Terrestrial broadcasting and spectrum use in the Arab states

A report for the GSMA

Tim Miller, Val Jervis and Tim Hogg

April 2015

Plum Consulting, London
T: +44(20) 7047 1919, **www.plumconsulting.co.uk**

Table of Contents

Executive summary 4
Number of multiplexes needed 4
Other considerations 5
Conclusions 6

1 Introduction 7
1.1 Geographical scope 8
1.2 Report structure 8

2 Strategic background 9
2.1 International experience 10
2.2 Progress in the Arab states 13

3 Methodology 17
3.1 Frequency and network planning 18
3.2 Spectrum requirements 19

4 Results 21
4.1 TV channels 21
4.2 Multiplexes 22
4.3 Spectrum requirements 23
4.4 The optimum number of TV channels 25

5 Case studies 28
5.1 Egypt 28
5.2 Oman 30
5.3 Saudi Arabia 32
5.4 UAE 33

6 Conclusions 36
6.1 Considerations for governments 36

Appendix A: Country overview 38
A.1 Algeria 38
A.2 Bahrain 38
A.3 The Comoros Islands 39
A.4 Djibouti 39
A.5 Egypt 39
A.6 Iraq 40
A.7 Jordan 40
A.8 Kuwait 40
A.9 Lebanon 41
A.10 Libya 41
A.11 Mauritania 41
A.12 Morocco 42
A.13 Oman 42

A.14 Palestine 43
A.15 Qatar 43
A.16 Saudi Arabia 43
A.17 Somalia 44
A.18 Syria 44
A.19 Sudan 44
A.20 Tunisia 45
A.21 UAE 45
A.22 Yemen 45

Appendix B: Bibliography 46
B.1 General sources 46
B.2 Algeria 47
B.3 Bahrain 47
B.4 The Comoros 47
B.5 Egypt 47
B.6 Iraq 48
B.7 Jordan 48
B.8 Kuwait 48
B.9 Lebanon 48
B.10 Libya 48
B.11 Mauritania 49
B.12 Morocco 49
B.13 Oman 50
B.14 Palestine 50
B.15 Qatar 50
B.16 Saudi Arabia 51
B.17 Somalia 51
B.18 Tunisia 51
B.19 UAE 51
B.20 Yemen 52

Appendix C: Glossary 53

Executive summary

This study examines the spectrum required to support the digitisation of terrestrial broadcasting in the Arab states and demonstrates the importance of the Arab Spectrum Management Group (ASMG) countries developing a joint position at the forthcoming World Radio Conference in 2015 (WRC-15) to allocate the band 470-694 MHz as co-primary for broadcasting and mobile services.

This study finds that a few countries with large terrestrial television broadcasts define the amount of spectrum that must be reserved for television broadcasting, but even with these constraints there is a significant amount of spectrum – all UHF spectrum above 582 MHz – that can be released for other services. Given appropriate coordination and interference analysis, on a sub-regional level even more spectrum may be released. This highlights the importance of flexibility in spectrum allocation; where coordination is effective, there is significant spectrum that can be released from broadcasting.

The analysis undertaken is based on the following.

- The number of terrestrial analogue television channels identified as broadcast in each country from publicly available information sources.
- The assumption that the countries will adopt DVB-T2 technology and MPEG-4[1] as it is more efficient that DVB-T and provides improved Single Frequency Network (SFN) performance.
- Not all programmes will be transmitted in High Definition (HD) format and many will continue in Standard Definition (SD) format .
- The frequency bands 174-230 MHz (VHF Band III) and 470-790[2] MHz (UHF Bands IV and V) are currently available to support DVB-T2 and also T-DAB networks. Band III can be subdivided into seven or eight RF channels (depending on whether RF channels have 8 or 7 MHz bandwidth) and also subdivided into 32 T-DAB blocks. The UHF spectrum can be subdivided into 48 RF channels with 8 MHz bandwidth.

It is also noted in this study that the process to modify the Geneva 2006 frequency plan among the Arab countries, initiated to release frequencies above 694 MHz, is based on each Arab country having four DTT multiplexes, which would allow for approximately 32 TV channels in each country. This in itself is an overestimation of the demand for broadcasting capacity.

However, the number of households across the region relying on terrestrial is decreasing although the overall size of the broadcasting market continues to grow. This could indicate that an assumption of keeping the number of TV channels broadcast over terrestrial as constant may even be overestimating the most efficient use of spectrum.

The outcome of the analysis is as follows.

Number of multiplexes needed

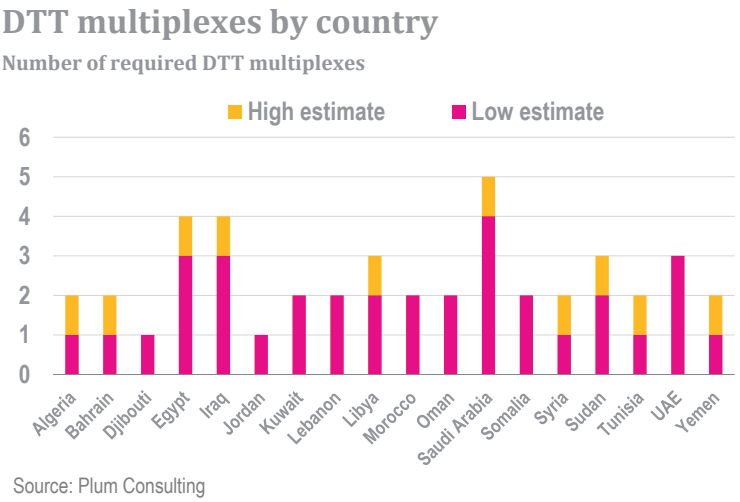
As shown in Figure 1, the number of multiplexes needed to carry the existing number of television channels varies between one and four. It is likely that three multiplexes would be able to accommodate all the countries, including Egypt and Iraq (depending on the extent of HD

[1] Some countries are currently using MPEG-2 but as this is a less efficient technology it is assumed that this can be upgraded.

[2] Current work is towards releasing spectrum above 694 MHz, but this has not yet been finalised

programming). Two multiplexes would definitely be able to accommodate 13 of the 18 countries, and potentially another two again depending on extent of HD programming.

Figure 1



This indicates the potential to release spectrum below 694 MHz.

Other considerations

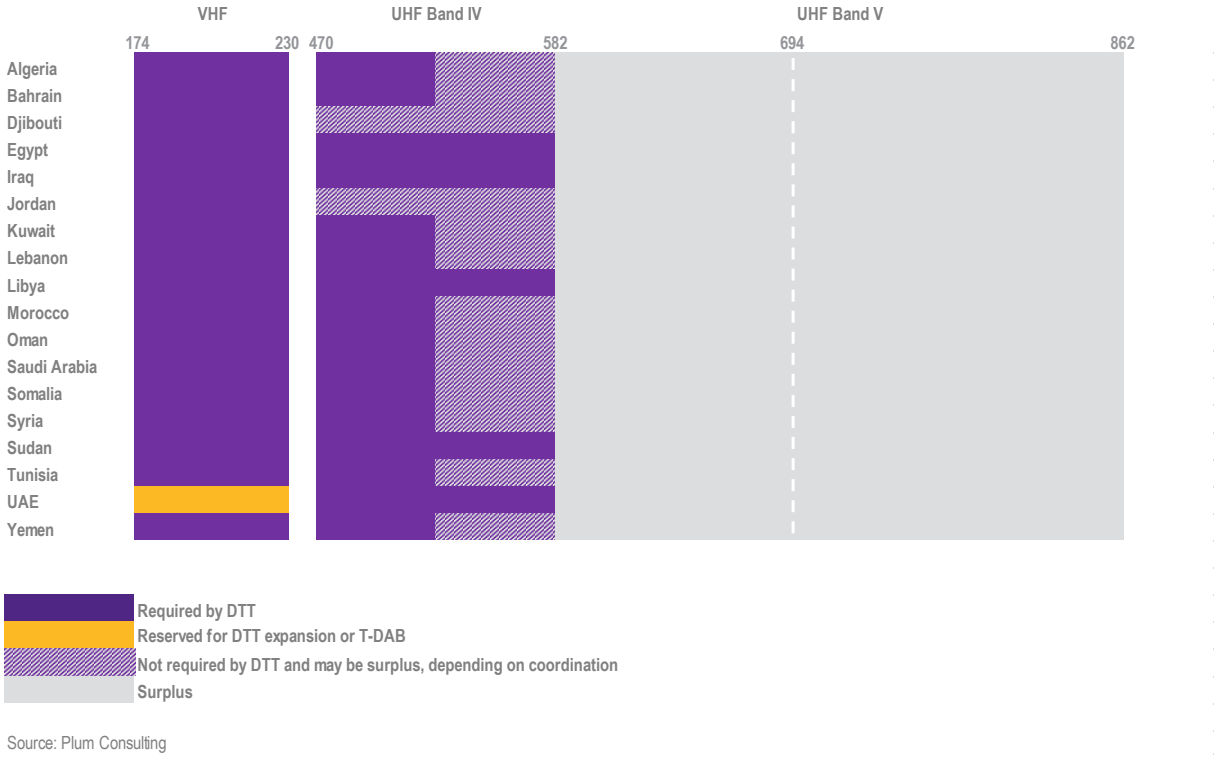
Actual spectrum requirements in each country will depend on:

- Provision for possible T-DAB deployment in VHF Band III;
- Provision for expansion of DVB-T2 in VHF Band III;
- Number of multiplexes in each country; and
- The need to avoid cross-border and in country interference. This means it is not possible to utilise the same and contiguous frequencies in each country.

The highest frequency assigned in each country will define the spectrum requirements for digital terrestrial broadcasting and therefore potentially vacant spectrum. The actual spectrum requirement will vary by country because the need to avoid interference means it is not possible to utilise the same and contiguous frequencies in each country. The precise spectrum required to support DVB-T2 can only be identified through a significant frequency planning process, however; it is probable that each country would be able to operate one multiplex[3] in any block of seven without significant interference. The result of this is a large amount of surplus spectrum, as shown in Figure 2.

[3] Some countries are already able to operate multiple multiplexes within the RF spectrum. However, to do so there must be strict coordination between few neighbouring countries, which is not the case in the Middle East in particular. Therefore, to be conservative, the assumption of one multiplex in VHF is used in this study.

Figure 2: Example of spectrum requirements



Source: Plum Consulting

This figure requires some further assumption over allocation; see Section 4.3 for details.

Conclusions

The analysis in this report shows that terrestrial digital broadcasting does not necessarily require all UHF spectrum between 470 and 694 MHz, and so there is potential for significant amounts of this to be released for other uses. The current assumption in the Arab replanning process of four multiplexes reserved for television, exclusively from UHF, may well lead to sub-optimal outcomes.

It will be necessary for this spectrum to be identified as co-primary for broadcasting and mobile if the benefits are to be accrued by releasing some of this spectrum for mobile broadband. The opportunity is available at WRC-15 but if no concerted action is taken by the Arab states it could be as late as 2030 before the spectrum can be released and utilised.

1 Introduction

The viewership of terrestrial television in some Arab countries is very low, with satellite, cable and (increasingly) IPTV the platforms upon which people choose to watch television. At the same time, the demand for mobile communications has rapidly accelerated across the region in recent years, with mobile voice services reaching penetration rates in some Arab countries of over 100%[4]. The availability of LTE technology means that access to fast broadband Internet is no longer limited to those with a fixed line connection to their residence. As well as the social benefits of mobile broadband, studies estimate that an increase of broadband penetration of 10% leads to an increase in GDP of up to 1.2%[5]. While mobile broadband is growing quickly, it still remains low in some Arab countries and this is in part because supply is restricted by a lack of available spectrum.

In countries where terrestrial broadcasting is less important or less used, therefore, it may be appropriate for regulators or government to take the opportunity to encourage further use of alternative platforms. The digitisation of broadcasting which is currently ongoing in a number of countries provides the potential to reduce further the demand for broadcasting spectrum to support digital terrestrial television (DTT)[6].

However, the analysis undertaken as part of this study does not rely on these assumptions. Underlying the analysis of this study is the premise that more spectrum can be allocated to mobile without reducing the number of terrestrial television channels[7]. This is made possible by the move to DTT as the amount of bandwidth needed to broadcast terrestrial television reduces significantly with the use of digital technology whilst providing the opportunity to support, for example, high definition television and interactive content.

The decision to allocate spectrum to mobile has to be taken at an international level as was the case for the 800 MHz band which was identified for mobile broadband services at WRC-07[8] and for the 700 MHz band at WRC-12. To provide the possibility of identifying further spectrum for mobile broadband, where needed in the medium to long term, requires the band 470-694 MHz to be identified as co-primary for broadcasting and mobile. Such an identification would give administrations the flexibility to use the spectrum in the most efficient way, and does not mean immediate clearance by broadcasting and use by mobile.

The opportunity for spectral efficiency and economic benefits that flow from allocating more spectrum to mobile in the Arab region must be taken at a regional level. This, in turn, requires the ASMG countries to have a joint position at WRC-15 because if no decision is made then there is considerable risk that discussion of this spectrum will not become an Agenda Item until 2023[9] with the spectrum potentially not being released until 2030 or beyond. These timescales highlight the need for flexibility and the need to act now.

[4] ITU Yearbook of Statistics, 2014

[5] For a literature review see Appendix A of 'The Economic and Social Impact of Mobile Broadband in Egypt', Plum Consulting, October 2014. http://plumconsulting.co.uk/pdfs/Plum_Sep14_The_Impact_of_Mobile_Broadband_in_Egypt.pdf

[6] See ITU presentation (2015), 'The Digital Dividend & the future of the 700/800 MHz Bands in Region 1' http://www.cto.int/media/events/pst-ev/2015/DBSF%202015/Presentations/6.3%20Michele%20Coat%20Degert.pdf

[7] As per common usage, the term TV channel is used to refer to a terrestrial TV station (e.g. BBC1). A broadcaster may operate one or more terrestrial TV stations.

[8] World Radio Conference held in 2007

[9] This assumes that at WRC-19 an Agenda Item is agreed for the 470-694 MHz band.

1.1 Geographical scope

This study focusses on the countries in the Arab Spectrum Management Group (ASMG):

- Algeria
- Bahrain
- The Comoros
- Djibouti
- Egypt
- Jordan
- Kuwait
- Lebanon
- Libya
- Iraq
- Mauritania
- Morocco
- Oman
- Palestine
- Saudi Arabia
- Somalia
- Sudan
- Syria
- Tunisia
- Qatar
- Yemen
- UAE

In each of these countries this study has aimed to examine the current broadcasting regime and detail how much spectrum is required for a continuation of this. However, in a number of cases publicly-available information has not been available, or has been contradictory to other sources. This paper therefore includes only information which can be independently verified, with sources listed in the Bibliography.

1.2 Report structure

This report is structured as follows:

- Section 2 provides the background to digital switchover (DSO) and usage of the VHF and UHF bands and addresses the importance of terrestrial television in the Arab states.
- Section 3 sets out the study methodology.
- Sections 4 outlines the results of the analysis.
- A number of case studies are described in more detail in Section 5.
- Section 6 summarises the conclusions of the study and puts forward recommendations for the governments of Arab states.

