OXFORD ECONOMIC RESEARCH ASSOCIATES

EUROPEAN COMMISSION

STUDY ON INTEROPERABILITY, SERVICE DIVERSITY AND BUSINESS MODELS IN DIGITAL BROADCASTING MARKETS

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1. Introduction and Background

OXERA has been commissioned by the European Commission to carry out a study on 'Interoperability, Service Diversity and Business Models in Digital Broadcasting Markets',[1] in order to help inform Commission policy towards digital broadcasting as the sector grows and matures.

Penetration of digital television (DTV) varies considerably across Member States, ranging from 3% of all households in Belgium to 40% in the UK in 2001.[2] In most Member States digital services have initially been introduced by pay-TV operators, with separate free-to-air (FTA) digital services being launched subsequently (so far in only a few Member States).

Pay-TV operators have stimulated the penetration of digital services by subsidising the receiving equipment required by consumers. This is feasible because the pay-TV operator has an ongoing relationship with consumers through subscription charges, and this provides a mechanism for recovery of the initial subsidy. In order to provide this equipment, the pay-TV operator usually has a direct relationship with the device manufacturer, specifying the receiver to match the requirements of their network. However, there is no coordination between different pay-TV operators of the characteristics of the equipment used on the different networks (especially in terms of the embedded application programming interfaces (APIs) used for interactive content). This has resulted in a lack of compatibility between equipment on different networks—that is, any given equipment may not support the interactive services of another platform.[3]

There is a concern that such non-interoperability may be inhibiting the development of the FTA digital sector, primarily by reducing the volume of any particular form of receiving equipment (which in turn impedes the full exploitation of economies of scale in production), and by inhibiting the development of interactive content (non-interoperability at the receiver level implies that re-authoring costs[4] are incurred in using content on different networks).

The focus of this study is to identify the ways in which interoperability could be introduced into the European digital broadcasting market, and to assess the relative merits of the different options that are identified. A further concern relates to the development of horizontal markets for the supply of receiving equipment; these are essential for the penetration of FTA services, as there is no single platform operator that could subsidise or coordinate the provision of equipment to consumers.

[1] See *Official Journal of the European Communities*, Issue S41.
[2] Strategy Analytics, 'Interactive Digital Television, February 2001 Market Forecast'
[3] In fact, for technical reasons, equipment cannot (currently) support any services on a different delivery platform (cable, satellite or digital terrestrial) from that for which it was designed.
[4] The process of translating an existing application from the API in which it has originally been written to another is called 're-authoring'.

On the issues of interoperability and horizontal markets, the study has two aims:

- to consider the issues arising from standardisation and interoperability with respect to DTV, and develop policy options to address any market failures identified; and
- to assess objectively the trade-offs involved in promoting horizontal markets.

The study aims to determine the extent to which the *market* may be expected to deliver these two outcomes. In the absence of a market-led introduction of, or progress towards, interoperability and/or horizontal retail markets, the study will present possible policy options/initiatives. The study provides an economic analysis of these issues in line with the Terms of Reference for the project specified by the Commission Services. As such, the study does not make policy recommendations, but presents a variety of options that may be adopted. Of particular relevance for the Commission Services in determining its policy approach are Article 18 and Recital 31 of the Framework Directive (see below) that require the introduction of some form of interoperability. The analysis contained herein contributes towards policy formation in this area, without providing definitive conclusions on the policy that should be adopted.

With respect to the delivery of a wide range of products and services (notably different displays and receivers), the study's objective is to analyse current delivery mechanisms within DTV, and to suggest some policy options to overcome the identified difficulties.

1.1 Background and context of the study

This study fits within the framework of European Union (EU) policy with regard to television standards and the electronic communications sector. Additionally, it sits within the general context of EU policy objectives with respect to: convergence and technological progress; the Information Society; and other areas such as spectrum management and competition issues. In this sub-section, the background to these objectives and the role that interoperability and horizontal markets play within their delivery are explained. Some of the terms used throughout the report are also defined.

1.1.1 Broadcasting policy

Digital services began to be rolled out in the second half of the 1990s. The regulatory framework was provided by the TV Standards Directive 95/47. This Directive was specifically aimed at promoting the development of advanced (ie, digital) television services in the EU. The intention was the establishment of a regulatory regime adapted to the start-up phase of new DTV services, while also providing adequate continuity with the earlier regulatory environment for advanced television services based on analogue technology.[5]

[5] This Directive was part of the policy shift away from high-definition television in the early 1990s, and was complemented by the Widescreen Action Plan.

The Directive's measures fell into three main categories: analogue legacy standardisation measures; measures covering analogue and digital systems; and measures for DTV. The measures for DTV relate to the requirement to use standards for transmission, establish a regulatory framework for conditional access (CA) (simulcrypt and multicrypt were defined as acceptable ways of achieving interoperability of CA), and ways to prevent the abuse of a dominant position with respect to a conditional access system (CAS). In order to prevent abuse of dominance, CA must be made available to all broadcasters on fair, reasonable and non-discriminatory (FRND) terms.[6]

The Directive therefore provided a neutral regulatory framework for the introduction of DTV services, focusing on CA issues. Interactive services and interoperability of APIs were not a focus of the debate at the time, and so were not a feature of the Directive.

