



The BBC's Efficient and Effective use of Spectrum

Review by Deloitte & Touche LLP commissioned by the BBC Trust's Finance and Strategy Committee

BBC's Trust Response

to the Deloitte & Touche LLP Value for Money study

It is the responsibility of the BBC Trust, under the Royal Charter, to ensure that Value for Money is achieved by the BBC through its spending of the licence fee.

In order to fulfil this responsibility, the Trust commissions and publishes a series of independent Value for Money reviews each year after discussing its programme with the Comptroller and Auditor General – the head of the National Audit Office (NAO). The reviews are undertaken by the NAO or other external agencies.

This study, commissioned by the Trust's Finance and Strategy Committee on behalf of the Trust and undertaken by Deloitte & Touche LLP ("Deloitte"), looks at how efficiently and effectively the BBC uses the spectrum available to it, and provides insight into the future challenges and opportunities facing the BBC in the use of the spectrum.

The Trust thanks Deloitte for undertaking this review. The report covers a wide range of issues that will help the Trust to make informed decisions regarding the use of the BBC's spectrum in the future.

The Trust has discussed Deloitte's findings and recommendations with the BBC Executive and considered its response, which is published in this document. The Trust is content that the Executive's actions are an appropriate response to Deloitte's findings overall.

As the report acknowledges the BBC's focus since the launch of Freeview on maximising the reach of the service, the robustness of the signal and the picture quality has supported the development and success of the digital terrestrial television (DTT) platform. Freeview is now established as the most popular digital TV platform.

This has led to increased demand for capacity as the BBC and other broadcasters develop aspirations for new services such as high definition television. Since capacity on the platform is finite, the opportunity costs of spectrum use are high. The BBC must now change its focus from building the DTT platform to ensuring that it uses its spectrum capacity as efficiently as possible and provides maximum Value for Money to licence payers. The BBC Executive affirms this position and outlines the action it will take in its response to the Deloitte report.

The attached response from the BBC Executive outlines what action is being taken to address the full set of recommendations made by Deloitte. It has been considered and approved by the Trust's Finance and Strategy Committee on behalf of the Trust.

BBC Trust
December 2007

BBC Executive Response

to the Deloitte & Touche LLP Value for Money study

The BBC Executive welcomes this study which undertakes an independent assessment into how efficiently and effectively the BBC uses the spectrum it has available to it. Radio spectrum is a scarce resource and the Executive recognises the importance of ensuring that it makes effective and efficient use of it in order to deliver the BBC's public purposes.

Deloitte's study shows that the BBC does make good use of the radio spectrum available to it:

"In our examination of the use of the FM band, we concluded that the frequencies are all heavily used and that there are no obvious gaps where the BBC is keeping unused spectrum." "The least used part of the band is the 99.9 – 103.4 MHz segment, which contains no BBC stations."

"Multiplex B is already benefiting from maximum coding and multiplexing technology gains and therefore is broadly as technically efficient as other DTT multiplexes."

In respect of DTT, Deloitte acknowledge that the decisions the BBC made in trading off capacity to achieve a robust broadcast signal for a wider population over the last five years have "arguably, supported Freeview to a point of critical mass and the commercial success it enjoys today". The BBC Executive recognises that the success of Freeview has increased demand for DTT capacity, and that is why it is committed to making further efficiency improvements. These improvements from digital switchover will be possible because of the significant financial investment the BBC is making to upgrade its infrastructure:

- At switchover the BBC will move to a new high power transmission network which will enable it to change modulation from 16QAM to 64QAM, releasing capacity in its two DTT multiplexes. This will commence on 6 November 2008 at switchover of the Selkirk transmitter and will continue throughout the switchover programme until the end of 2012.
- A new coding and multiplexing facility for the BBC's DTT and satellite services will employ the latest generation equipment enabling more efficient coding and multiplexing in both DTT multiplexes. This facility is currently under construction and will come into service in advance of switchover at Selkirk. The full facility is expected to be deployed by the end of August 2009.
- In addition, with the introduction of this new facility, the BBC will employ some of the techniques identified in this study to maximise capacity efficiency. These techniques will be introduced from 2009 following the implementation of the new coding and multiplexing facility.

The BBC supports the adoption of new technologies that maximise spectrum efficiency, such as MPEG-4 and DVB-T2, and is currently actively engaged with Ofcom on their proposal for re-organising the DTT platform in order to accommodate HD television services within existing multiplex capacity.

Responding to the recommendations

The BBC's use of the DTT spectrum

The BBC Executive will undertake consumer research on the picture quality of BBC services on DTT. It will conduct this research on multiplex configurations assembled by technical experts enabling the varying parameters that may affect picture quality to be properly technically managed. This research will be used to judge picture quality output against different multiplex configurations and against the picture quality of other multiplex operators.

The BBC Executive is developing a framework for the allocation and management of DTT capacity based on the BBC's performance measurement framework of reach, quality, impact and value for money (RQIV). This will be presented to the BBC Trust in February 2008.

Value for Money of different television platforms

The BBC makes its services available on a range of platforms in order to ensure universal availability of its services. The BBC Executive actively considers the potential of platform functionality in order to effectively deliver services to licence fee payers. For example, it is currently working with the Digital Television Group on open IPTV solutions, which in the future may offer a means of providing interactive services to hybrid set-top-boxes.

The BBC's use of the radio spectrum

The BBC is currently undertaking a trial of the Digital Radio Mondiale technology in Plymouth with National Grid Wireless. The trial is due to end in April 2008 at which point we expect to share the research findings within the industry in order to help inform the future strategy of AM.

The planning process for spectrum use

The BBC Executive notes the recommendations for the planning process of spectrum use and will build those into the framework for DTT capacity previously referred to.

The BBC Executive will continue to ensure that the content and editorial teams are properly engaged in proposals regarding what services to offer.

Deloitte.

B B C

BBC Trust

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Effective use of Spectrum

Deloitte & Touche LLP
December 2007

Audit . Tax . Consulting . Corporate Finance .

Contents

Preface	1
1. Executive Summary	3
2. Introduction	7
3. Spectrum planning and use	9
4. The BBC's current use of the DTT spectrum and options for improving spectrum efficiency	15
5. The BBC's allocation of the DTT spectrum to services	27
6. Analogue and digital radio – Value for Money in the BBC's use of spectrum	35
7. Value for Money of different platforms	38
8. The planning of spectrum use by the BBC	41
9. Conclusions and recommendations	44
Appendix 1	48

Preface

This report is one of a series of studies that review Value for Money at the British Broadcasting Corporation (“BBC”).

This report was prepared by Deloitte & Touche LLP (“Deloitte”) for the BBC Trust. In the report we review Value for Money of the BBC’s use of spectrum.

This report has been prepared for and only for the BBC Trust in accordance with the terms of our engagement letter dated 10th August 2007 and for no other purpose. We do not accept or assume any liability or duty of care for any other purpose or to any other person to whom this report is shown or into whose hands it may come, save where expressly agreed by our prior consent in writing.

While we have consented to allow this report to be made public, we have not in so doing agreed to extend any liability or duty of care that we may have beyond that referred to above.

We have not carried out an audit of management information provided by the BBC or the BBC’s financial statements. Our work has been based primarily on internal management information, collated during July to September 2007, which we have not verified or corroborated, and interviews with key BBC staff.

We have followed an approach to assessing efficiency, effectiveness and Value for Money that we think is appropriate to this situation. However, we recognise that there might be other methodologies that might also produce valid results.

Glossary

AAC	Advanced Audio Coding	HF	High Frequency
AIP	Administered Incentive Price	IPTV	Internet Protocol Television
AM	Amplitude Modulation	LF	Low Frequency
BBC	British Broadcasting Corporation	MF	Medium Frequency
DAB	Digital Audio Broadcasting	MPEG-4	Moving Picture Experts Group 4
DDR	Digital Dividend Review	MW	Medium Wave
DGFC	Director General's Finance Committee	PVT	Public Value Test
DRM	Digital Radio Mondiale	PMSE	Programme Making and Special Events
DTT	Digital Terrestrial Television	PSB	Public Service Broadcast
DSO	Digital Switchover	QAM	Quadrature Amplitude Modulation
DVB-T2	Digital Video Broadcasting – Terrestrial 2	RQIV	Reach, Quality, Impact and Value for Money
EDG	Executive Direction Group	UHF	Ultra High Frequency
FM	Frequency Modulation	SD	Standard Definition
GOP	Group of Pictures	VHF	Very High Frequency
HD	High Definition		

1. Executive Summary

- 1.1 Deloitte was commissioned by the BBC Trust to undertake an independent assessment into how efficiently and effectively the BBC uses the spectrum it has available to it, and to provide insight into future challenges and opportunities facing the BBC in the use of the spectrum.
- 1.2 Radio spectrum is a scarce resource and hence its use by the BBC creates a potential opportunity cost resulting from the spectrum being denied to other possible uses.
- 1.3 The BBC uses significant amounts of spectrum to transmit terrestrial broadcast television and radio services to audiences across the UK, and makes further use of spectrum in programme making and special events. Whilst we have looked at each of these areas, our focus has been on DTT.
- 1.4 Since the launch of Freeview in 2002, DTT has evolved from a start-up service subordinate to analogue and satellite services to the mainstay UK public broadcasting and free to air TV platform. This is against the background of previous failed attempts to develop a DTT service.
- 1.5 During the development phase of the Freeview platform, the BBC has given priority to maximising the reach of the service and encouraging consumer acceptability. Hence its choices regarding the use of the spectrum have focused on optimising the level of picture quality of the services and achieving a more robust signal for a wider population. During this period, achieving effectiveness of the platform has been a primary consideration for the BBC, rather than just maximising capacity efficiency. These trade-off decisions on the use of the spectrum over the past five years have, arguably, supported Freeview to a point of critical mass and the commercial success it enjoys today, with over nine million homes having DTT as the primary viewing platform.
- 1.6 With the service under development and less pressure on the spectrum, the BBC has previously considered DTT costs and Value for Money primarily on a per-multiplex level, with less focus on the Value for Money of the service components within multiplexes.
- 1.7 In recent times, and driven by the success of the platform, demand for DTT capacity has rapidly increased. The BBC and other broadcasters have developed aspirations for offering new services over the platform, such as high definition, which require significant amounts of capacity. Ofcom has resisted broadcasters' requests for additional capacity for high definition services, and plans to allocate the capacity released through digital switchover through auctions. Going forward, the use of capacity will have ever more important Value for Money implications. The opportunity cost of the BBC's use of spectrum is also now higher in the light of increased demand for UHF spectrum from both third party broadcasters and alternative users of the spectrum.
- 1.8 In these changed circumstances, the BBC needs to re-consider the appropriate trade-off choices, and how the capacity can be used effectively for different competing service demands. BBC management will need to be better prepared in the future to make more critical judgements around the use of capacity

for individual service streams. This will require a more value-based process for making decisions relating to these capacity trade-offs.

- 1.9** Decisions on the use of capacity for services should be made based on an overall service strategy set out by BBC management. This should also involve greater editorial input into decisions about the appropriate capacity and proportionate cost for each service stream than has been necessary to date.
- 1.10** Going forward, decisions on the use of the spectrum should be based on a clear public value framework for making trade-off choices, consistent with the BBC's RQIV framework, and approved by BBC management and the Trust. Specific criteria need to be developed against which to measure whether capacity is being used efficiently and effectively on an ongoing basis and to consider the benefits of different services against their spectrum "cost". Regular assessment against the criteria should be based on consumer and audience research. The BBC acknowledges this point and is actively considering what such a framework would include.
- 1.11** In the next five years, efficiency improvements in the BBC's multiplexes are possible from a number of sources:
- More efficient coding and multiplexing.
 - Reductions in the picture quality of services.
 - The adoption of new technologies such as DVB-T2 and MPEG-4.
 - Change in modulation from 16QAM to 64QAM.
- 1.12** We estimate that the BBC could release approximately 6.4 Mbps of capacity through new coding and choices that might affect quality whilst maintaining the same programme line up. This compares with approximately 2.5 Mbps of capacity which is required for a standard definition channel, and between 12 to 15 Mbps for a high definition channel. Although the released capacity may not be sufficient to accommodate high-definition services, these opportunities need to be considered in the context of other BBC service aspirations and possible directions from the Secretary of State under clause 42 of the BBC Agreement.
- 1.13** Larger gains are expected to come from migration to 64QAM during digital switchover and the introduction of DVB-T2 and MPEG-4. While capacity gains from modulation changes (move to 64QAM) are certain to occur upon the switch to high power, there is much less certainty over potential capacity gains from technology changes. In addition, before the transition to MPEG-4 can be made, a majority of UK homes will need to have MPEG-4 set-top-boxes, as the current generation of set-top-boxes cannot decode MPEG-4 signals. Having only recently purchased their set-top-boxes ahead of DSO, it is unlikely that a critical mass of UK homes will upgrade them in the near future. As a result, the full benefits from these technologies may not materialise for about a decade.
- 1.14** The figure opposite summarises the opportunities facing the BBC for increasing spectrum efficiency, as well as the viability and cost implications.
- 1.15** The BBC has a clear understanding of these options for achieving efficiency improvements, and is already investing in a centralised infrastructure that will allow capacity gains from more efficient coding and multiplexing by mid 2009, the switch to higher modulation during digital switchover and the potential implementation of changes that might have an impact on quality. The BBC is also aware of the potential opportunities arising from new technologies such as DVB-T2 and MPEG-4. Implementation of DVB-T2 and MPEG-4 on Multiplex B starting in 2010 is likely to leave some of the MPEG-2 coding equipment stranded although it is not clear at this stage which. However, the transition to MPEG-4 on Multiplex 1 is likely to involve a period of simulcasting and is unlikely to leave any substantial proportion of the costs that are being incurred now on the new centralised coding and multiplexing infrastructure as stranded costs.
- 1.16** The BBC does not appear to have a sufficiently value-based process for making decisions relating to the trade-offs between capacity and picture quality. We recommend that, going forward, the BBC should undertake robust subjective audience research to support decisions regarding the picture resolution of TV channels. Lower picture resolution might result in poorer pictures, but the BBC should test where the consumer acceptability threshold lies.

Figure 1 Summary of opportunities for increasing spectrum efficiency

	Estimated Capacity Gain*	By when	Feasibility	Cost
Changes potentially affecting quality	3.7 Mb/s	Mid 2009	✓✓✓✓✓	Small cost**
New coding and multiplexing	2.7 Mb/s	November 2008 to April 2009	✓✓✓✓	£104m for coding and multiplexing provided by Siemens, and £27m for property works by BBC Workplace ***
Modulation changes at switchover	12 Mb/s	2009-2012	✓✓✓	
MPEG-4	Capacity used by each channel would be reduced eventually by half, although capacity gains will be minimal in the early years	Starting from 2010 in Multiplex B and from 2013/14 Mux 1	✓✓	The cost of implementing MPEG-4 is undetermined at this stage
DVB-T2	16 Mb/s (8Mb/s from each multiplex)	Starting from 2010 in Multiplex B and from circa 2016 in Multiplex 1	✓	The cost of DVB-T2 is undetermined at this stage of technology development

* The BBC multiplexes currently have 18Mb/s of total available capacity. New coding and reductions in picture resolution would reduce the channel bit rates. Modulation changes and technology changes would increase total multiplex available capacity.

** However, it will only be possible to make these changes when the centralised coding and multiplexing infrastructure is in place by mid 2009

*** Part of this cost is attributable to satellite transmission

1.17 Going forward, decision making with respect to individual services needs to be undertaken with the support of a fuller understanding of the specific costs and benefits relating to the choices being made. In particular:

- Greater measurement of the benefit of the interactive services and subtitling in relation to the value of the capacity for other possible services should be undertaken to justify their operation on DTT, taking into account the regulatory requirements regarding subtitling. The benefits of these services should be assessed against their spectrum "cost".
- With respect to data services, the bit rates used are, in total, significant, and look increasingly generous in comparison to video service rates that have improved substantially in past years as a result of gains made in MPEG compression rates.
- Options for using the overnight gaps of under-utilised capacity should be explored, such as those pursued by other DTT multiplexes.

1.18 As well as determining the optimal mix of permanent scheduled channels, the BBC needs to give increasing thought to how non-permanent capacity demands could be met more cost effectively. These demands are either scheduled or irregular. Scheduled peak demand may be accommodated by buying timeslots on multiplexes subject to capacity being available. Such a market model is now well established among commercial multiplex operators.

1.19 Irregular peak demand, such as the coverage of major live events, is not well served currently. The BBC's approach to carrying such transmissions is either to "punch" a hole in an existing schedule e.g. Wimbledon coverage on BBC ONE, or to use interactive video stream capacity, which is currently highly underutilised.

1.20 The DTT and satellite platforms currently represent broadly similar Value for Money for the BBC when considering reach against the cost incurred by the BBC, although the main BBC services achieve slightly higher usage on DTT in relation to costs than on satellite.

- 1.21 While the cable and IPTV platforms represent Value for Money, they could not substitute for the DTT platform for the BBC services due to their limited population coverage and penetration. Freesat is the only platform, other than DTT, which is free at the point of use for consumers. However, the Freesat platform appears unlikely to be a viable alternative to DTT in the foreseeable future.
- 1.22 With regard to radio, given the simulcasting of a number of BBC radio services on AM, FM and DAB, there is a possibility of rationalising the number of transmissions in order to release spectrum and save transmission costs. A review of the case for the BBC switching off some or all of its AM services should be conducted following the results of current tests of possible alternative uses such as DRM.
- 1.23 For reasons of commercial confidentiality, our report has not assessed the BBC's plans with regard to spectrum auctions. However, going forward this issue will pose important Value for Money considerations for the BBC.

2. Introduction

2.1 The BBC Trust has responsibility for keeping under review the BBC's achievement of Value for Money in the conduct of its operations, and the efficient use of the spectrum. In particular, the BBC Agreement¹ states:

- *"The Trust must examine the Value for Money achieved by the BBC in using the sums paid to it";* and
- *"It is the duty of the Trust to secure the efficient use of the radio spectrum that is available for use by the BBC or its contractors".*

2.2 Deloitte have been commissioned by the BBC Trust to undertake an independent assessment into how efficiently and effectively the BBC uses the spectrum it has available to it, and to provide insight into future challenges and opportunities facing the BBC in the use of the spectrum.