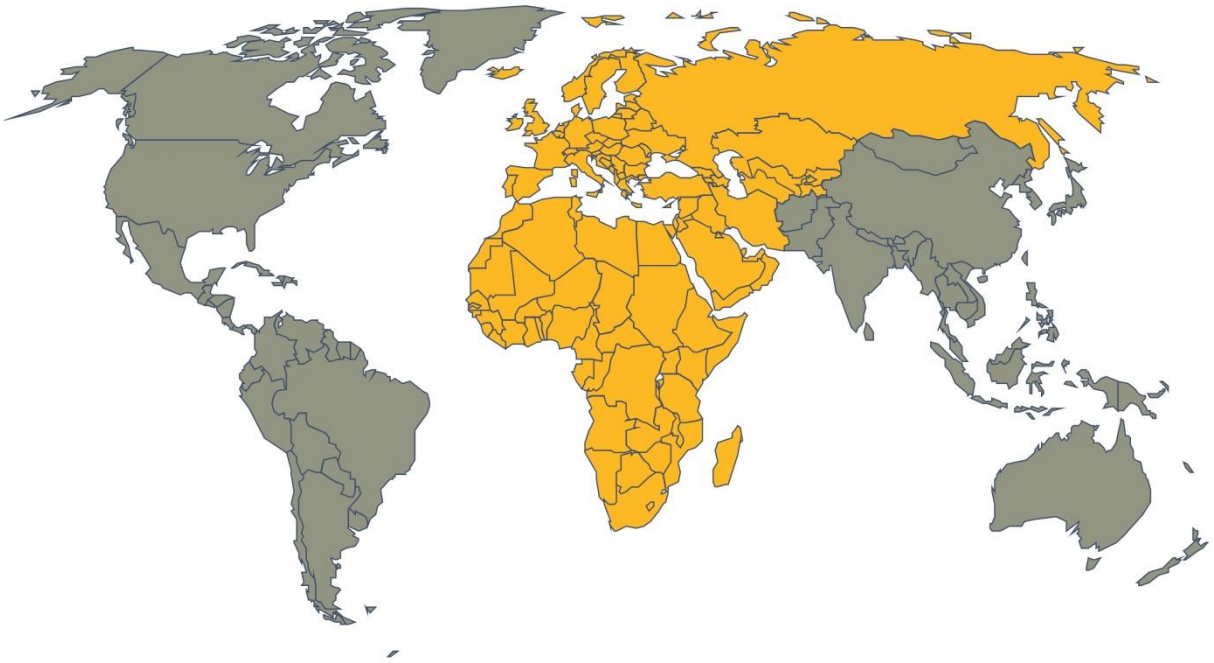
The Appendices provide the detailed results for each country in the study, the sources of information and a glossary of terms.

2 Strategic background

Decisions over spectrum usage require international harmonisation, and discussions around digital terrestrial broadcasting spectrum requirements in the VHF and UHF bands started with the Geneva 2004 and 2006 planning processes. Technological advances and international agreements mean that allocation decisions may be adapted, and this is the case with the outcome of the latest process of re-planning in the Arab States due to be reported later in 2015.

The Geneva 2006 frequency plan (GE06) was developed to provide for T-DAB and DVB-T digital services in the VHF (Band III) and UHF (Bands IV and V) broadcasting bands in 118 countries, as highlighted in Figure 2-1.

Figure 2-1: RRC-06 Planning Area



Source: Plum Consulting

The planning process started in May 2004 with RRC-04 where the technical basis (that is, the planning criteria and parameters) for the Plan were determined. Then, at RRC-06 the frequency planning was undertaken – the work was divided between five Coordination and Negotiation Groups covering: Europe and the North Eastern area, Western and Central Africa, Eastern and Southern Africa, Red Sea area (area with extreme propagation conditions) and Other States, and Mediterranean. The basis of the digital TV planning was deployment of DVB-T.

The frequency band 174-230 MHz (Band III) was subdivided into 7 or 8 DVB-T RF channels depending on whether the country proposed to use 8 or 7 MHz bandwidth and also subdivided into 32 T-DAB blocks with 1.75 MHz bandwidth. The 470-862 MHz (Bands IV and V) was subdivided into 49 RF channels with 8 MHz bandwidth. This is shown in Figure 2-2.

Figure 2-2: Frequency bands for digital TV planning (RRC-06)

Source: Plum Consulting

There were a significant number of iterations undertaken for the frequency planning and before each one the Administrations submitted their digital requirements; planning software[10] was then used to undertake calculations to try and satisfy as many of these requirements as possible. Account was also taken of where Administrations had agreed that two or more digital platforms could use the same channel even though the compatibility analysis had shown that interference would occur[11]. In some instances agreements were reached on the basis of, for example, reducing transmitter powers and accepting a smaller coverage area.

In addition, to try and meet each country's requirements there was the possibility for Administrations to mutually agree to accept a higher level of interference than the one agreed at RRC-04. In some instances an increase of up to 5 dB extra interference was agreed. It was also agreed to ignore protection of the analogue TV in the planning process – it would however need to be considered during implementation.

The outcome of the planning process typically provided for seven nationwide frequencies for DVB-T in Bands IV and V and one in Band III. In addition frequencies were identified for T-DAB in Band III.

2.1 International experience

Since the RRC-06 the band 790-862 MHz (also referred to as the 800 MHz band) has been identified at WRC-07 for mobile broadband services and 694-790 MHz (700 MHz band) at WRC-12 for Region 1.

To make the 700 and 800 MHz bands available for mobile services requires intensive national re-planning and international coordination activities. It requires the countries to adopt DVB-T2 and MPEG-4 or H.265 as DVB-T2 provides at least a 30% higher transmission capacity as it is more efficient. DVB-T2 also provides improved Single Frequency Network (SFN) performance and supports larger scale networks than DVB-T. It also allows a reduction in the power used at transmitter sites by around 25% while achieving the same coverage.

[10] Provided by the ITU Bureau

[11] For example, there might be terrain shielding which would limit the potential for interference but was not taken into account in the planning software.

Table 2-1: Comparison of DVB-T and DVB-T2[12]

Format	Source coding	Number of RF channels DVB-T	Number of RF channels DVB-T2	Number of RF channels DVB-T2
		Fixed MUXing		Fixed MUXing future
SD	MPEG-2	6	10	10
SD	MPEG-4/AVC	9	13	15
HD-720p	MPEG-4/AVC	3	4	5
HD-1080i	MPEG-4/AVC	2	4	4
		Statistical MUXing		Statistical MUXing future
SD	MPEG-2	8	13	13
SD	MPEG-4/AVC	11	16	19
HD-720p	MPEG-4/AVC	3	5	5
HD-1080i	MPEG-4/AVC	3	4	5

Source: ITU

Countries that have not started the introduction of digital terrestrial broadcasting are in the best position to take advantage of the benefits provided by adoption of DVB-T2 and minimise the costs associated with such a move. However the associated re-planning to release spectrum is not being undertaken at the same time throughout all the countries that had frequencies allocated through the RRC-06 process, but on a subset of countries instead.

2.1.1 Analogies in Sub-Saharan Africa

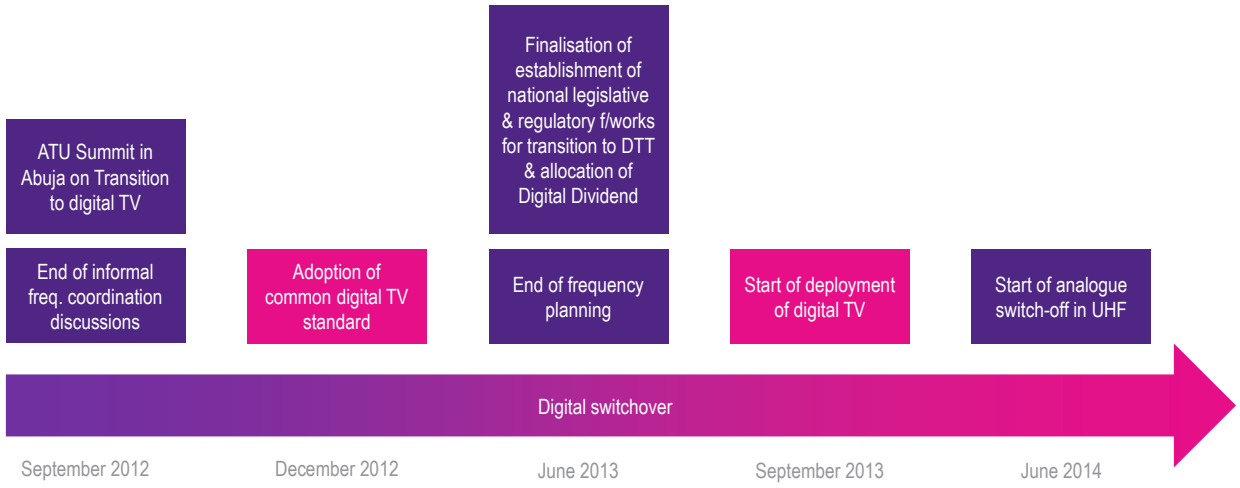
In Sub-Saharan Africa work has been ongoing to modify the RRC-06 frequencies to release frequencies above channel 48 (694 MHz). According to a presentation from the Radiocommunications Bureau[13] two co-ordination groups were established – Western and Central Africa and Eastern and Southern Africa – and using the GE-06 calculation approach and input data from 47 African countries these looked to re-plan the UHF band to support a minimum of four coverage layers (multiplexes[14]) in RF channels 21-48 (470-694 MHz). The recommended timeline that was identified as being necessary for the process is shown below.

[12] The TV video stream is compressed and the amount of compression varies depending on the complexity of the picture. Statistical multiplexing allows the total multiplex capacity to be shared between the RF channels based on their bit rate requirements. The amount of data required will vary rapidly depending on the picture and this allows the resources to be dynamically shared. This can be more efficient compared with allocating a fixed bit rate per channel.

[13] See "Frequency Coordination Exercises in Sub-Saharan African Countries" presented by Pham Nhu Hai at the WP6A Rapporteur Group Meeting 16 October 2012

[14] A DTT multiplex (MUX) is a bundle of TV services that have been digitised, compressed and combined into a data-stream for transmission to the consumer over a single channel. The receiver separates each service from this compressed data-stream and turns it into a form which can be viewed. Anything that can be digitised can be contained in a multiplex. This can include: sound, video, text, computer applications, electronic programme guide information, receiver upgrades and conditional access (descrambling).

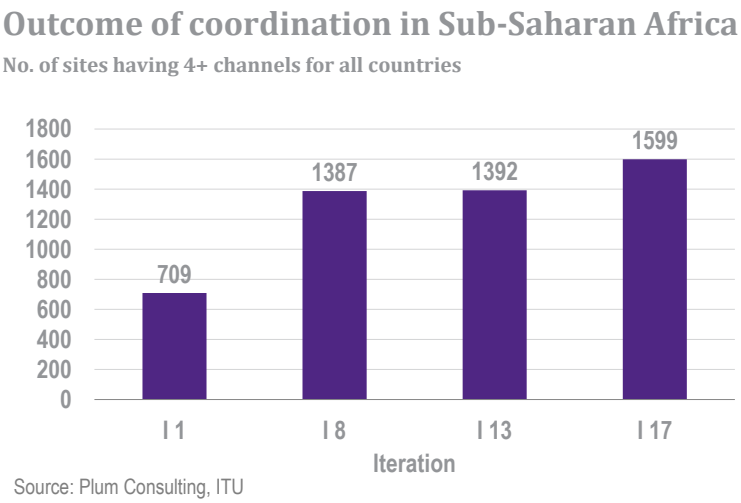
Figure 2-3: Recommended timeline for terrestrial TV broadcasting changes



Source: Plum Consulting, Radiocommuncations Bureau

To modify the frequency requirements a number of iterations of the planning and coordination analysis were undertaken and the figure below shows how over time and number of iterations (1 to 17) it was possible to increase the number of sites having access to four or more RF channels.

Figure 2-4



Source: Plum Consulting, ITU

In practice there were a total of 33 iterations before the revised frequency plan was finalised. According to the ITU the outcome of the planning process, following a "lot of effort and mutual co-operation from all countries" was:

- 100% of the sites in 4 countries had access to four or more RF channels
- Over 75% of the sites in 12 countries had access to four or more RF channels
- Most major cities in all the countries had access to four or more RF channels.

It was considered that with the implementation of Single Frequency Networks (SFNs) more than four multiplexes may be possible.

2.2 Progress in the Arab states

A similar process to that undertaken in the Sub-Saharan Africa countries to release frequencies above 694 MHz has been initiated among the Arab Countries[15]. Some Arab countries already use the 800 MHz band for mobile services and so did not have TV frequencies identified in this band. A key issue for the Arab states is minimising interference with Iran[16]. At the first coordination meeting it was agreed that:

- Those countries that had not yet started the introduction of digital terrestrial TV would be invited to adopt DVB-T2 and MPEG-4.
- A maximum margin of 4 dB would be used for coordination between the Arab countries, with the option of individual countries agreeing to less stringent criterion during bilateral meetings.
- Each country would aim to have four DTT multiplexes.
- There would be two further coordination meetings – one took place in September 2014 and the final one was scheduled for April 2015. It was anticipated that it would take 9 months to complete the necessary iterations[17].
- Four sub-regional groups were created:
  - Group A: UAE, Bahrain, Saudi Arabia, Oman, Qatar, Kuwait, Iraq and Yemen
  - Group B: Saudi Arabia, Jordan, Syria, Palestine, Iraq, Lebanon and Egypt
  - Group C: Saudi Arabia, Egypt, Sudan, Djibouti, Somalia, the Comoros, Yemen and Libya
  - Group D: Libya, Algeria, Tunisia, Morocco and Mauritania
- Those non-Arab countries that would be affected by the GE-06 Plan would be invited to the coordination meetings.

The situation for iteration 22 is shown below – the figure shows the percentage of required RF channels that have been identified for each country[18] both on the basis of ignoring interferers up to 3 or 4 dB and on the basis of ignoring all interferers.

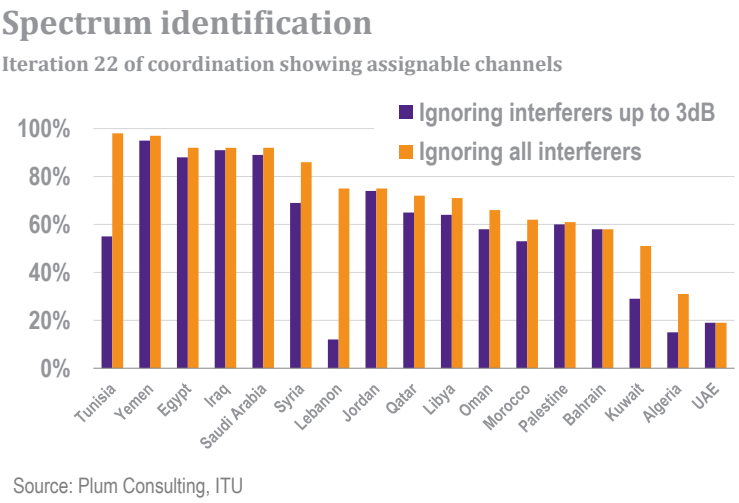
[15] See http://www.itu.int/en/ITU-R/terrestrial/broadcast/ASMG/Pages/default.aspx

[16] ITU presentation (2015), 'The Digital Dividend & the future of the 700/800 MHz Bands in Region 1'

[17] The deadline of inputs for iteration 23 was the 30 March 2015

[18] !00% indicates that frequencies are available for all the identified transmitters based on the requirement for 4 layers.