In recognition of the growth and economic potential of the digital economy, and of the changing market place, a new common regulatory framework for the electronic communications sector has been developed. The aim is for this common regulatory environment to harmonise regulation of converging networks and services across the EU. The new framework comprises six Directives and a Decision. Five of the Directives were formally adopted in February 2002: the Framework Directive,[7] the Authorisation Directive,[8] the Access Directive,[9] the Universal Service Directive[10] and the Directive concerning personal data and privacy in the sector.

The Framework Directive makes reference to digital broadcasting and to interoperability with respect to digital interactive services. Specifically, Recital 31 is about achieving interoperability[11] of digital interactive services and STBs, which is facilitated through open APIs. Article 18 then notes that Member States should encourage the use of an open API by providers of digital interactive television standards and by providers of all enhanced DTV equipment; and that proprietors of APIs make available the information necessary to allow third parties to provide services supported by the API on FRND terms.

This encourages an industry-led approach to standardisation and interoperability, but Article 18 allows the Commission to impose a standard or specification if it perceives that interoperability and freedom of choice for users have not been adequately achieved (through an open API) in one or more Member State within a year of application of the Framework Directive. However, recognising the difficult trade-offs involved in setting such standards where technology is uncertain and markets are not well established, the

[6] European Commission (1999) 'The Development of the Market of Digital Television in the European Union', COM(1999)540.
[7] Directive 2002/21/EC.
[8] Directive 2002/20/EC.
[9] Directive 2002/19/EC.
[10] Directive 2002/22/EC.
[11] Defined as 'portability of interactive content between delivery mechanisms, and full functionality of this content on enhanced digital television equipment'.

Directive allows for 'the need not to hinder the functioning of the receiving equipment' hardware to be taken into account.

1.1.2 Other policy initiatives

Digital convergence refers to the breakdown of the traditional separation between voice, visual and imaging data, as the multi-media environment develops. This is increasingly possible due to digitisation of content such that the transmission and reception media are indifferent to the type of information carried (ie, binary-encoded information). Convergence will mean the ability to deliver outputs from traditionally separate sectors—audio-visual, telecommunications and information technology—over the same types of terminal.

Progress on information and communication technologies provides opportunities for social and economic development, and this lies at the heart of policy goals related to the Information Society. There are significant challenges, as exploitation of technological progress is uneven and inconsistent between and within regions and/or countries, leading to greater inequality in access to the opportunities afforded by technology and a deepening 'digital divide'. Policies and strategies for the development of the Information Society for all therefore need to be carefully structured and closely monitored.

The Barcelona Council in March 2002 thus noted that 'technological convergence affords all business and citizens new opportunities for access to the Information Society. DTV and third generation mobile communications (3G) will play a key role in providing widespread access to interactive services.' It then went on to encourage the Commission and Member States 'to foster the use of open platforms to provide freedom of choice to citizens for access to applications and services of the Information Society, notably through DTV, 3G mobile and other platforms that technological convergence may provide in the future'.[12]

DTV, and the potential for the interactive services that it may deliver, fits neatly into this agenda. Indeed, DTV is perceived as a tool for the dissemination to all of more information (ie, access to new and innovative services), as well as access to existing services in new and innovative ways. The use of the television, in an environment of convergence, to deliver Information Society services such as the Internet and '*e*government' to those without such access is clearly one of the ideas behind the Barcelona Council's conclusions.

The importance of achieving the Information Society within a framework of convergence and technological progress is not the only pressure towards digitisation. Other factors include, for example, more efficient and effective use of spectrum (ie, allowing more information to be broadcast as a result of digital compression techniques and reallocating spectrum that is freed up by the transition to digital), and significantly reduced

[12] Barcelona European Council, Presidency Conclusions, paragraph 40, available at http://ue.eu.int/en/Info/eurocouncil/index.htm.

transmission costs for broadcasters.[13] Both these factors should lead to enhanced competition. The move to digital also allows for a boost to the consumer electronics manufacturers, in terms of both innovation in retail equipment and volumes, as individuals invest in new, digital equipment.[14]

The delivery of more and new content and services as broadly as possible *requires* digitisation:

- large volumes of material cannot be made available in an efficient and effective manner over an analogue network;
- the efficient delivery of interactive services requires digitisation; and
- by lowering barriers to entry, digitisation increases the competitive pressures within broadcasting, thereby helping to ensure the delivery of innovative content.

Achieving very high digital penetration requires that *all* consumers have a digital decoder of some form in their home. In light of the fact that the pay-TV operators, who have driven digital penetration in many instances, are likely to reach a level of maximum penetration that falls short of full digital take-up, digital switchover must ultimately be achieved within an FTA framework. There are various ways to achieve this:

- decoders are provided to consumers directly;
- consumers are required to purchase a decoder (eg, as a direct result of analogue switch-off); or
- consumers have the option to purchase a digital product and choose to do so.

As outlined in section 2.4.2, the former option is unlikely to arise within an FTA environment. Of the latter two, the final option of consumer choice is preferable to mandating, and this study seeks to elucidate how to encourage such an outcome. For consumers to engage with the digital market, FTA digital services must provide an attractive, differentiated product from existing television services in order to encourage consumer investment. In addition, the delivery of such content is encouraged by broadening the market available to content producers; one of the potential ways of doing this is through greater interoperability. Given that there are limited incentives for FTA broadcasters to subsidise receivers, a viable horizontal market for receivers must also exist.[15]

[13] Digital production costs are lower, and costs will fall as the need to simulcast reduces owing to the spread of digitisation.
[14] BIPE (2002), 'Digital Switchover in Broadcasting', April.
[15] Pay-TV platform operators have been able to participate extensively in encouraging penetration since their business model allows for a continuing financial relationship with the customer. This enables a sharing of the risks of investment with the viewer. These issues are considered further in section 2.4.

