2018.

We therefore recommend that the NTRA should concentrate on freeing up these bands and identifying the timescales for release and award.

Existing frequency bands:

i. Discuss with existing users the potential to release further 1800 MHz spectrum
ii. Discuss with operators options to possibly rearrange the band once additional spectrum is available and so provide contiguous spectrum, ideally in 10 MHz blocks, that can support LTE (4G) technology.
iii. Discuss with existing users the potential to release further 2.1 GHz spectrum.
iv. Identify how to cease the current use of CDMA 850 to minimise the potential for interference into the 900 MHz (E-GSM) bands
v. Identify how service licences may be updated to be service and technology neutral or as a minimum in the short term allow the operators to deploy 4G technologies to ensure efficient use of available spectrum.

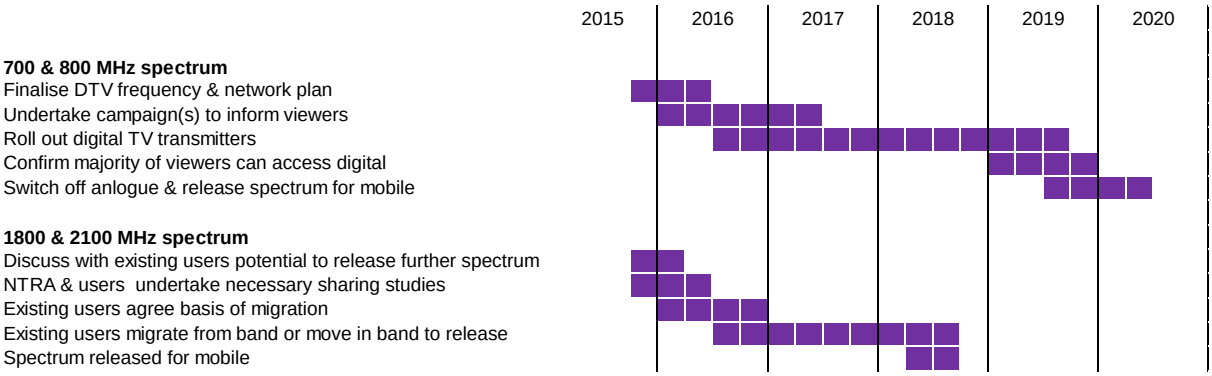
700 MHz and 800 MHz bands:

i. Identify the frequency and network plan for digital terrestrial TV based on releasing, as a minimum, spectrum that will allow the release of the 700 MHz and 800 MHz frequency bands for mobile.
ii. Establish a clear and transparent migration plan to try and avoid the risk of litigation that will delay the process (see case studies in Section 4.2.1.).
iii. Inform viewers of the terrestrial TV plans and as necessary encourage purchase of necessary set top boxes or new TV sets that support DVB-T2 technology.
iv. Monitor progress against the migration plan.
v. Liaise with neighbouring administrations to assess their progress and possible implications regarding cross border interference.

Figure 7-1 gives one possible roadmap for spectrum release for the existing and sub-1 GHz spectrum bands. This indicative roadmap is estimated on the assumption that the 700 MHz and 800 MHz bands are released in 2020 and the remaining spectrum in the 1800 MHz and 2.1 GHz bands is released by 2019. Thus the roadmap is estimated backwards from these dates.

In addition, the NTRA also need to ensure there are sufficient and suitable frequency bands available to connect the base stations to the core network.

Figure 7-1: Indicative roadmap



The L-Band, 2.6 GHz band and C-Band are of lower priority than the sub-1 GHz bands and the existing bands and thus may be released over a different timescale. Given the uncertainties over the timescales an indicative roadmap is not given, however; the NTRA must publish expected timescales of release so that the operators have investment certainty. Other tasks are listed below.

L-Band:

i. Monitor the outcome of the WRC-15 in respect of the likely band that will be agreed for harmonisation
ii. Notify existing users that there will be need for them to migrate from the spectrum in the short to medium term and that licences will not be automatically renewed beyond [2020]. After [2020] their renewal will depend on the demand for access to the spectrum from the mobile operators but the situation will be reviewed on an annual basis commencing in 2017[71].
iii. Monitor the equipment and device ecosystem and also operator demand to identify the timing for full release of the band.
iv. Publish planned timescales for the band to be used for mobile to inform both the existing licensees and also the mobile operators

2.6 GHz band:

i. Continue discussions with existing users of the spectrum and identify a clear timeline for release of spectrum (in particular, timescales from when notifying existing users that they need to migrate from the band to when the spectrum will be totally freed up and available for award).
ii. Publish planned timescales for the band to be used for mobile to inform both the existing licensees and also the mobile operators

C-Band:

i. Commence discussions with existing users of the band and consider whether they should remain in the band or move to alternative spectrum or technologies
ii. Develop a time plan for release of some or all of the band
iii. Publish planned timescales for the band to be used for mobile to inform both the existing licensees and also the mobile operators

As this report has demonstrated, it is vital that the NTRA make rapid progress on the release of spectrum so that the Egyptian economy may fully benefit from mobile broadband.

[71] This may allow some users to retain use of the band for slightly longer rather than "removing" all users and leaving the spectrum unused.