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Spectrum Matters in the All-Digital Future

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Abstract

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Key words: digital television, SFNs, MFNs, 2k, 8k, transmission networks, service requirements, all-digital future, spectrum

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SPECTRUM MATTERS IN THE ALL-DIGITAL FUTURE

T. Everest

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ABSTRACT

In Europe, the vast sums of money raised in some countries by the recent auctions of spectrum for third generation (3G) mobile telephony have forced broadcasters to think carefully about their aims for digital television and the amount of spectrum satisfying these will require. In addition, the prospect of a full regional re-planning conference in 2004/5 is intensifying debate about the spectrum requirements for DVB-T systems. The DigiTAG Task Group on the Commercial Aspects of Spectrum Demand have done much work on identifying the service requirements for DVB-T systems in the all-digital future, including conducting a questionnaire amongst a wide-range of industry groups and countries. This paper discusses the prospect of renewed spectrum scarcity, the principal elements of service requirements and presents some highlights from the questionnaire.

INTRODUCTION

Spectrum scarcity is an issue which dates back to the birth of broadcasting in the early decades of the twentieth century. The lack of spectrum then meant that only a few broadcasting services could be made available in any geographical area. This, in turn, led governments in many countries to heavily regulate the content of the services provided, ensuring that all viewers got most out of the spectrum available. The model of television broadcasting which grew up in much of Western Europe was one of a few – typically four – general interest programme services; a model ultimately defined by the scarcity of spectrum.

Digital television technologies allow the possibility of using the spectrum traditionally allocated to a single analogue programme service to broadcast a number of programme services and related interactive elements in the form of a multiplex. Suddenly, some would wish to argue, the ambitions of television broadcasters are no longer limited by the amount of spectrum available but by the range of services they wish to offer. Indeed, the BBC in the United Kingdom has recently announced its intention to extend its range of television services from two general interest channels to five services, each aimed at a smaller, more focussed demographic. These five can be accommodated in the same amount of spectrum – one 8 MHz channel – as was used by just one of the BBC's analogue services.

The effect of the elimination of spectrum scarcity through the development and deployment of technologies for digital terrestrial television (DTT) such as the DVB-T standard has been to excite the interest of other industries in the broadcasting spectrum. If all a nation's television services and more can be delivered digitally in one multiplex, it might be thought, where they had been delivered previously over four analogue networks, then surely in the all-digital future, the broadcasters will require only one quarter of the spectrum they do currently. As mobile telephony always needs spectrum, and will require more as 'third generation' services start to take off, could not spectrum currently reserved for broadcasting be transferred to the mobile telephone companies? With the

amounts of money that such companies have been willing to pay in previous auctions in some countries, many administrations are keenly eyeing the spectrum used for broadcasting.

The effect is to re-introduce the concept of spectrum scarcity to the broadcasting industry. For the first time in their history, broadcasters are able to consider what services they wish to make available in the all-digital future and how they best wish to serve their audiences, with the apparent limitless capacity available through digital television. But with the prospect of spectrum pricing and increased spectrum fees in the near future, broadcasters are also being asked to account for every Hertz they wish to use. Only by capturing what they want out of television in the all-digital future, the service requirements, can the broadcasting industry come to a consensus over how much spectrum is required.

In the interests of stimulating this debate, DigiTAG established a task group in 2001 to investigate commercial aspects of the spectrum requirements for digital broadcasting. The group has two roles. First, to examine the impact that spectrum pricing and the charging of market-rate spectrum fees by administrations could have on broadcasters. Second, to identify, as far as possible, a set of standard service requirements for television in the all-digital future.

This paper looks at the second part of this mandate. We shall look at the possible factors which define and influence the service requirements for DVB-T in the all-digital future. We shall then consider the results of a Europe-wide questionnaire designed and analysed by the task group which gives an impression of how broadcasters, administrations, network operators and equipment manufacturers currently see the role of DTT in the all-digital future.

WHAT ARE SERVICE REQUIREMENTS?

The term ‘service requirements’ has been used by the group, and will be used throughout this paper, to mean all those things which define how a television service fulfils its goals and how a viewer experiences it. The service requirements for DVB-T in any one country can be defined in terms of a number of groups of ideas and technical parameters. The amount of spectrum required to deliver a service will depend on how a country defines its service requirements for DTT.

The following list of elements of service requirements was drawn up by the group to aid its discussions about the exact service requirements of countries in Europe:

1. Type of service – for example, traditional TV, video-on-demand, internet access, data-casting, IP-based services;

2. Coverage – typically defined by the percentage of population to which the service is available but also to include the need for regional and local programmes and particular language services;

3. Capacity – in absolute terms, the bit-rate required (typically expressed in terms of Mbit/s), although for countries with heavily congested television spectrum, this may be expressed in terms of the number of multiplexes together with the DVB-T variant;

4. Quality and Reliability – ranging from the amount of bit-rate to be allocated to a video stream to the percentage of time availability and percentage of locations to serve;

5. Reception mode – whether the service is required for reception to fixed receiving locations, to portable sets or on the move;

6. Type of Reception Equipment – what devices will be used to receive the services, understanding that a higher bit-rate may be required to serve large flat screen displays, for example;

7. Interactivity – the level (local to the receiver or including a return path) of interactivity and the bandwidth and implementation of any return channel.