1.2 Some important definitions

A glossary of terms and terminology is included at the end of the document. However, given the emphasis placed on horizontal markets and interoperability, it is useful to define these clearly at the outset.

1.2.1 Horizontal markets

A number of markets can be identified in digital broadcasting, including retail distribution of broadcasting services, programme or channel content, consumer premises receiving equipment and interactive services. This study is concerned with the market to supply the consumer retail equipment associated with digital broadcasting services.

A *horizontal* market is defined in this context as competition between manufacturers to supply equipment directly to consumers (albeit normally through third-party retail outlets), rather than consumers being provided with their equipment as part of a bundled tariff arrangement with a pay-TV operator. The present study is therefore concerned with encouraging a market for digital receiver equipment, which includes STBs, i-DTVs, STB-personal video recorders (PVRs), widescreen TVs, and multimedia PCs.

There are also issues relating to the standards that are used to provide equipment in the horizontal market—in particular, whether they are 'open'. In this report an *open* standard is defined as one for which the specification is available to third parties to use either without restraint or under a reasonable licence arrangement.[16] This implies that an open standard may also be proprietary, and users of the standard may or may not be charged a licence fee.

In principle, the owner of a proprietary standard can develop the standard as they see fit, without regard to the end-users. *In extremis* such proprietary ownership can be used for anti-competitive means. However, unless the owner of the standard is integrated into applications development and produces a very broad range of applications, there is little incentive to create technological barriers to use of the standard. This is because there are network effects in the use of the standard, and the benefits accrue to the standard owner the more users there are.

On the other hand, developers of proprietary standards have an incentive to make their standard non-interoperable in order to benefit from these network effects in terms of acquiring more users of their technology. This would need to be taken into account by regulatory authorities when determining a potential common standard.

1.2.2 Interoperability

The focus of this report is the establishment of receiver populations. To this extent, the definitions of interoperability used relate to the operation of receiving equipment between

[16] There are a number of different definitions of what constitutes an open standard. This operational definition is used because it captures the essential requirements as they impact on interoperability.

networks over delivery platforms. However, notwithstanding the definitions below, if content were to be considered as the focus for interoperability, then re-authoring would be an alternative solution to options delivering compatibility between APIs. If such a definition were adopted, it could be considered that there is already interoperability, as re-authoring content does occur in the market at the moment. In this context, the non-intervention option (option 1) specified in section 5 provides the relevant analysis and policy solution.

Interoperability of consumer hardware refers to the situation where a consumer's digital receiver device is able to decode and descramble, where authorised, all digital interactive services that are potentially available to that consumer. Interoperability requires compatibility across interactive digital services and applications that require consumer-side middleware to support them.[17] Where middleware only supports applications written specifically to it, and assuming there are several middlewares in use in the market, there will be a lack of interoperability. In these circumstances, a decoder may only support the services and applications that are written to its specific middleware, meaning that the consumer may not easily switch between service providers who use different middleware.

There are different levels of equipment interoperability:

- intra-platform interoperability;
- inter-platform interoperability; and
- geographical interoperability.

These three are related. The first is required for the latter two to exist. Other aspects of these types of interoperability are considered below.

Intra-platform interoperability

This is where a consumer may receive (ie, using the same decoder) digital broadcast content and services that are broadcast by different (potentially competing) operators from the *same* platform type (eg two satellite broadcasters). This kind of interoperability would require a digital receiver relating to any one platform type to be able to understand and support the viewing, interactive applications and Internet service of all the operators on that same platform.

The main advantage of intra-platform interoperability is that it would allow for more (national) competition where more than one operator may operate on a common platform. Where there are regional cable operators, it has the additional benefit that it would ease the transition from one network to another—for example, when moving house. Other than

[17] Middleware is non-operating system software that exposes APIs to applications developers. In the context of digital broadcasting, the terms API and middleware are used interchangeably.

the latter, these benefits are contingent on there being competition between service providers over the same network.

Inter-platform interoperability

This is where a consumer may receive digital broadcast services that are transmitted over *different* delivery platforms (eg, satellite, cable or terrestrial), subject to the appropriate network connection equipment being installed. This would require a digital receiver to be able to understand and support the viewing, interactive applications and Internet services of all the operators on all the different platform types. One of the main technical issues in this context is that each platform uses a distinct transmission band and modulation scheme, and hence each would require a different tuner in the receiver. Therefore until multiple tuners are incorporated into receiving equipment, inter-platform interoperability will necessarily be limited.

Inter-platform interoperability could allow for (national) competition between all platform operators, by facilitating the move across platforms. It could also allow operators to develop, and consumers to take advantage of, bespoke or à la carte services. That is, consumers may be able to select their preferred content from the different platforms available to them, effectively creating their own DTV package. In the case of FTA content, this benefit is considerably easier to achieve as there is no need for contractual arrangements to be entered into with a content provider.