Objectives and Scope

2.3 The BBC Trust required Deloitte to consider the following main questions:

- How spectrum usage is planned and how robust are the processes and framework for deciding the use of the spectrum.
- Whether Value for Money is considered in the spectrum use planning process.
- Whether the BBC uses its current allocation of spectrum efficiently and effectively.

- How the BBC is preparing for the future use of spectrum in terms of potential pressure on spectrum and efficiency.
- What the relative Value for Money of the different means of distribution is, given the aim of universality, and how this is likely to change over time.

2.4 In order to assess the BBC's current use of the spectrum, the Trust asked us to analyse what spectrum the BBC has access to, how it is used in terms of services, and whether there are any unutilised gaps.

2.5 The BBC Trust also asked us to consider what options the BBC faces going forward in the use of the spectrum, and what the BBC could achieve in the next 3-5 years.

2.6 As agreed with the BBC Trust, our study has focused on the spectrum used for DTT broadcasting, as well as analogue and digital radio. We have only briefly considered PMSE. We have not considered issues related to spectrum used for analogue television, as these services will start to be switched off from next year.

2.7 Our assessment of likely future opportunities and challenges for the BBC is based on the BBC's identified future spectrum plans.

¹ Department for Culture, Media and Sport, *An Agreement Between Her Majesty's Secretary of State for Culture, Media and Sport and the British Broadcasting Corporation*, Presented to Parliament by the Secretary of State for Culture, Media and Sport by Command of Her Majesty, July 2006

Why is it important to consider Value for Money in the use of the spectrum by the BBC?

- 2.8 Radio spectrum is a scarce resource and hence its use by the BBC creates a potential opportunity cost on the economy from spectrum being denied to possible alternative uses.
- 2.9 Potential alternative uses could, amongst other, include mobile TV, broadband wireless networks and communications services.
- 2.10 There is also an increasing level of demand on broadcasting spectrum from broadcasters, both the BBC itself and other broadcasters, due to aspirations to offer more SD channels or channels in HD, which requires more capacity.
- 2.11 The range of potential alternative uses in the bands occupied by the BBC, coupled with the increased demand and the scarcity of the spectrum, makes it crucial to ensure the BBC make the most efficient possible use of this resource.

Defining efficiency, effectiveness and Value for Money

- 2.12 The National Audit Office defines Value for Money as *"obtaining economy, efficiency and effectiveness by respectively, spending less, getting the same for less, and spending wisely"*.
- 2.13 In this study, we have broadened the standard definition of Value for Money in order to take into account the opportunity cost of the BBC's use of the spectrum. In particular, we have analysed whether the BBC minimises the opportunity cost by using the spectrum efficiently and effectively.
- 2.14 In analysing "efficiency" in the use of spectrum we have distinguished between two types of efficiency:
- Spectrum efficiency, defined as the amount of spectrum used to broadcast one TV channel or one radio service.
 - Economic efficiency, defined as the value provided to audiences from the services for which the spectrum is used.
- 2.15 There are trade-offs in the use of the spectrum, whereby increases in spectrum efficiency can, in some circumstances, lead to reductions in picture quality, population coverage, or other effects. We have considered "effectiveness" in terms of the ability to maximise the quality of the broadcasting output for a given amount of spectrum capacity, as well as the reach of the services for which the spectrum is used.
- 2.16 The definition of Value we use in this report is consistent with the RQIV framework that has been

developed for measuring the Public Value of BBC services². This involves consideration of the:

- Reach of the services.
- Quality and distinctiveness.
- Impact (measured in terms of citizen and society value).
- Cost.

2.17 However, due to the limited data relating to quality and distinctiveness, our analysis of Value for Money focuses on reach, impact and cost.

Structure of the report

- 2.18 This report considers first the efficiency and effectiveness in the BBC's use of the DTT spectrum, followed by its use of spectrum for radio services. It then analyses the Value for Money of different television platforms and of the different bands used for radio services. Finally we consider the planning and approvals process which applies to both television and radio services.
- 2.19 The rest of this report is structured as follows:
- Section 3 provides an overview of the spectrum bands used by the BBC, including a description of how spectrum is planned and used across different spectrum bands, and Ofcom's regulation.
 - Section 4 assesses the BBC's current use of the DTT spectrum and the opportunities for the BBC to improve DTT spectrum efficiency in the next 3-5 years through implementation of different technical options.
 - Section 5 assesses efficiency in the BBC's allocation of DTT spectrum to different services, how effectively those services use the capacity allocation they have, and opportunities for improving efficiency in the allocation of spectrum to services.
 - Section 6 analyses efficiency in the BBC's use of the analogue and digital radio spectrum, and opportunities for the BBC to increase efficiency in the next few years.
 - Section 7 analyses the Value for Money of different platforms.
 - Section 8 assesses the BBC's planning processes for the use of the spectrum, and the extent to which those processes support the delivery of Value for Money.
 - Section 9 contains our conclusions and recommendations.

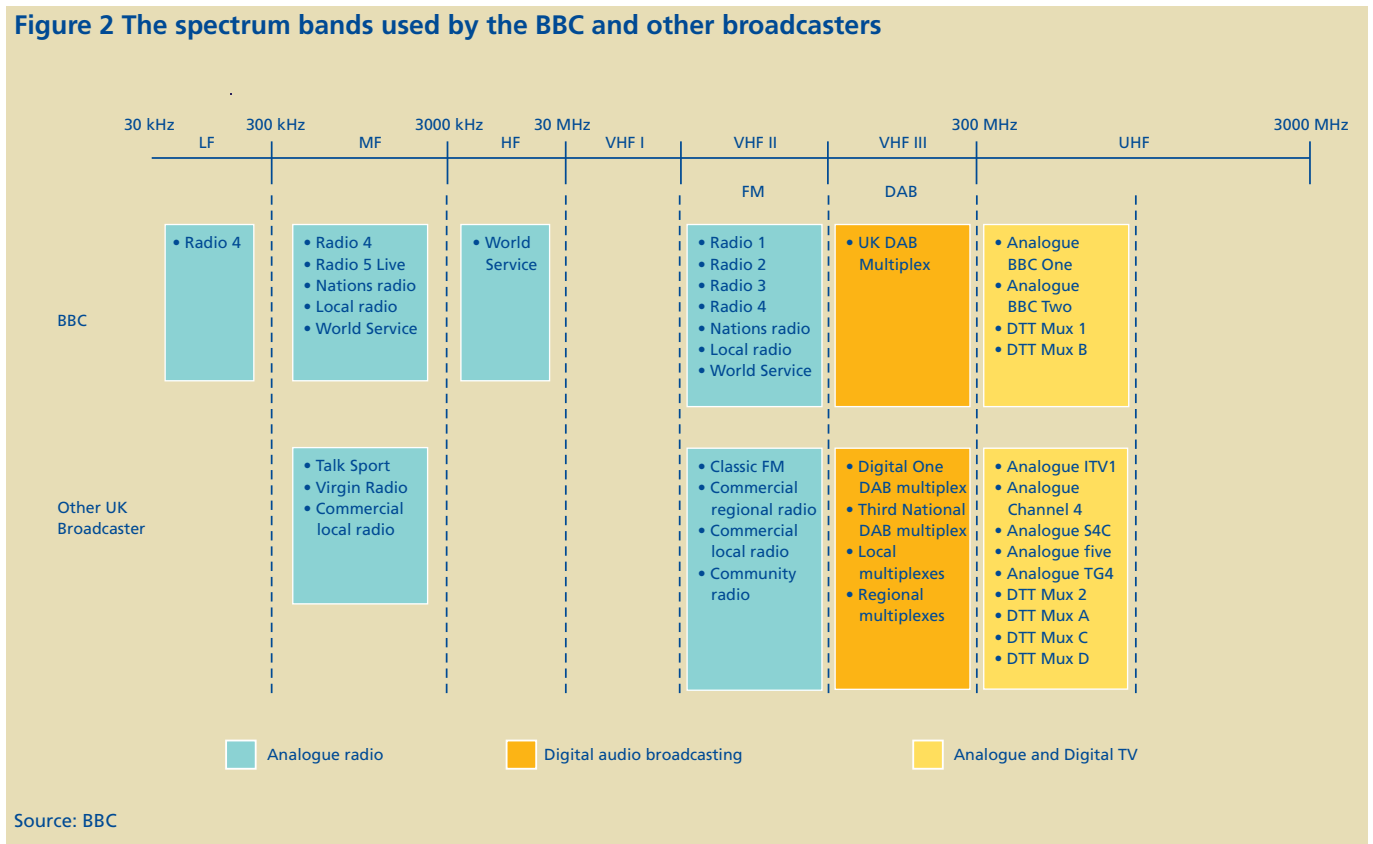
² RQIV stands for Reach, Quality, Impact and Value for Money. BBC *Building Public Value* 2005.

3. Spectrum planning and use

Services and spectrum bands

- 3.1** The BBC uses significant amounts of radio spectrum to transmit terrestrial broadcast television and radio services to audiences across the UK, and makes further use of spectrum in PMSE.
- 3.2** The particular spectrum bands used for broadcast services are largely determined by international industry standards and coordinated agreements, and are common for broadcasters across the UK. The BBC operates analogue and DTT services in UHF Band IV and Band V; DAB services in VHF Band III, FM services in VHFII and AM radio services in the Short Wave, Medium Wave and Long Wave bands. The location of the BBC's broadcast services within these bands is shown in Figure 2 overleaf.
- 3.3** The Short Wave band is used solely for World Service broadcasts, predominantly from overseas transmitters, and using frequencies allocated on an internationally coordinated rather than national basis. A substantial portion of funding for this band is provided by the Foreign & Commonwealth Office, and it has not been a focus of this study.
- 3.4** The technologies used for broadcast services are also largely determined by international industry standards and conventions. Coordination of the use of frequencies with neighbouring countries is required to manage cross-border interference. International standardisation of receiver equipment results in restrictions in the manner particular frequencies are used in practice.
- 3.5** Analogue and low power digital terrestrial television services currently co-exist within the UHF bands. As digital switchover progresses over the next five years, analogue services will be switched off, region by region, and DTT signal power will increase to high power. When digital switchover is complete, each major transmitter site will use six frequencies to carry the six digital multiplexes, in place of the previous five frequencies to support the five analogue channels. However, DTT supports a more efficient frequency reuse pattern across transmitter sites, and hence a smaller set of frequencies is required to support the digital configuration compared with the previous analogue configuration. As a result, 112 MHz of spectrum in the UHF band will be available post digital switchover, which Ofcom intends to release as part of the DDR.
- 3.6** Analogue and full digital radio broadcast services are currently operated simultaneously, each within their own bands. There are no current plans to switch off analogue radio broadcast services, largely as a result of limited take up to date of DAB receivers, the large installed base of analogue receivers, and the ability of DAB to be launched and developed in its own band, without recourse to reuse of the analogue radio bands.
- 3.7** Extensive secondary reuse of the UHF band is currently made for PMSE applications. The BBC and other broadcasters, programme and events producers reuse frequencies outside their primary locations to support outside broadcast transmissions, wireless microphones and similar production-related applications.

Figure 2 The spectrum bands used by the BBC and other broadcasters



Competing demands for spectrums

- 3.8 The level of potential competing demand for broadcast spectrum varies by band. Lower bands, particularly AM, have considerably less capacity and tend to have much tighter channel structures, limiting the bandwidth of potential alternative services. Conversely, higher bands, particularly UHF which is used for DTT, contain considerable capacity and could potentially be used for a variety of high bandwidth services.
- 3.9 Ofcom has consulted on potential uses for the UHF spectrum that will be released as part of the DDR. Considerable interest has been expressed for a variety of applications including mobile TV and broadband wireless networks. The band appeals to proponents of these services as it offers a valuable combination of capacity and signal reach. The degree of signal reach that can be achieved with transmissions in this band is attractive to players considering building and operating new wireless networks. Fewer transmitter sites would be required to achieve a given level of

population coverage compared with services operating at alternative bands higher up within the radio spectrum, e.g. the L-band for mobile TV or the 2.6 GHz band for wireless broadband services.

- 3.10 DAB frequencies offer modest capacity and considerable range, and some capacity in this band has been used to operate mobile TV services. However, it is generally considered that a mobile TV service would require a greater amount of capacity than would be practically available in this band.

DTT spectrum planning and use

- 3.11 The BBC operates two of six DTT multiplexes in the UK. Each multiplex at a transmitter site requires its own frequency, and therefore up to six frequencies are required at each site where 6 multiplexes are operated. Frequencies can be reused, generally on non-adjacent sites, without interference. Multiplex operators are therefore able to build and operate a nationwide network of multiplex transmitters by reusing a relative small set of frequencies. The exact

Figure 3 Frequencies occupied by the DTT multiplexes

470MHz

21	22	23	24	25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44
45	46	47	48	49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64	65	66	67	68
69											

862MHz

	Spectrum available from digital switchover
	Spectrum assigned to six DTT multiplexes post-DSO, and resulting "interleaved" spectrum
	Currently unavailable spectrum – 36 is radar, 38 is radio astronomy
	Spectrum currently used by PMSE

Source: Ofcom

level of reuse that is possible is determined by factors such as land topology, interference effects with neighbouring countries, population coverage targets and the density and power levels of the installed transmitter site infrastructure.

- 3.12 For the post digital switchover configuration of three PSB multiplexes with high population coverage, and three commercial multiplexes with more moderate population coverage, the UK's multiplex operators, in aggregate, will occupy 32 frequencies in the UHF band. This is shown in the illustration opposite. This compares a total of 46 channels currently used for analogue transmissions and low power DTT, i.e. channels 21 to 68 inclusive, with the exception of 36 and 38.
- 3.13 Multiplex operators have little latitude to use less spectrum than is specified in their current plans and licences unless they are prepared to make substantial changes to population coverage targets.

DAB spectrum planning and use

- 3.14 The BBC operates one of three national DAB multiplexes, the third being only recently awarded and not yet in commercial operation.
- 3.15 All UK DAB multiplexes operate in Band III. A DAB multiplex is able to reuse the same frequency at each of its transmitter sites, so national multiplex services can be operated with only one frequency. The BBC operates its DAB multiplex as a single frequency network in the 12B block at 225.468 MHz.

- 3.16 The BBC also broadcasts its local and Nations radio services on commercial local DAB multiplexes licensed by Ofcom using capacity reserved under the Broadcasting Act 1996, for which it pays commercial rates. BBC services are currently on 38 of the 46 local DAB multiplexes. Ofcom are in the process of licensing further local DAB multiplexes.

DTT multiplex configuration

- 3.17 The digital capacity provided by a DTT multiplex can be used to carry a combination of digital services, including TV channels, radio channels, data services, interactive services as well as information associated with multiplex management.
- 3.18 The mix of channels currently carried on multiplexes is shown in the illustration below. Multiplex operators have made various trade-offs in their decisions regarding modulation schemes (such as use of 16QAM or 64QAM), digital capacity and the mix of TV, radio and data services carried.

Figure 4 Services on each of the six DTT multiplexes

Multiplex	1	2	A	B	C	D
Multiplex Operator	BBC (PSB1)	Digital 3&4 (PSB2)	SDN (50% capacity reserved for Five)	BBC Free to View Ltd (PSB3)	National Grid Wireless	National Grid Wireless
Bandwidth & Modulation	18Mb/s 16 QAM	24Mb/s 64 QAM	24Mb/s 64 QAM	18Mb/s 16 QAM	18Mb/s 16 QAM	18Mb/s 16 QAM
Population coverage	87%	81%	80%	85%	81%	81%
TV Streams	Television <ul style="list-style-type: none"> • 4 channels • BBCONE • BBCTWO • BBCTHREE/ CBBC • BBC News24 	Television <ul style="list-style-type: none"> • 8 channels • ITV1 • ITV2 • ITV3 • ITV4/CITV • Channel 4 • E4 • More4 / Teleshopping • Film4+1 / Teleshopping 	Television <ul style="list-style-type: none"> • 9 channels • QVC / S4C • Bid tv / Screen Shop • Price-drop tv / Screen Shop • Five • Five US / Quizcall • Five Life / TV X • Setanta Sports / Top-Up Anytime 1 • Thomas Cook TV / Top-Up Anytime 2 • British Eurosport / Teachers TV / UKTV Style / UKTV Gold / Top-Up • Anytime 3 	Television <ul style="list-style-type: none"> • 5 channels • BBCFOUR / CBeebies • BBC Parliament • BBCi 301 • BBCi 302 / Community Channel • BBCi Multiscreen 	Television <ul style="list-style-type: none"> • 5 channels • Sky News • Sky Sports News • SkyThree • UKTV History / Smile TV / Sumo • E4+1 	Television <ul style="list-style-type: none"> • 6 channels • TMF • The Hits • UKTV BrightIdeas / Ftn • ITV2+1 • Ideal World • Film4 / Teleshopping
Radio Streams	Radio <ul style="list-style-type: none"> • BBC Radio Scotland; Wales; Ulster; Nan Gaidheal; Cymru; Foyle <p>(Not UK wide – Only available in certain Nations)</p>	Radio <ul style="list-style-type: none"> • UTV Radio (NI only) • Heart • RadioMusicShop 	Radio <ul style="list-style-type: none"> • BBC Radio 1; 2; 3; 4 (until Oct -07) 	Radio <ul style="list-style-type: none"> • BBC Radio 1xtra; 5Live; 5Live Sports Extra; 6Music; 7; Asian Network + BBC Radio 1;2;3;4 (from Oct -07) 	Radio <ul style="list-style-type: none"> • Premier • Emap Radio (3C) • UTV Radio: talkSPORT • SMG Radio: Virgin 	Radio <ul style="list-style-type: none"> • Emap Radio: The Hits; Smash Hits; Kiss; Magic; Q; Kerrang • Channel 4 Radio: Oneword • BBC Radio: World Service • GMG Radio: Smooth FM
Data Streams	Data <ul style="list-style-type: none"> • BBCi Text 	Data <ul style="list-style-type: none"> • Teletext on 4 • Teletext on cars • Text ITV1/2/3/CiTV, C4, More 4, E4 	Data <ul style="list-style-type: none"> • Teletext Games • Teletext Holiday • MHEG 	Data <ul style="list-style-type: none"> • BBCi Text • BBC 303 channel 	Data <ul style="list-style-type: none"> • Sky Text • MHEG 	Data <ul style="list-style-type: none"> • MHEG

Source: BBC, www.dtt.me.uk

Figure 5 National DAB multiplexes

Multiplex	12B (BBC)	11D (Digital One)	11A (Third National)
Multiplex Operator	BBC	Digital One	Digital Group
Population Coverage	Currently 86% with the aim of reaching 90%	Currently over 85% with the aim of reaching 90%	Not yet determined
Channels	<ul style="list-style-type: none"> • BBC Radio 1 • BBC Radio 2 • BBC Radio 3 • BBC Radio 4 • BBC Radio 4 LW • BBC Radio 5 Live • BBC Radio 5 Live Sports Extra • BBC 1Xtra • BBC 6 Music • BBC 7 • BBC Asian Network • BBC World Service • Data 	<ul style="list-style-type: none"> • Classic FM • Core • Capital Life • Oneword • Planet Rock • talkSPORT • theJazz • Virgin Radio • Data 	<ul style="list-style-type: none"> • E4 Radio • Channel 4 Radio • Pure 4 • Talkradio • Closer • Sky News Radio • Sunrise Radio • Virgin Viva Radio • Original • Radio Disney • Data <p>Note: The third national multiplex was licensed in July 2007 and is not yet in commercial service</p>

Source: BBC, Radio Engineering, Digital Radio Technologies

DAB multiplex configuration

3.19 The digital capacity provided by a DAB multiplex can be used to carry a combination of audio and data services. Licences for the commercial multiplexes specify a maximum amount of capacity that may be used for non-audio services. The BBC carries a dozen audio services plus associated data services. The mix of channels currently carried on DAB multiplexes is shown in the illustration above.