Whilst this defines the service that the viewer experiences, a number of more technical service requirements need to be captured, as these will have a direct impact on the implementation of DVB-T in any country. The following list gives an outline of the elements which need to be considered:

1. Transmitter network – which may consist of all or part of an existing TV network or a new network configured to exploit interactivity, such as a network of low-power, cellular sites;

2. DVB-T variant – the factors which define how the network performs and, to an extent, what is possible with it: comprising modulation type, forward error correction (FEC) rate, FFT size (2k or 8k) and the duration of the guard interval;

3. Planning model – DVB-T allows the configuration of a single frequency network (SFN), a multi-frequency network (MFN) or a hybrid topology containing both;

4. Convergent technologies – the use of multiple technologies to deliver a single user experience might have a major impact on the bit-rate, interactivity and coverage a DVB-T network would require.

It is likely that the service requirements for DVB-T will vary from country to country, such is the flexibility of the DVB specification. Furthermore, and of somewhat more concern, the service requirements for digital television will differ between the various interested groups and organisations in each country. Countries will have a difficult time trying to weigh up the costs and benefits of each element of the service requirements, consequently the exact requirements defined and taken through to the building and commissioning stage of a DTT network will necessarily be a compromise.

The issue of the need for spectrum by the DTT community is coming to the fore and will only rise in importance as time progresses. Under the leadership of the CEPT (the European conference of post and telecommunications administrations) the European broadcasting area is committed to a regional re-planning conference (RRC) in 2004/5 to lay out a frequency plan for digital broadcasting (both radio and television). It is vital, therefore, that before detailed work is undertaken for the preparation of this plan, all concerned in its drafting have a clear view of the spectrum requirements for DVB-T in the all-digital future. As we stated earlier, spectrum requirements are directly and irrevocably linked to the service requirements envisaged for digital television. A clear view of the shape of DTT is of great importance; DigiTAG's work in identifying broad service requirements is helping to bring this picture into focus.

THE DIGITAG QUESTIONNAIRE ON DVB-T SERVICE REQUIREMENTS

The questionnaire, widely distributed amongst DigiTAG members, sought to discover whether there was any consensus on the key requirements in the all-digital future and whether these could be used to generate a standard model or a small set of standard models for DVB-T. Although the group itself is not directly involved in the preparations for the RRC, it is its intention to feed the results of the

questionnaire into those groups in the European Broadcasting Union (EBU), CEPT and ITU considering the spectrum requirements for the all-digital future.

In total, thirty-four replies were received from respondents, representing twenty-one different countries. In addition, a good breadth of responses were received representing the views of broadcasters, government departments, network operators, spectrum regulators, manufacturers and many others. Of those who replied, just over half (56%) indicated that the view they expressed was a personal one, whilst the remainder stated that their response represented the view of their organisation. Intriguingly, no respondent stated that they were giving a country specific view, despite the fact that a significant number of replies were received from government departments and spectrum regulators.

The questions asked in the questionnaire can be split into three broad categories: first, service requirements for the all-digital future; second, transmission modes, networks and characteristics; third, capacity requirements. It is not possible in the space available for this paper to examine the responses given to each of the fourteen questions asked; instead, some key questions and findings have been chosen and analysed. We shall deal with each of the categories in turn.

Service Requirements for the All-Digital Future

Types of service

We began by asking about types of service: respondents were asked to rate different types of service as having a 'high', 'medium' or 'low' priority. Figure 1 shows the responses.

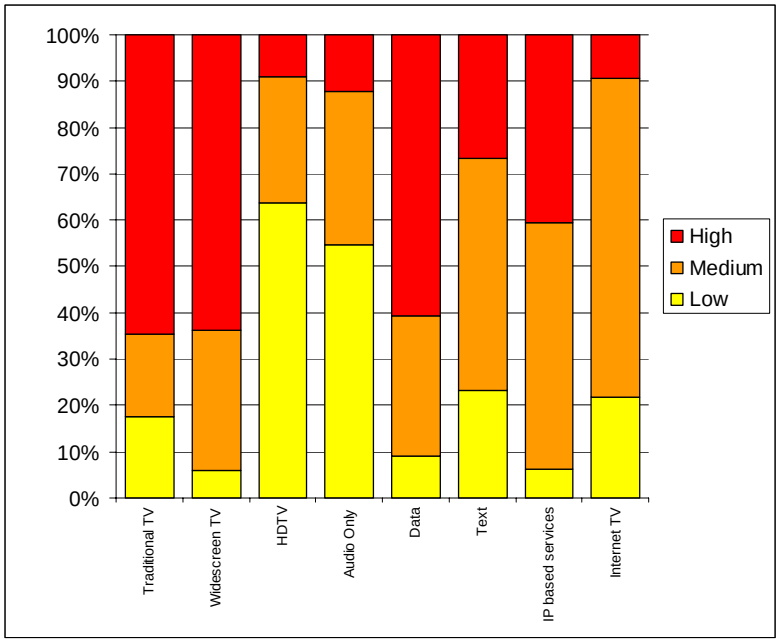


FIGURE 1. Priority of different types of service.