Geographic interoperability

This is where a consumer may easily receive digital broadcast services (intra- and/or inter-platform) with the same receiver equipment, on crossing national borders.[18] The advantages would be similar to those outlined above in intra- and inter-platform interoperability, but would apply to a Europe-wide market. This would have particular implications for those moving country, for manufacturers of consumer equipment who would only need to comply with one set of standards, and for content providers, as it would effectively limit the need for re-authoring.

1.3 Methodology and outline of the study

There are two key outputs from the report:

- a set of evaluated policy options/initiatives, designed to encourage horizontal markets and interoperability. The policies/initiatives are evaluated in two ways: against these goals and against the EU policy objectives;
- a range of options is put forward to correct for market weaknesses or failures with respect to the delivery of a diverse range of digital services. This focuses on different television display formats and digital audio broadcasting.

[18] The issue of accessing ‘foreign’ content is not addressed here, since it is tied up with intellectual property rights (IPR) issues. Geographic interoperability refers only to the possibility of moving countries and using the same digital receiver.

There were three principal stages to the development of the analysis in this report:

- background research;
- identifying the options and developing the framework for their evaluation; and
- evaluating the policy options.

Research into five issues was carried out, to inform the policy analysis for each of the key outputs from the report detailed above:

- EU policy objectives;
- technical issues;
- industry and market environment—including a consultation process designed to elicit input from across the industry (including consumer bodies) on the relevant issues of standardisation, interoperability and horizontal markets;
- lessons from economic theory; and
- comparative case studies—ie, experience in other, similar, network industries, and experience from Australia and the USA.

This research, together, provided the building blocks for stage two: identifying the feasible policy options (both technical and commercial),[19] and developing a framework for evaluating them (ie, defining the evaluation tool).

The final output (the evaluated policy options) was developed in stage three by applying the evaluation tool to the set of feasible policy options. Each option was assessed against how well it meets the goals of the study (interoperability and the encouraging of horizontal markets). It was then assessed to establish whether it also meets the general EU policy objectives. In this way, the trade-offs implicit between various policy options can be understood, providing the EU with a means for selecting regulatory or promotional initiatives that meet its goals.

Issues beyond the scope of the study include: the question of content regulation and its effect on the penetration of digital services; the recommendation of any particular technical solution (eg, the appropriate middleware standard); and the promotion of the interests of EU business in global markets.

This report is in two volumes: Volume I provides the evaluated policy options for achieving interoperability and/or horizontal markets, with summarised supporting evidence and the analysis of the building of digital receiver populations more generally. The supporting evidence itself is contained in detailed appendices in Volume II.

[19] Note that the issue of legal feasibility is beyond the remit of this study, and that the European Commission may take action in accordance with the procedure laid down in Article 17(3) and (4) of the Framework Directive.

In this first volume, section 2 provides an overview of the development of digital markets, building on the understanding of the current market participants, the likely incentives arising from economic theory, and analyses of the development of standards in other technology markets. It results in the derivation of parameters that characterise the important attributes of digital broadcasting. These parameters constitute the evaluation tool.

Section 3 describes the evaluation process in detail, relating the goals and objectives of the study to these parameters. Section 4 benchmarks the goals of interoperability and horizontal markets, and the EU policy objectives in this area against the parameters. Section 5 outlines the policy options, identifying how well they deliver the parameters and the likely impact on the different stakeholders. In section 6, the options are evaluated using the parameters to provide a comparative measure of each option's performance against the individual goals and objectives. This allows an examination of how well the options meet the goals of the study and the EU's objectives, and highlights any trade-offs required to achieve these outcomes.

Sections 7 and 8 present the issues and recommendations with respect to the build-up of other screen format receiver populations, and penetration with respect to digital radio (DAB).

A separate appendix, Volume II, is devoted to each of: the economic literature (Appendix 1); an overview of DTV and business models in Member States (Appendix 2); experience in other network industries (Appendix 3); and experience in the USA and Australia (Appendix 4).

2. Market Overview

This section presents an economic analysis of the development of digital broadcasting in the EU, drawing on the main areas of research that were undertaken for this study. In particular the issues covered are:

- the nature of digital services;
- an analysis of the market for these services (including the market structures through which they are provided);
- the implications of DTV technology for the development of the digital services market; and
- a summary of the economic theory that is applicable when considering the DTV market.

These aspects are all drawn together in the final section (section 2.6), which identifies a number of important factors that affect the development of interoperability and/or horizontal markets in European digital broadcasting. These factors are used as parameters in the mechanism that is used to evaluate the policy options; they provide a means of benchmarking both the goals and relevant policy objectives and the identified policy options, to facilitate an evaluation of the latter against the former. The evaluation process is described in detail in section 3.

2.1 Digital broadcasting—characteristics and development

The development of a digital broadcasting and communications infrastructure has the potential to deliver both increased numbers of, and more diverse, services to consumers compared with analogue communications infrastructure. In particular, digital infrastructure can:

- deliver more content within any bandwidth constraint, through the use of compression techniques (eg, around six channels of digital broadcast television for each one channel of analogue television);
- provide interactive services and allow for user intervention in tailoring the services they receive (difficult, if not impossible, using analogue infrastructure); and
- be linked to other digital infrastructure (eg, the Internet) and deliver new services, or provide alternative delivery of existing services.

The *potential* that arises from digital infrastructure is very broad, and includes new ways of delivering government services, new forms of citizen-to-citizen interaction, as well as better (technical) quality and quantity of more traditional broadcast services. The value of these services, especially if access to them is widely distributed, is likely to be very high.