Figure 2-5



Source: Plum Consulting, ITU

Figure 2-5 shows that in some countries the percentage of assignable RF channels is very low. This is not unexpected for smaller countries where all transmitters have to be coordinated with neighbouring countries. Those Arab countries requiring more than four multiplexes in the UHF bands might be able to increase them according to the GE-06 Article 4 Procedures.

In the current re-planning for the Arab States it is assumed that there will be four DTT multiplexes in the UHF band and no mention is made of the VHF Band III. It is noted that in some countries the VHF Band has been identified for T-DAB or held in reserve to provide additional capacity if required in the future and that may be the reason why it is not being used for television. However access to the VHF band can reduce the requirement for UHF spectrum and TV multiplexes can also support digital radio. It is noted that the agreed switch off date in some African and Arab countries for the VHF band is 2020 not 2015 which will impact on when the band can be used for digital terrestrial services.

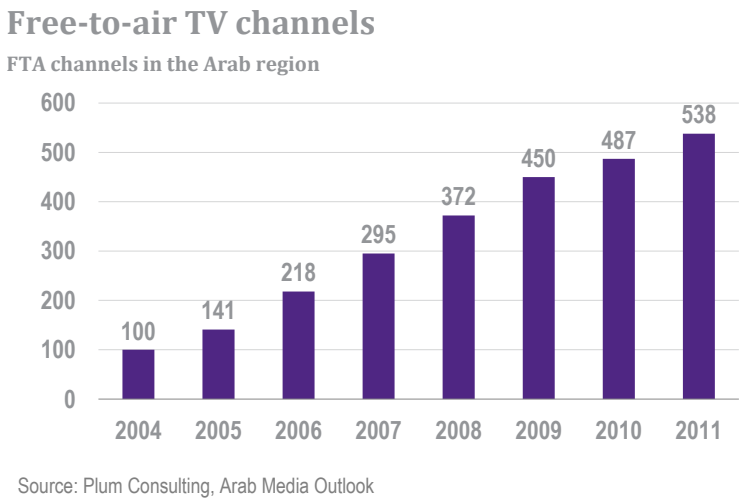
2.2.1 Demand and supply of bandwidth from television

The decision to have four multiplexes in the UHF band needs reconsideration. This study uses a bottom-up approach to estimate the number of multiplexes that the existing number of terrestrial television channels requires. In some countries this will mean that fewer than four multiplexes are required, thus freeing up spectrum for mobile broadband. Indeed, as discussed later, the requirement for four layers of terrestrial broadcasting per country appears excessive in a number of cases. In some Arab countries there is already use of the 800 MHz band for mobile services, and there is reduced use of terrestrial broadcasting.

Further, the decision to reserve spectrum only in the UHF band should be revisited. VHF spectrum is ideally suited to broadcast technologies, and should be considered during replanning exercises as an ideal place in which to run digital terrestrial service.

On the supply side, when considering the number of TV channels being broadcast over terrestrial platforms, many countries have very few TV channels available, and there has been little growth over time. The number of TV channels carried over terrestrial platforms is set out in Section 4. This is not to say that there is no growth in broadcasting as demonstrated by the number of free-to-air TV channels, however – as shown by Figure 2-6, there has been a constant growth since 2004.

Figure 2-6

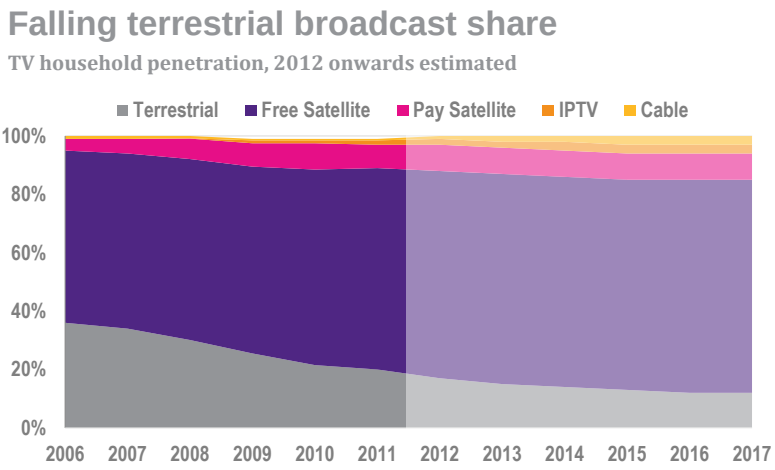


Source: Plum Consulting, Arab Media Outlook

This increase in the number of TV channels available has been enabled by the increasing penetration of other broadcasting platforms, particularly free-to-air satellite and IPTV, which have the ability to carry more programming at a lower price. On the spectrum demand side, looking at the market share of terrestrial as a delivery platform, although the overall size of the broadcasting market continues to grow the number of households across the region relying on terrestrial is decreasing, as shown in Figure 2-7. It should be noted that the percentage of TV households equipped for satellite rose to 92% in 2013[19] according to Eutelsat. Of satellite households, over 90% rely on free-to-air broadcasting[20].

Figure 2-7 uses Plum estimates based on existing trends to forecast the broadcast share by platform up to 2017.

Figure 2-7



Source: Plum Consulting, Arab Media Outlook

[19] Digital TV News article (11th March 2014), 'Eutelsat-Nilesat 7/8°W video audience exceeds 50 million homes', http://www.digitaltvnews.net/?p=23765

[20] Digital TV News article (11th March 2014), 'Eutelsat-Nilesat 7/8°W video audience exceeds 50 million homes',

This growth in reliance on other platforms can be partially attributed to the technical advantages that other platforms hold over the more traditional analogue broadcasting which is currently employed in most Arab countries. While HDTV penetration remains relatively low[21], the number of TV channels broadcasting in HD, or even with 3D content, has increased significantly on other platforms, well beyond the capacity of even the most advanced digital terrestrial technologies. However, across the Arab states 29% of households are now equipped for HD[22].

Despite this, availability of television over terrestrial platforms remains an important political issue, particularly since it represents the most affordable entry point for television consumption and also the platform over which governments have most control – particularly important in the event of national emergency or disaster planning. Governments must carefully balance this political desire for extensive terrestrial platforms against the economic loss that a country may face from constraints on mobile broadband availability.

This study looks at each of the countries in the ASMG region individually, to identify the spectrum requirements of their current terrestrial broadcasting portfolio.

[21] In 2011, it was estimated that only 13% of households owned an HDTV, significantly lower than similar proportions in America or Europe.

[22] Digital TV News article (11th March 2014), 'Eutelsat-Nilesat 7/8°W video audience exceeds 50 million homes',

3 Methodology

This section explores the methodology used in this report to estimate the amount of spectrum that can be released for mobile broadband.

Figure 3-1: Study methodology

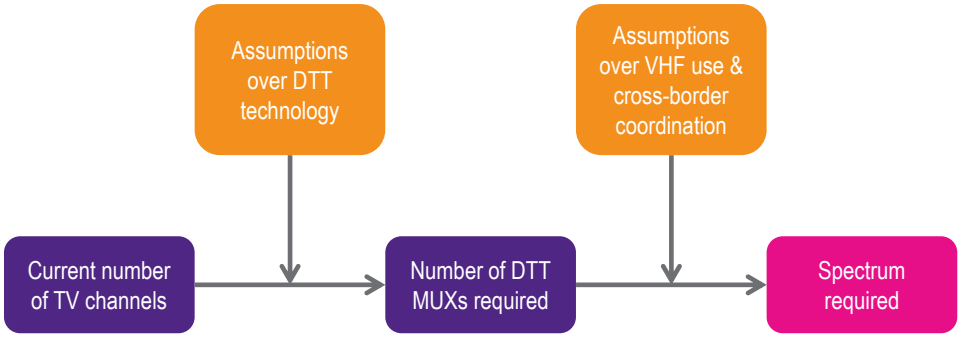


Figure 3-1 shows how the amount of spectrum that is required for terrestrial television is calculated to ensure it can support the same number of TV channels as currently. This is a conservative assumption and with the current trend of falling terrestrial broadcast share, as shown in Figure 2-7, in practice there may be fewer TV channels. There are two key areas where assumptions have to be made:

- DTT technology:
  - Will DVB-T2 be used? DVB-T2 is more efficient than DVB-T – it can carry more TV channels using the same amount of spectrum. For those countries that have not commenced their migration to DTT it should be relatively easy to implement DVB-T2.
  - Will MPEG-4 be used? MPEG-4 is more efficient than MPEG-2.
  - How many HD TV channels will be carried? HD TV channels are of limited benefit if the population are unlikely to be willing or able to purchase HD television sets, or if those who do buy HD sets are those who subscribe to alternative broadcast platforms.
  - Will there be a single frequency network (SFN) or a multi-frequency network (MFN)? Single frequency networks are more efficient, but are not always technically possible across the totality of a country and may not be suitable or ideal if there are local or regional TV channels.
- VHF use and cross-border coordination:
  - Will VHF (Band III) be used for DTT or will it reserved for some other use? Some countries have reserved Band III for digital radio (T-DAB), but it should be noted that this may not be an efficient use of spectrum as consumer uptake of digital radio services has generally been low.
  - Will one or two multiplexes be able to fit in Band III? This will depend on cross-border coordination. Some countries have been able to fit two or more multiplexes into Band III.[23]

[23] For example at RRC-06 Finland and Italy planned most of Band III for DVB-T services and in Finland there are three national multiplexes used for DVB-T2. The VHF band can provide the potential to support larger area SFNs or increase the capacity of a RF channel due to the improved link budget compared with the UHF bands. Also the lower diffraction losses can lead to more uniform coverage compared with UHF. So there could be advantages in migrating from UHF to VHF once spectrum is released

– Will the differing timescales for digitisation of VHF bands and the UHF bands have an impact? By international agreement, analogue broadcasting has to be removed from UHF in 2015 but in some Arab countries it must be removed from VHF as late as 2020; some countries may use a two-step approach whereby one (or two) DTT multiplexes are migrated from UHF to VHF in 2020.

– Will spectrum have to be left fallow due to neighbouring countries DTT networks? Will the placement of multiplexes have to be arranged in alternate frequencies to those used by neighbouring countries multiplexes?

Regarding the last point, the coordination process will limit the potential for interference between neighbouring countries, but it does mean that the same frequencies cannot be used for DTT within a defined distance from the border. The outcome of such planning will be agreement on which specific frequencies can be used for high power transmitters in each country. However, there is still the possibility of using the remaining spectrum for other services, such as outside broadcast or even low power transmitters to provide coverage in-fill. This process of cross-border coordination was undertaken at RRC-06 and is currently being revisited in the Arab States to release spectrum in the Region above 694 MHz. Planning around cross-border interference is not the focus of this study, and simplifying assumptions are made here.

The remainder of this section explore these assumptions in more detail.

3.1 Frequency and network planning

As noted earlier, the DVB-T2 standard offers a large choice of OFDM[24] parameters and – depending on how the modulation scheme, FFT[25] sizes and guard intervals are combined – SFN (single frequency) and MFN (multi frequency) networks can be designed for different applications; ranging from low bit rate robust mobile reception to high bit rate fixed reception. The aim to achieve at least the same level of TV coverage as the existing terrestrial analogue network and make use of the existing domestic receiving antennas and transmission infrastructure (transmitter sites) implies the use of both the VHF and UHF frequency bands.

In planning a DVB-T2 network the first consideration is whether the network is required to support rooftop reception or, for example, portable outdoor reception. This will define the DVB-T2 equipment parameters and the resulting coverage and capacity. In the case of national TV channels there is the possibility of deploying a single frequency network (SFN) but this requires the largest guard intervals and robust modulation schemes to avoid situations where coverage is severely limited by self-interference and this requirement for greater robustness reduces the capacity. However, assuming SISO (single input, single output) operation of DVB-T2, whereby each transmitter emits the same signal, and an RF channel bandwidth of 8 MHz, the maximum transmitter distance can be around

by analogue switch off in the VHF band. However, the benefits of deploying one or more multiplexes in the VHF band either initially or after switch-over are dependent on the existing transmitter installations and plans to re-use transmitter sites and also the existing domestic receiver antennas. For example, if there is a mix of both VHF and UHF multiplexes providing services in a geographic area it may be necessary for viewers to invest in combination antennas (support both VHF and UHF bands with lower gains in both bands) or separate VHF and UHF receiver antennas. It will be important that in countries where a number of services are provided over the UHF bands that the VHF offering is compelling if there is a need for the viewers to make these additional investments

[24] Orthogonal frequency-division multiplexing

[25] Fast Fourier Transform

150km in the UHF bands[26]. This will support around 12 to 14 standard definition (SD) TV channels as shown in the table below. Also if a multiplex is used for high definition (HD) TV channels there is the possibility of supporting 4 to 5 HD TV channels assuming DVB-T2 and MPEG-4[27].

Table 3-1: Comparison of capacity for a DVB-T2 SFN

	Fixed reception	Portable reception
Modulation	64 QAM	64 QAM
FFT size	32k	16 k
Guard interval	19 / 128	1 / 4
Maximum transmitter distance	159.6 km	132.4 km
Code rate	2 / 3	2 / 3
Carrier mode	Extended	Extended
Capacity	24.5 Mbit/s	22.4 Mbit/s
Number of TV channels (MPEG4)	14 SD or 2 HD	12 SD or 2 HD

Source: LS Telecom based on planning in Europe

Another consideration is the frequencies that should be used. It is noted that in the GE-06 Agreement, which applies to Region 1 and Iran, there was a single DVB-T coverage layer identified for each country in VHF Band III[28] and also identification of T-DAB in this band. Further frequencies for DVB-T are normally identified in the UHF bands.

There are potentially fourteen 8 MHz bandwidth RF channels in UHF Band IV (470-582 MHz). In terms of frequency utilisation it is possible for adjacent RF channels to be used so long as the Muxes are radiated from the same site. It has even been possible for transmitters serving directly adjacent area to be co-channel based on the receiver aerial discrimination at the border of the two areas.

It is also important to recognise in some countries it may be impractical to deploy a wide area SFN[29] so a country's network may use re-broadcast links (RBLs). In such cases it is expected that primary distribution will be provided via satellite, IP over fibre and microwave or a combination of these. Clearly satellite is likely to provide the most efficient solution in areas which are sparsely populated and there is little or no IP fibre. DTT will then be used to provide the final link between transmission sites and viewers at a national or regional level.

3.2 Spectrum requirements

The spectrum requirements in each country will depend on:

[26] In practice, the transmitter distance for VHF bands is roughly the same as for UHF, but signal within the broadcast area is more reliable. Nevertheless, this indicates that VHF broadcasting may be more advantageous than only using UHF bands.

[27] Coding standard

[28] Band III is suitable for portable broadcasting services as its Doppler performance is up to 4 times better than UHF Band IV.

[29] For example, there may be wide geographic areas where it is difficult to install transmitter sites for a very limited number of viewers. This is already the case for analogue television where there may be some geographic areas not covered by terrestrial transmitters.