It is clear from Figure 1 that respondents attach a high importance to traditional and widescreen TV; perhaps a fact that should not be overly surprising, given that the sample was drawn entirely from those with a stated professional interest in television broadcasting. Indeed, only one respondent thought that neither traditional nor widescreen TV were important.

Worthy of note, however, is the relatively low importance assigned to HDTV, which was once seen to be the future of the television industry, whilst a different change to the display standard – widescreen – is now seen as having high importance by two-thirds of the sample. Perhaps it can be inferred that those responding to this questionnaire are conscious of the relatively limited bit-rate available in digital terrestrial television systems, and consider that the high bit-rate required by HDTV is best delivered by another platform.

Moreover, it is important to note the apparent disinterest in transmitting audio only services using DVB-T. We can only guess why this might be, though it does seem to indicate that T-DAB will be the technology of choice for the terrestrial distribution of digital radio services.

Types of reception

Respondents were asked to rate each of fixed, portable and mobile reception as ‘high’, ‘medium’ or ‘low’ priority. The questionnaire defined the meaning of each of the reception conditions in its notes: ‘fixed’ meaning reception via a directional roof-top antenna at 10 m above ground level; ‘portable’ meaning reception via a simple set-top antenna; and ‘mobile’ meaning reception in a moving vehicle via a simple antenna at 1.5 m above ground level. Figure 2 shows the distribution of responses to this question.

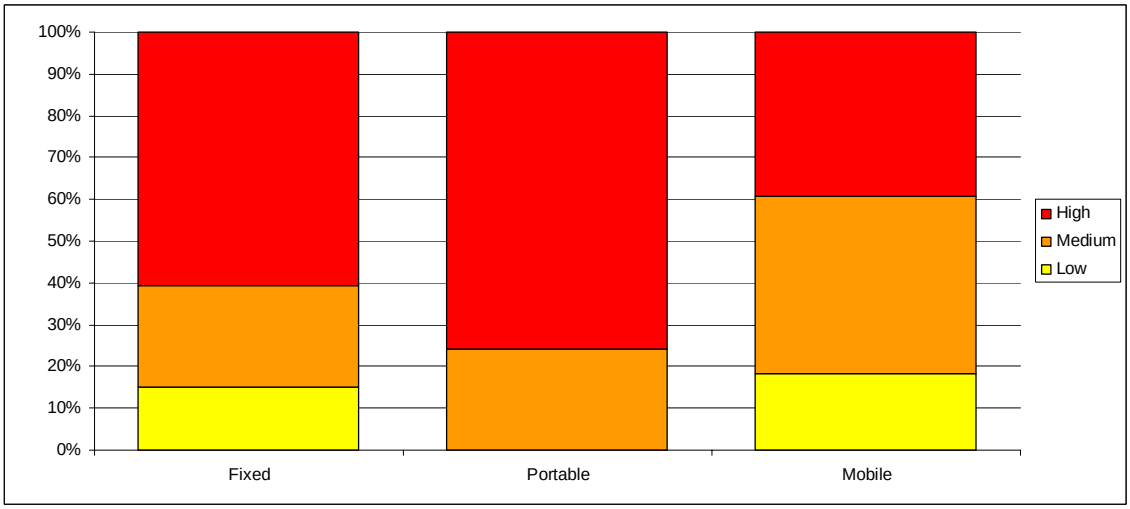


FIGURE 2. Priority of different types of reception conditions.

It is clear that although 15% of our sample thought that fixed reception will have a low priority in the all-digital future, all assigned a positive need to portable reception. A relatively small proportion of the sample (less than 20%) thought that mobile reception was of low importance, though the relatively large proportion assigning it a medium importance may indicate that few have made up their minds decisively.

We still need to understand whether our sample believed that digital terrestrial was to be a ‘mixed mode’ system in the all-digital future, or whether we had simply found three separate groups of respondents, each believing that their preferred reception condition was going to prevail. By comparing the answers that each respondent gave for each reception condition, as in Figure 3, we can see that an overwhelming majority – two-thirds of the sample – believe that no one set of conditions will be dominant. Further, no respondent thought that DTT would be received solely on the move; all those who thought mobile was of some importance rated it either less than or as important as fixed or portable.