The impact of regulation

3.20 Ofcom has a significant role in determining the availability and use of the radio spectrum used by the BBC and competing users. Its guiding principles are to seek to have spectrum put to best use, and for it to be put into the hands of those users who can put it to best use. It therefore regularly reviews the use of

spectrum, either by band or by application, to assess whether changes in its regulatory treatment are necessary.

3.21 With respect to television, the Government and Ofcom have been instrumental in driving the digital switchover programme. Here Ofcom is seeking the double benefit of increased channel choice for viewers and lower utilisation of spectrum to deliver the service, compared with analogue TV.

3.22 The spectrum that becomes free as a result, commonly referred to as the digital dividend spectrum, is intended to be auctioned to bidders on a technology and application neutral basis. This spectrum could be used for constructing additional multiplexes or for alternative services such as mobile TV or wireless broadband services.

- 3.23** With respect to radio, Ofcom is currently considering the future of radio services, including their use of spectrum. In its April 2007 Future of Radio Consultation³, Ofcom considered the potential alternative uses of the spectrum bands currently used by radio services that could be freed-up in the near future.
- 3.24** Mobile TV, data services, digital radio and community radio are some of the alternative services that, according to Ofcom, could use the spectrum currently used for FM broadcasting (VHF Band II). However, the listening share of FM is such that Ofcom considers that it is still too early to start consulting on a possible switchoff of FM services⁴, and suggests that a review should be undertaken *"in 2012, or when listening on digital platforms accounts for 50% of all radio listening, whatever is earlier"*.
- 3.25** The scenario for medium wave portrayed by Ofcom is different. Ofcom notes that medium wave services offer considerably lower sound quality than FM, and suffer from falling audiences, and that there may be potentially more valuable uses of the medium wave band such as DRM. Ofcom also identifies that medium wave licenses are due to expire at different times over the next few years, and is therefore currently proposing to start a consultation on the future use of the medium wave spectrum in 2009.
- 3.26** With regard to use of spectrum for PMSE, Ofcom is currently consulting on future arrangements for accessing the interleaved UHF spectrum currently used by the PMSE industry⁵. Ofcom is proposing to move towards a more market-based approach for PMSE use of spectrum in order to ensure efficient use, and plans to publish its final proposals by the end of 2007.

³ See Ofcom, "The Future of Radio – The future of FM and AM services and the alignment of analogue and digital regulation", consultation document, 17 April 2007.

⁴ Ofcom observes that, to date, the majority of radio listening is to services broadcasted on FM, although the share of digital radio listening is expanding rapidly. See Ofcom, "The Future of Radio – The future of FM and AM services and the alignment of analogue and digital regulation", consultation document, 17 April 2007, page 88.

⁵ Ofcom, Programme Making and Special Events: future spectrum access Consultation, June 2007.

4. The BBC's current use of the DTT spectrum and options for improving spectrum efficiency

- 4.1 In this section we assess the BBC's current use of the spectrum and technical options for improving spectrum efficiency. In particular we:
- Set out the BBC's current choices in the trade-off between capacity and quality/population coverage.
 - Assess the BBC's efficiency and effectiveness in its current use of the spectrum.
 - Assess the opportunities facing the BBC to increase spectrum efficiency through a set of technical options, as well as their feasibility and cost implications.
 - Summarise the options facing the BBC for improving spectrum efficiency over the next five years.
 - Consider the impact that Ofcom's administered incentive pricing might have on the BBC's use of the spectrum.

The BBC's current efficiency/effectiveness trade-off choices

- 4.2 Multiplex operators face a number of choices which have an impact on the overall multiplex capacity available and on the number of services that can be accommodated.

- 4.3 In the first instance, multiplex operators have some latitude to trade-off the population reach and robustness of the signal versus its digital capacity, for a given number of transmitter sites. 16QAM modulation represents a smaller useable payload of capacity than 64QAM⁶, but wider population coverage at the same transmitter powers. Testing by the BBC suggests that 16QAM gives approximately 5% extra population coverage on the existing low power system compared with 64QAM, which is in line with our expectations. This is also corroborated by independent testing. 64QAM also has a more "fragile" signal than 16QAM meaning that the signal will have a greater tendency to fail in marginal reception areas.

- 4.4 While DTT services still operate at low power, the BBC and National Grid Wireless have made the decision to operate their multiplexes at 16QAM, whereas the Digital 3&4 and SDN multiplexes (Multiplexes 2 and A respectively) have decided to operate at 64QAM. As a result, the BBC's multiplexes have less available capacity, but have a wider population reach and a more robust signal. This is illustrated in Figure 6 overleaf.

⁶ 16QAM provides 18.1 Mbps of capacity whilst 64QAM represents 24.1 Mbps.

Figure 6 Modulation, total capacity and population coverage

	MUX 1 (BBC)	MUX B (BBC)	MUX 2	MUX A	MUX C	MUX D
Modulation scheme	16QAM	16QAM	64QAM	64QAM	16QAM	16QAM
Total capacity, Mbps	18	18	24	24	18	18
Coverage, % UK population	87%	85%	81%	80%	81%	81%

Source: BBC, Digital Television Action Plan - Spectrum Planning Group, 2003⁷

- 4.5** The BBC took the view, when they re-launched the DTT platform as Freeview in 2002 with Crown Castle UK – now National Grid Wireless – and Sky, that signal reach and robustness was a key priority in order to re-establish consumer confidence in the DTT platform and therefore settled for 16QAM. Arguably this choice has been one of the factors underpinning the success of the DTT platform.
- 4.6** Once digital switchover is complete in a given region, DTT signals will be increased to high power. This will increase signal reach and robustness and all multiplex operators will then operate at 64QAM, with a resulting 24 Mbps of capacity available on all multiplexes.
- 4.7** Beyond modulation, choices regarding picture resolution and GOP length have an impact on the number of services that can be accommodated within the total multiplex capacity available.
- 4.8** Broadcasters can reduce the capacity used by any individual channel by reducing the picture resolution from full screen to three-quarter screen or less. Lower picture resolution will generally impact picture quality, e.g. a lower picture resolution will look softer as fine detail might be missing although this is not always the case. Whether subjective quality is affected depends on consumer perception.
- 4.9** The BBC offers more channels on full resolution than other PSBs, and broadcasts BBC ONE, BBC TWO, BBC THREE/CBBC, BBC FOUR/CBeebies and BBC News 24 at full resolution. ITV and Channel 4 only broadcast their primary channels, ITV1 and Channel 4, at full resolution.
- 4.10** As a result, 100% of the channels on the BBC's Multiplex 1 are broadcast at full resolution, as shown in the figure below, whereas Multiplexes B, 2 and A have a lower proportion of video streams at full resolution.
- 4.11** Broadcasters can also reduce the capacity used by any individual channel by increasing the GOP length. A longer GOP length will increase channel switching times because the decoder must wait longer for the next complete picture frame. There may also be an effect on some Personal Video Recorders that use complete picture frames to operate the "fast forward" function. Extending the GOP length is only beneficial for video that is slow moving, and as this will tend to have a low coding rate anyway, the saving from GOP length will tend to be low in absolute terms.
- 4.12** Multiplexes 1, B and 2 currently use the shortest GOP length whilst other multiplexes broadcast at higher (variable) GOP lengths rates.

Figure 7 Proportion of channels at full resolution

	MUX 1	MUX B	MUX 2	MUX A	MUX C	MUX D
Proportion of video streams in SD full resolution, %	100%	20%	25%	11%	100%	100%

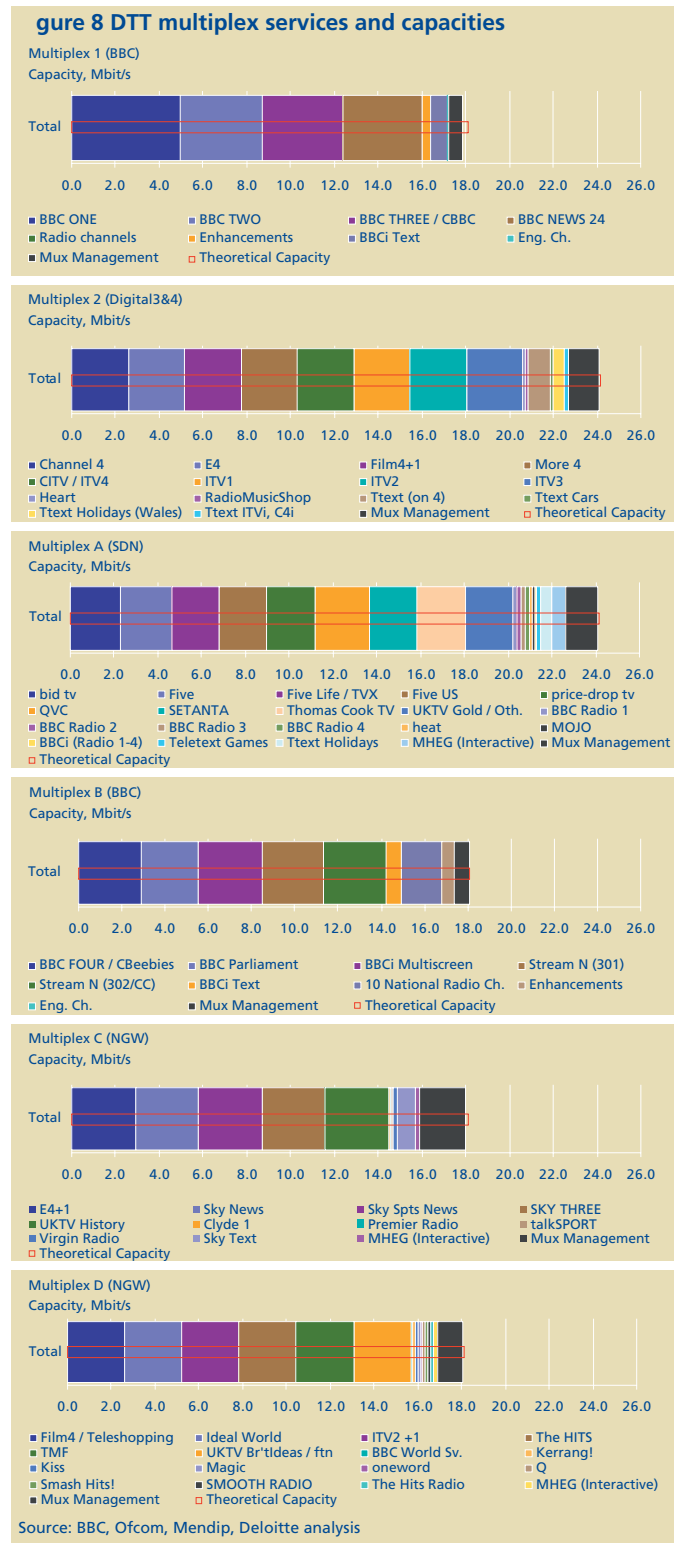
Source: BBC, Deloitte analysis

⁷ The Spectrum Planning Group is formed of Arqiva, National Grid Wireless, Ofcom and the BBC.

The BBC's current spectrum efficiency and effectiveness

4.13 The number of services that can be accommodated in a multiplex or, conversely, the amount of capacity that is required to carry a given set of services, depends on the mix of services carried⁸, the desired quality for each service, the coding efficiency of each service, and the effectiveness of the multiplexing process.

4.14 The figure on the right shows how services are accommodated within each of the six DTT multiplexes and the capacity taken up by each service. It can be seen that video channels on Multiplex 1, particularly BBC ONE, take significantly more capacity than video channels in any of the other multiplexes.

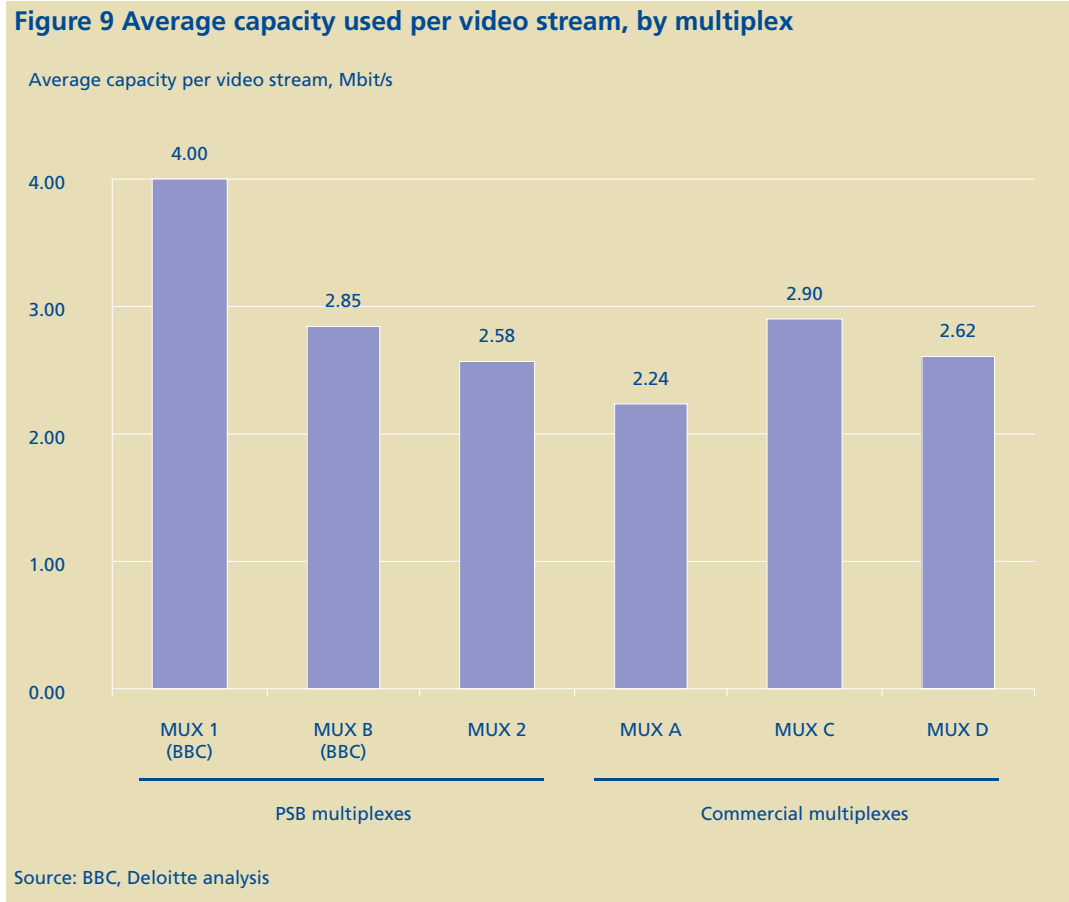


⁸ For example, a TV channel will typically require of the order of 3 Mbps of digital capacity (including audio description, audio and subtitles), radio stations 128 kbps and data capacity will depend entirely upon the application.

- 4.15 Comparing the average data rate of video streams⁹ across each of the six multiplexes, it can be seen that channels on Multiplex 1 require at least a third more capacity than channels on other multiplexes.
- 4.16 The higher video bit rates on Multiplex 1 are a result of older coding technology, less extensive use of statistical multiplexing and choices regarding picture resolution and GOP length.
- 4.17 The coding and multiplexing technology used on Multiplex 1 is much older than that used on Multiplex B, which was recently upgraded. Older coders achieve less compression on signals and result in higher bit rates.
- 4.18 Higher video bit rates on Multiplex 1 are also a consequence of a legacy multiplex architecture. Most DTT multiplexes feed component TV channels into a statistical multiplexer (Statistical Multiplex) which is

able to take advantage of randomly varying bitrates per channel, and generate a combined or multiplexed signal that is more compact or efficient than discretely coded channels. The level of efficiency increases with the number of TV channels feeding into the Statistical Multiplex. Multiplex 1 carries BBC ONE, which has regional scheduling that requires programmes to be inserted regionally. The current legacy multiplex architecture does not allow BBC ONE in England to be included within the Multiplex 1 Statistical Multiplex, resulting in a reduction in possible efficiency. This is expected to be resolved when the BBC introduces a new coding and multiplex solution from the end of 2008.