- The number of TV channels;
- Whether they are national or regional TV channels; and
- Whether they are in SD or HD, as this will determine the number of multiplexes that are required.

Decisions need to be made on what TV channels are carried on which multiplex. For example, if there are two broadcasters in a country they might each have access to their own national multiplex and then there might be a separate regional multiplex. The broadcasters might, as part of the licensing process, be required to support TV channels for others on their multiplex or they might be able to retain spare capacity to allow expansion, at a later date, to support HD TV channels.

In general, as part of this study, when assessing the number of multiplexes that are required to support the current analogue terrestrial TV channels we have assumed that broadcasters will generally have access to their own multiplex or a number will share a multiplex if they each only require a single TV channel.

The total spectrum requirement per country is given by the number of multiplexes multiplied by the RF channel bandwidth of 8 MHz[30], assuming that it is feasible to plan a SFN DVB-T2 network.

In a number of the Middle Eastern countries there may only be a realistic requirement for two or three multiplexes, as discussed in Section 4.3, taking into account the limited market penetration of terrestrial TV and the availability and take-up of alternative delivery methodologies.

This means that in each country there is significant potential to release frequencies below 694 MHz, as in UHF band IV there are fourteen RF channels of 8 MHz bandwidth and only a small number of these would be required to meet the needs of each individual country.

[30] This is the bandwidth for the UHF band and could be applicable in the VHF band as well.

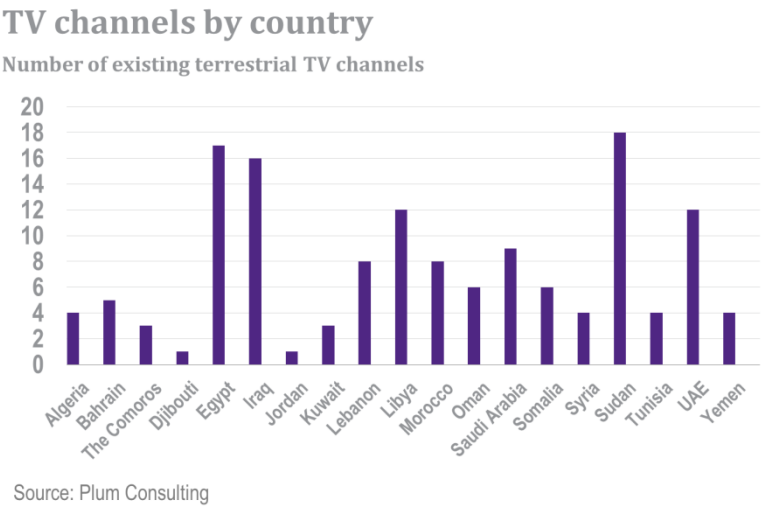
4 Results

Following the methodology set out in Section 3, the number of television channels has been used to calculate the number of DTT multiplexes required in each ASMG country. The details around these calculations can be found in Appendix A.

4.1 TV channels

Figure 4-1 gives the number of current (or planned) terrestrial television channels for each country. In general to be conservative when estimating the amount of spectrum that can be released for mobile, where there is contradictory or unclear information the higher number of television channels was used in the analysis[31].

Figure 4-1



Source: Plum Consulting

The number of existing analogue television channels varies from one in Djibouti and Jordan, to eighteen in Sudan. Countries differ in terms of the amount of regional broadcasting: Iraq has 16 regional TV channels while the three terrestrial TV channels in Kuwait are national. Obviously, the size and geography of a country will influence the extent to which regional programming is realistic, and the extent of regional cultural and linguistic diversity will influence the extent to which it is desirable. It is also unclear where TV channels may share multiplex slots on a time-limited basis.

In order to be conservative, this study assumes that all existing TV channels may wish to launch a nationwide 24-hour service once the transition to digital has taken place. If multiplex slot-sharing continues, this study may overestimate the amount of spectrum that may be required for television broadcasting, but such analysis will need to take place during any detailed band planning exercise.

There is also variation in the ownership of terrestrial television channels, with terrestrial broadcasting dominated by state-owned broadcasters across the Arab states. For example, all seventeen TV channels in Egypt are broadcast by the state broadcaster ERTU, and seventeen of the eighteen TV

[31] While there have been some intentions in Saudi Arabia to expand the number of channels broadcast over terrestrial to 30, there have been no confirmed plans. This analysis therefore uses only the current number of channels.

channels in Sudan are wholly state-owned, with the one other TV channel part-owned by the Government. In contrast, four of the six terrestrial TV channels broadcast in Oman are broadcast by privately owned broadcasters.

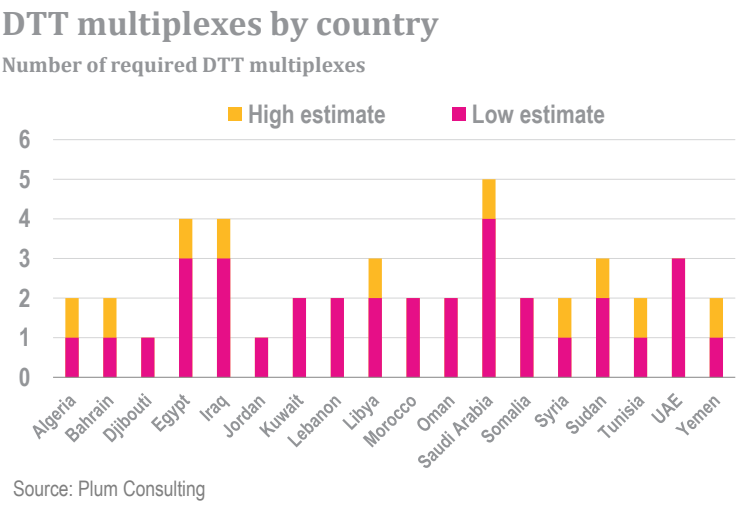
There are some countries for which there is difficulty assessing the precise number of television channels currently in operation. There is not enough certainty around the amount of terrestrial television in Mauritania, Palestine and Qatar to include them in this chart; however, what information can be found is included in Appendix A. Libya, Syria and Yemen were included in the analysis, but the volatile political situations may have changed matters prior to this report being published.

4.2 Multiplexes

Figure 4-2 gives the number of required DTT multiplexes, based on the number of television channels shown in Figure 4-1. Two figures are given: a high estimate and a low estimate; this is because there is some uncertainty over the extent to which a country will have HD programming.

The additional bar shows where a country would need an extra multiplex if there were to be significant HD programming. Where there are no additional multiplexes required HD programming could be accommodated by the base level of multiplexes required to replicate the current level of service. In this way, the chart gives a range for the maximum number of DTT multiplexes that each country will need. As explored in Section 4.4, the optimum number of DTT multiplexes may be significantly fewer than shown in the chart.

Figure 4-2



As shown in Figure 4-2, the number of multiplexes needed to carry the existing number of television channels varies between one and four, averaging 1.8 (or 2.3 if all countries were to move to significant HD broadcasting). Three multiplexes would be able to accommodate all the countries, including Egypt and Iraq (depending on the extent of HD programming). Two multiplexes would definitely be able to accommodate 13 of the 18 countries, and potentially another two.

With only one analogue terrestrial TV channel, Djibouti and Jordan clearly only require one multiplex; indeed, one multiplex would also provide room for expanding the number of TV channels and the

introduction of HD programming. Algeria, Bahrain, Syria, Tunisia and Yemen could carry the existing number of TV channels over one DTT multiplex, but significant HD programming would require another multiplex.

Kuwait, Lebanon, Morocco, Oman, Saudi Arabia and Somalia all require two multiplexes, which would also provide space for expansion into HD programming. Libya and Sudan require two multiplexes, but may need three depending on the amount of HD programming, while the UAE requires three which would have spare capacity for HD programming. Egypt and Iraq require a minimum of three multiplexes, potentially requiring four, depending on HD programming.

The number of multiplexes has not been estimated for The Comoros Islands because they will not use DVB-T or DVB-T2 (see Appendix A).

4.3 Spectrum requirements

The precise spectrum required to support DVB-T2 and also T-DAB can only be identified through a significant frequency planning process such as undertaken for RRC-06 and the current review in the Arab countries based on each country requiring four DTT multiplexes which is aimed at releasing frequencies above 694 MHz.

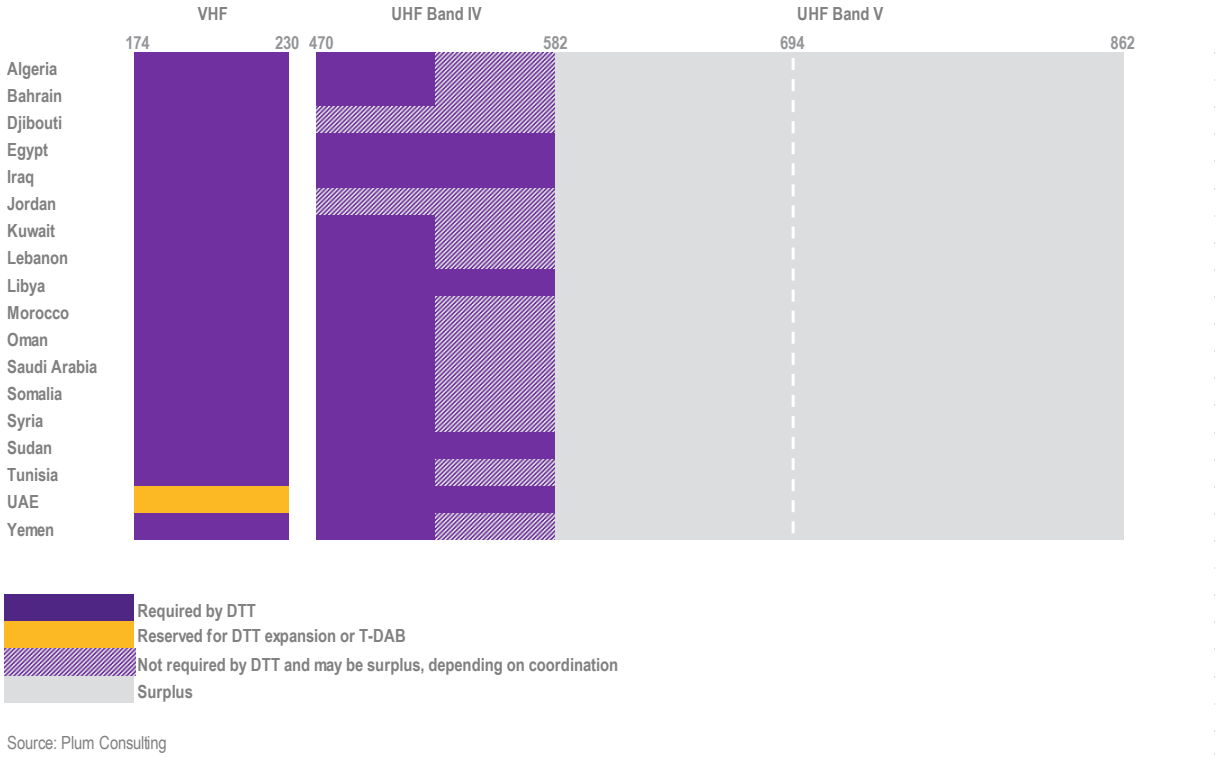
However it is clear from this analysis and the results in Section 4.2 that the actual number of multiplexes will be less than four in each country and therefore it should be feasible to support these in less spectrum. The actual spectrum requirement will vary by country because the need to avoid interference means it is not possible to utilise the same and contiguous frequencies in each country. Further, some countries with multiple neighbours may find that no matter what level their own terrestrial broadcasting needs are, they are forced to restrict use of much of Band IV due to cross-border interference.

Such a planning exercise could result in significant amounts of spectrum being made available for other uses. This study does not seek to prescribe which individual RF channels should be used by each county, but estimates how RF channels may be used by dividing countries into seven groups where it is likely that interference issues will be minimised. These seven groups are set out below.

Figure 4-3: Example grouping of countries

Given these seven groups, it is likely that each country would be able to operate one multiplex in any block of seven without significant interference; while it may be possible for countries to organise their multiplexes in a more efficient way with some operating two multiplexes in a block, this would require considerable coordination and would be difficult with such a large number of countries in close proximity and therefore a conservative assumption of one multiplex per block is used. Therefore, by considering how these countries are located, Figure 4-4 shows how the required multiplexes could be arranged within blocks.

Figure 4-4: Example of spectrum requirements



Source: Plum Consulting

This calculation requires some further assumption over allocation: since the UAE's immediate neighbours are not using the upper part of Band IV it is assumed that additional multiplexes will be able to be operated within the Emirates to carry the high number of TV channels; and VHF bands are suitable for all geographies across the region. The highest frequency assigned in each area will define the vacant spectrum. Across the Arab states, the frequencies assigned in Egypt, Iraq, Libya, Sudan and the UAE will define the vacant spectrum that can be harmonised across all the countries – and therefore spectrum above 582 MHz could be used by other platforms. There may be sub-regions where additional spectrum could be freed up, and within countries there will be gaps between the assigned frequencies which can potentially be used for other services.

This highlights the importance of flexibility in spectrum allocation. If countries coordinate appropriately, there is significant spectrum that can be released from broadcasting to other uses.

4.4 The optimum number of TV channels

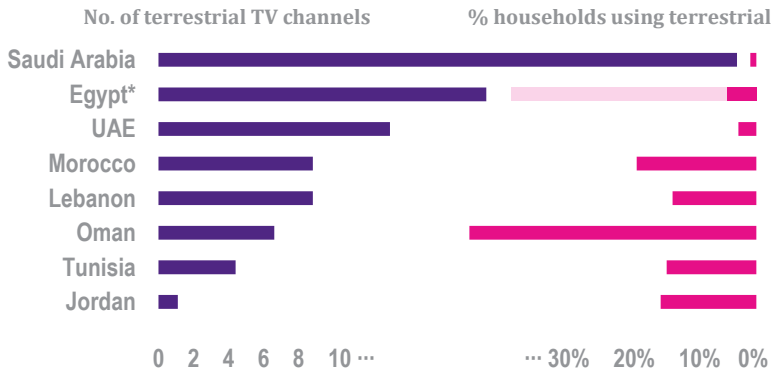
The analysis presented so far looks at the spectrum required to replicate the current terrestrial broadcasting market using new technology over digital platforms. However, this may not be the optimal use of spectrum. This study also raises the issue of whether the current number of terrestrial television channels in each country is appropriate given terrestrial television penetration rates. The economic and social benefits of mobile broadband mean that the opportunity cost of broadcast spectrum is high.

In countries with very low terrestrial viewing figures, such as Saudi Arabia where only 1% watch terrestrial television, a high number of terrestrial television channels may not be an optimal use of

spectrum. The left-hand side of the Figure 4-5 considers the relative number of TV channels that are currently broadcast, or are planned to be broadcast, over terrestrial platforms; the right-hand side identifies the platform market share held by terrestrial.