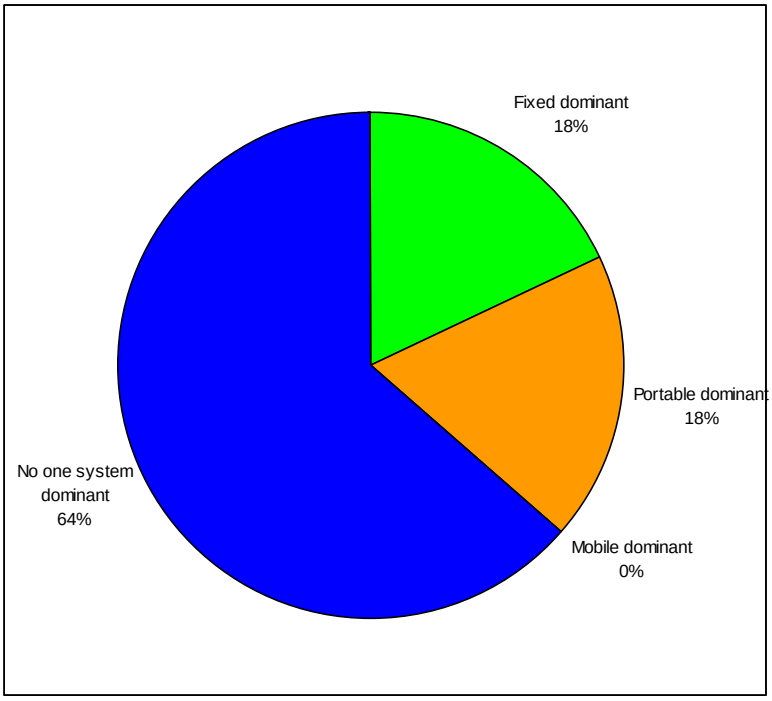


FIGURE 3. Dominance of different types of reception conditions.

This leaves us with one further question: given that the majority see the all-digital future as a hybrid environment, where fixed,

portable and mobile reception will all play a part, is there any general trend this future will take? It might be thought that the current analogue networks as they are engineered across Europe are fixed-portable, with fixed reception the primary objective and portable reception secondary. By looking again at each respondent's answers, we can see if this is reflected in their answers about the digital future: will it be fixed-portable (as analogue is now) or mobile-portable?

(Note that this simple analysis excludes a small number of respondents who effectively chose a fixed-mobile, but not portable, environment.)

The answer is, perhaps, somewhat surprising. A majority, and just over 50% of our sample, think that the broadcasting ecology of the all-digital future will be predominantly the same as that for the analogue present: that is, fixed-portable. This does not mean to say that a mobile-biased system is not thought to be important; in truth, just under a third of those who replied to the questionnaire thought that mobile-portable is the preferred model for digital reception in the future.

Also through the questionnaire, we were keen to fully explore respondents' views of the importance of interactivity in the all-digital future. A question which asked for a simple 'yes' or 'no' answer about whether a return channel would be needed met with near unanimity in the replies received: 94% thought that some form of return technology would be required.

Following this, another question sought to understand which technologies were being identified as suitable for the return-path. This asked for respondents to chose from a list of current and future mobile telephone standards, fixed-line systems and in-band solutions, such as DVB-RCT. The responses are shown in Figure 4.

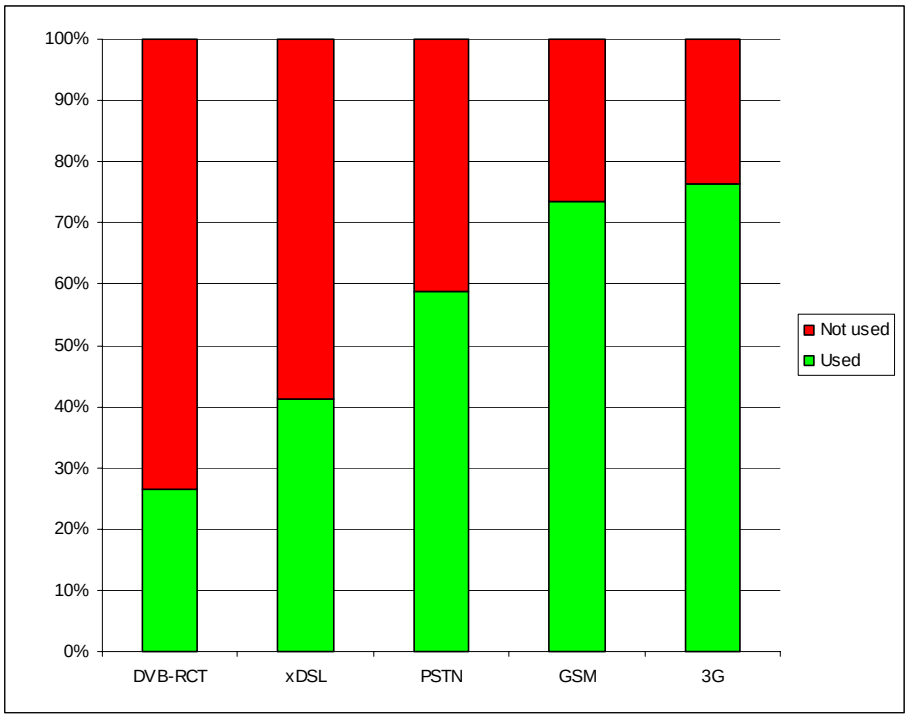


FIGURE 4. Possible use of return-channel technologies.

As can be seen, there is broad support for established and emerging mobile telephone technologies, and even a fair level of support for DVB-RCT. It can be demonstrated that respondents' choice of return-channel technology is independent of their views regarding reception conditions and even display device types; moreover, on average, respondents selected nearly three technologies as possibilities for the return-channel. It is to be noted that only one respondent chose DVB-RCT alone.