However, there are some problems that have to be overcome in order to deliver these services. In particular, the technical sophistication of the infrastructure (that is used to deliver even quite simple services, including linear broadcasting) means that each consumer requires more advanced receiving equipment in order to receive the available content and services. Such equipment needs to be configured so that it coordinates with the technical characteristics of the network on which it operates, and this requirement in itself introduces the potential for the coordination to fail, thereby disrupting the service delivery to individual consumers.

Digital networks involve a significant upgrade of the network infrastructure[20] and consumer equipment, which may be relatively costly. However, digital networks also deliver discrete advantages over analogue, such as greater capacity and technical functionality. As a result, there is a cost–benefit trade-off between analogue and digital services for network operators and potentially also for consumers.

There are a number of generic functions, which are common across all platforms, that receiving equipment must be able to carry out in order for consumers to view digital signals (although there are also many differences in detail between platforms). The technology currently in use requires that each consumer's equipment must have the capability of tuning to the broadcast frequency, decoding the digital transmission, and, where subscription services are involved (and sometimes for FTA services as well), must incorporate a CAS to unscramble the service. In addition, the equipment must contain, inter alia, an API in order to receive (and successfully display) interactive applications and services (see section 2.2.2 for a full discussion of APIs). Successful service delivery (and display on the screen) requires that the STB (or equivalent) is able to interpret the broadcast stream. For example, to display audio-visual content, the STB must have the correct frequency demodulation capability for the *specific* signals broadcast and probably also the CAS used by the broadcaster.

This receiving equipment is usually in the form of an STB that fits between the source of the broadcast signal (eg, aerial, cable, satellite dish) and the television (or other display device), although such functionality could be equally well integrated into a television set (an iDTV), a video recorder (eg, a PVR) or a computer.[21]

Many of the aspects of the manipulation of digital signals required for linear broadcasting have been standardised in Europe. As a result, a significant proportion of the component elements of the digital STB is already common across Europe. Although the CAS is not standardised *per se*, there is some basis for interoperability through the combination of establishing a common scrambling algorithm (CSA), commercially negotiated simulcrypt and a common interface allowing for different CA modules to be used in the same STB. However, the APIs required for running interactive and other non-linear broadcast services are not standardised at all.

Different broadcast networks use different CAS and different APIs; these are discussed in more detail in section 2.2.2. As a result, an STB that can be used in conjunction with

[20] The degree of cost increment in moving from analogue to digital is dependent on the type of platform concerned. It is generally most expensive for cable networks where the entire cable infrastructure must be upgraded. Satellite is usually relatively less expensive, as the replacement of equipment is more limited (but will include the satellite transponder).

[21] Throughout this report, the term 'STB' is used to indicate the functionality described in this paragraph. It does not specifically refer to a set-top box, but to any device that incorporates the functionality that is embodied within a set-top box. To this extent, it refers equally to an iDTV or PVR as to a set-top box per se.

broadcast services (including interactive services) delivered over one network may not be able to operate in conjunction with services delivered over a different network. That is, an STB may not interoperate with services specified for different networks, or in some cases even with different interactive applications written in the appropriate resident API.

2.1.1 Benefits of digital services

As noted in section 1, there are strong incentives at the EU level to encourage digitisation across Member States. Given the fact that, even for linear broadcasting, consumers and network operators are required to make additional investments in digital equipment, the key to a successful transition to digital broadcasting infrastructure lies in creating a market for the digital services. In effect, this will involve convincing consumers of the intrinsic benefits that switching to digital can bring.

In terms of the audio-visual offering, the compression techniques allow more than 600 channels to be transmitted digitally (both FTA and pay-TV).[22] This additional channel capacity facilitates the delivery of a wider variety of channels that are more likely to match any particular consumer's requirements. These channels need not deliver traditional linear broadcast content; content could be near-video-on-demand (NVOD) (or even full video-on demand, VOD), or pay-per-view (PPV) events.

Furthermore, interactive services that combine traditional television viewing with the active-user experience more typically found through the Internet or PC are becoming increasingly available on digital platforms. Interactivity implies a significant change from the historical model of television passively delivering linear content into consumers' homes. Potentially, it can provide a greater variety of services, more information, consumer participation, content on demand, and can also facilitate two-way communication. The interactive services now being developed build on the interactivity that has been delivered to the homes of consumers in Europe for many years, in the form of Teletext.

Interactive television may be broadly divided into two groups, according to the nature of the interactivity, although there is no hard and fast dividing line between the two:[23]

- **enhanced programming**: interactivity is associated with the programme or advertisement. Examples of enhanced programming include the ability to place bets relating to the content being viewed, choose the camera angle in a sports match, or play along with a quiz game. A return path may or may not be required; those services or applications that do not require a return path are sometimes referred to as 'locally interactive';

[22] BIPE (2002), 'Digital Switchover in Broadcasting', April.
[23] Some definitions use a more technological basis: enhanced services are defined as those not requiring a return path (ie, all the necessary information is broadcast); and interactive services as those that do require a return path.

- **interactive services**: these are services that operate independently of broadcast content, such as news and information services and games. Examples of the services currently available include detailed programme schedule information (ie, an electronic programme guide, EPG),[24] and access to 'walled gardens' (a controlled number of retail or other 'sites', often based on Internet content). In addition, interactive software facilitates the delivery of content in a variety of purchase formats, such as PPV, VOD or NVOD. As with enhanced content, a return path is not necessarily a component of an interactive service.