Figure 4-5

Terrestrial TV usage in Arab states



Source: Plum Consulting
*Reports unclear over % households using terrestrial, see section 5.1

While this study's analysis of spectrum requirements does not consider the number of households actually using the signal, it is useful to explore how countries may use spectrum most efficiently. Relevant considerations for the optimum number of terrestrial TV channels include:

- Terrestrial television penetration (proportion of households who can receive terrestrial). Will this reduce during the digital switchover?
- Terrestrial television viewership – what proportion of households actually watch terrestrial television? The lower the viewership; the lower the value from having each terrestrial television channel.
- Is there a trend away from terrestrial television take-up to other platforms (satellite, IPTV)? The trend away from terrestrial towards satellite, especially in the Middle East, and IPTV, especially in wealthy states, means that the viewership of terrestrial is unlikely to grow. See Figure 2-7 in Section 2.2.1.
- Are culturally important TV channels, such as regional TV channels, provided over other platforms? Are there regional TV channels that are not provided over other platforms? Is this likely to change?
- How many terrestrial TV channels are needed for social cohesion or in case of national disasters? Terrestrial TV channels may be useful for disaster relief or in emergency situations, but one may be sufficient in this case. Additionally, terrestrial television gives the government more control over licences and access.

4.4.1 High definition programming

The advantage of HD is the higher quality that consumers enjoy, however, the decision to offer HD programming should weigh up the disadvantages as well. HD TV channels require more spectrum, reducing the amount of spectrum that can be used for other TV channels or other servies, so it should not be an automatic option especially as it may not be necessary for some content such as 24 hour news programming and similar programmes.

Also HD TV channels are only of value to consumers if they own HD televisions. While this may be the case for wealthy consumers, less-wealthy consumers will not be able to watch TV channels in HD. If the purpose behind having terrestrial television is to reach less-wealthy consumers who cannot afford satellite or IPTV, then there may not be much value to broadcasting in HD.

5 Case studies

Further to the analysis set out in Section 4, it is useful to examine a few countries in more detail to consider how specific circumstances may impact on how broadcasting policy is decided. The need for broadcast spectrum in Egypt, Oman, Saudi Arabia and the UAE is described in more detail below. These four countries produce a variety of different results and, due to their size and state of advancement, are likely to influence regional decision making.

The analysis, detailed below, is indicative of the analysis undertaken on all the countries in the scope of this report.

5.1 Egypt

In Egypt, the penetration of terrestrial television is unclear.

- According to the Arab Media Outlook 2011:2015, 41% of households watch terrestrial television.
- According to Digital Europe (2014), half of households rely on DTH, while most of the rest watch terrestrial analogue television.
- According to the ITU in the 'Working Document On Options For The Refinement Of The Lower Edge Of The Frequency Band 694-790 MHz In Region 1' (30 July 2013) under 5% of households watch terrestrial television.

The state broadcaster, the Egyptian Radio and Television Union (ERTU), provides 17 channels over terrestrial[32]. ERTU is the only terrestrial broadcaster, which relies heavily on advertising revenue[33] [34].

Almost all Egyptian homes have a television (96%)[35]. The proportion of TV homes that subscribe to pay TV is only 6% (2011)[36]. However, piracy of pay TV is prevalent in Egypt meaning that the percentage of homes that watch pay TV may be significantly greater than 6%[37]. The low penetration of pay TV may be due to the popularity and thus importance of terrestrial television.

In addition to private satellite and IPTV broadcasters, the state-owned broadcaster ERTU broadcasts 27 (free-to-air) DTH TV channels[38]. This means that consumers will still be able to watch ERTU programming if they only use the satellite platform. There is also the state-owned Nile TV, which also broadcasts on satellite, and provides nine TV channels.

[32] ITU, 'Working Document On Options For The Refinement Of The Lower Edge Of The Frequency Band 694-790 MHz In Region 1', 30 July 2013, Appendix 1.

[33] Dr Hussein Amin, 'Report on the State of the Media in Egypt – 2nd Draft' http://www.arabruleoflaw.org/Files/PDF/Media/English/P2/Egypt_MediaReportP2_En.pdf

[34] Arab Media Outlook 2011:2015

[35] The Arab Media Outlook 2011:2015 estimated 96% were TV homes in 2011; the ITU Yearbook 2014 estimated 96.9% were TV homes in 2012; and the Broadcasting Board of Governors estimated 98.8% of Egyptians have a working TV in their home in 2014. See BBG, 'Contemporary Media Use in Egypt', March 2014. http://www.bbg.gov/wp-content/media/2014/03/Egypt-research-brief.pdf http://www.arabmediaforum.ae/userfiles/EnglishAMO.pdf

[36] Digital TV Europe, 'Mixed fortunes: free to air and pay TV in the Middle East', 5th November 2014. http://www.digitaltveurope.net/272331/mixed-fortunes-free-to-air-and-pay-tv-in-the-middle-east/ The Arab Media Outlook 2011:2015 estimated 9% of people subscribe to pay TV in 2011.

[37] The Arab Media Outlook 2011:2015 estimated that 11% of the population used illegal decoding cards, and that 61% of pay TV subscribers share it with their neighbours.

[38] High Committee for Coordination among Arab Satellite Channels, 'Arab Satellite Broadcasting Annual Report 2014'. http://www.asbu.net/article.php?artid=1277&lang=en

It may be appropriate for DTT to have the same number of TV channels that the analogue platform carried. ERTU broadcasts two national TV channels: Channel 1, which broadcasts news, soap operas, films and sports; and Channel 2 which broadcasts more entertainment oriented programmes. In addition there are local (regional) stations (TV channels 3 to 8) that provide news, religion, cultural and entertainment programmes.

The digital switchover is underway in Egypt. Prior to switchover there were 216 analogue TV stations, of which[39]:

- 78 transmitter stations were in the VHF band (Band III); and,
- 138 transmitter stations in the UHF band (around 23 stations in RF channels 49-69 and ~ 115 stations in RF channels 21-48).

In January 2014 it was reported that "The Egyptian Ministry of Communications and Information Technology is beginning to replace traditional analogue broadcasting with digital broadcasting" and that in September 2013 the government TV channels had begun broadcasting in digital as well as analogue[40]. The move to digital would include all the analogue terrestrial TV channels as well as satellite TV channels.

In respect of spectrum required to provide DTT, the Head of Spectrum Management in Egypt has stated that:

> "*Current programmes could all be accommodated in the spectrum below 694 MHz with room for introducing a larger number of programmes*."[41]

This is significant because it shows recognition that DTT does not require the entirety of the UHF bands and that the opportunity cost of spectrum is high due to the benefits of mobile broadband. The analysis of this report, see below, shows that all the existing television channels could be accommodated in less spectrum than recognised in the above quote.

On the basis of the BRIFIC[42] data for digital TV transmitters around 2006 it appears that the original intention was to deploy a Multi Frequency Network (MFN) in Egypt with significantly greater capacity than required for the 17 state owned terrestrial TV channels.

If it was assumed that a SFN could be deployed and all the existing terrestrial TV channels were to be transmitted country wide in standard definition, as with analogue, then using three multiplexes should be more than sufficient (one for the main two TV channels, another for TV channels 3 to 8 and the other for the nine Nile TV channels). This would not only support the existing TV channels but allow expansion to HD or the addition of other TV channels if desired. Another option might be to use one multiplex solely for HD TV channels and the other two for SD. There is also the possibility that all 17 state owned TV channels could be provided in HD assuming that each multiplex can accommodate six TV channels[43].

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

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

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

[42] Radiocommunication Bureau International Frequency Information Circular published by the ITU

[43] This will depend on the network planning and use of higher modulation to provide the necessary bandwidth so may be an optimistic scenario.

Post switchover at least one multiplex could be accommodated in Band III and the remaining two potentially in the UHF Band IV where there are fourteen RF channels available. This would allow the entirety of UHF Band V to be released to mobile and supports the comment above that "[c]urrent programmes could all be accommodated in the spectrum below 694 MHz". In fact, given the number of TV channels there would be the potential to release further spectrum, as all broadcasting needs would be met in the spectrum below 582MHz.

However, the precise frequencies that could be used in Egypt will depend on co-ordination with neighbouring countries (Israel, Jordan, Libya, Saudi Arabia and Sudan, and probably Cyprus and Turkey). This would require a significant study and the outcome will depend on the number of multiplexes and network configuration required in the neighbouring countries as well as in Egypt.

5.2 Oman

Similarly to Egypt, terrestrial television is an important platform in Oman, as shown in Figure 5-1. At least 90% of households own a television[44], of which 48% receive terrestrial and 48% receive satellite[45]. This alone makes it unusual in the region, since most countries have significantly greater satellite penetration than terrestrial television, especially when there are only six TV channels broadcast over terrestrial. The current importance of terrestrial television means that it would be justifiable to have the same number of television channels broadcast in the future.

Oman TV, the state broadcaster, broadcasts two TV channels over terrestrial and five (free-to-air) TV channels over satellite[46]. This means that if terrestrial television were to lose popularity consumers would still be able to access Oman TV's broadcasting. Pay TV penetration is relatively low in Oman, with only 7% of households subscribing to some form of pay TV[47]. This may be a reflection of the popularity of terrestrial television, or of the relative wealth of much of the population.

[44] The Arab Media Outlook 2011:2015 estimated 90% in 2011; the ITU Yearbook 2014 estimated 93% in 2010.

[45] Arab Media Outlook 2011:2015

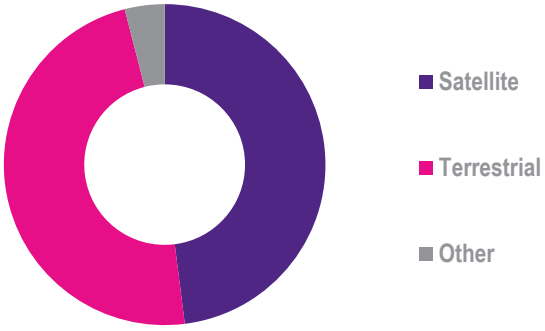
[46] High Committee for Coordination among Arab Satellite Channels, 'Arab Satellite Broadcasting Annual Report 2014'.

[47] Arab Media Outlook 2011:2015; Digital TV Europe, 'Mixed fortunes: free to air and pay TV in the Middle East', 5th November 2014.

Figure 5-1

Oman TV households by platform

2011



Source: Plum Consulting, Arab Media Outlook

Sultanate of Oman Television (Oman TV) began broadcasting in 1974 and it now has a network of transmitters across the country, consisting of 119 transmitters of which 29 are the main transmitter stations and 90 are repeaters (re-broadcast links). Oman TV operates two national TV channels – one for general entertainment and the other a sports-oriented TV channel[48]. There are also four private free-to-air TV channels from broadcasters Majan TV and Jai Hind TV which launched in 2009 and 2011, respectively[49]. The popularity of terrestrial television may be driven by competition amongst broadcasters.

The analogue to digital switchover process started in 2012. The Sultanate decided to adopt the second generation of terrestrial digital video broadcasting (DVB-T2) standard and trialed the system in three regions, Muscat, Barka, and Salalah using 256 QAM. It was reported that "there are some coincidences between the practical and simulation results in some places"[50]. The analysis in this report assumes that the DTT will use an SFN network.

On the basis of six terrestrial TV channels there is the potential to use a single multiplex, but to allow for expansion and deployment of HD and to be conservative it is assumed that two multiplexes will be used – for example, one for Oman TV and the other for the private broadcasters. This would preserve and enhance the competition between terrestrial broadcasters in Oman.

Post-switchover at least one multiplex could be accommodated in Band III and the remaining one potentially in the UHF Band IV where there are 14 RF channels available. This would allow the entirety of UHF Band V (and potentially Band IV) to be released to mobile and thus Oman would be able to benefit from mobile broadband on a wider scale.

However, the precise frequencies that could be used in Oman will depend on co-ordination with neighbouring countries (Iran, Qatar, Saudi Arabia, UAE and Yemen, and possibly Pakistan and Somalia). This would require significant study and the outcome will depend on the number of multiplexes and network configuration required in the neighbouring countries as well as in Oman.

[48] Netia, 'Oman's HD Future', February 2011 http://www.netia.com/images/press_review/02-11/Oman001.pdf

[49] Arab Media Outlook 2011:2015

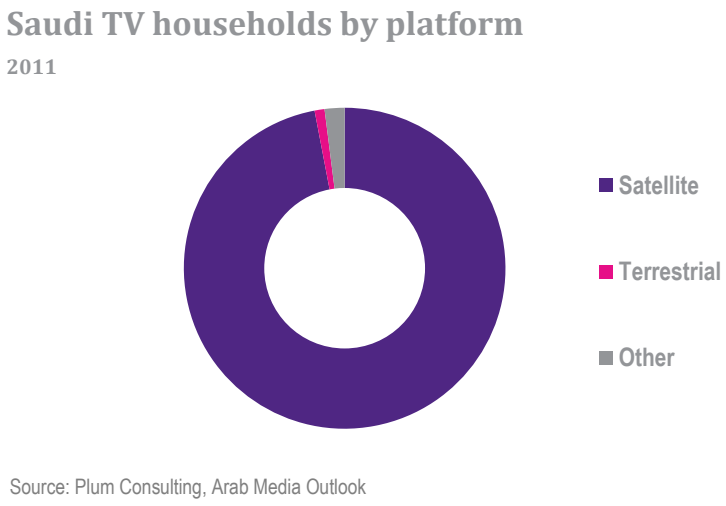
[50] IEEE paper "DVB-T2 in Oman: Trial Results"

5.3 Saudi Arabia

Television is almost universal in Saudi Arabia, with 98% of households owning a TV[51]. However, this is almost entirely provided through the satellite platform – 97% of TV homes receive satellite[52] – despite satellite reception being illegal in the country since 1990. While DTT may be strategically and politically important in Saudi Arabia, only 1% of TV homes receive it[53], meaning it has reduced significance in the television market. Given this, it may be optimal to have few terrestrial TV channels, with slots reserved for those important from a political and cultural viewpoint.

There are a significant number of satellite TV channels based in Saudi, including the state-owned Saudi TV which broadcasts eight free-to-air TV channels and one pay TV channel over DTH[54]. Pay TV is significant in the Saudi television market; different sources suggest that between 25% and 37% of households subscribe to pay TV[55]. Another source puts free-to-air DTH penetration at 70% of households[56]. The popularity of pay TV may contribute to the unpopularity of terrestrial television. The high penetration of pay TV also points to the relative wealth of the population – few households lack the wealth to afford satellite television and many can afford to subscribe to pay TV over satellite.

Figure 5-2



Source: Plum Consulting, Arab Media Outlook

It was reported in June 2006 that the first phase of DTT transmission had been launched in the 3 main cities of Riyadh, Jeddah and Dammam. It supported the four Saudi Arabian TV channels – Channel One, Channel Two, Arriyadiah and AL-Ekhbariya – as well as radio channels[57].

In September 2010 it was considered that there should be 30 TV channels by 2012 on DTT in order to provide greater local content and control. Dr Riyadh Najm, the Assistant Deputy Minister for Engineering Ministry of Culture & Information, is reported to have said:

[51] Arab Media Outlook 2011:2015

[52] Arab Media Outlook 2011:2015

[53] Arab Media Outlook 2011:2015

[54] High Committee for Coordination among Arab Satellite Channels, 'Arab Satellite Broadcasting Annual Report 2014'.

[55] The Arab Media Outlook 2011:2015 estimated 37%; Digital TV Europe (2014) estimated 25%.

[56] Digital TV Europe, 'Mixed fortunes: free to air and pay TV in the Middle East', 5th November 2014.