Transmission modes, networks and configurations

A three-fifths majority of respondents to the questionnaire believe that both UHF and VHF will need to be used for broadcasting DVB-T in the all-digital future. This is significant, as it implies that Band III is being thought of as usable by television broadcasters for DVB-T as well as by radio

broadcasters for T-DAB. (Perhaps this is a legacy of the high usage made of Band III for analogue television and the thought that it would continue to be used in the all-digital future.) Nevertheless, a substantial number – around 35% – believe that only UHF will be required.

Perhaps this information allows us to identify an emerging point of debate: this questionnaire has shown a desire to use all of the current broadcasting spectrum for DTT in the all-digital future. This is perhaps all the more surprising as our sample included a large number of people representing government departments and spectrum regulators.

Further questions sought to understand how much of the existing transmitter network would be required for the delivery of DVB-T: 64% believed their entire network would be required. In addition, eight in ten respondents answered that more transmitter sites would be required in their country in the all-digital future. Correlating these answers with those given to a question about whether more sites would be required to create a denser network is revealing: just over half of the sample believe that only part of their existing network will be used but that it will be supplemented by new, additional sites.

Given the history of debate about an 8k versus a 2k FFT in Europe in the early years of DVB-T, it was deemed expedient to ask a question about which DVB-T mode was envisaged by our sample. Here, respondents were asked to select either, or both, 2k or 8k. Three-quarters of the sample believed that only an 8k system would be used in their country in the all-digital future, while not one respondent thought that 2k alone would be used in the all-digital future – not even those responding from countries which have a 2k-only system on-air at the present time.

One further question that is posed by these results is why should anyone chose 2k as part of their network in the all-digital future, as over a quarter of our sample seemed to do? Perhaps the apparent popularity of 2k in this survey is due to the fact that it is understood that 2k might offer some advantages when deploying mobile networks, and countries wish to take advantage of this.

Capacity requirements

A range of questions asked respondents to give an estimate of the amount of bit-rate required in their country in the all-digital future. Respondents could either give a total number of multiplexes and the DVB-T variant to be used or specify the exact network configuration they foresaw; either way, a simple conversion was made in the analysis to convert these results into a raw number of Mbit/s.

It is recognised that delivering a certain bit-rate to, say, 100% of the population will require much more spectrum than delivering the same capacity to, say, 50% of the population. The analysis attempted to take this into account by multiplying the bit-rate required by each respondent by their estimate of the percentage of the population to be served. Figure 5 shows the results of this analysis. This demonstrates that there is a spread of between almost 300 Mbit/s and around 40 Mbit/s, but most respondents see a need for DVB-T to deliver around 100 – 150 Mbit/s in their country. The dominance of fixed reception is clear and, although some respondents see a need for dedicated capacity for the mobile reception of DVB-T, a greater number see a need for dedicated portable bit-rate. This is significant for the spectrum requirements, as it suggests that a number of countries wish to design and build a network for portable reception, where fixed reception is guaranteed and mobile reception is a fortuitous by-product.