The appropriate signals and content that are needed for the interactive application are transmitted in parallel with the broadcast stream if the application is based upon audio-visual content. If the interactive application is an independent service (a game or information channel, for example), the transmission of the content and instructions is stand-alone, and the STB downloads the application in response to a command (via the remote control) from the viewer. Either way, broadcasting interactive applications use up bandwidth. Therefore, the impact of transmitting interactive applications will depend on the bandwidth capacity of the particular platform. For example, terrestrial transmission is typically more bandwidth-constrained than satellite transmission, so a particular application would use *proportionately* more bandwidth on terrestrial than satellite. At the other end of the broadcast stream, a receiver requires some minimum level of computing power, memory and ability to generate computer graphics in order to run interactive applications, making it a more 'intelligent' device than an analogue receiver.

The most successful enhanced programming or interactive services to date include sports programmes and gaming (either stand-alone games channels or enhanced TV shows, where the viewer can play at home); gambling has also been successful, where regulation allows it. However, as noted in section 2.4.1, platform operators have not managed to identify enhanced or interactive content that has generated significant revenues, and there are few, if any, successful commercial business models.

2.1.2 Delivering digital services

Digital broadcast services are most commonly delivered over cable, satellite or terrestrial 'platforms'; however, technological advance will make digital subscriber line (DSL) platforms a commercial possibility in some countries (eg, UK) in the very near future, if not already.[25] Multi-channel, multi-point distribution system (MMDS) networks are a further possibility in some areas. Each network platform, while often offering essentially similar services, differs in its characteristics and performance. In particular:

[24] An application which relays information on the specific potential programming that is available to the viewer.
[25] For example BSkyB recently acquired a local delivery licence for broadcast DSL services, and it is currently experimenting with such services in Kingston upon Hull in conjunction with Kingston Telecom.

- each platform type requires a different diffusion technology,[26] and therefore the receiving equipment for each platform requires a different tuner. These differences relate to the fundamental characteristics of the diffusion medium and/or technology used, so some duplication would be required if consumer equipment were to work with more than one platform type;

- the different platforms offer different possibilities for a return path (as noted above, this may be necessary for interactive services). Terrestrial and satellite platforms cannot provide the return path over the broadcast network infrastructure, so must use the fixed-telephone network with the appropriate modem in the STB; cable requires a cable modem if it is to take advantage of the capacity of the cable network infrastructure. For other technologies, particularly DSL, the return path is an intrinsic part of the network infrastructure architecture; and

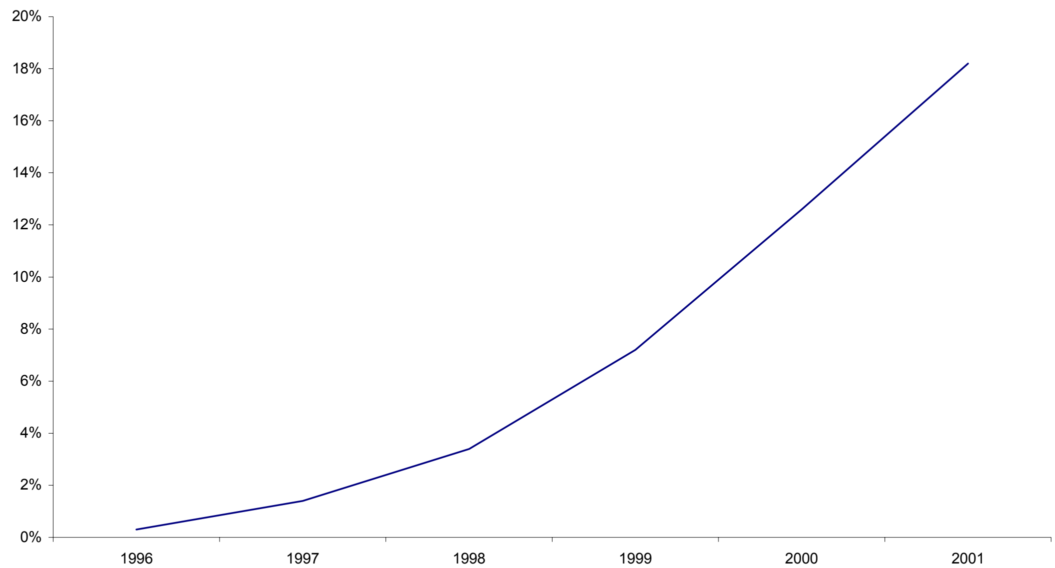
- terrestrial broadcast networks are typically more bandwidth-constrained than either cable or satellite, but are the most appropriate medium for potential mobile services.[27]

2.1.3 Current development of European digital markets

The first digital broadcast service was commercially available in France in 1996 over satellite. However, the market really started to expand in 1998 when several countries launched digital services. The following graph shows the growth of digital penetration across Europe since 1996.

[26] A satellite diffusion channel requires QPSK demodulation; digital terrestrial television (DTT) uses COFDM; and cable requires QAM. In cable, the modulation frequencies used for the upstream and downstream channels are different (QAM 64 or QAM 256 for downstream; QAM or QPSK for upstream).
[27] The COFDM technology in DTT can be used so that it is robust to motion of the receiver.