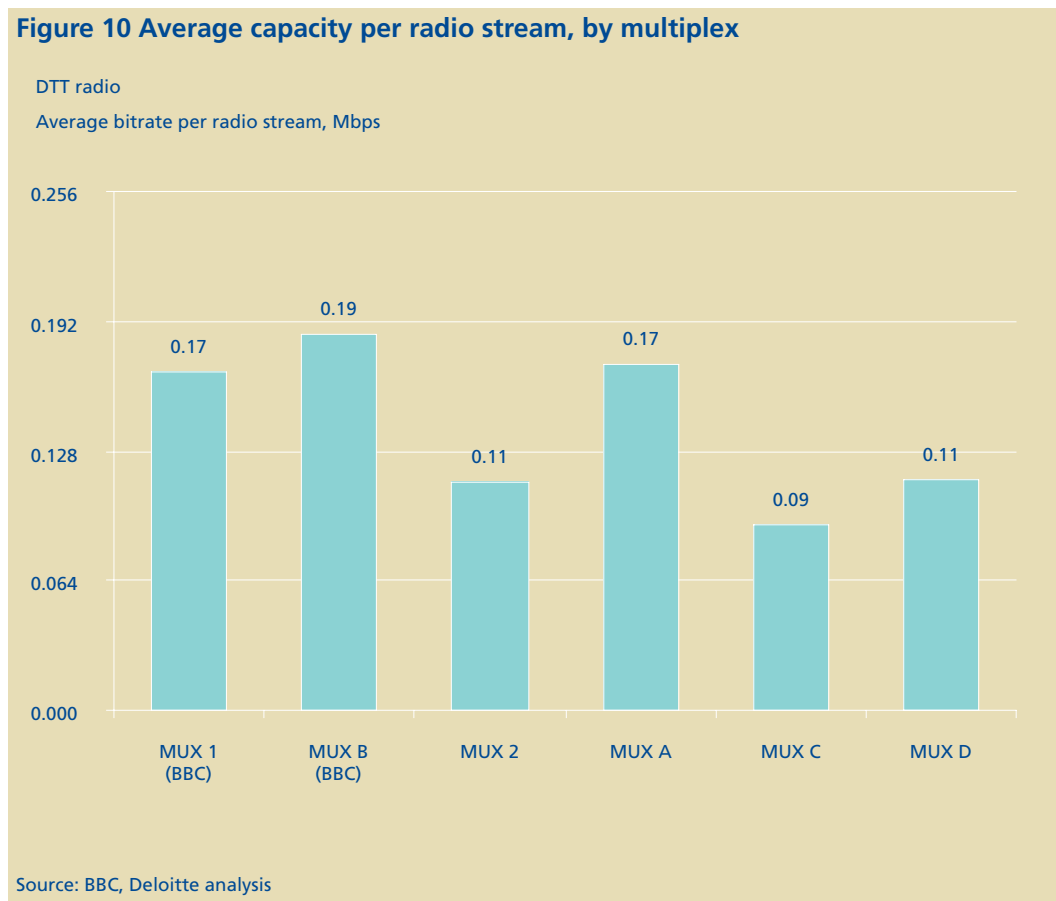
Figure 9 Average capacity used per video stream, by multiplex



⁹ A video stream may share capacity between different channels which are broadcast at different times of the day. The capacity of each video stream includes the audio and data component of that video stream.

- 4.19** As well as video streams, the DTT multiplexes also carry radio and data services. Radio services take much less capacity than video services. As a result, the impact of choices regarding radio coding rates on the overall capacity available for other services is less significant than for video services.
- 4.20** BBC radio services are carried on DTT Multiplexes 1, B and A¹⁰ and these have higher average data rates than radio services on other multiplexes. This appears to be as a result of the BBC's tendency to broadcast at a higher level of quality, in terms of both bit rate per audio channel and stereo versus mono.
- 4.21** There is some scope to reduce quality down to the levels used for DAB, but radio rates are low already compared with video streams and absolute gains and their reuse value would be limited.
- 4.22** DTT multiplexes also carry text/data services. The BBCi text service includes a 24/7 service, CBeebies interactive learning games and the BBCi multiscreen service¹¹. In addition, some capacity is used for subtitling and audio description¹² and for providing links to the interactive streams in Multiplex B from Multiplex 1. The BBC multiplexes carry higher average data rates than other multiplexes, as illustrated overleaf. However, the nature of the data services offered is at the discretion of each broadcaster, so there is limited benefit in benchmarking.

Figure 10 Average capacity per radio stream, by multiplex



¹⁰ The four services on Mux A are moving to Mux B on October 2007. In addition, the BBC World Service has an agreement with NGW for capacity for BBC World Service in Mux D. The BBC expect to move that service out of Mux D into Mux B in October next year, although the commercial arrangements have not been agreed yet.

¹¹ In addition to the data services and the BBCi multiscreen, the BBCi service also includes interactive video services. The BBCi video service is composed of two interactive video streams. These video components of the BBCi service are discussed in paragraphs 5.13 to 5.20.

¹² Ofcom requires television licenced services to provide access services such as subtitling, signing and audio description, including meeting annual targets on the proportion of programmes that should include such services.

- 4.23 The BBCi text service can be accessed from all BBC TV channels on the two multiplexes and, as a result, is replicated across the two multiplexes. This duplication could be avoided by restricting the service to those channels on the one multiplex, which would become practical if the BBC were to consolidate the majority of its channels within one multiplex.
- 4.24 The BBCi text service uses a significant amount of capacity (approximately 700 kbps) to carry a revolving "carousel" of data. There is a trade-off between the bitrate used for the service and the time taken to download a screen of information. There are a few data services, such as the "red button" quiz service linked into the "Test the Nation" TV series, where speed of delivery is critical. However, for most services speed is less critical. Expanded set-top-box memory could be used to cache less critical data services, and thereby reduce capacity requirements.
- 4.25 The CBeebies games component of the BBCi text service uses approximately 200 kbps of capacity. The CBeebies games are not essential to the operation of the rest of the BBCi text service. However, the CBeebies service licence requires some programmes to have interactive television features available on digital platforms. Therefore modifications to this service might require a Public Value Test.
- 4.26 The BBCi multiscreen service, which consists of four quarter-screen video services, uses the capacity permanently during 24 hours a day.
- 4.27 Subtitling uses up to 100 kbps per channel to achieve instantaneous presentation of live generated titling during live programming. In respect of subtitling there is a trade-off between bandwidth used and synchronisation of the audio and pictures. In practice the level of utilisation is low for the majority of the

Figure 11 Average bitrate per data service



time, but the BBC is required by the Communications Act to increase the proportion of programmes with subtitles to 80% by 2013. Even with those targets, the BBC has freedom to decide how much spectrum capacity is dedicated to the services, and therefore it seems appropriate that the spectrum "cost" of the bandwidth used is assessed against the benefits of better synchronisation.

- 4.28 The links to the interactive streams in Multiplex B from Multiplex 1 take up 200 kbps of capacity.

Existing evidence of consumer preferences in the effectiveness/efficiency trade-off

- 4.29 The BBC's decision to broadcast five video streams at full resolution has so far been supported by limited consumer research into what level of picture quality is acceptable to audiences.
- 4.30 In September 2006, the BBC undertook a small sample piece of quantitative research among viewers in Hull. This research suggested that the majority of viewers found the picture quality obtained with seven SD channels in a multiplex unacceptable, whilst the sample was divided in their opinion of picture quality with six channels in a multiplex.
- 4.31 However, this research was limited by a number of factors: the relatively small survey sample, the limited set of scenarios presented to viewers and the fact that viewers were unaware of the alternative benefits that would have to be traded off against picture quality, e.g. greater choice of channels on offer.
- 4.32 Much more extensive research has been conducted recently in the context of HD, which has identified positive viewer benefits, but these results cannot reasonably be extrapolated into decisions between full-screen and three-quarters screen SD.
- 4.33 Ofcom have told us that they have received very few complaints about the picture quality of other public services broadcast channels, which operate at lower bit rates, suggesting that consumers might find lower levels of picture resolution acceptable.
- 4.34 Availability of services may, arguably, be of more concern to consumers than picture quality. According to the BBC Trust, complaints are received frequently about inability to receive the BBC services.
- 4.35 The limited research that has been conducted by the BBC on picture quality to date, and the insights from Ofcom's data on complaints, indicates the importance of fully understanding consumer preferences of picture quality versus capacity so that decisions on trade-off choices reflect consumer value.

Opportunities for the BBC to improve spectrum efficiency

- 4.36 The BBC faces a range of technical options for increasing spectrum efficiency in the next five years. Some of those options might have an impact on quality, although whether the impact would be sufficient to affect consumer perceptions significantly would need to be tested. We distinguish between:
- Potential capacity gains from more efficient coding and multiplexing, while maintaining picture quality and range of services.
 - Potential capacity gains which might result in reductions of the quality of the services.
 - Potential capacity gains from the adoption of new technologies.
 - Potential capacity gains at digital switchover resulting from the change in modulation from 16QAM to 64QAM.

Potential capacity gains from more efficient coding and multiplexing

- 4.37 As discussed elsewhere in this report, video streams on Multiplex 1 use more capacity on average than the other multiplexes, partly as a result of its older coding technology and the use of statistical multiplexing across fewer channels. The BBC is investing in updated MPEG-2 coding and multiplexing infrastructure as part of the digital switchover programme which, from the end of 2008, will support more efficient coding and allow all video streams in Multiplex 1 to be included within the Statistical Multiplex.
- 4.38 Multiplex B is already benefiting from maximum coding and multiplexing technology gains and therefore is broadly as technically efficient as other DTT multiplexes. Efficiency improvements were easier to achieve on Multiplex B than on Multiplex 1 as it is currently a single UK stream, while Multiplex 1 has a structure with 18 regions.
- 4.39 We estimated that the potential capacity gains on Multiplex 1 from new coding and full statistical multiplexing to be of the order of 2.7 Mbps, see Figure 12 overleaf. This result is based on the difference between the capacity used by TV channels on Multiplex 1 today and the capacity that would be required if channels were coded at the average bit rate of full resolution TV channels (with broadly similar content) currently broadcast across all other multiplexes¹³.

¹³ This is BBC FOUR/CBeebies in Multiplex B; Channel 4, ITV1 in Multiplex 2; Five in Multiplex A; E4+1, Sky News, Sky Sports News, Sky Three, UKTV History in Multiplex C; Ideal World and The HITS in Multiplex D.

4.40 Our estimate of capacity gains is sensitive to the set of DTT TV channels that are used for comparison. We therefore also created high and low case savings estimates based on different sets of comparison channels. For our high case, the comparison set includes channels with a broadly similar content on more efficient Multiplexes 2, A and C¹⁴. Our low case also includes channels of a similar content on Multiplex B and more channels from Mux C, which is less efficient than Muxes 2 and A¹⁵. The savings were 3.1 Mbps and 2.5 Mbps respectively. Our high and low case estimates of potential capacity gain from statistical multiplexing assume 4% and 2% capacity gain respectively.

4.41 We estimated the potential gain resulting purely from full statistical multiplexing, i.e. including BBC ONE within the Multiplex 1 Statistical Multiplex, to be 0.4 Mbps assuming a 3% capacity gain of going from three to four channels in a Statistical Multiplex pool¹⁶. The remaining gain comes purely from latest coding technology.

4.42 Our estimate of capacity gain from new coding includes 0.5 Mbps capacity gain from a reduction of capacity taken by null packets following the upgrade of SI/PSI equipment across all multiplexes.

4.43 According to our estimates the BBC could release between 3.1 Mbps and 2.5 Mbps though technical efficiencies without impacting quality, and with the majority of the saving coming from using newer coding infrastructure. This estimate of potential capacity gains compares to approximately 2.5 Mbps of capacity which are typically required for a standard definition channel.

4.44 These efficiencies should be achievable by April 2009, as the BBC introduces the new coding and multiplexing infrastructure which is being deployed to support switchover. The BBC will pay Siemens £104m over the period to March 2015 for coding and multiplexing services. The new coding infrastructure will be used for both DTT and satellite broadcasting with an estimated 75% of direct costs relating to DTT but large shared costs.

4.45 In addition, the BBC will spend £27m over the period to March 2015 for property works by BBC Workplace including construction works and ongoing operation of the sites.

Potential capacity gains that might impact on quality

4.46 Further capacity gains would require the BBC to make reductions in picture resolution and increase GOP lengths, which might have an impact on the quality of viewing.

4.47 As noted elsewhere in this report, very limited research has been undertaken to date to help inform decisions on the optimal balance between quality and capacity requirements. There is also very limited anecdotal evidence. On the one hand, we understand few complaints have been received by Ofcom regarding the picture quality of non-BBC channels, but we also understand the BBC has received complaints on occasions when quality has been dropped, e.g. during televised coverage of the "Jubilee Weekend".

Figure 12 Estimates of potential capacity gains due to new coding/multiplexing and a larger statistical multiplex pool on Multiplex 1

	MUX 1 (BBC)		
	High case	Base case	Low case
Capacity that could be released by using:			
Newest coding infrastructure, Mbps	2.5	2.3	2.2
Full statistical multiplexing, Mbps	0.6	0.4	0.3
Total	3.1	2.7	2.5

Source: Deloitte analysis

¹⁴ Channel 4, ITV1 in Multiplex 2; Five in Multiplex A; Sky Sports News in Multiplex C.

¹⁵ BBC FOUR/CBeebies in Multiplex B; Channel 4, ITV1 in Multiplex 2; Five in Multiplex A; E4+1, Sky News, Sky Sports News, Sky Three, UKTV History in Multiplex C.

¹⁶ This is based on manufacturer information.

- 4.48** Decisions regarding the appropriate level of picture quality should be based on sufficient evidence. In Appendix 1, we identify some issues that need to be taken into account in designing future consumer research in this area.
- 4.49** We have estimated the potential capacity gains from reducing the picture resolution of some channels and allowing a longer lapse time for switching between channels. We have assumed that BBC THREE/CBBC and BBC News 24 on Multiplex 1, and BBC FOUR/CBeebies on Multiplex B, would be reduced from full to 3/4 picture resolution. In our estimates we have also assumed a possibility to vary GOP length. It is generally accepted that increasing GOP length beyond 12 frames is possible, although there is still debate within the industry as to how much GOP should be. We have assumed a possibility to vary GOP length from 12 to 36 frames. On this basis, we estimate in our base case that the BBC could release 2.2 Mbps on Multiplex 1 and 1.5 Mbps on Multiplex B, as shown in the table below.
- 4.50** In the base case we used, as a benchmark, channels with broadly similar content to the BBC channels. However, picture resolution capacity gains depend on the nature of the content being broadcast and what other services share the Statistical Multiplex. We therefore also created a high case where the benchmark included channels with more challenging content on more efficient multiplexes 2 and A, and a low case where we took only DTT channels with similar content including those on Multiplex B that are broadcast at 3/4 resolution¹⁷. Based on our conversations with industry players, we have assumed, as a base case, a 4% capacity gain from increasing the GOP length and 6% and 2% for our high and low cases respectively. These scenarios suggest the saving on Multiplex 1 would be in the range of 2.6 Mbps and 1.9 Mbps and between 2.5 Mbps and 0.9 Mbps on Multiplex B.
- 4.51** On Multiplex 1, the majority of those capacity gains would be made as a result of reductions in picture resolution to BBC THREE/CBBC and BBC News 24. On Multiplex B, slightly less than 1 Mbps of capacity could be gained by reducing BBC FOUR/CBeebies' picture resolution, while approximately 0.5 Mbps could be gained by increasing GOP length.
- 4.52** We note that GOP lengths beyond 24 frames might create problems for older set-top boxes. However, we would expect manufacturers to continue to develop their standards according to higher GOP lengths going forward. If the BBC was to opt for GOP length 24 rather than 36, then we estimate that potential capacity gains would range between 0.4 and 0.1 Mbps.
- 4.53** Technically, changing picture quality and GOP length is relatively straightforward, although we understand that some expenditure might be needed to fund changes in upstream channel filtering to match a change in picture quality.
- 4.54** These efficiencies can be easily achieved by the BBC from a technical perspective, and without a very significant cost implication. However, consumer acceptability should be tested. The consumer evidence currently available to the BBC does not make it possible to adequately assess the appropriateness of introducing picture resolution and GOP length changes in order to release capacity.
- Potential capacity gains through new technology standards**
- 4.55** Further capacity gains could in principle be achieved by using new technologies, notably MPEG-4 and DVB-T2.
- 4.56** Changing the video coding standard from MPEG-2 to the more recent and advanced MPEG-4 H.264/AVC standard would allow channel coding rates to be reduced. However, this would also require new coding equipment and receivers, and full gains (where MPEG-4 might be twice as efficient as MPEG-2) would be perhaps at least two years away, dependent on evolution of coding algorithms.

Figure 13 Estimates of potential capacity gains due to reduced picture resolution and longer channel switch times, base case and sensitivities

Efficiency levers – impact on quality	MUX 1 (BBC)			MUX B (BBC)		
	High case	Base case	Low case	High case	Base case	Low case
Higher GOP, Mbps	0.8	0.6	0.3	0.8	0.5	0.3
3/4 resolution for some of video streams, Mbps	1.8	1.6	1.6	1.7	0.9	0.6
Total	2.6	2.2	1.9	2.5	1.5	0.9

Source: Deloitte analysis

¹⁷ Base case: Multiplex B: 301, 302, BBCi multiscreen; Multiplex 2: E4, Film4+1, More 4, ITV4/CITV, ITV2, ITV3; Multiplex A: QVC. High case (higher efficiency): Mux 2: E4, Film4+1, ITV4/CITV, ITV2, ITV3; Mux A: bid tv, Five Life, price-drop tv, QVC. Low case (lower efficiency): Mux B: 301, 302; Mux 2: ITV2, ITV3; Mux A: QVC.