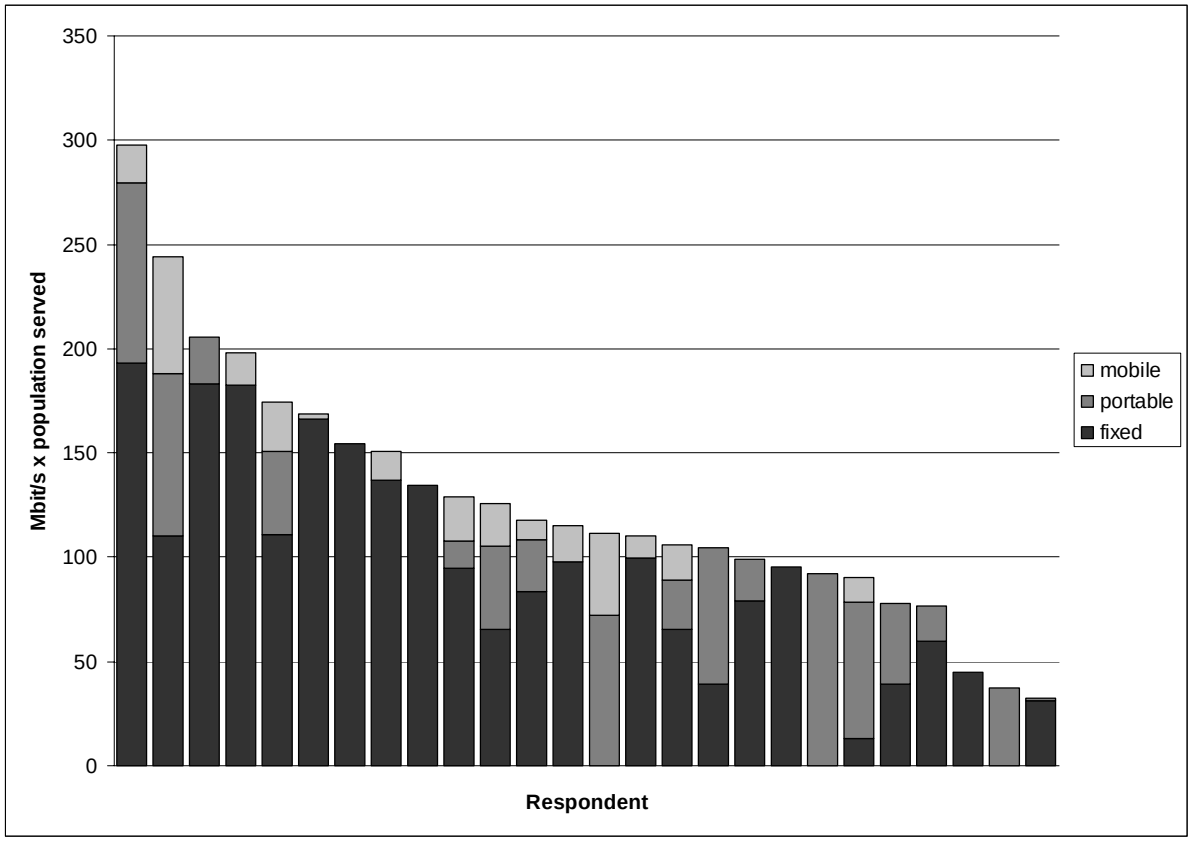


FIGURE 5. Bit-rate required scaled by percentage of population to serve.

CONCLUSIONS

From the results of the questionnaire, it is clear that DVB-T is currently seen as a 'big tent' solution, able to accommodate a wide range of different applications and service requirements. Given the wider ranging possibilities for DVB-T, it is perhaps surprising that there is anything approaching a consensus. But an outline emerges from the mist: the respondents to our questionnaire seem to indicate a preference for a fixed-portable environment, where receiving devices will tend towards large, flat screens, and where the delivery of traditional TV services is of equal importance to the delivery of data services. In general, respondents believe that the network should deliver around 100 to 150 Mbit/s (which is around the same total bit-rate as is currently delivered by on-air DTT networks in the UK and elsewhere).

With the introduction of digital transmission technologies, one might have been forgiven for thinking that the era of spectrum scarcity was over. Instead, the phenomenal growth of mobile telephony in the past few years and the increased hunger for spectrum looks as though it will force spectrum fees higher and cause broadcasters to account for their use of spectrum. Only by capturing service requirements can an estimate of the amount of spectrum required ever be calculated; from the results of the questionnaire, the DigiTAG task group have captured and evaluated a representative set of service requirements for Europe. The environment they present is one which could be implemented, for which serious frequency planning could be undertaken and which offers a sound base for further discussion.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the great debt he owes to the other members of the DigiTAG Task Group on Commercial Aspects of Spectrum Demand.

ANNEX

The following pages are a copy of the presentation given at Broadcast Asia 2002 to support the text in the published paper. The majority of the information on the slides comes from the paper itself, although there are some details which are not covered elsewhere. It is presented for completeness.

Spectrum Matters in the All-Digital Future

Tom Everest
Spectrum Planning Group, BBC Research & Development

Singapore, 19 June 2002

The legacy of analogue broadcasting

- Spectrum scarcity has always been a problem
  - dates back to the birth of broadcasting in the early 1920s
  - BBC began in 1922 with just one 107 kHz band available for broadcasting a service to the entire United Kingdom
    - better than what had been anticipated: the Government had originally offered just one frequency - at 682 kHz - for licensing!
- thus, the model and economics of broadcasting have always been dictated by the availability of spectrum
  - hence (in most countries) heavy regulation and Government involvement
  - and the growth of general entertainment and information services: particularly in the public sector

The analogue environment

- Governments' views about spectrum have changed little since the birth of broadcasting
  - other users and industries have always had need of spectrum
  - incumbent upon them to get the greatest possible benefit from the use of spectrum for the country as a whole
- despite this broadcasters have been allocated significant amounts of spectrum
- **BUT** analogue television broadcasting uses a lot of spectrum
  - necessarily a multi-frequency network if aiming for near-universal coverage with high-power transmitting stations
  - high levels of protection required between co-channel and even adjacent-channel services

The ending of scarcity: DIGITAL!

- Digital broadcasting - especially by DAB and DVB - are more efficient users of spectrum
- Two benefits:
  - allows the same number of services to be offered in less spectrum
    - whilst still maintaining the benefits of going digital (e.g. better quality video and audio, improved performance against multi-path interference etc.)
  - allows broadcasters to better serve their audiences
    - more, better quality services
    - interactive and enhanced data services
  - e.g. BBC's digital television portfolio: eight focussed services, rather than just two general channels

More spectrum, more television?

- All this coincides with the phenomenal growth in mobile telecoms and the pressure from many parts of that industry to release broadcasting spectrum for other users
- Must balance the public's needs/desires for broadcasting with the economic benefit to the government of selling off spectrum

Country	Award date	€/Hz
Australia	April 2001	4.86
Austria	November 2000	4.87
Belgium	March 2001	4.29
Germany	August 2000	348.28
Italy	October 2000	97.28
Netherlands	July 2000	19.26
Portugal	December 2000	2.86
United Kingdom	April 2000	270

Source: DigiTAG

Amounts raised by 3G/UMTS Auctions

The analogue service model

- European analogue television service model is enshrined in the regional spectrum plan prepared at Stockholm in 1961
  - provided (generally) for 4 programme services, each with universal coverage, in each country
  - networks were to be built primarily around a few, geographically distant, high-power stations
- Stockholm 61 turned out to be enduring and flexible
  - for example, UK able to build a large network of low-powered relay stations
  - France able to introduce a further 2 programme services
  - with the addition of the multilateral agreement made at Chester in 1997, it even facilitated the introduction of DVB-T