Figure 2.1: Digital penetration rates in Europe since 1996



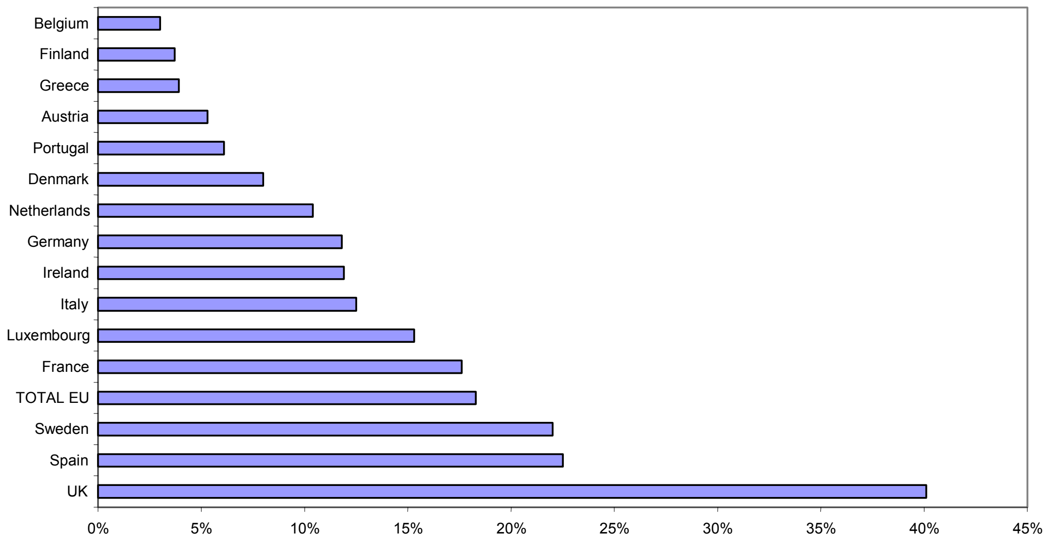
Note: 2001 is a forecast.
Source: Strategy Analytics, 'Interactive Digital Television–February 2001 Market Forecast'.

Penetration accelerated in 1998, possibly because this was the year that digital services began in the UK, which is now Europe's largest DTV market, accounting for 36% of all digital homes in the EU in 2001. The next largest markets, France and Germany, account for almost 16% each.[28]

Figure 2.2 illustrates household digital penetration rates by Member State for 2001.

[28] BIPE (2002), 'Digital Switchover in Broadcasting', April.

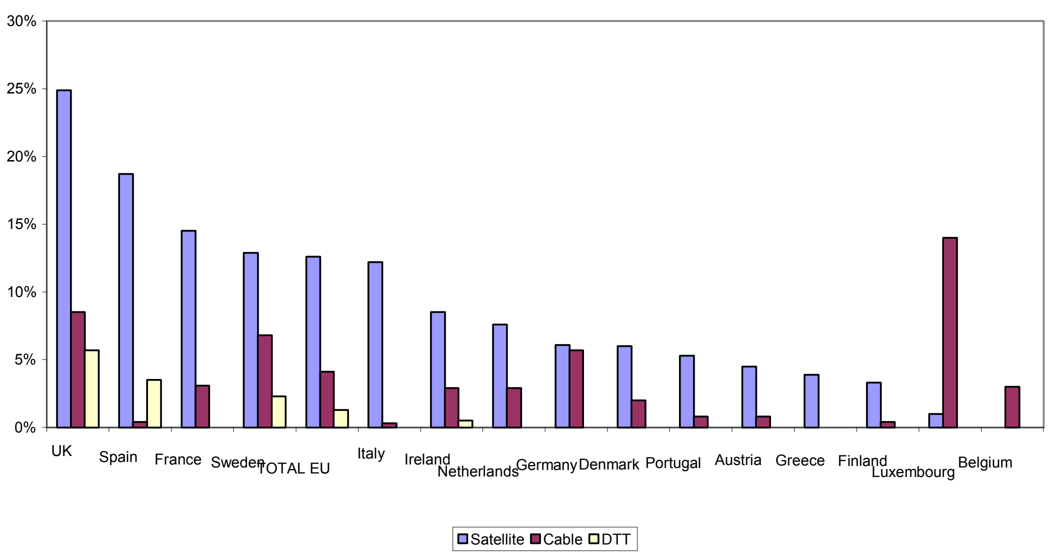
Figure 2.2: Digital household penetration rates by Member State, 2001



Source: Strategy Analytics, 'Interactive Digital Television, February 2001 Market Forecast'. Except Denmark: 'Gallup Annual survey week 31–48 2001'; and Luxembourg: 'Jupiter MMXI DTV Forecasts, 2/02' (western Europe only).

Digital penetration has been led by the satellite platform, but, over time, digital services have also become available through cable and terrestrial means. Figure 2.3 shows that at least one digital service is now available in all Member States. Nonetheless, satellite continues to dominate the digital offering, with 70% of viewers across the Member States.

Figure 2.3: Digital household penetration rates by platform, by Member State, 2001



Source: Strategy Analytics, Interactive Digital Television, February 2001 Market Forecast. Except Denmark: Gallup Annual survey week 31–48 2001; and Luxembourg: Jupiter MMXI DTV Forecasts, 2/02 (western Europe only).