- 4.57** Transition to MPEG-4 also has a cost impact on consumers, as they would be required to change their receivers. As a result, MPEG-2 and MPEG-4 would have to be simulcast over a few years, until most consumers have upgraded their equipment.
- 4.58** Changing the mode of operation of a multiplex from DVB-T to DVB-T2 is expected to increase multiplex capacity from 24.1 Mbps to about 32 Mbps. However, new transmitter equipment and receivers would be required, the standard is still under development and the start of its commercial implementation is not expected before 2010-2012 on Mux B. The transition to DVB-T2 on other multiplexes including Mux 1 will take much longer as it will be driven by the consumer takeup of MPEG-4 HD boxes.
- 4.59** Practically, broadcasters could be expected to coordinate the introduction of DVB-T2 and MPEG-4 so that only one upgrade of receivers would be required. Linking this upgrade to the launch of high definition services would create greater customer incentive to upgrade receivers.
- 4.60** The cost implication of MPEG-4 and DVB-T2 is difficult to determine as it depends on the implementation strategy and which parts are implemented. In respect of DVB-T2, improved error coding has little cost impact, however a different transport architecture and higher order modulation may mean major reengineering of the distribution and transmitter network. Until the standard is more developed it is not possible to know how much the introduction of DVB-T2 will cost.
- 4.61** In summary, it appears that the BBC would be able to achieve further capacity gains of about 8 Mbps per multiplex (16 Mbps across multiplexes 1 and B) from implementing these technologies plus a reduction in the bitrates of channels of up to half their consumption with MPEG-2. However the commercial implementation of DVB-T2 is not expected to begin before 2010. As the DVB-T2 standard is under development, uncertainty remains regarding estimates of potential capacity release, as well as about the potential cost implications on the BBC. These will need to be clarified once the standard has been fully defined and decisions taken regarding how it would be implemented.
- 4.62** In any case, transition to these new technologies is unlikely until there is a significant population of MPEG-4 set-top-boxes in UK homes. Many people are buying their set-top-boxes now ahead of DSO, but the current generation of set-top boxes cannot decode MPEG-4. Several years are likely to pass before a critical mass of UK homes upgrade their set-top-boxes. It is therefore unlikely that the BBC will be able to fully reap the benefits of capacity gains from implementation of these technologies for about a decade.
- Capacity gains resulting from digital switchover**
- 4.63** As digital switchover occurs, the BBC will increase the transmitter power of Multiplexes 1 and B in order to extend population coverage. This will allow the BBC to increase modulation from 16QAM to 64QAM, and thereby expand each multiplex's capacity from 18 Mbps to 24 Mbps. Capacity across both multiplexes will therefore increase by 12 Mbps.
- 4.64** In order for Multiplexes 1 and B to be able to match the 98.5% population reach of today's analogue channels, the BBC will need to transmit DTT signals from 1,163 sites rather than the current 80 DTT sites, which the BBC estimates will cost £1.3bn in real terms over the contract lifetime.
- Comparison of options to increase spectrum efficiency**
- 4.65** Capacity gains from changes in picture quality and GOP to BBC channels would be relatively straightforward to achieve, and the cost implications would be insignificant.
- 4.66** Capacity gains from new coding and multiplexing on Multiplex 1 and from modulation changes at switchover can be achieved subject to an investment programme which the BBC is currently undergoing and which is expected to be fully completed by the end of summer 2009. The investment programme consists of new coding and multiplexing to be provided by Siemens (at a cost of £104m) and property works to be carried out by BBC Workplace on the sites (at a cost of £27m).

- 4.67** Capacity gains from implementation of the new coding and multiplexing systems would materialise from the end of 2008, while capacity gains from modulation changes will be achieved progressively as the analogue signal is switched off across different regions between 2008 and 2012.
- 4.68** New technologies such as DVB-T2 and MPEG-4 are expected to allow substantial amounts of capacity to be released, but these standards are still under development by the industry. As a result, there is still considerable uncertainty regarding exactly how much capacity will be gained with these new technologies. Transition to these new technologies is unlikely until there is a significant population of MPEG-4 set-top- boxes in UK homes. As a result, it is unlikely that the BBC will be able to reap the full benefits from these technologies for another decade.
- 4.69** The costs of transition to MPEG-4 would depend on the precise implementation strategy, which is still uncertain. Regarding DVB-T2, until the standard is more developed it is not possible to know how much it will cost.
- 4.70** Implementation of DVB-T2 and MPEG-4 on Mux B starting in 2010 is likely to leave some of the MPEG-2 coding equipment stranded although it is not clear at this stage which. However, the transition to MPEG-4 on Mux 1 is likely to involve a period of simulcasting and is unlikely to leave any substantial proportion of the costs that are being incurred now on the new centralised coding and multiplexing infrastructure as stranded costs.
- 4.71** While capacity gains from changes affecting quality and new coding and multiplexing relate to opportunities facing the BBC in particular, efficiency improvements from modulation changes and new technology standards are open to all broadcasters.
- 4.72** The illustration below summarises the opportunities the BBC faces for increasing spectrum efficiency over the next five years.

Figure 14 Summary of technical options for increasing BBC spectrum efficiency

	Capacity Gain*	By when	Feasibility	Cost
Changes potentially affecting quality	3.7 Mb/s	Mid 2009	✓✓✓✓✓	Small cost**
New coding and multiplexing	2.7 Mb/s	November 2008 to April 2009	✓✓✓✓	£104m for coding and multiplexing provided by Siemens, and £27m for property works by BBC Workplace ***
Modulation changes at switchover	12 Mb/s	2009-2012	✓✓✓	
MPEG-4	Capacity used by each channel would be reduced eventually by half, although capacity gains will be minimal in the early years	Starting from 2010 in Mux B and from 2013/14 Mux 1	✓✓	The cost of MPEG-4 implementation is undetermined at this stage
DVB-T2	16 Mb/s (8Mb/s from each multiplex)	Starting from 2010 in Mux B and from circa 2016 in Mux 1	✓	The cost of DVB- T2 is undetermined at this stage of technology development

* The BBC multiplexes currently have 18Mb/s of total available capacity. New coding and reductions in picture resolution would reduce the channel bit rates. Modulation changes and technology changes would increase total multiplex available capacity.

** However, it will only be possible to make these changes when the centralised coding and multiplexing infrastructure is in place

*** Part of this cost is attributable to satellite transmission

**** Capacity gains with MPEG-4 will be minimal in the early years, but would be expected to improve as MPEG-4 technology matures.

The impact of spectrum pricing

- 4.73** Ofcom recently announced that it proposes to set an administrative price for the use of DTT spectrum from 2014, in order to introduce a further incentive for spectrum to be used efficiently¹⁸. The AIP will take into account the opportunity cost from broadcasters use of DTT capacity, by reference to the value that alternative users of that spectrum would derive.
- 4.74** The exact price that will be charged will be set by Ofcom closer to the time of AIP introduction, and its financial impact on the BBC is still uncertain. However, work undertaken for Ofcom during the consultation on the AIP proposals indicated it could be in the region of £22m per multiplex per annum¹⁹. This price might change in the run up to 2014, and will take into account the value of capacity revealed through the spectrum auctions.
- 4.75** At this stage it is unclear how the BBC would respond to this charge, and whether this will provide further incentives on the BBC to use spectrum more efficiently beyond those resulting from increasing service aspirations.
- 4.76** Arguably, a further incentive might be provided if the BBC could trade some of its existing capacity. However, it is unclear whether the BBC would be able to sublease any unused capacity on Multiplex 1, or whether any such capacity would have to be released, or allocated by the Secretary of State to another PSB.

¹⁸ See Ofcom, "Future pricing of spectrum for terrestrial broadcasting – A statement", 2007.

¹⁹ Study into the potential application of Administered Incentive Pricing to spectrum used for Terrestrial TV & Radio Broadcasting, Indepen and Aegis, October 2005.

5. The BBC's allocation of the DTT spectrum to services

5.1 In this section we consider efficiency in the BBC's use of the spectrum for different services, in the context of increasing demands on DTT capacity and spectrum scarcity. We also assess:

- Opportunities for increasing efficiency in the use of the spectrum by making more effective use of the capacity allocated to certain services.
- Whether services that appear to offer lower incremental value to consumers could be taken off the platform to accommodate services with higher incremental value.
- Whether DTT uses of the spectrum that could be released by the BBC are more valuable to consumers than other potential uses of the spectrum.

Efficiency in the allocation of spectrum to BBC services

5.2 The BBC uses its allocation of spectrum to provide a range of video, radio and data services over the DTT platform.

5.3 The demand for DTT capacity has been increasing, both from the BBC and other broadcasters. Given the capacity constraints, and the increased service demands, it is important to ensure that capacity is used for those BBC services that provide most value to consumers, and that those services use the capacity that has been allocated to them effectively.

5.4 Up to now, the BBC has had sufficient capacity to provide the services it wished to offer to audiences. However, going forward, the capacity requirements of the BBC's service aspirations will exceed available capacity.

5.5 We have considered whether the current allocation of the BBC's spectrum to different BBC services maximises value for consumers. This analysis has been conducted against the background of the extended BBC service aspirations and taking account of the potential capacity gains through technical efficiencies that we believe the BBC could make before switchover.

5.6 We have relied on research and analysis conducted by external consultants Human Capital for the BBC regarding the allocation of spectrum to different BBC uses²⁰. Human Capital estimate the incremental value that DTT households derive from the different BBC services, on the basis of estimates of:

- Incremental DTT reach, i.e. reach of the particular service by DTT households that could not find the service elsewhere if it was not available on DTT (unless they subscribed to an alternative platform)²¹.
- Value per household, taken from their own previous research²².

²⁰ BBC Digital Terrestrial Television: Spectrum Allocation, July 2007, Human Capital.

²¹ Human Capital's estimates incremental DTT reach using a range of sources including BBC household forecasts, BARB, BBC data, the HD and Local TV PVAs, Ofcom data and their own assumptions.

²² 2004 Human Capital Research, HD and local PVA research by Human Capital.

- 5.7 Figure 15 suggests that an HD service would provide higher incremental value to households than some of the existing services on the BBC multiplexes. However, the current service line-up takes up virtually all the capacity currently available on the BBC's multiplexes. Potential capacity gains (including technical efficiencies and efficiencies potentially impacting quality) would not be sufficient to accommodate an HD service pre digital switchover.
- 5.8 An HD service could only be provided pre digital switchover by displacing other existing services which are reported to have lower incremental value to households, such as the interactive video services and the BBCi multiscreeen services, the radio services on DTT and BBC Parliament. An HD service would take up between 12 and 15 Mbps of capacity, though this is expected to decrease following technological improvements.

- 5.9 The BBC's PVT application for an overnight HD service proposes to take down the interactive video services, the BBCi multiscreeen, BBC Parliament and (if necessary), BBC FOUR/CBeebies between 2-6am to accommodate the HD service. The Trust is currently consulting on these proposals, including whether the four hour HD service on DTT should be launched as soon as possible, or whether it should be delayed until after Ofcom's proposals for digital spectrum are clear early next year.
- 5.10 Post digital switchover, an HD service could be provided due to the increase in total capacity resulting from the increase in modulation.
- 5.11 We have not assessed the incremental household value of non-BBC services to which the BBC might be required to provide capacity in its multiplexes, such as five, S4C or TG4. Assessing the value of third party services is beyond the scope of our study.

Figure 15 Incremental household value and use of available capacity by service, including efficiency gains, pre DSO



Source: Human Capital, BBC Digital Terrestrial Television: Spectrum Allocation, July 2007; Deloitte analysis

5.12 However, if some of those services were to be directed to be carried on the BBC's multiplexes by the Secretary of State, then some of the BBC services with lower incremental household value relative to other BBC services might need to be taken off DTT. According to Human Capital's analysis, the radio services, BBC Parliament, interactive video services and the BBCi multiscreen are among the services with lower incremental household value relative to other BBC services, also post digital switchover. It should be noted that those services might have some social value which should also be taken into account in reaching decisions about them. Obligations on the BBC regarding the provision of BBC Parliament are discussed further below.

Opportunities for increasing efficiency in the use of the spectrum allocated to interactive services

5.13 The BBC has two video streams dedicated to interactive video services, commonly referred to as 301 and 302, both using capacity on Multiplex B (these are different and in addition to the interactive data services referred to in paragraphs 4.22 to 4.24).

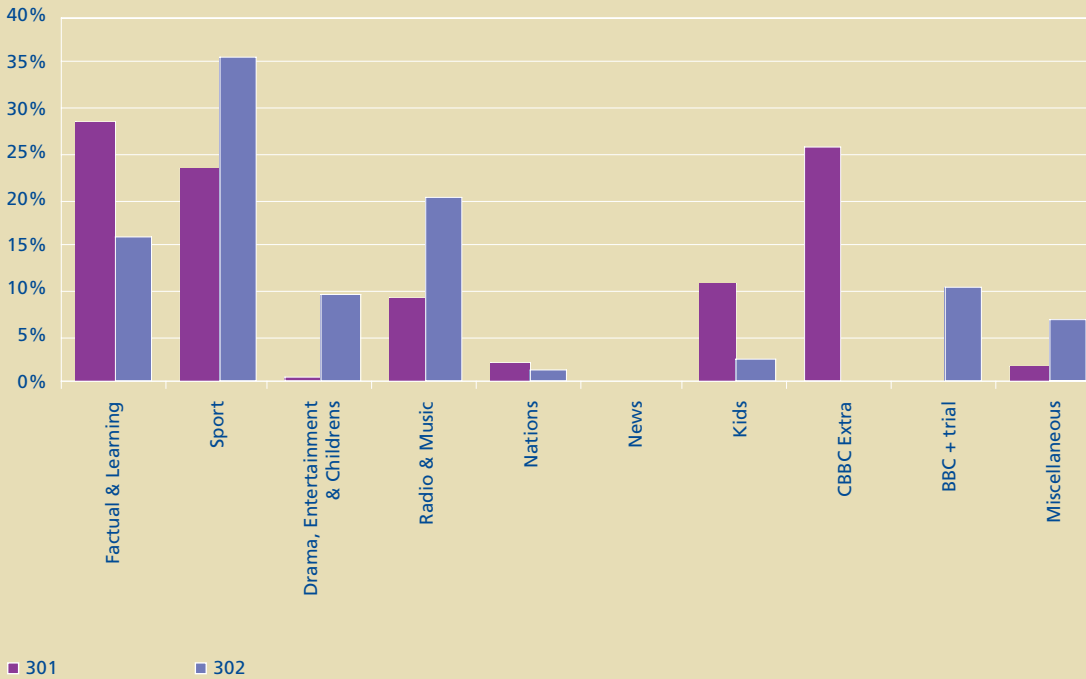
5.14 The following illustration shows the proportion of time that the interactive capacity was used between January and August 2007 (as a proportion of total available minutes during this period). While 301 used its capacity virtually all of the time, the 302 capacity remained unused at times. The 301 capacity appears to be used more frequently partly as a result of a decision to offer CBBC interactive over that capacity.

Figure 16 Proportion of time that the 301 and 302 capacity was used between January and August 2007



Figure 17 Proportion of time that the 301 and 302 capacity was used by type of content, January to August 2007

Proportion of time that the 301 and 302 capacity was used for different types of programmes, January to August 2007 (in aggregate)



Source: BBC
Note: BBC+ is a trial of data download to PVRs using overnight capacity

- 5.15 The illustration above shows the proportion of time that the 301 and 302 capacity was used for different types of programmes. The interactive capacity is most frequently used for learning, children, sports and music programming. It should also be noted that the childrens programming on 301 and 302 is additional to the CBeebies interactive learning games offered through BBCi text (see paragraph 4.22).
- 5.16 The interactive capacity was used more frequently in 2007 than in 2006. In 2007 more capacity is being used for radio and music services than was the case in 2006, and some new applications have been introduced (the Join Anytime Quiz). Some of the radio and music services, quiz applications and children programmes run for extended periods of time to increase the opportunity for the content to be accessed.

- 5.17 The interactive video streams 301 and 302 are part of the statistical multiplex pool. When these streams are static, i.e. no interactive services are being broadcast they utilise a low bitrate of about 500 kbps, and their remaining share of the statistical multiplex capacity becomes available to the other services in the Multiplex B's statistical multiplex pool, BBC Parliament, BBC FOUR/CBeebies, and the BBCi multiscreen. However, the other services in the statistical multiplex pool are unlikely to use that left-over capacity as they are unlikely to require additional capacity than their allocation.
- 5.18 The BBC tracks audience appreciation for some services offered over the interactive capacity. However, given the amount of spectrum capacity that these services use, it seems that greater measurement of the benefit of these services in relation to their spectrum "cost" would be appropriate. Such measurement should also consider the value of alternative services that could be offered over that capacity.