The need for a digital service model

- Europe - in the shape of the European Broadcasting Area - is preparing for an ITU-R regional re-planning conference in 2004/5
- The Stockholm 61 analogue model only goes so far; in order to get the most from the promise of digital broadcasting, we need an all-digital service model
- Part of the work of DigiTAG's Spectrum Matters Task Group was to consider this digital service model
  - what does Europe want from television in the all-digital future? How do they wish to receive it? On what? Is there consensus?
  - What impact does this have on the amount of spectrum required?

Deriving a model

- It makes little sense to simply and solely define an arbitrary number of multiplexes
  - the flexibility of DVB-T means many different types of service can be included
  - and developments in lifestyle and technology make more applications conceivable
  - ultimately, we will end up with an ideal number of multiplexes, but this is the **result** not the **input**!
  - and the network configuration will define how many RF channels we require
- Boils down to 3 questions
  - **what?** HD? SD? Text? Data? Audio-only?
  - **where?** At home? On the wall? On the move? In your hand?
  - **how?** MFNs? SFNs? 2k? 8k? Data-rate? Return channels?

The questionnaire

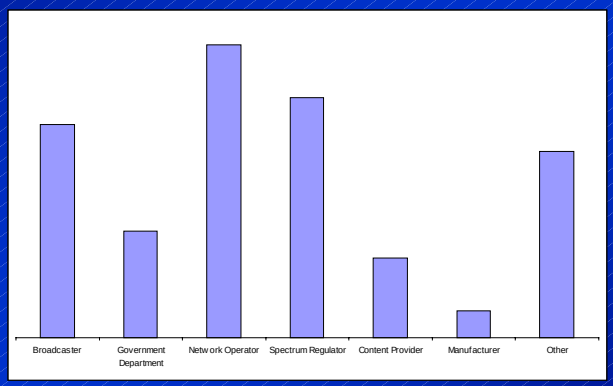
- Devised by the Spectrum Matters Task Group of DigiTAG
- Intended to have a breadth of response
  - pan-European
  - to include manufacturers, broadcasters, network operators, regulators etc
  - considering technical and commercial interests
- Full results and report available to DigiTAG members and will be fed into groups preparing for RRC04/5
- **Not** the intention to find a magic number of MHz required for television in the all-digital future
  - **but** to provide the input to that process

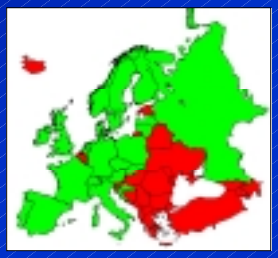
Results: Breadth of response

Organisation type

NB: Respondents could select more than one industry sector

Shows a good level of response from all main types of organisation

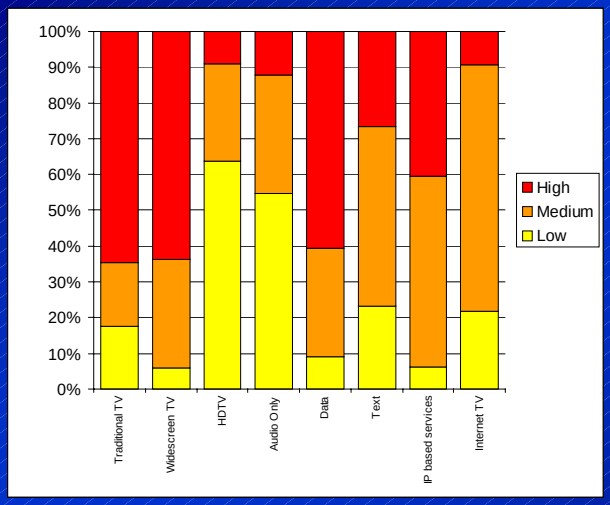




Responding countries

Only one respondent did not give their home country; replies received from across Europe, including Russia

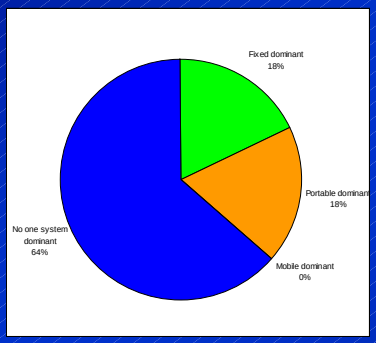
Results: Types of service

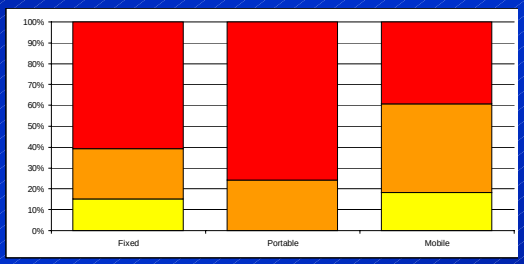


- Only one respondent thought that neither traditional nor widescreen TV were important - choosing solely HDTV as high or medium priority
- Fairly high proportion of respondents attached a low priority to HDTV - although there is widespread support for widescreen
- Low support for audio-only services: perhaps T-DAB will be the digital audio delivery mechanism, not DVB-T