[57] ABU website June 2006

"The majority of people want programmes that are socially acceptable, that are good for the family and at the same time provide reasonable entertainment… Then, you don't need to go to satellite, you just go to digital terrestrial."[58]

There is no evidence that such an expansion of content has occurred, but some sources indicate that this may still be planned. There has been significant investment in the DTT platform, and the network has been expanded to 100 TV broadcasting towers covering nearly 80% of the population. Additionally, Saudi Arabia is upgrading from DVB-T to DVB-T2[59].

However, given the high penetration of satellite, and the continuing trend towards other platforms it is unlikely that an increased number of terrestrial TV channels would increase the penetration of terrestrial. If consumers can already afford to be on satellite and IPTV, they are unlikely to revert back to terrestrial. The low penetration of terrestrial television might imply that efficient use of spectrum would be maximised by having fewer digital terrestrial TV channels and more spectrum for mobile broadband.

This study has therefore assumed that the current nine TV channels broadcast by Saudi TV over terrestrial will continue to be broadcast over the digital terrestrial network. . Assuming an SFN, nine SD TV channels would require two multiplexes, and this will support the addition of further SD TV channels and some HD TV channels. This would leave Band V, and potentially part of Band IV, unoccupied. The percentage of homes with an HD Ready or Full HD television is over 50%[60], indicating some demand for HD content, but as discussed previously almost all of this demand is met by satellite.

However, the precise frequencies that could be used in Saudi Arabia will depend on co-ordination with neighbouring countries (Bahrain, Egypt, Jordan, Kuwait, Israel, Iraq, Oman, Qatar, UAE and Yemen, and possibly Eritrea, Iran and Sudan). This would require significant study and the outcome will depend on the number of multiplexes and network configuration required in the neighbouring countries as well as in Saudi Arabia.

5.4 UAE

With a household penetration rate of 95%, television has a high uptake in the UAE[61]; however, terrestrial television is watched by few and the commercial opportunities around DTT are uncertain[62]. Satellite is the main TV platform, with 30% of homes subscribing to pay DTH and 24% of homes receiving free-to-air DTH[63]. Terrestrial television has a lower penetration than IPTV in the UAE; 29% of households receive IPTV[64] while (in 2009) only 3% households relied solely on terrestrial[65]. The low level of terrestrial penetration weakens the case for there being many terrestrial TV channels.

[58] advanced-television.com, September 2010. Cited by The Digital Video Broadcasting Project, '30 DTT Freeview channels in two years', 10th September 2010. https://www.dvb.org/news/30-dtt-freeview-channels-in-two-years/country/saudi-arabia

[59] The Digital Video Broadcasting Project, 'Migration to DVB-T2 continues in Saudi Arabia', 21st March 2013 https://www.dvb.org/news/migration-to-dvb-t2-continues-in-saudi-arabia/country/saudi-arabia

[60] Digital TV News article (11th March 2014), Eutelsat-Nilesat 7/8oW video audience exceeds 50 million homes

[61] Arab Media Outlook 2011:2015; ITU Yearbook 2014

[62] The Digital Video Broadcasting Project, 'Going digital will offer the UAE huge opportunities', 3rd May 2011. https://www.dvb.org/news/going-digital-will-offer-the-uae-huge-opportunities/country/united-arab-emirates

[63] Digital TV Europe, 'Mixed fortunes: free to air and pay TV in the Middle East', 5th November 2014.

[64] Digital TV Europe, 'Mixed fortunes: free to air and pay TV in the Middle East', 5th November 2014.

Pay TV is popular with 45% of adults subscribing to it[66] – this may be a result of weak terrestrial television or a cause of it. Either way, it points to the fact that the cost of IPTV or satellite is not a barrier to most of the population. The prevalence of IPTV shows that the UAE is ahead of the trend towards a converged platform and almost one third of the population use broadband to watch television. Broadband is made more affordable by mobile broadband, which also introduces new television applications.

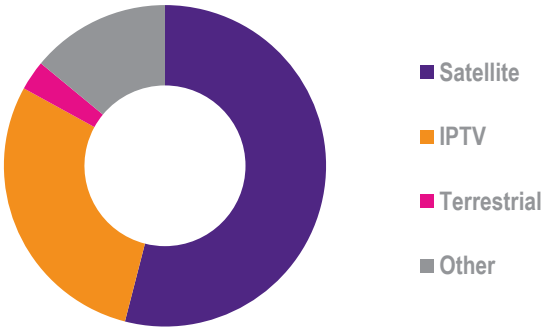
The UAE is important for the pan-Arab satellite industry: there are 72 free-to-air TV channels based in the UAE over all platforms[67]. There are six free-to-air satellite broadcasters based in the UAE which distribute 27 free-to-air TV channels and six pay TV channels over DTH[68].

Figure 5-3 shows the reduced significance of terrestrial television in the UAE. Given the low importance of terrestrial to the television market, it may be appropriate for there to be a low number of digital terrestrial TV channels.

Figure 5-3

UAE TV households by platform

2009, 2014 data



Source: Plum Consulting, TRA, Digital TV Europe

According to the TRA in 2011[69], the three terrestrial analogue broadcasters (including Sharjah TV and Dubai TV) broadcast a total of 12 analogue terrestrial TV channels. Post-switchover, the TRA aimed for all 12 TV channels to be broadcast over DTT and that noted that three DTT multiplexes would allow the existing broadcasters to transmit existing analogue TV channels digitally and in HD, with the possibility of including some additional services. The percentage of homes with an HD Ready or Full HD television is over 50%[70], and HD capacity was noted to be a key success factor for DTT to provide competition to satellite and cable.

[65] TRA presentation on 'UAE Digital Switchover Plan' to the ITU Regional Workshop on Efficiency of the Frequency Spectrum Use in the Arab Region, Amman-Jordan 5-7th December 2011.

[66] Arab Media Outlook 2011:2015, 2012.

[67] Arab Media Outlook 2011:2015, 2012.

[68] High Committee for Coordination among Arab Satellite Channels, 'Arab Satellite Broadcasting Annual Report 2014'.

[69] TRA presentation on 'UAE Digital Switchover Plan' to the ITU Regional Workshop on Efficiency of the Frequency Spectrum Use in the Arab Region, Amman-Jordan 5-7th December 2011.

[70] Digital TV News article (11th March 2014), Eutelsat-Nilesat 7/8oW video audience exceeds 50 million homes

The TRA adopted DVB-T2 with MPEG-4 coding and 64 QAM modulation in February 2013. A single frequency network has been chosen to maximise the available capacity. The TRA kept VHF Band III unoccupied with a view to either expanding DTT or using the band for T-DAB if there should be demand. The specific frequencies identified to provide national DTT were RF channels 21 (474 MHz), 27 (522 MHz) and 60 (768 MHz). The plan was then modified to support the release of 698-806 MHz for mobile and RF channel 60 was replaced by RF channels 31 (554 MHz) and 37 (602 MHz). This new system can telecast 16 SD TV channels or 5 HD TV channels.

In May 2013 the TRA published the band plan for 700 MHz and 800 MHz, as shown by Figure 5-4. The UAE falls in Region 1, but like many Arab states is near the border with Region 3, so the band plan is a sub-1 GHz band plan that harmonised as much as possible with both regions.

Figure 5-4: UAE UHF band plan

694MHz 790MHz 862MHz

Source: Plum Consulting, TRA

This plan allocates 120 MHz to mobile, with two blocks of 30 MHz for uplink and the same for downlink[71]. Above 790 MHz, the plan is the same as the European band plan for 800 MHz. Below 790 MHz, the plan is similar to the Asia-Pacific Telecommunity (APT) 700 MHz plan. The difference is that the uplink and downlink frequencies are smaller than the APT plan and the guard band is wider. This band plan was chosen to minimise cross-border interference, enable roaming and maximise economies of scale in the manufacture of mobile equipment (such as handsets and network infrastructure). Crucially, the allocation of this spectrum to mobile will hasten the rollout of mobile broadband in the UAE.

[71] TRA Whitepaper, 'Channel Planning & Availability for Mobile Broadband in the UAE', 22nd May 2013

6 Conclusions

This study demonstrates that there are significant amounts of spectrum that may be freed up across the Arab region through the efficient placement of terrestrial broadcasting in the spectrum bands, even if all existing TV channels continue to be broadcast over digital terrestrial platforms. The amount that may be released varies by country, and some governments must consider whether continuing to use significant amounts of spectrum for a small number of consumers is an efficient allocation of a scarce resource.

In general, it appears that the latest re-planning aim of retaining four layers for broadcasting in the UHF bands is, in many countries, overstating the spectrum that is likely to be needed. In the short to medium term this objective should be revisited based on actual usage of terrestrial broadcasting post analogue switch off. Where this platform sees lower demand, governments need to have the flexibility to award UHF spectrum both above and below 694 MHz to mobile. However, without a significant move to international harmonisation the amount of spectrum that can be released may be artificially constrained to above 694 MHz. To achieve the maximum efficiency from the spectrum, therefore, the UHF band above 470 MHz should be harmonised on a co-primary basis, and governments and regulators must work closely together to re-plan the spectrum with the aim of minimising interference and the numbers of multiplexes needed.

As previously mentioned, the move to DTT presents an opportunity for broadcasters – there is the potential for interactive services and HD TV channels, as well as encrypted and pay TV platforms. The longer term trend of convergence may involve IPTV in conjunction with terrestrial broadcasts, or replacing them. Broadcasters, such as the BBC in the UK[72], are treating the move towards IPTV as an opportunity to reach new audiences and provide new services and mobile broadband will provide another platform for IPTV services.

The level of advancement in migrating to digital and freeing up spectrum in the UHF bands for mobile broadband varies across the region. The UAE appears to be the most advanced, with the growth of IPTV and continuing roll-out of high-speed broadband indicating that the long-term future of terrestrial television is uncertain. However, the government plans to keep Band III reserved for DTT or DAB in the medium-term, in case demand increases. Many other countries currently have either a very small number of TV channels broadcast over terrestrial (such as Oman), or a limited use of the platform (such as Saudi Arabia).

It is crucial that governments realise the substantial opportunity costs of reserving too much spectrum for terrestrial broadcasts, when these may not be used or may not be watched.

6.1 Considerations for governments

This study recommends that governments and regulators in each of the Arab nations should reconsider the use of spectrum by terrestrial broadcasting. There are a number of considerations that will impact on the potential to release frequencies above and potentially below 694 MHz. These include:

[72] BBC Blog, 8th April 2015, 'Engineering a more flexible and efficient BBC for the future'
http://www.bbc.co.uk/blogs/aboutthebbc/entries/e73d552e-8e73-462d-a37d-b78e3dc69803

- The number of standard definition (SD) and high definition (HD) TV channels that need to be supported over digital terrestrial TV after analogue switch-off. This number may not be as high as the current broadcasting platform, if the number of households relying on this platform is sufficiently small.
- Likely future requirements to support 3DTV and UHD (ultra-high definition) – with recognition that these may only be possible when using satellite, cable or IPTV systems, and there is likely to be significant overlap between consumers owning advanced televisions and consumers subscribed to other platform services.
- Increased spectral efficiency afforded by DVB-T2, MPEG-4 and any future new transmission systems. This will allow programming to be carried over a smaller spectrum bandwidth, potentially releasing all of Bands IV and V to mobile broadband.
- Availability of the same TV channels over alternative delivery mechanisms (such as satellite) and the need to retain terrestrial broadcasting. At the same time, there may be political and cultural concerns about the other direction, with TV channels carried over satellite platforms in particular not subject to state control. This is important for some governments who wish to retain the right to classify content or use the television systems at times of national emergency.
- Arab countries that have a small geographic footprint will have a much larger burden compared with others because of the requirements of cross-border coordination. There is the potential that spectrum usage, not just in neighbouring countries, but countries further away will have to be considered when identifying whether spectrum can be released. This could require bilateral coordination with a number of "neighbouring" countries after the current replanning exercise is completed if less multiplexes are required in practice.
- The availability of VHF band, which in some countries would be able to carry all existing TV channels, and indeed with improvements in technology may be able to suffice for the majority of countries. However, there are competing demands for this band, particularly from radio, and governments must be clear with their expectations for how this will evolve.

Appendix A: Country overview

This Appendix sets out the findings regarding terrestrial broadcasting in each ASMG country. These findings are based on publically available sources, including regulator websites.

A.1 Algeria

Broadcasters	Enterprise Nationale de Television (ENTV)
Terrestrial television channels	4[73]

There is a single terrestrial television broadcaster providing four TV channels over analogue and the DSO has begun. A single multiplex could support four TV channels in SD and even allow them to be broadcast in a number of languages, or for the addition of new TV channels or broadcasters. Two multiplexes would provide significant spare capacity for HDTV or another broadcaster. Algeria is looking at DAB or DRM in VHF band (once TV removed) to solve issue re lack of FM frequencies. TV penetration is high in Algeria (98%), with free-to-air (FTA) satellite penetration at 94% - ENTV has five FTA satellite TV channels.

- 1-2 multiplexes required

A.2 Bahrain

Terrestrial broadcasters	Bahrain Radio & Television Corporation (BRTV)
Terrestrial television channels	5

There is a single terrestrial TV broadcaster providing five TV channels over analogue. A single multiplex would be sufficient for five SD TV channels and would provide spare capacity. Two multiplexes would provide significant spare capacity for HD TV channels or another broadcaster. Almost all households have a television (98.9%) and half of all households subscribe to pay TV. FTA satellite penetration is 51%, and BRTV provides six FTA satellite TV channels.

- 1-2 multiplexes required

[73] 2 may be satellite

A.3 The Comoros Islands

Terrestrial broadcasters	Television National Comorienne (TNC), Mtsangani TV and Radio-Television Anjouanaise
Terrestrial television channels	3

Office de la Radio et de la Television is state-owned and runs the national TNC, while the other two TV channels are both run by the Anjouan regional Government. The Comoros Islands use a different technology to DVB-T2: the Chinese standard DTMB (Digital Terrestrial Multimedia Broadcast) supports both mobile and fixed terminals. The Comoros Islands, due to their geographic location, are not expected to impact on the release of frequencies in other Arab countries.

A.4 Djibouti

Terrestrial broadcasters	Radiodiffusion Télévision de Djibouti
Terrestrial television channels	1

The sole terrestrial broadcaster in Djibouti is the state owned broadcaster and broadcasts one TV channel. One multiplex would be sufficient for this and would provide substantial extra capacity. Current information on television penetration is not available; however, it will be greater than 46% which was the figure in 2004.

- 1 multiplex required

A.5 Egypt

Terrestrial broadcasters	Egyptian Radio and Television Union (ERTU)
Terrestrial television channels	17

ERTU is the fully state-owned and is the only terrestrial broadcaster in Egypt and broadcasts two national TV channels and six regional TV channels. In addition to private satellite and IPTV broadcasters, the state-owned broadcaster ERTU broadcasts 27 (free-to-air) DTH TV channels[74].

The DSO has started in Egypt, with the original intention of using a MFN to provide greater capacity than 17 TV channels. If a SFN was deployed then three multiplexes would be enough to accommodate 17 TV channels and have significant room for expansion to HD or more SD TV channels.

A full description of the analysis can be found in Section 5.1.