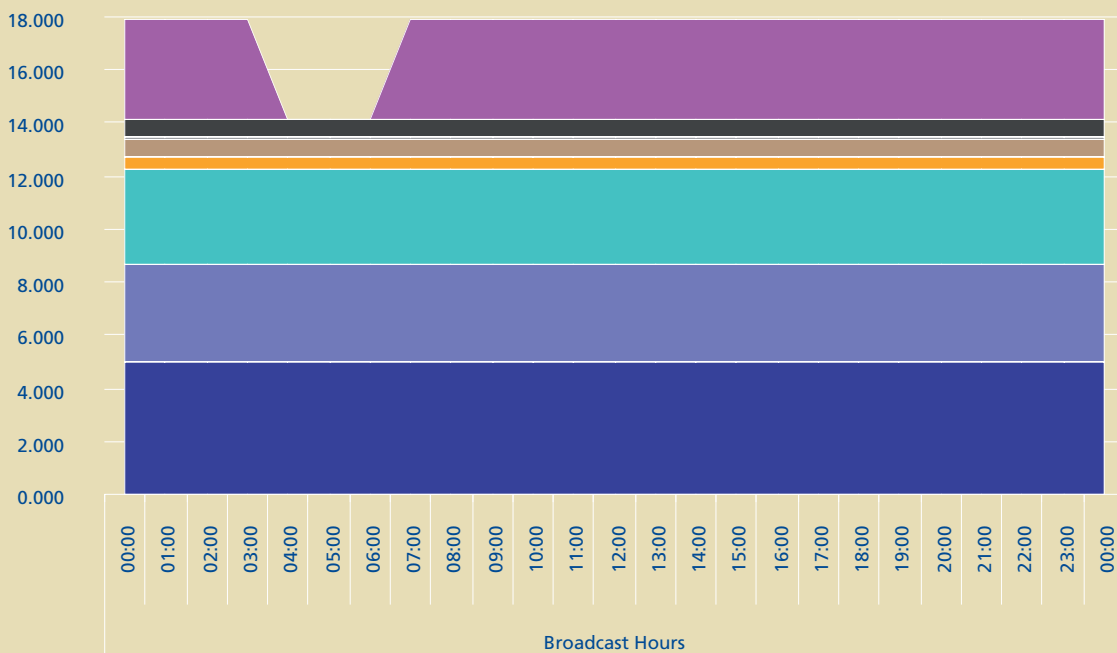
- 5.19 Alternative uses of the unused interactive capacity might include BBC or third party video-on-demand services and data downloading services but this would require some form of technical and commercial coordination between sharing uses, which is clearly beyond the scope of the BBC's multiplex operations currently. Critically, contention for the capacity between multiple users would have to be resolved, which could either be done on a rule basis (i.e. primary user versus secondary user) or on a willingness to pay basis (i.e. as some sort of market).
- 5.20 There may be merit in considering how some of the BBC's interactive services could be carried in the future over IP networks, such as IPTV or the internet, to hybrid set-top-boxes, i.e. boxes capable of receiving services from both DTT signal and IP services. This would potentially allow interactive TV services to be delivered without the need for dedicated capacity on DTT multiplexes. The potential impact of taking services such as interactive off the DTT platform is discussed further below.

Opportunities for using overnight gaps of unused capacity

- 5.21 Besides the interactive streams, there are other video streams whose capacity is not used 24-hours a day. The video stream occupied by CBBC/BBC THREE in Multiplex 1 is unused for 4 hours overnight, between 3am and 7am, although the BBC have told us that the schedule for BBC THREE can sometimes run to 4.30am.
- 5.22 The video stream occupied by CBeebies/BBC FOUR in Multiplex B is unused for 3 hours overnight (between 3am and 6am), although the BBC have told us that the schedule for BBC FOUR can sometimes run to 4.30am.

Figure 18 Use of Multiplex 1 capacity during 24 hour period

MUX 1
Capacity used (assuming no stat. mux) by broadcast hour, Mbps

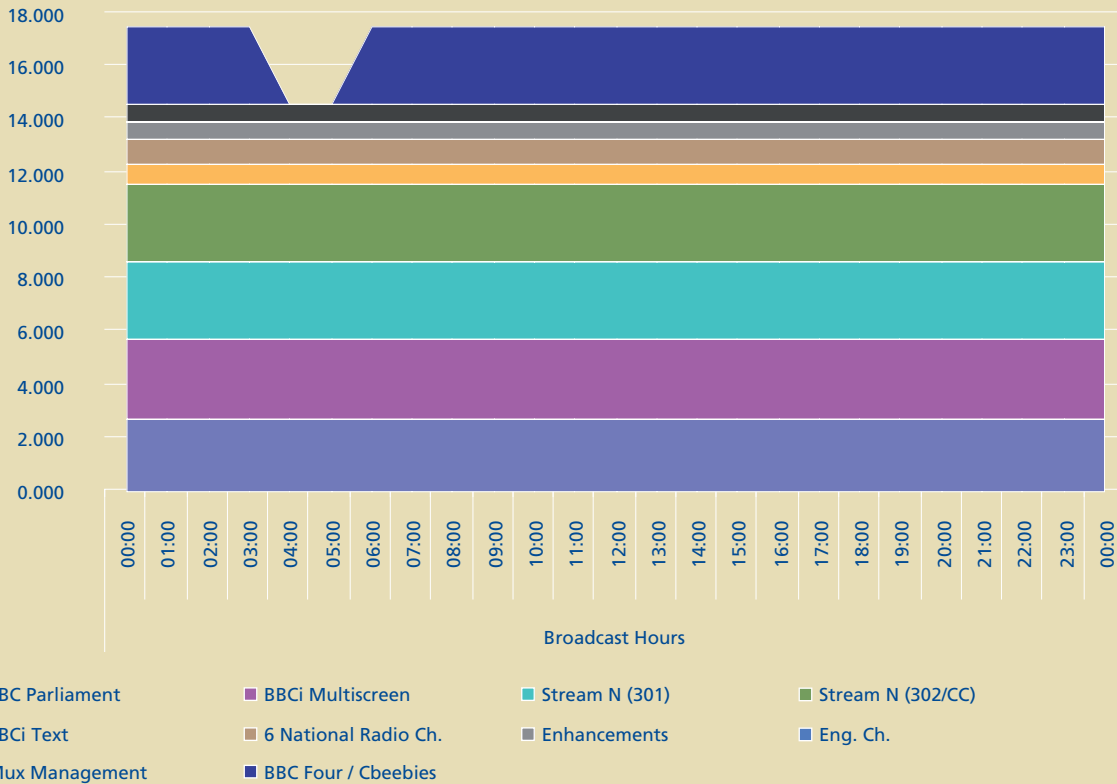


- BBC ONE
- BBC TWO
- BBC NEWS 24
- Radio channels
- Enhancements
- BBCi
- Eng. Ch.
- Mux Management
- BBC THREE / CBBC

Source: BBC, Deloitte analysis

Figure 19 Use of Multiplex B capacity during 24 hour period

MUX B
Capacity used (assuming no stat. mux) by broadcast hour,
Mbps



Source: BBC, Deloitte analysis

5.23 The capacity that is not used by BBC THREE/CBBC and BBC FOUR/CBeebies is returned to the statistical multiplex pool in each multiplex respectively, where it is made available for other channels in the statistical multiplex pool²³. However, it is questionable whether those other channels need that additional capacity overnight, if their daytime allocation is sufficient. Again, the other services in the statistical multiplex pool are unlikely to use the left-over capacity.

5.24 The BBC Trust is currently consulting on the PVT application for an HD overnight service which would be provided on Multiplex B between 2-6am. In its provisional conclusions, the BBC Trust are minded to delay the launch of the four-hour HD service on Freeview until after Ofcom's proposals for digital spectrum are clear early next year, although they are currently consulting on the issue. If the proposal for the overnight HD service was to go ahead, the

available overnight capacity in the BBC FOUR/CBeebies videostream would likely no longer be unused.

5.25 Possible options for using the unused capacity in the stream occupied by BBC THREE/CBBC include extended hours of those channels, or the provision of data downloading services to the BBC or third parties. The feasibility and cost implications of extending the broadcast hours of existing services would depend on whether new programmes or repeats are broadcast. Regarding the possibility of offering this capacity for overnight data downloading services, we note that there are examples of other DTT multiplexes making some of the overnight capacity gaps available to third parties, such as Top-Up TV, although we have not examined the level and value of demand for such services.

²³ BBC THREE/CBBC shares the Multiplex 1 statistical multiplex pool with BBC TWO and News 24. BBC FOUR/CBeebies share the Multiplex B's statistical multiplex pool with BBC Parliament, the BBCi multiscreen and the interactive video streams.

5.26 The costs associated with reusing spare sub-capacity in a DTT multiplex are minimal because the multiplex and transmission systems must be operated regardless of how full the multiplex is.

Impact of taking some services off the DTT platform

5.27 The Human Capital work discussed above showed that the interactive video streams, the BBCi multiscreen, the radio services and BBC Parliament have lower relative incremental household value than other potential services that could be offered with that capacity, such as HD.

5.28 Approximately 13.5 Mbps of capacity could be released pre digital switchover by taking the interactive video streams, the BBCi multiscreen, the radio services and BBC Parliament off the DTT platform. This could be sufficient to offer an HD channel over DTT pre digital switchover. The capacity currently used by each of those services is illustrated below.

Figure 20 Capacity use by the BBC interactive video streams, BBCi multiscreen, the BBC radio services and BBC Parliament

Channel	Capacity, Mbps
BBCi 301	2.8
BBCi 302	2.9
BBCi multiscreen	3.0
Radio on DTT (Mux 1N – nations)	0.3
Radio on DTT (Mux B)	1.9
BBC Parliament	2.6
Total	13.5

Source: BBC, Deloitte analysis

Note: radio services on Mux B include the new radio services to be transferred from Mux A to Mux B from October 2007

5.29 We have explored the potential feasibility, impact on reach and cost implications of taking those services off the DTT platform.

5.30 The BBC has different degrees of flexibility regarding each of these services. For example, the BBC Agreement²⁴ and commitments made to DCMS²⁵ might limit the BBC's ability to drop BBC Parliament off the DTT platform altogether. However, this would not seem to prevent the BBC from considering a one quarter screen Parliament service accompanied by text. The BBC would have more flexibility over other services such as the interactive video streams, the multiscreen and the radio services.

5.31 However, if those services were to be taken off DTT, their reach would decline. The interactive video streams, the BBCi multiscreen, and BBC Parliament are currently offered on all the other platforms (cable, satellite, and broadband). It is nevertheless very unlikely that any current DTT only viewer would start using alternative platforms such as satellite or cable simply in order to get access to the interactive video streams, the BBCi multiscreen or BBC Parliament if those services were taken off DTT.

5.32 33% of households have DTT as their main television set. Therefore, the reach of the interactive video streams, the BBCi multiscreen or BBC Parliament would decline by up to this percentage of UK households if these services were to be taken off the DTT platform.

Figure 21 Platform share in Q1 2007 by main television set

Platform Share in Q1 2007 by main television set	
Digital terrestrial	33.00%
Satellite	35.10%
Cable	13.40%
Broadband	0.20%

Source: Ofcom, The Communications Market 2007

²⁴ The Agreement requires the BBC to promote the understanding of the UK political system (including Parliament and the devolved structures), including through dedicated coverage of Parliamentary matters, transmitting an impartial account day by day of the proceedings in both Houses of Parliament. BBC Agreement 2007, Section 6, paragraph 2.

²⁵ BBC Parliament Service Licence, December 2006, Annex III. Among other commitments, the BBC agreed to provide "gavel to gavel coverage of the Westminster Parliament".

- 5.33** In 2006/07, BBC Parliament achieved 41% of its total viewing hours on the DTT platform²⁶. Therefore, if BBC Parliament was taken off DTT, its viewing would decline substantially.
- 5.34** The impact of taking the BBC radio services off DTT on their reach is likely to be smaller, as these services can be accessed through analogue and digital radio sets, although radio on DTT is broadcast at higher sound quality. Ofcom estimates that 92% of radio listeners use analogue radio daily or weekly²⁷. Only a proportion of radio-listening on DTT may be incremental, i.e. people who would not listen to radio otherwise, and therefore the impact on the reach of radio services may be reduced.
- 5.35** In addition, there would be a small amount of stranded costs, i.e. costs incurred in making these services available on the DTT platform and which have not yet been fully depreciated. They would represent a small share, relating to labour costs, of the £0.8m which were incurred in making these services available on DTT.

Potential value of released DTT capacity to alternative uses

- 5.36** The capacity that could be released by the BBC depending on the choices made could be used for additional DTT services (SD or HD services) or for mobile TV. Non-broadcast uses of the released spectrum, such as wireless broadband services, are not feasible unless one entire multiplex was cleared. This is because non-broadcast uses could not be accommodated within a multiplex partially used for broadcasting.

- 5.37** Both Ofcom and the BBC have commissioned research into the value attached by consumers to these alternative services. We have considered the results of the research commissioned by Ofcom in the context of the DDR²⁸ and research by Human Capital commissioned by the BBC²⁹.
- 5.38** Both find that DTT uses of the spectrum, whether HD TV or extra SD channel, are preferred over non-DTT uses such as mobile TV.

Spectrum auctions

- 5.39** 112 MHz of clear spectrum in the UHF band is expected to be released as a result of the digital switchover programme. PSBs including the BBC have lobbied Ofcom to try and obtain a loan of DDR capacity to support the move to MPEG-4 coders, but Ofcom has opposed the proposals. Instead, Ofcom intends to offer the spectrum by auction on a technology-neutral basis giving it potential application for further DTT multiplexes as well as for other services such as mobile TV or broadband wireless.
- 5.40** As a result, if the BBC wished to acquire any further capacity beyond the two 24 Mbps high power multiplexes, it would have to participate in the auctions. For reasons of commercial confidentiality, our report has not gone into further depth regarding the BBC's plans in regard to spectrum auctions. However, going forward this issue will pose important Value for Money considerations for the BBC. Therefore, before the BBC takes decisions regarding its potential participation in the spectrum auctions, it should ensure that it uses its current spectrum allocation efficiently, on the basis of identified service priorities within a value framework.

²⁶ Viewing Hours information provided by the BBC, from BARB.

²⁷ Ofcom, *The Communications Market 2007*.

²⁸ Ofcom, December 2006, "Digital Dividend Review". A report of consumer research conducted for Ofcom by Holden Pearmain and ORC International", available at www.ofcom.org.uk.

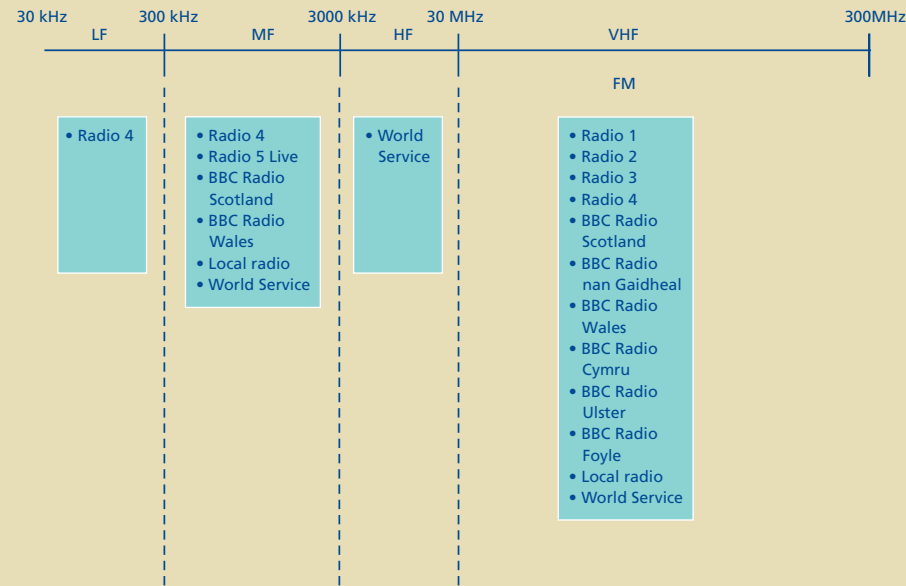
²⁹ Human Capital, "HD TV – A Deliberative Research Project", July 2006.

6. Analogue and Digital Radio – Value for Money in the BBC's use of spectrum

The BBC's current use of spectrum

- 6.1 The BBC broadcasts national and local radio services in analogue in the AM and FM bands, as illustrated below. Most national services are carried on FM to deliver good sound quality. Radio 5 Live is carried on Medium Wave due to a lack of capacity on FM. Some of the Nations radio services and the local radio services in England are simulcast on Medium Wave to increase geographic reach. Radio 4 is also carried on Medium Wave in certain areas and on Long Wave across the UK. World Service is carried internationally on Short Wave from a series of transmitters mostly located overseas.
- 6.2 The FM band is planned using informal sub-bands approximately 2 MHz wide. Each BBC station plans to operate across a set of frequencies within an assigned sub-band to minimise interference and allow nationwide frequency reuse. There is also considerable interleaved use of BBC sub-bands by local commercial radio stations.
- 6.3 DAB services in the UK operate in Band III. The BBC operates a national multiplex in the "12B" block band. Digital One operates a commercial national DAB multiplex in block 11D in England and Wales (12A in Scotland), and a third national multiplex has been granted to the 4 Digital Group to operate in the 11A block. Each multiplex network uses a single frequency nationwide.
- 6.4 Five spectrum blocks in the DAB band are used for 46 local and regional commercial multiplexes across the UK and the BBC has reserved capacity on those multiplexes that overlap with the local BBC analogue services. Ofcom is licencing more local multiplexes in three new blocks of spectrum.

Figure 22 The radio spectrum bands used by the BBC and other broadcasters



Source: BBC

- 6.5** Multiplex operators have some discretion over the proportion of multiplex capacity allocated to audio versus data services. The BBC allocates more than 97% of its capacity to audio services, whereas the commercial multiplexes allocate less than 80%. Programme related information requires minimal data capacity. Digital One uses more significant amounts of data capacity to support mobile TV services.
- 6.6** For a given amount of multiplex capacity allocated to audio services, the number of channels that can be accommodated is dependent on the coding rate used for the channels. DAB multiplex operators in the UK use the MPEG-1 Layer 2 coding standard requiring 64 kbps for low quality mono, 80 kbps or 96 kbps for higher quality mono, 128 kbps for low quality stereo and 160 kbps or 192 kbps for higher quality stereo.
- 6.7** Audio channels on the BBC multiplex operate at a higher average bit rate than on the commercial multiplexes, a 112 kbps average compared with a 104 kbps average by Digital One and a planned average of 88 kbps on the 4 Digital Group multiplex (which is due to launch in summer 2008). This is due to the BBC's choice of broadcasting at higher sound quality than other DAB multiplexes, therefore coding channels at higher rates.
- 6.8** There has been some concern from some listeners about audio quality being lower on DAB than FM. However, research by Ofcom suggests that most listeners think DAB sound quality is at least as good as FM³⁰.
- 6.9** FM requires many more transmitter sites than AM to achieve population reach targets. BBC Radio 1, 2, 3 and 4 are transmitted from approximately 230 sites across the UK achieving 99% population coverage. Reliable, interference free daytime coverage of BBC Radio 4 on Long Wave and Medium Wave is achieved by 95% of the UK population. BBC Radio 5 on Medium Wave is reached by 98% of the UK population.
- 6.10** In our examination of the use of the FM band, we concluded that the frequencies are all heavily used and that there are no obvious gaps where the BBC is keeping unused spectrum (the total number of transmitters for national coverage is broadly similar for all stations). The least used part of the band is the 99.9-103.4 MHz segment, which contains no BBC stations.