Results: Reception Conditions

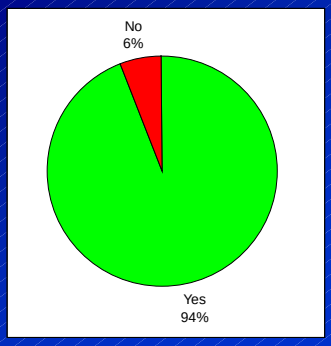
- 15% thought DVB-T to fixed locations was of low priority in the all-digital future, while all assigned some positive need to portable reception



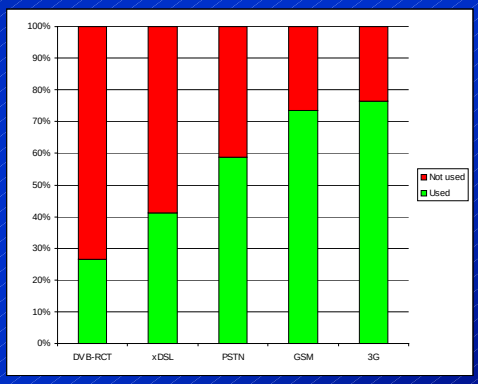


- Have we just found three separate groups of activists or is DVB-T really envisaged as a mixed-mode system?
- Comparing results between questions (left) shows that two-thirds of the sample believe that no one set of conditions will be dominant
- And every respondent who assigned a positive value to mobile reception thought it would be as or less important as fixed or portable

Results: Return Channel Technologies

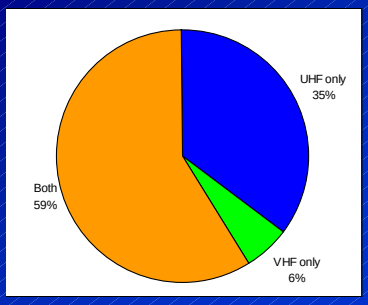


- Overwhelming conviction that a return channel will be needed for DTT in the all-digital future, although which technology is less clear-cut

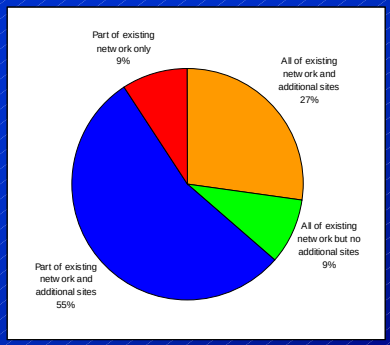


- Broad support for established and emerging mobile telephone technologies and even some support for DVB-RCT
- Trend seems to be consistent between those who rated static and non-static devices highly; suggests that return technologies are not directly influenced by the nature of the display device

Results: Network configurations



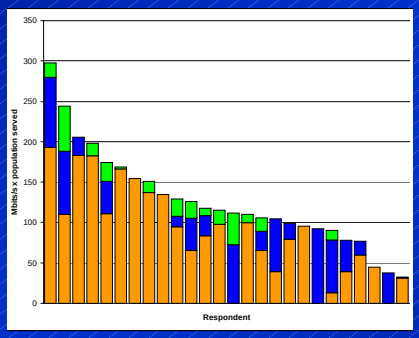
- Results suggest that 6% of respondents envisage only VHF being used for DVB-T in their country
- Does not accord with the known position of any country in Europe, so could be an erroneous result

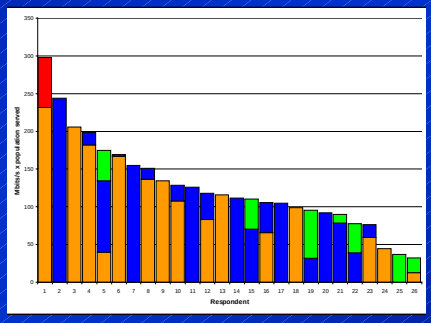


- A clear majority envisage that DVB-T will occupy part of their transmitter network in the all-digital future.
- Over half believe that only part of the existing network will be used but that it will be supplemented by further sites

Results: Bit-rate required

- There is a fair split between use of MFNs and Regional SFNs, although MFNs are marginally more popular.
- The relatively low use of National SFNs is important; perhaps an indication that re-using analogue transmitter networks places a limit on the benefits achievable with an SFN





- It takes more spectrum to deliver the same number of Mbit/s to 100% of the population as to 50%, for instance.
- The charts attempt to take this in to account, by multiplying the bit-rate required by the percentage of the population to be served.

Conclusions

- Clear that DVB-T is currently perceived as a ‘big tent’ solution
  - perhaps, given its flexibility, it is surprising that there is any sort of consensus
- But the questionnaire identifies some trends in thinking
  - tendency to think that the all-digital future will be predominantly fixed-portable, with mobile reception as an added bonus
  - enthusiasm for both large, flat panel screens and small, portable receiving devices
  - desire to deliver around 100 - 150 Mbits/s via DVB-T using either Regional SFNs or a true MFN