- 3-4 multiplexes required

[74] High Committee for Coordination among Arab Satellite Channels, 'Arab Satellite Broadcasting Annual Report 2014'. http://www.asbu.net/article.php?artid=1277&lang=en

A.6 Iraq

Terrestrial broadcasters	Not identified
Terrestrial television channels	Between 16-21 depending on source

Three multiplexes would be able to carry 21 SD TV channels, but four may be required if there was a need for HD TV channels. Satellite was illegal until 2003, currently there are 49 FTA satellite TV channels based in Iraq. Almost all (98%) of households own a television.

- 3-4 multiplexes required

A.7 Jordan

Terrestrial broadcasters	Jordan Radio and Television Corporation (JRTV)
Terrestrial television channels	1

JRTV is the sole terrestrial broadcaster and broadcasts one TV channel over terrestrial and satellite. One multiplex would be sufficient for this and would provide substantial extra capacity. Terrestrial penetration is only 16%, while FTA satellite has penetration of 80%. Private broadcasters provide local TV channels over satellite. Pay TV penetration is low (4%). The percentage of homes with an HD Ready or Full HD television is over 50%.

- 1 multiplex required

A.8 Kuwait

Terrestrial broadcasters	Kuwait TV
Terrestrial television channels	3

The state-owned Kuwait TV, founded in 1961, broadcasts three TV channels over analogue and it has been determined by the Government how this will translate into digital format. There will be one SFN which will use three UHF transmitters with 1 to 2 kW power to cover the whole country. There will be 12 HD encoders and 2 multiplexes. Thus all TV channels will have the potential to be transmitted in HD. Satellite is dominant in Kuwait, with the combined penetration of cable and terrestrial only 20%. Kuwait TV runs eight FTA TV channels and one pay TV channel over satellite. Pay TV penetration is about 50%.

- 2 multiplexes required

A.9 Lebanon

Terrestrial broadcasters	Not identified
Terrestrial television channels	8

There are currently eight terrestrial TV channels, and the TRA has decided that there will be two DTT multiplexes with a mix of SD and HD TV channels, over a SFN. Terrestrial penetration is 14%, with 83% of households watching satellite. Pay TV penetration is 5%. There is one state-owned FTA TV channel over satellite, broadcast by Tele Liban.

- 2 multiplexes required

A.10 Libya

Terrestrial broadcasters	Al Wataniyah, Qanat Libya Rasmiyah
Terrestrial television channels	12

The volatile political situation makes it difficult to assess the current state of terrestrial television in Libya, however, publically available sources indicate that there are six national TV channels (Al Aseemah, Libya Al Ahar, Libya Al Hurria, Libya Awalan, Libya TV, Libya One) and six regional TV channels (Misrata TV, Fezzan TV, Benghazzi TV, Benghazi BBN, Musrata TV, Tobactes TV) broadcast by the state-owned Al Wataniyah and the privately broadcaster Qanat Libya Rasmiyah. One multiplex would be sufficient for the national TV channels and one for the regional TV channels, an additional one may be needed for expansion or HD provision. Before the political situation changed in the last few years planning for the DSO was undertaken. Television penetration is 76% of households.

- 2-3 multiplexes required

A.11 Mauritania

Terrestrial broadcasters	Television de Mauritanie (TVM) which is state run and 3 private broadcasters (Sahel TV, Al-Mouraitoun TV and Chinguett TV)
Terrestrial television channels	5

TVM broadcasts two TV channels (MTV1 and MTV2) plus some regional outlets and it is assumed that each of the private broadcasters require at least one TV channel. It is therefore estimated that one, but most likely two, multiplexes will be required with the national and regional TV channels of TVM on one and the private broadcasters on the other. About a quarter of households have a television. There is one state-owned FTA satellite TV channel.

- 1-2 multiplexes required

A.12 Morocco

Terrestrial broadcasters	Société Nationale de Radiodiffusion et de Télévision (SNRT)
Terrestrial television channels	8

There are eight terrestrial TV channels; six are state-owned (SNRT) while two are partly privately owned. DTT is being rolled out and covers at least 80% of the population; however, take-up of DTT has been low. 18% of Moroccans view the national TV channels – the rest view foreign satellite programming. DTT has already been introduced into the UHF bands and there will be two multiplexes. A quarter of households subscribe to pay TV. Private television channels are planned in Morocco.

- 2 multiplexes required

A.13 Oman

Terrestrial broadcasters	Oman TV, Majan TV and Jai Hind TV
Terrestrial television channels	6

Oman TV, the state broadcaster, broadcasts two TV channels over terrestrial and five (FTA) TV channels over satellite. Two privately owned broadcasters, Majan TV and Jai Hind TV, provide another four TV channels between them. At least 90% of households own a television[75], of which 48% receive terrestrial and 48% receive satellite. Pay TV penetration is relatively low in Oman, with only 7% of households subscribing to some form of pay TV.

The DSO started in Oman in 2012, with DVB-T2 (using 256 QAM) being deployed. On the basis of six terrestrial TV channels there is the potential to use a single multiplex, but to allow for expansion and deployment of HD and to be conservative it is assumed that two multiplexes will be used – for example, one for Oman TV and the other for the private broadcasters.

- 2 multiplexes required

[75] The Arab Media Outlook 2011:2015 estimated 90% in 2011; the ITU Yearbook 2014 estimated 93% in 2010.

A.14 Palestine

Terrestrial broadcasters	Palestinian Broadcasting Company (PBC)
Terrestrial television channels	Not identified

The situation in Palestine is unclear; there are many terrestrial TV channels but sources differ over the exact number. Different reports suggest that there are around 25-30 local terrestrial TV channels; with around 17 in the West Bank and around 2 in Gaza. PBC broadcasts at least one national TV channel over terrestrial and one over satellite. The strategy report for DSO in 2014 indicates 2 multiplexes and 3 HD TV channels. It is considered unlikely that DTT will support all the local TV channels. Almost all households own a television (97%).

A.15 Qatar

Terrestrial broadcasters	Not identified
Terrestrial television channels	Not identified

Television penetration is 95% of households, with 83% subscribing to pay TV. Cable and satellite are dominant, with cable customers being moved to IPTV. It appears that the Government is planning to deploy T-DAB in VHF Band III and that a new licensing regime will be implemented to award the multiplexer network licence. There are currently 17 transmitter locations in Qatar.

A.16 Saudi Arabia

Terrestrial broadcasters	Saudi TV
Terrestrial television channels	9

Television is almost universal in Saudi Arabia, with 98% of households owning a TV. However, this is almost entirely provided through the satellite platform – 97% of TV homes receive satellite. Only 1% of TV homes receive DTT, meaning terrestrial has reduced significance in the television market. Pay TV is significant in the Saudi television market; different sources suggest that between 25% and 37% of households subscribe to pay TV. Saudi TV broadcasts 9 TV channels over terrestrial.

The DSO process is underway in Saudi Arabia, with DVB-T currently being upgraded to DVB-T2. Despite there being few terrestrial TV channels in Saudi Arabia and low penetration of terrestrial, the Saudi Arabian (2010) plan for the DSO was to have 30 DTT channels although there is no evidence whether this is supported by market demand so the basis of this analysis is the 9 TV channels.

Assuming an SFN, 9 SD TV channels would require two multiplexes and also support some HD TV channels.

- 2 multiplexes required

A.17 Somalia

Terrestrial broadcasters	Bulsho TV, Eastern Television Network, Shabelle TV, Somali Broadcasting Corporation, Somaliland Space Channel, Somaliland National Television (SLNTV)
Terrestrial television channels	6

It is unclear whether the broadcasters broadcast on a national or regional basis, but two DTT multiplexes would be sufficient capacity for six national TV channels and expansion into more TV channels and HD provision.

- 2 multiplexes required

A.18 Syria

Terrestrial broadcasters	Syrian Arab Television & Radio Broadcasting Commission (SA TRBC)
Terrestrial television channels	4

SA TRBC broadcasts two national TV channels and two regional TV channels. One multiplex should be sufficient to provide this DTT service, but another may be needed if it was decided to separate out the regional TV channels. The penetration of television is 93% of households, with 15% of households watching terrestrial and 85% watching FTA satellite. The penetration of pay TV is 0.2% of households. RTV broadcasts four FTA satellite TV channels.

- 1-2 multiplexes required

A.19 Sudan

Terrestrial broadcasters	Sudanese Radio and Television Corporation, Blue Nile
Terrestrial television channels	18

The wholly state-owned Sudanese Radio and Television Corporation operates 17 terrestrial TV channels, while the partly privately owned Blue Nile operates one terrestrial TV channel. Assuming mostly SD TV channels and that Blue Nile share a multiplex with SRTC two multiplexes will be required. HD programming would require a third. Television penetration in Sudan is low with around 20% of households owning a television.

- 2-3 multiplexes required

A.20 Tunisia

Terrestrial broadcasters	Office National de Telediffusion (ONT)
Terrestrial television channels	4

The number of terrestrial TV channels currently broadcast is up to 4. For this 1 multiplex would to be sufficient. The DSO has begun in Tunisia, with the plan using an MFN and DVB-T. This would require two multiplexes. Almost all (98%) of households own a television. FTA satellite penetration is 79%, with terrestrial reaching 15% of households (over analogue and DTT).

- 1-2 multiplexes required

A.21 UAE

Terrestrial broadcasters	Sharjah TV, Dubai TV[76]
Terrestrial television channels	12

Satellite is the main TV platform in the UAE, with 30% of homes subscribing to pay DTH and 24% of homes receiving free-to-air DTH. Terrestrial television has a lower penetration than IPTV in the UAE; 29% of households receive IPTV while (in 2009) only 3% households relied solely on terrestrial. Pay TV is popular with 45% of adults subscribing to it.

Post-switchover, the TRA aimed for all 12 TV channels to be broadcast over DTT and that noted that three DTT multiplexes would allow the existing broadcasters to transmit existing analogue TV channels digitally and in HD, with the possibility of including some additional services. The TRA adopted DVB-T2 with MPEG-4 coding and 64 QAM modulation over a SFN. The TRA kept VHF Band III unoccupied with a view to either expanding DTT or using the band for T-DAB if there should be demand.

- 3 multiplexes required

A.22 Yemen

Terrestrial broadcasters	Yemen General Corporation for Radio and Television
Terrestrial television channels	4

Four TV channels could be provided over one multiplex, but an expansion into HD would require another one. Current information on television penetration is not available; however, it is likely to be greater than 44% which was the figure in 2004. Most television households watch terrestrial television. Local television is the most prominent media platform and satellite reception is prohibitively high for most of the population. Likewise, there is little pay TV.

- 1-2 multiplexes required

[76] And one other

Appendix B: Bibliography

Below is a list of the publicly-available information sources used to inform this report. Where countries are not listed separately, all information has been derived from general sources.

B.1 General sources

Arab Satellite Broadcasting Union (2015), *Annual Report 2014,* available at: http://www.asbu.net/article.php?artid=1277&lang=en

Balancing Act, *Snapshot of progress of analogue to digital migration in Africa: Outcome of ATU survey*, presentation at ATU Digital Migration and Spectrum Policy Summit, available at http://slideplayer.com/slide/1378034/

CIA (2007)[77], *The World Factbook*, available at: https://www.cia.gov/library/publications/the-world-factbook/

Digital TV Europe (5th November 2014), *Mixed fortunes: free-to-air and pay TV in the Middle East*, available at: http://www.digitaltveurope.net/272331/mixed-fortunes-free-to-air-and-pay-tv-in-the-middle-east/

Digital TV News article (11th March 2014), Eutelsat-Nilesat 7/8°W video audience exceeds 50 million homes, available at: http://www.digitaltvnews.net/?p=23765

Dubai Press Club (2012), *Arab Media Outlook 2011:2015*, available at: http://www.arabmediaforum.ae/userfiles/EnglishAMO.pdf

European Broadcasting Union (October 2006), *GE06 — overview of the second session (RRC-06) and the main features for broadcasters*, available at: https://www.ebu.ch/fr/technical/trev/trev_308-rrc-06.pdf

Human Capital report for the GSMA (2009), *The limits to terrestrial television's case for further spectrum*, available at: http://www.gsma.com/spectrum/wp-content/uploads/DigitalDividend/DDtoolkit/uploads/assets/downloads/04/the-limits-to-terrestrial-televisions-case-for-further-spectrum.pdf

ITU, December 2014, *Yearbook of Statistics 2014: Telecommunication/ICT Indicators 2004-2013*, Geneva.

ITU webpage (undated)[78], Status of the transition to Digital Terrestrial Television Broadcasting: Summary, available at: http://www.itu.int/en/ITU-D/Spectrum-Broadcasting/Pages/DSO/Summary.aspx

Mohsen Ghomman Malek (2012), *Introduction and Overview on International and Arab States Digital TV broadcasting Experiences*, CoE/ARB Workshop, available at: https://www.itu.int/ITU-D/arb/COE/2012/DTV/documents/doc1.pdf

OECD (2013) Competition Issues in Television and Broadcasting, Policy Roundtable, available at: http://www.oecd.org/daf/competition/TV-and-broadcasting2013.pdf

[77] Most broadcasting data in the CIA World Factbook comes from 2007

[78] It is unclear how up to date (and thus accurate) this data is

B.2 Algeria

Eutelsat press release (11th March 2013), *Télédiffusion d'Algérie renews business with Eutelsat for nationwide Digital Terrestrial Television (DTT) deployment*, available at: http://www.eutelsat.com/home/news/press-releases/Archives/2013/press-list-container/telediffusion-dalgerie-renews-bu.html

NexTV article (20th January 2015), *Algeria ropes in Egatel to boost DTT extension*, available at: http://nextvame.com/dtt/algeria-ropes-in-egatel-to-boost-dtt-extension/

Radio World article (26th January 2015), *Spectrum still issue in Algeria*, available at: http://www.radioworld.com/article/spectrum-still-issue-in-algeria/274273

B.3 Bahrain

Proudly Arabian article (undated), *The Media in Bahrain*, available at: http://www.proudlyarabian.com/Bahrain/The-Media.aspx

B.4 The Comoros

Indian Ocean Times article (21st May 2014), *Comoros choose the Chinese standard for the deployment of digital terrestrial television in June 2015*, available at: http://en.indian-ocean-times.com/Comoros-choose-the-Chinese-standard-for-the-deployment-of-digital-terrestrial-television-in-June-2015_a3752.html

B.5 Egypt

Al-Shorfa article (16th January 2014), *Egypt begins transition to digital broadcasting*, available at: http://al-shorfa.com/en_GB/articles/meii/features/2014/01/16/feature-03

Dr Hussein Amin (undated) *Report on the State of the Media in Egypt – 2nd Draft*, published by The Arab Center for the Development of the Rule of Law and Integrity, available at: http://www.arabruleoflaw.org/Files/PDF/Media/English/P2/Egypt_MediaReportP2_En.pdf

Associate Professor Dr El Sayed Azzouz, Head of Spectrum Management at the NTRA (undated) *Practical Aspects of Digital Switchover: The Egyptian Experience*.