³⁰ See Ofcom, "The Future of Radio – The Future of FM and AM services and the alignment of analogue and digital regulation", page 114.

- 6.11 The BBC national DAB multiplex currently operates from 98 transmitter sites (September 2007) and reaches about 86% of the population³¹. There are plans to extend coverage to 230 sites.

Opportunities in the future use of BBC's AM/FM/DAB spectrum

- 6.12 Given the simulcasting of a number of BBC radio services on AM, FM and DAB, there is a possibility of rationalising the number of transmission sites in order to release spectrum and save transmission costs.
- 6.13 However, this might have an impact on some audiences who might not be able to receive some of the BBC's services. Although very few of the BBC's services are now carried on AM alone³², medium-wave remains an important way for some audiences to access some of the BBC's services. BBC Radio 5 Live and the BBC Asian Network still rely upon Medium Wave transmissions to serve much of their audiences, despite their being carried on digital platforms. BBC Radio Wales has substantially less coverage on both FM and DAB than Medium Wave and so depends on the latter to serve much of mid- and west Wales. Similarly, BBC Radio Scotland makes much use of its Medium Wave network to provide coverage to otherwise hard-to-serve areas in the highlands and central Scotland.
- 6.14 AM transmission would appear to be the most likely candidate for switch-off, given their lower audience levels and poorer sound quality. Ofcom is not intending to renew existing Medium Wave licences for commercial operators after 2009. Some listeners would reasonably be able to make alternative arrangements to continue listening on FM or DAB, although at the margin there would be a small group of listeners who would fall outside the coverage areas of FM and DAB transmissions.
- 6.15 In terms of savings, the amount of spectrum released from discontinuing AM transmissions would be relatively small, and there has been little expressed demand for this spectrum, given its limited capacity. DRM is a potential use for AM frequencies, although this is expected to be used by AM broadcasters to replace their analogue signals with digital ones, with no change in use.
- 6.16 Compared with DAB in Band III, DRM would have certain advantages operating in AM bands, namely better coverage requiring fewer transmission stations and being better suited to serving mountainous or other geographically challenging areas. As a result, it

is expected that difficult to reach audiences could be reached more cost effectively with DRM than with DAB.

- 6.17 The transmission savings associated with discontinuing AM transmissions would be modest. Excluding international Short Wave World Service transmissions, the BBC incurs £9.2m a year on national AM transmission contracts. The BBC spends £8.2m a year on costs relating to FM and MW transmission of the 46 nations and local radio stations and only a proportion of these costs would be saved by switching off AM.
- 6.18 In relation to DAB, more efficient use of the capacity could be achieved by introducing more efficient audio coding standards. AAC is considered to be twice as efficient as the current MPEG-1 Layer 2 coding and HE-AAC three times. However, the introduction of a new coding standard would require a complete replacement of receivers, which would be highly disruptive in a market that arguably still requires more time to become established.

The impact of AIP on analogue and digital radio broadcasting

- 6.19 Ofcom is planning to charge AIP on the BBC's analogue radio spectrum from 2008. The BBC will pay £1.5m per annum to Ofcom. Although the objective of the AIP charge is to encourage broadcasters to take into account the opportunity cost of the spectrum, the BBC regards the AIP charge as a "tax". The BBC have told us that the introduction of AIP is unlikely to have an impact on the way in which they plan and use the analogue radio spectrum because they are not able to change spectrum use on radio without reducing coverage or availability.
- 6.20 As discussed above, the potential alternative uses of the AM/FM band are more limited than in DTT, and therefore AIP could be expected to have a smaller impact on the use of the AM/FM spectrum by the BBC than in respect of the DTT spectrum.

³¹ The BBC expects to switch on a further 3 transmitters by the end of 2007.

³² BBC Somerset Sound is the only "full" service to be delivered by medium-wave alone, although medium-wave is the sole distribution platform for opt-out programming on a number of stations including BBC Radio Ulster's educational and sports coverage and football commentary (or other additional services) on many local radio stations.

7. Value for Money of different platforms

Television platforms

- 7.1 The BBC broadcasts its services over a range of different TV platforms, namely DTT, satellite, cable and IPTV.
- 7.2 The BBC Agreement requires the BBC to ensure wide availability of its services using a range of available platforms, and taking into account those platforms' cost effectiveness. Section 12 of the Agreement states that *"The BBC must do all that is reasonably practical to ensure that viewers, listeners and other users... are able to access the UK Public Services that are intended for them... in a range of effective and cost efficient ways which are available or might become available in the future. These could include... broadcasting, streaming or making content available on demand, whether by terrestrial, satellite, cable or broadband network (fixed or wireless) or via the internet."*
- 7.3 In analysing the Value for Money of different platforms, we have used a number of indicators consistent with the RQIV framework that has been developed for measuring the Public Value of BBC services. However, due to only limited data being available, our analysis of Value for Money focuses on platform reach, usage and costs.
- 7.4 Some platforms are constrained in their ability to achieve wide population coverage. For example, the BBC's DTT multiplexes combined currently cover approximately 82% of the UK population³³. With the current low power transmission, it is not possible to extend DTT population coverage further, although this constraint will no longer exist at digital switchover. From digital switchover, the BBC's DTT multiplexes will reach 98.5% of the UK population, which will broadly provide similar coverage of the population reach of satellite. Cable's population coverage is smaller, at 50% of UK population.
- 7.5 Satellite and DTT achieve broadly similar reach and viewing hours, but the satellite costs incurred by the BBC (pre-switchover) are slightly higher than those incurred on DTT³⁴. The BBC currently reaches 33% of UK households through the DTT platform, and 35% through satellite. On DTT, the BBC will incur £27m of costs in 07/08³⁵, while it will incur £33m on satellite³⁶.
- 7.6 Penetration of Freesat from Sky is low (less than 5% of main TV sets) and next year the BBC and ITV plan to launch their Freesat service.
- 7.7 The BBC does not incur any costs for linear broadcasting on the Cable platform³⁷, as carriage for the BBC is free. However, the current penetration of cable is relatively low, 13% of UK households, and the cable platform's ability to reach a wide population is limited.

³³ Multiplexes 1 and B cover respectively 87% and 85% of the UK population.

³⁴ It should be noted however that the BBC has more capacity on satellite than on DTT.

³⁵ The DTT costs include ongoing transmission costs for Multiplex 1 and B, coding and multiplexing charges and switchover related costs, plus some one-off costs.

³⁶ The satellite costs include ongoing transponder costs (7 transponders) and uplinking plus some one-off costs. This also includes costs directly payable to Sky for EPG and regionalisation services enabling the BBC's services to be presented on the EPG in Sky set top boxes.

³⁷ The BBC pays £3m p.a. for on-demand services on cable.

Figure 23 Reach, usage, cost and Value for Money of BBC services on different platforms

	DTT	Satellite	Cable	IPTV
Platform Coverage	82%	98%	50%	99.8% ³⁹
Platform Penetration	33%	35.1%	13%	0.2%
Total viewing hours of BBC channels/services 06/07 (millions) ⁴⁰	7,425	7,338	2,620	Not measured
Total cost	£27.1m ⁴¹	£33.4m ⁴²	£0m	£0m ⁴³
Index 1 – penetration/cost	0.01	0.01	-	-
Index 2 – viewing hours/cost	274	220	845	na

Source: Ofcom, "The Communications Market 2007 Report; Ofcom Digital Progress Report, September 2007, BARB/TRP; BBC; BT

- 7.8** The BBC incurs no direct costs for broadcast on IPTV as it does not pay for carriage on BT Vision or Tiscali³⁸, but the current penetration of IPTV is very low.
- 7.9** Regarding consumer costs, DTT and Freesat from Sky are free at the point of consumption for BBC services, while consumers for pay services on satellite, cable and IPTV incur monthly subscription/rental charges. The DTT set-top-box can be purchased for a one-off £25 charge, while Freesat from Sky customers incur about £150 on satellite dish and a set-top-box. Households on a pay satellite subscription pay a monthly fee of at least £15 (plus £30 in one-off installation costs), and at least £11 on the cable platform (plus a minimum of £25 in one-off installation costs). IPTV consumers also incur a one-off and monthly cost of subscription to broadband.
- 7.10** The figure above summarises the reach, usage, cost and Value for Money for the BBC of different platforms.
- 7.11** In summary, the DTT and satellite platforms (pay satellite and FreeSat from Sky jointly) currently represent broadly similar Value for Money for the BBC when considering reach against the cost incurred by the BBC, although the BBC services achieve slightly better usage on DTT in relation to costs than on satellite. However, the DTT platform is free for consumers at the point of use whilst pay satellite is not.
- 7.12** The base of viewers on DTT is expected to increase during digital switchover as coverage increases and as residual analogue viewers have the analogue option taken away from them.
- 7.13** The Freesat from Sky platform currently has limited penetration, but the costs are shared with the pay satellite service. Despite being free at the point of use, the FreeSat platform is unlikely to become a viable alternative to DTT in the foreseeable future.
- 7.14** Although cable and IPTV have higher penetration and usage in relation to the costs incurred by the BBC on these platforms, offering the BBC's services only on those platforms would seriously undermine the BBC's objective of being universally available as a result of these platforms' limited reach.
- AM, FM and DAB**
- 7.15** AM and FM services achieve almost universal coverage, and the BBC spends approximately £30m per annum in national, regional and local radio station transmission costs in these bands.
- 7.16** Although the BBC incurs less transmission costs in DAB than on AM/FM, DAB coverage is more limited, with only 86% of the UK population covered for national services. In addition, take-up of DAB services is currently relatively limited, with approximately 5m DAB sets sold to date⁴⁴.
- 7.17** The following figure shows the relative reach, usage and cost of AM, FM and DAB.

³⁸ The BBC incurs network costs of £8m in making services available through bbc.co.uk.

³⁹ This figure is based on BT's broadband population coverage (as reported by Ofcom). BT customers with a broadband subscription can purchase BT Vision. Tiscali's population coverage is 65% following its acquisition of Pipex.

⁴⁰ Viewing hours of BBCONE, BBC TWO, BBC THREE, BBC FOUR, BBCNews24, CBBC, CBeebies.

⁴¹ This includes payment to Multiplex A for capacity for some BBC radio services. This cost will no longer be incurred after 07/08 as the services are being moved to Multiplex B.

⁴² The majority of these costs are common to the satellite platform, except £9.5m which relate to EPG charges only attributable to receiving BBC services on Sky set top boxes (pay or free). When the BBC launch their Freesat service with ITV next year they will pay an EPG charge to enable their channels to be presented on the Freesat EPG.

⁴³ The BBC bears no direct cost associated with IPTV although it spends £8m on IP facilities to support internet services.

⁴⁴ See Ofcom, "The Communications Market 2007 – Radio", page 191.

Figure 24 AM, FM and DAB reach, usage and cost			
	AM	FM	DAB
Reach and Usage			
Coverage	95% - 98% (*)	~99%	86%
Cost to BBC (£m) - 07/08 budget			
Direct cost	£9.2	£12.3	£6 ⁴⁵
Shared cost (nations and local radio stations)	£8.2		
Source: BBC			
(*) Population coverage varies by service. This coverage relates to Radio 4 and Radio 5 Live in AM			

- 7.18** The BBC wishes to increase DAB's population coverage to 90% of the UK population, which we understand would cost £11m per annum in total to increase the number of transmitters from the current 96 to 230. Increasing coverage further to levels similar to those of FM radio may cost the BBC up to £40m per annum, as the number of transmitters would need to be increased to approximately 1000.
- 7.19** As noted in paragraph 3.16, the BBC services are currently on 38 of the 46 local DAB multiplexes. The BBC incurs an additional £3.6m in local DAB transmission costs.
- 7.20** It might be possible for the BBC to use DRM on the Medium Wave band to obtain the incremental reach more cheaply than through an extension of the number of transmitters used by DAB, but as noted above the case for DRM is not fully tested yet.

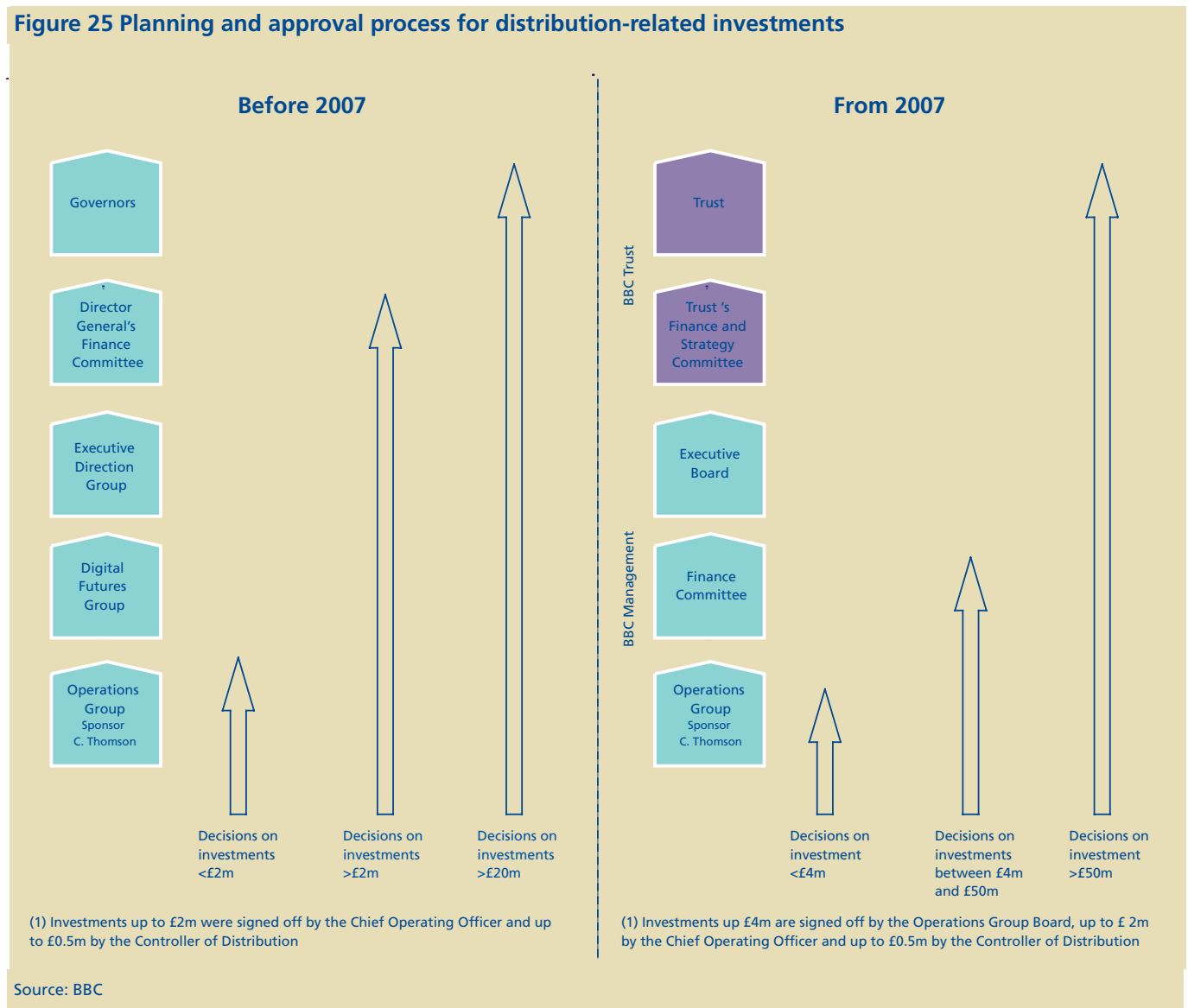
⁴⁵ The BBC incurs an additional £3.6m in local DAB.

8. The planning of spectrum use by the BBC

The planning and approvals process

- 8.1** The process for making decisions on the use of capacity is initiated and led by the Distribution Team. The Controller of Distribution discusses service aspirations with the editorial teams on a regular and informal basis. On the basis of those discussions the Controller of Distribution, sponsored by Caroline Thomson, puts forward and takes a proposal for a service change request through the approvals process.
- 8.2** The approvals process has changed since the creation of the Trust in January 2007.
- 8.3** Before the creation of the Trust, only proposals regarding the use of BBC capacity which related to offering capacity to the Secretary of State for direction would reach the Board of Governors. Decisions on the use of capacity for BBC services having editorial implications would be taken by the EDG, chaired by Mark Thompson and attended by the Directors of all BBC Divisions.
- 8.4** Distribution-related investments above £2m required approval by the DGFC before 2007. From 2007, the threshold for scrutiny by the Finance Committee increased to £4m. Below this threshold financial investments above £2m are delegated to the Operations Group Board, and investments up to £2m are signed off by the Chief Operating Officer, Caroline Thomson, or the Controller of Distribution for investments up to £0.5m.
- 8.5** Since the creation of the Trust in January 2007, strategically significant decisions relating to spectrum and capacity including those requiring investment worth more than £50m require approval by the Trust. Within BBC management such decisions will be considered by the Executive ahead of them being put before the Trust for approval.
- 8.6** The following figure portrays the planning and approvals process for distribution related investments.
- 8.7** Both before and after 2007 proposals are put forward and taken through the planning process by the Controller of Distribution, rather than the editorial teams, when proposals concern the use of spectrum capacity for services.
- 8.8** Before 2007, decisions with a financial impact were taken to a higher level in the approvals process than decisions on the use of the spectrum capacity by the BBC. This situation seems to have changed with the establishment of the Trust.

Figure 25 Planning and approval process for distribution-related investments



Compliance with the planning and approvals process

- 8.9** Since the launch of Freeview in 2002, a series of proposals regarding the use of BBC capacity have been taken through the processes described above:
- Change of BBC Parliament to full screen.
 - Introduction of two additional quarter screens for the BBCi multiscreen.
 - Application by the Community channel for increased capacity hours.
 - Request from Channel 4 for access to BBC capacity from digital switchover.

- 8.10** There have been two distribution related investments in recent times, the approval of the new coding and multiplexing infrastructure to deliver digital switchover, and an investment in new refreshing coding and multiplexing equipment for Multiplex B (for £0.8m). Both of these investments followed the approvals process described above during the course of 2006.

Suitability of the planning and approvals process to the delivery of Value for Money

- 8.11** The planning and approvals process that existed prior to 2007 for the use of spectrum capacity reflected a situation where the BBC had sufficient capacity available for the services that it wished to provide. Decisions on how to use the capacity were taken based on the BBC's view of what was best.
- 8.12** However, in recent years both the BBC's and third parties' service demands have increased. In addition to the BBC's aspirations to provide HD and extended service aspirations, several public service broadcasters, including five, S4C and TG4, are expected to be directed by the Secretary of State to be carried in BBC multiplex capacity.
- 8.13** Given these increasing demands, the planning and approvals process needs to be able to respond to the constraints on spectrum capacity. The Trust's specific remit to ensure the efficient and effective use of the spectrum and responsibility for approving decisions on the use of the spectrum is appropriate to these changed circumstances.
- 8.14** Internally, the BBC appears to appreciate that available capacity may no longer be sufficient to cover their service aspirations, and therefore the importance of using the spectrum efficiently and effectively. However, while technical options may be well understood by the BBC, the planning processes for deciding how to use the capacity effectively for those services most valued by licence fee payers would benefit from further development.
- 8.15** In 2006, BBC Strategy launched a project ("the capacity project") to determine whether the BBC's DTT spectrum capacity was being used efficiently and to identify criteria and options for future capacity usage to determine how to derive best value for Freeview users. However, this project was not pursued by the BBC and only limited work was undertaken.
- 8.16** The BBC is currently undertaking a service prioritisation project, which is seeking to determine the BBC's service priorities over the next few years. However, a robust framework with adequate measurement tools is not yet sufficiently established to enable the BBC to adequately assess what services would make a more effective use of the spectrum capacity. This hampers the BBC's ability going forward to establish a service line-up that maximises value for consumers with the available capacity.
- 8.17** More robust processes and tools need to be developed by the BBC in order to ensure that capacity is used in a way that maximises value for licence-fee payers while minimising the opportunity cost of the BBC's use of the spectrum.
- 8.18** A clear framework for assessment of the value of different proposed services needs to be developed, consistent with the BBC's RQIV framework. Specific criteria need to be developed against which to measure whether capacity is being used efficiently and effectively on an ongoing basis. Consumer and audience research should be conducted regularly in order to ascertain consumer value for potential new services, so that decisions are taken with a strong evidence base. The BBC acknowledges this point and are actively considering what such a framework would include.
- 8.19** We suggest that proposals regarding what services to offer should be taken forward through the planning and approvals process with the explicit engagement of the content/editorial teams.
- 8.20** The practical framework for liaison between Management and the Trust on spectrum issues is expected to evolve and consolidate going forward. Management have told us that they expect the role of the Trust in supervising the efficient and effective use of the spectrum to be clarified over time.

9. Conclusions and recommendations

- 9.1** Since the launch of Freeview, the BBC has had access to two multiplexes of DTT capacity. During the development phase of the platform, and against a background of previous failed attempts to create a digital terrestrial television service, the BBC has given priority to encouraging consumer acceptability of the service. Hence the BBC's trade-off choices in the use of the spectrum have focused on maximising the reach of the services, the robustness of the signal and the picture quality.
- 9.2** Through these choices the BBC has, arguably, supported the development and success of the DTT platform, which is now used by over nine million households⁴⁶.
- 9.3** Recently, demand for DTT capacity has increased. The BBC and other broadcasters have developed aspirations for new services such as HD. At the same time, other potential uses of the spectrum have shown great interest for obtaining access to some spectrum in the UHF band in the future.
- 9.4** This increased interest in the UHF band has meant that the opportunity cost resulting from the BBC's use of capacity is now also higher. The BBC needs to adapt to these changed circumstances, and ensure that it has a robust framework to ensure it uses the spectrum efficiently and effectively, thus minimising the opportunity cost.
- 9.5** Going forward, decisions on the use of capacity for services should be made based on an overall service strategy set out by BBC management, and agreed with the Trust. This will also involve greater editorial input into decisions about the appropriate capacity and proportionate spectrum "cost" for each service stream than has been necessary to date, and a more value-based process for making decisions relating to the capacity trade-offs.
- 9.6** Although the same processes apply to radio services, the number of alternative uses of the spectrum occupied by radio services is more limited than on DTT. In radio, not only are the opportunities for increasing efficiency in the use of the spectrum more limited, but they also have a lower Value for Money impact.

The BBC's use of the DTT spectrum

Our findings

- 9.7** The BBC uses more capacity on average for video services than other multiplexes. This can be explained by a combination of current technical inefficiencies and choices regarding quality. Although the BBC offers most of its video channels on full picture resolution, very little research has been done to support that decision.
- 9.8** There are a number of opportunities for the BBC to increase spectrum efficiency in the next five years.

⁴⁶ Ofcom Digital Progress Report, September 2007.

- 9.9** We estimate that the BBC could release approximately 6.4 Mbps of capacity through new coding and choices that might affect quality.
- 9.10** These capacity gains compare with approximately 2.5 Mbps of capacity which are required for a standard definition channel, and between 12 to 15 Mbps for a high definition channel. Although this capacity may not be sufficient to accommodate high-definition services, these opportunities also need to be considered in the context of other BBC service aspirations, such as extended hours of some channels. Aspirations from third parties – such as five, S4C, TG4 and the Gaelic language service - to obtain carriage on BBC multiplexes under direction from the Secretary of State also need to be borne in mind in this context.
- 9.11** Capacity gains through new coding can be achieved from the end of 2008, subject to the completion of a capex programme that the BBC is undergoing, and which will also support digital switchover. Picture resolution changes and GOP changes can be easily achieved from a technical perspective and without a very significant cost implication.
- 9.12** Larger gains are expected to come from migration to 64QAM during digital switchover and the introduction of DVB-T2 and MPEG-4 (with commercial implementation starting from 2010 in Multiplex B but not before after DSO in Multiplex 1). The BBC will be able to achieve capacity gains from modulation changes upon the switch to high power. In relation to technology changes there is still considerable uncertainty over potential capacity gains and the cost implications of their implementation. It is unlikely that the full benefits from these technologies will materialise for about a decade, as a significant population of UK homes will need to have MPEG-4 set-top-boxes before the transition can be made.
- 9.13** The BBC understands and is currently pursuing opportunities arising from new coding and multiplexing and the migration to 64QAM. The BBC is also aware of the opportunities arising from DVB-T2 and MPEG-4. However, the BBC should seek to explore further the opportunities to implement picture resolution and GOP changes, based on robust consumer research about these trade-offs.
- 9.14** While the BBC is investigating various options for increasing technical efficiencies, editorial decisions of what services the capacity is used for will need to be strengthened going forward. Services should not be offered simply to fill-up the capacity available, but based on a robust assessment of what services provide value.
- 9.15** The interactive services take a significant amount of capacity. Although this capacity has been used more frequently in 2007 than in the previous year, some of the capacity remains fallow at times. In other video streams used by BBC THREE/CBBC and BBC FOUR/CBeebies, the capacity remains unused for some hours overnight.
- 9.16** The BBCi data service uses a significant amount of capacity to carry a revolving “carousel” of data. There is a trade-off between the bit rate used for the service and the time taken to download a screen of information. For most services speed is not critical. Expanded set-top-box memory could be used to cache less critical data services, and thereby reduce capacity requirements, although this might require coordination with manufacturers.
- 9.17** Some of the new BBC service aspirations, such as HD, are reported to provide higher value to consumers than some of the existing services on the BBC's Multiplexes, e.g. the interactive video services and the multiscreen, the radio services, and BBC Parliament. Sufficient capacity could be released for an extended HD service pre digital switchover if those services were taken off the DTT platform. However, this will have a significant impact on the reach of those services. In addition, the BBC Agreement and commitments made to DCMS limit the freedom on the BBC in respect of BBC Parliament.
- 9.18** DTT uses of the spectrum such as more SD or HD channels are found by both Ofcom and BBC research to provide higher value to consumers than mobile TV. Other potential uses of the spectrum could not be accommodated within the capacity that can be released by the BBC in the next five years. This conclusion assumes that none of the BBC's multiplexes are cleared completely, as the multiplex cannot be shared for broadcast and non-broadcast uses.
- Our recommendations**
- 9.19** The BBC should aim to make future decisions regarding picture quality based on a robust evidence base, to inform its decisions relating to the trade off with channel availability. We have put forward some issues that need to be taken into account in designing future consumer research in this area in Appendix 1.
- 9.20** Decision making with respect to individual services should be undertaken with a more robust understanding of the specific value of different services, rather than to fill-up the capacity. The BBC should also set criteria for deciding what services will be allocated capacity going forward, based on the RQIV framework, against their capacity requirements.

Greater measurement of the value of the interactive services in relation to their spectrum "cost" and in relation to other potential uses of the capacity should be undertaken. Whilst management are aware of this challenge, such a framework is not yet established.

- 9.21** In order to increase viewer value, the BBC needs to consider its service prioritisation, e.g. accommodating HD services which the public appear to value highly, extending the broadcast hours of some existing channels such as BBC THREE and CBBC, or other potential services that might emerge over time. We are aware that the BBC is currently considering such issues.
- 9.22** The BBC should explore the extent of incremental radio listening on DTT to support decisions about whether these services could be taken off the DTT platform. However, given their low bandwidth consumption, dropping those services would not be sufficient on its own to accommodate another video stream. Options for offering BBC Parliament in a manner that consumes less spectrum capacity, e.g. in a shared frequency with another channel, should be explored.
- 9.23** The BBC should give increasing thought to how non-permanent capacity demands such as those of the interactive services could be met more resource effectively. Scheduled peak demand can be accommodated by buying timeslots on multiplexes, a market model that is now well established among commercial multiplex operators. Irregular peak demand, such as the coverage of major live events, is not well served currently. The BBC's approach to carrying such transmissions is either to interrupt the existing schedule, e.g. Wimbledon coverage on BBC ONE, or to use interactive video stream capacity, which is currently not fully utilised.
- 9.24** In relation to the use of data services such as interactive data services and subtitling, greater cost/benefit analysis is required.

Value for Money of different television platforms

Our findings

- 9.25** The DTT and satellite platform represent broadly similar Value for Money for the BBC. DTT and satellite achieve broadly similar reach and viewing hours, although the satellite costs incurred by the BBC are slightly higher than those incurred on DTT. Penetration of Freesat from Sky is still small but the costs are shared with the pay satellite service. Although the DTT platform's current coverage is

about 82% (BBC multiplexes), it will reach near universal coverage after switchover, matching satellite coverage.

- 9.26** Other platforms such as cable and IPTV, while representing Value for Money (due to the fact that the BBC does not pay for carriage on these platforms), could not substitute for the DTT platform for BBC services due to their limited population coverage and penetration.
- 9.27** Freesat from Sky is the only platform, other than DTT, which is free at the point of use for consumers and next year the BBC and ITV plan to launch their Freesat service. However, the Freesat platform is unlikely to be a viable alternative to DTT in the foreseeable future.

Our recommendations

- 9.28** The BBC Agreement requires the BBC to ensure universal availability of its services using a range of platforms, and taking into account those platforms' cost effectiveness.
- 9.29** However, this requirement would not seem to prevent the BBC from exploring whether particular services could be offered more cost-effectively if they were only made available over certain platforms. For example, there is merit in considering how some of the BBC's interactive services could be carried in the future over IP networks, such as IPTV or the internet, to hybrid set-top-boxes. This would potentially allow interactive TV services to be delivered without the need for dedicated capacity on DTT multiplexes.

The BBC's use of the radio spectrum

Our findings

- 9.30** Given the simulcasting of a number of BBC radio services on AM, FM and DAB, there is a possibility of rationalising the number of transmission sites in order to release spectrum and save transmission costs. AM transmission would appear to be the most likely candidate for switch-off, given the poorer sound quality. However, this might have an impact on some audiences that might not be able to reach some of the BBC's services, notably Radio 5 Live.
- 9.31** The amount of spectrum released from discontinuing AM transmissions would be relatively small and there has been little expressed demand for this spectrum given its limited capacity. DRM is a potential use for AM frequencies. The transmission savings associated with discontinuing AM transmissions would be modest.

- 9.32** It might be possible for the BBC to use DRM on the Medium Wave band to obtain the incremental reach that DAB cannot achieve cost effectively. However, the case for DRM has not been fully tested and the BBC is currently conducting a trial.
- 9.33** In the DAB environment, it is not possible to increase efficiency other than by introducing more efficient audio coding standards such as AAC.

Our recommendations

- 9.34** A review of the case for the BBC switching off some or all of its AM services should be conducted after the current DRM trial. At this stage no final conclusion can be drawn on this issue.

The planning process for spectrum use

Our findings

- 9.35** During the development phases of the DTT platform, the BBC has considered cost and Value for Money primarily in the context of distribution platforms, with less focus on the Value for Money of using the spectrum for particular services. Decisions regarding the use of capacity appear to have been driven primarily by the technical experts, rather than the editorial teams, when proposals concerned the use of spectrum capacity for services.
- 9.36** The planning and approvals process that existed prior to 2006 for the use of spectrum capacity reflected a situation where the BBC had enough capacity available for the services that it wished to provide and the primary concern was to achieve effectiveness of the platform, with less emphasis on efficient spectrum use.
- 9.37** The BBC recognises that the available capacity may no longer be sufficient to cover their service aspirations, and the importance of using the spectrum efficiently and effectively. However, while technical options may be well understood by the BBC, the planning processes for deciding how to use the capacity effectively for those services most valued by licence fee payers is still not adequately developed.
- 9.38** In the context of increasing demand and more important Value for Money implications of the use of the spectrum, the BBC needs to re-consider the appropriate trade-off choices, and how the capacity can be used effectively for different competing service demands. This will require more robust processes and tools in order to ensure that capacity is used in a way that maximises value for licence-fee payers while minimising the cost on the BBC and the opportunity cost placed on other potential users.

Our recommendations

- 9.39** We suggest that, going forward, decisions on the use of capacity for services and trade-off choices should be made based on an overall strategy set out by BBC management. The BBC is currently considering its service priorities over the next few years, and we expect that this will provide the starting point for future decisions on the use of capacity.
- 9.40** Going forward, decisions on the use of the spectrum should be based on a clear public value framework for making trade-off choices, consistent with the BBC's RQIV framework, and approved by BBC management and the Trust. Specific criteria need to be developed against which to measure whether capacity is being used efficiently and effectively on an ongoing basis. Assessment against the criteria should be based on regular consumer and audience research. The BBC acknowledges this point and is actively considering what such a framework would include.
- 9.41** Criteria for decision making with respect to individual services need to consider the benefits of those services against their spectrum "cost". Before decisions are made on specific services, their benefits and costs should be assessed in relation to other potential services that could be offered by the BBC or by third party public service broadcasters that might request access to the BBC capacity through direction. The benefits would need to include consideration of the direct consumer and wider social value of each service. The criteria should also consider the potential Value for Money implications of the BBC acquiring capacity for new services on a commercial basis in the future. The BBC has initiated some work in this direction.
- 9.42** Assessment of whether the spectrum costs of particular services are proportionate to the benefits will also require greater editorial input than has been the case so far. In the future, proposals regarding what services to offer should be taken forward through the BBC's planning and approvals process with the explicit engagement of the content/editorial teams.
- 9.43** BBC management expects the role of the Trust in supervising the efficient and effective use of the spectrum to be clarified over time as the Trust becomes established in its role.

Appendix 1

Factors guiding the design of future consumer research on viewer's preferences in the trade-off between quality and efficiency

In deciding whether to reduce the picture resolution of some channels in the future, the BBC should seek to have a strong evidence base. As noted in Section 4, very limited research has been undertaken so far to support current choices regarding picture resolution, which impacts on both perceived picture quality and bandwidth availability. Further consumer research should therefore be undertaken to support future decisions on this issue.

Issues to take into account when designing future research, as highlighted in a BBC R&D White Paper⁴⁷, include:

- Video quality perception is subjective and is highly influenced by viewers' expectations and experience. Therefore the results of any such research depend on the sample of people selected.
- The choice of display can influence the perception of video quality, since video compression artefacts are more visible on modern matrix displays than on CRT displays.
- The choice of material used for viewing test can also influence the results. It is important to use a range of material that is representative of the channel on which the technical settings under test will be applied.
- Due to group pressure, an individual's judgment can be easily influenced and modified if the research is conducted by gathering a sample of viewers around the same display.
- Perceptions can be influenced by the behaviour of the presenter, who can unintentionally direct the attention of the audience to the specific aspect under examination in the demonstration.

Other aspects of picture quality research that should be taken into account in future research include:

- When conducting video quality research the BBC should consider the trade-offs involved. Since better video quality generally implies larger use of spectrum capacity and therefore smaller number of services available, interviewees should be made aware of the impact of the choice of better quality.
- In HD research, presenting the viewer with reference scenarios has proved useful as it allowed researcher to identify the relative values assigned by viewers to different alternative services and scenarios.
- In our discussions with Mike Armstrong and Stephen Baily at the BBC, it emerged that the BBC has until now relied more on monitoring viewers' reactions and complaints in reaction to a temporary changes in the video quality of BBC services, rather than on picture quality research. This approach is second-best as it does not allow viewers to be presented with a full set of options for the use of BBC spectrum capacity.
- The "sip test" problem where distorted and biased results are reached based on small volumes of the entity being tested. This affects picture quality research which relies on showing short video clips rather than whole programmes, so that the experience of video quality in tests could substantially differ from watching TV at home.

In conclusion, we recognise that picture quality research could be an expensive and resource intensive exercise. However, this research is necessary to inform BBC quality choices in the future. The results of the research would be of particular importance when choices need to be made involve significant trade-offs between the quality and the quantity of the services offered.

⁴⁷ M. Armstrong, "Video Quality and Digital TV Broadcasting", BBC R&D White Paper.

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