Broadcasting Board of Governors (March 2014), *Contemporary Media Use in Egypt*, available at: http://www.bbg.gov/wp-content/media/2014/03/Egypt-research-brief.pdf http://www.arabmediaforum.ae/userfiles/EnglishAMO.pdf

Fraunhofer Institute for Systems and Innovation Research ISI (undated), *TK Egypt: Digital Terrestrial Television in a developing country: Strategies for the transition including a roadmap*, available at: http://www.isi.fraunhofer.de/isi-en/t/projekte/archiv/bb_tk_egypt.php

B.6 Iraq

Asia-Pacific Broadcasting Union news item (undated), *Iraq leads the Arab World with most terrestrial TV channels*, available at: http://www.abu.org.my/Latest_News-@-Iraq_leads_the_Arab_World_with_most_terrestrial_TV_channels.aspx

B.7 Jordan

JRTV webpage (undated), *About TV*, available at: http://www.jrtv.jo/page.aspx?page_key=key_abouttv&lang=ar

JRTV (undated), *Media Strategy 2011-2015*, available at: http://www.jrtv.jo/page.aspx?page_key=key_strategy&lang=ar

Open Society Foundations (10th October 2013), *Mapping Digital Media: Jordan*, available at: http://www.opensocietyfoundations.org/sites/default/files/mapping-digital-media-jordan-20131121.pdf

B.8 Kuwait

Ministry of Information webpage (undated), *About Kuwait TV*, available at: http://www.media.gov.kw/TVRadio/TV.aspx

NexTV article (26th February 2014), *Kuwait TV chooses Harris Broadcast for DVB-T2 implementation*, available at: http://nextvame.com/4-free-to-air-dtt/kuwait-tv-chooses-harris-broadcast-for-dvb-t2-implementation/

PR Newswire article (26th February 2014), *Harris Broadcast Delivers Over-the-Air National Digital Television for Kuwait TV*, available at: http://www.prnewswire.com/news-releases/harris-broadcast-delivers-over-the-air-national-digital-television-for-kuwait-tv-247197611.html

B.9 Lebanon

Telecommunications Regulatory Authority consultation document (November 2008), *Digital migration strategy for TV broadcasting*

Telecommunications Regulatory Authority (May 2011), *Draft Framework for Digital Terrestrial Television Broadcasting in Lebanon*, EMERG Workshop, Cyprus

Telecommunications Regulatory Authority webpage (undated), *About Digital Terrestrial Broadcasting in Lebanon*, available at: http://www.tra.gov.lb/QA-About-Digital-Terrestrial-Broadcasting-in-Lebanon

B.10 Libya

Altai Consulting report for the Foreign and Commonwealth Office (May 2013), *Libya Media Assessment: One Year Later - An Assessment of the Media Landscape and Consumption Patterns*, available at: http://www.altaiconsulting.com/docs/Altai%20Consulting%20-%20Libyan%20Media%20One%20Year%20Later.pdf

European Broadcasting Union news item (7th March 2014), *EBU, UNESCO Aid Libya With Roadmap to Digital Switchover*, available at: http://www3.ebu.ch/contents/news/2014/03/ebu-unesco-aid-libya-with-roadma.html

Libyan Italian Digital Infrastructure Architects webpage (undated), *Projects*, available at: http://www.lidia.ly/lidia/projects.aspx

B.11 Mauritania

BBC article (26th January 2015), *Mauritania profile - Media*, available at: http://www.bbc.co.uk/news/world-africa-13882165

B.12 Morocco

Digitvcoop article (13th October 2013), *Morocco set up a National Committee for the transition from analogue to digital terrestrial broadcasting*, available at: http://digitvcoop.net/en/news/157-morocco-set-up-a-national-committee-for-the-transition-from-analogue-to-digital-terrestrial-broadcasting

The Free Library article (26th April 2007), *NEC Supplies Middle East and Africa's First Ever Digital TV Transmitters through Morocco SNRT; Marks Total Sales of 1000 Digital TV Transmitter Systems*, available at: http://www.thefreelibrary.com/NEC+Supplies+Middle+East+and+Africa's+First+Ever+Digital+TV...-a0162640637

Haute Autorité de la Communication Audiovisuelle webpage (undated), "الـ عمومي الـ قطب", available at: http://www.haca.ma/indexAr.jsp?id=40

Net insight press release (21st March 2011), *Net Insight chosen for expansion of Digital Terrestrial TV network in Morocco*, available at: http://www.netinsight.net/News/News-archive/2011/6/

The North Africa Post article (25th December 2014), *Moroccan official upbeat about launch of Private TV Channels Soon*, available at: http://northafricapost.com/6660-moroccan-official-upbeat-about-launch-of-private-tv-channels-soon.html

Open Society Foundations (11th May 2011), *Mapping Digital Media: Morocco*, available at: http://www.opensocietyfoundations.org/sites/default/files/mapping-digital-media-morocco-20130805.pdf

Spain Business article (1st March 2011), *Egatel expands the digital TV network in Morocco*, available at: http://www.spainbusiness.com/icex/cda/controller/pageGen/0,3346,1549487_6719796_6728280_4464035,00.html

Telecompaper article (26th April 2007), *NEC ships 12 digital TV transmitters to Morocco's SNRT*, available at: http://www.telecompaper.com/news/nec-ships-12-digital-tv-transmitters-to-moroccos-snrt--553702

B.13 Oman

Alaraimi, A.S.; Alsulaimi, A.S.; Alshuriani, K.A. (June 2012), *DVB-T2 in Oman: Trial results*, Broadband Multimedia Systems and Broadcasting (BMSB), *2012 IEEE International Symposium on*, vol., no., pp.1,5, 27-29. Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6264242&isnumber=6264224

Netia interview with Mohammed Al Marhouby (February 2011), *Oman's HD Future*, available at: http://www.netia.com/images/press_review/02-11/Oman001.pdf

Oman TV webpage (undated), *Frequencies*, available at: http://part.gov.om/ar/web/omantv/freq.-channels;jsessionid=A3B75D10CC982771C59C9A45F168FB01

Rapid TV News article (24th November 2014), Asset management expansion enables Oman TV Live launch, available at: http://www.rapidtvnews.com/2014112436185/asset-management-expansion-enables-oman-tv-live-launch.html#axzz3UeU7V3T8

B.14 Palestine

BBC article (31st August 2011), *Palestinian territories profile – Media*, available at: http://www.bbc.co.uk/news/world-middle-east-14631745

Ministry of Telecom and Information Technology (2013), *Transition to Digital Broadcasting (Questionnaire),* available at: http://www.pmtit.ps/ar/cp/plugins/spaw/uploads/files/Digital%20Switch%20Over%2011.pdf

Ministry of Telecom and Information Technology (2014), *National Strategy for the transition to digital broadcasting*, available at: http://www.mtit.pna.ps/ar/cp/plugins/spaw/uploads/files/National%20Strategy.pdf

Ministry of Telecom and Information Technology webpage (2014), *The adoption of the National Strategic Plan*, available at: http://www.mtit.pna.ps/ar/index.php?p=main&id=1540

Internews (29th July 2014), *Media and Telecommunications Landscape in the West Bank and Gaza*, available at: https://www.internews.org/sites/default/files/resources/Media-Landscape_WestBank-Gaza_29July14.pdf

Euromed Audiovisual presentation (2014), *TV market in Palestine*, available at: http://www.med-media.eu/wp-content/uploads/2014/07/1380639600473.pdf

B.15 Qatar

Communications Regulatory Authority consultation document (June 2014), *Future Spectrum Demand in Qatar*, available at: http://www.cra.gov.qa/sites/default/files/documents/Future%20Spectrum%20Demand-CRA%20Consultation%20-V11.pdf

Telecompaper article (12th December 2013), *Qatar picks Rohde & Schwarz to launch DVB-T2,* available at: http://www.telecompaper.com/news/qatar-picks-rohde-and-schwarz-to-launch-dvb-t2--985344

B.16 Saudi Arabia

Television and Satellite TV in Saudi Arabia, *Saudi TV broadcasts 9 channels on terrestrial*, available at http://saudiarabia.angloinfo.com/housing/setting-up-home/television/

The Digital Video Broadcasting Project (26th June 2006), *DTT transmissions began in Saudi Arabia on the 11th June 2006*, available at: https://www.dvb.org/news/dtt-transmissions-began-in-saudi-arabia-on-the-11th-june-2006/country/saudi-arabia

The Digital Video Broadcasting Project (10th September 2010), *30 DTT Freeview channels in two years*, available at: https://www.dvb.org/news/30-dtt-freeview-channels-in-two-years/country/saudi-arabia

The Digital Video Broadcasting Project (13th September 2011), *Multichannel upgrade for DVB-T planned*, available at: https://www.dvb.org/news/multichannel-upgrade-for-dvb-t-planned/country/saudi-arabia

The Digital Video Broadcasting Project (21st March 2013), *Migration to DVB-T2 continues in Saudi Arabia*, available at: https://www.dvb.org/news/migration-to-dvb-t2-continues-in-saudi-arabia/country/saudi-arabia

B.17 Somalia

African Union and United Nations (2014), *Media Mapping Briefing Note*, IST Briefing Note 007, available at: http://somali-media.so/wp-content/uploads/2014/05/2014_05_01_Somali-Media-Mapping-Report.pdf

B.18 Tunisia

Thompson Broadcast news item (10th September 2009), *Tunisia's Office National de Télédiffusion (ONT) Selects Grass Valley for Digital Terrestrial Television Deployment*, available at: http://thomson-broadcast.com/tunisias-office-national-de-telediffusion-ont-selects-grass-valley-for-digital-terrestrial-television-deployment/

B.19 UAE

The Digital Video Broadcasting Project (3rd May 2011), *Going digital will offer the UAE huge opportunities*, available at: https://www.dvb.org/news/going-digital-will-offer-the-uae-huge-opportunities/country/united-arab-emirates

Khaleej Times article (19th December 2014), *Sharjah Media Corporation switches to digital telecasting*, available at: http://www.khaleejtimes.com/kt-article-display-1.asp?xfile=data/nationgeneral/2014/December/nationgeneral_December169.xml&section=nationgeneral

IT Telecom Digest article (13th August 2014), *ITU Rules Out Deadline Extension*

TRA presentation (December 2011) *UAE Digital Switchover Plan*, presented to the ITU Regional Workshop on Efficiency of the Frequency Spectrum Use in the Arab Region, Amman-Jordan

TRA Whitepaper (22nd May 2013), *Channel Planning & Availability for Mobile Broadband in the UAE*

B.20 Yemen

Yemen Times article (12th March 2012), *Ten Private TV Channels Compete For The Yemeni Public's Attention*, available at: http://www.yementimes.com/en/1554/report/563/Ten-private-TV-channels-compete-for-the-Yemeni-Public%E2%80%99s-attention.htm

Appendix C: Glossary

Term	Definition
3DTV	3-D TV is a television display technology that enables a three-dimensional effect, so that viewers perceive that an image has depth as well as height and width, similar to objects in the real world.
ASMG	The Arab Spectrum Management Group is the forum through which Arab states coordinate frequency planning.
Carrier mode	In DVB-T the RF (radio frequency) channel carries a large number of digital streams (sub-carriers) and the carrier mode defines the number of sub-carriers. 2k-mode has 1,705 carriers and 8k-mode 6,817.
Channel	A channel may be either: • A TV channel, which is a set of programmes broadcast in sequence and with specific branding. • An RF channel, which defines a specific frequency range into which broadcasts can fit. This paper attempts to use the phases "TV channel" (or "television channel") and "RF channel" to distinguish between these.
Code rate	Parameter that can be set according to the bit-rate to be achieved over a 8 MHz channel.
dB	A decibel is a measure of signal strength.
DSO	The Digital Switchover is the process of replacing analogue terrestrial television with digital terrestrial television.
DVB-T	Digital Video Broadcasting – Terrestrial. European standard developed for the broadcast of digital terrestrial TV. Standardised by the European Standards Institute (ETSI)
DVB-T2	Digital Video Broadcasting – Second Generation Terrestrial. Extension of DVB-T.
DTT	Digital Terrestrial Television, the successor to analogue terrestrial television, uses efficient digital technology
FFT	The Fast Fourier Transform is an algorithm that allows the translation (conversion) from time to frequency and vice versa.
FTA	Free To Air television channels can be viewed by consumers without payment.
H.265	Video codec standard for HD (high definition)
H.264/MPEG-4 AVC	Video compression standard which support high definition TV. AVC is advanced video coding.
HD-720p	High Definition TV format with 720 scan horizontal lines that create the image and using progressive (p) scan to display the picture on the TV.
HD-1080i	High definition TV format with 1080 scan horizontal lines that create the image and using interlaced (i) scan to display the picture on the TV.

Term	Definition
GE-06	The Geneva 2006 frequency plan (GE06) was developed to provide for T-DAB and DVB-T digital services in the VHF (Band III) and UHF (Bands IV and V) broadcasting bands in 118 countries.
Guard interval	Parameter that can be set and provides a trade-off between data rate from a transmitter or the SFN coverage area.
IPTV	Internet Protocol Television is the term for television that is watched over a Local Area Network or the Internet and is delivered using internet protocol.
ITU	The International Telecommunications Union is the United Nations forum through which nations coordinate frequency planning and set international telecommunications and broadcasting standards.
LTE	Long Term Evolution is the name of the mobile broadband technology commonly referred to as 4G
MFN	A Multi Frequency Network uses a number of different transmitter frequencies, carrying the same data, to provide the required coverage.
Modulation	A way of sending a signal, which could be a digital bit stream or analogue audio signal, inside another signal that can be transmitted.
MUX	A DTT multiplex (MUX) is a bundle of TV services that have been digitised, compressed and combined into a data-stream for transmission to the consumer over a single channel. The receiver separates each service from this compressed data-stream and turns it into a form which can be viewed. Anything that can be digitised can be contained in a multiplex. This can include: sound, video, text, computer applications, electronic programme guide information, receiver upgrades and conditional access (descrambling).
MPEG-2	Standard developed for encoding high quality videos.
MPEG-4	Standard developed for encoding for devices where there are limited resources compared with MPEG-2 (e.g. handheld devices)
OFDM	Orthogonal frequency-division multiplexing is a type of modulation.
QAM	Quadrature Amplitude Modulation is a type of modulation
RBL	Re-Broadcast Links are used to transmit broadcast information from one TV transmitter to another.
RRC-04 and RRC-06	Regional Radiocommunications Conference in 2004 and 2006 respectively where the planning for digital broadcasting was undertaken
SD	Standard definition TV format uses a resolution that is not considered to be either high definition (HD) or enhanced definition (ED).
SFN	A Single Frequency Network uses one frequency to provide required coverage via a number of transmitters (2 or more) carrying the same data
SISO	Single Input Single Output refers to an antenna configuration
Statistical MUXing	Statistical multiplexing allows the total multiplex capacity to be shared between the channels based on their bit rate requirements. The amount of data required will vary rapidly depending on the picture and this allows the resources to be dynamically shared. This can be more efficient compared with allocating a fixed bit rate per channel.
Terrestrial television	Terrestrial television uses radio frequencies and a number of transmitter sites to broadcast TV. The signals can be received via users TV antennas that can, for example, be roof mounted.

Term	Definition
T-DAB	Terrestrial Digital Audio Broadcasting. Replacement for analogue radio.
UHD	Ultra High Definition television is higher definition than HD
UHF	Ultra High Frequencies is the name given to Bands IV and V (470-862 MHz)
VHF	Very High Frequencies is the name given to Band III (174-230 MHz)
WRC-15	The World Radio Conference, organised by the ITU as a forum for frequency coordination, will be held in late 2015.