Despite the apparent range of digital offerings indicated in Figure 2.3, the availability of DTT services in particular remains patchy, following the collapses of ITV Digital in the UK (although this has been replaced by an FTA-based service, Freeview) and of Quiero in Spain. Services remain in Sweden and Berlin, but many other countries, while planning for a DTT service, are still some way from implementation.

In order to receive digital broadcasting services, consumers have to incur additional expenditure, either in the form of an ongoing pay-TV subscription or through the purchase of receiving equipment for an FTA service. However, most consumers in Europe already have access to analogue FTA broadcasting for which they pay relatively modest amounts (if anything), so the decision to invest in digital will be driven by the *additional* net benefit (taking into account the additional costs) that consumers gain from the digital offering. This additional benefit depends positively on the range and diversity of the new digital services offering (including interactive services) and negatively on that of the *current* analogue content. (The more analogue content there is, the lower is the incremental benefit of switching to digital.) Both of these vary considerably across Member States.

In terms of historical (analogue) television offerings, Member States fall broadly into two groups: those where there have been multiple channels (typically FTA) delivered over the analogue broadcasting infrastructure to a large proportion of the population, and those where the analogue offering has in general only been limited to a small number of channels (again, typically FTA). Countries that have had multiple channels available include Austria, Belgium, Denmark, Finland, Germany, Greece, Italy,[29] Luxembourg, the Netherlands, Sweden and Ireland. Countries that historically have not enjoyed access to multiple FTA channels include France, Portugal, Spain, Sweden and the UK.

Countries where there has been no FTA multi-channel content provision have developed differently from those with a greater range of analogue channels. In the former case, consumers had an unfulfilled demand for greater range of television channels, resulting from the scarcity of FTA channels. As the technological feasibility of delivery infrastructures, along with practicable CAS developed, pay-TV operators introduced services to meet this need. In general, therefore, it could be expected that those countries with a low level of FTA content would have a higher rate of pay-TV penetration than those where there was already access to multiple FTA channels. Table 2.1 bears out this description reasonably well.

[29] Both Greece and Italy can be classed as ‘near-multi-channel’, due to the large supply of terrestrial FTA programming. BIPE (2002), ‘Digital Switchover in Broadcasting’, April.

Table 2.1: Pay- and digital television penetration rates by Member State

	FTA multi-channel?	Pay penetration (%)	Digital penetration (%)
UK	N	40.0	40.0
France	N	34.0	18.0
Spain	N	27.0	27.0
Portugal	N	26.0	6.0
Ireland	Y	n/a	12.0
Luxembourg	Y	17.0	low
Italy	Y	12.6	12.0
Sweden	Y	11.5[1]	22.0
Germany	Y	10.0	12.0
Greece	Y	10.0	4.0
Belgium	Y	8.6	5.0
Denmark	Y	8.3	8.0
Finland	Y	5.0	4.0
Netherlands	Y	4.6	10.0
Austria	Y	3.6	5.0
Average		**15.1**	**13.2**

Notes: Pay-TV penetration rates are for 2000; digital television penetration rates are estimates for 2000. [1] Estimate.
Source: BIPE (2002), op. cit.

On the whole, countries without a multi-channel FTA background have a higher than average pay-TV penetration rate, while those with multiple FTA channels available have a lower than average pay-TV penetration rate. One exception is Luxembourg, which has a higher than average pay-TV penetration rate, even though it has multiple FTA channels available.

Furthermore, pay-TV operators are best placed to launch digital services and ensure that they are successful. As the benefits of using digital rather than analogue broadcasting include the ability to broadcast more channels and additional services, pay-TV operators have a clear incentive to switch to digital in order to exploit these opportunities. The digital infrastructure enables operators to provide greater value to subscribers, but also facilitates the development of different revenue streams in addition to linear broadcast content. In addition, as will be discussed in section 2.4, individual pay-TV operators control their entire network infrastructure, and are thus less likely to face the coordination problems encountered by FTA channel providers in moving to digital.

Pay-TV operators also have an ongoing relationship with their customers (subscribers) that involves payment for content received. This provides a mechanism for subsidising consumer receiving equipment and recovering this cost over time through the subscription charges. Being able to supply consumers with a digital STB for zero (or very low) up-front cost overcomes one of the major impediments to digital take-up. FTA operators do not have the same relationship with viewers, so an equipment subsidy is not feasible (unless funded by an external body such as the government). These issues are considered in more detail in section 2.4.

This analysis suggests that countries with established pay-TV operations would be more likely to convert to digital. Again, Table 2.1 indicates that this is largely borne out by experience to date.

Countries with a higher than average pay-TV penetration rate (linked to the absence of multiple FTA channels) also tend to have higher than average digital penetration rates. Similarly, where the penetration of pay-TV is lower than average, the penetration of digital is also below average. The clear exception is Portugal. Portugal has a lower than expected digital penetration rate, given the high pay-TV penetration rate and the lack of multiple FTA channels. This is probably because both sectors (pay and digital) are relatively young in Portugal. In particular, the cable networks remain predominantly analogue and the satellite service was only launched in 1998, albeit as a digital network.

Although not a perfect explanation of the stylised facts, this general logic does appear to be useful in explaining the difference in digital penetration rates across Member States. First, there is a relationship between ‘thin’ analogue offerings and pay-TV penetration, and then there is a link between the penetration of pay-TV and digital take-up. National broadcasting markets with substantial FTA services (commercial channels and/or public service broadcasters, PSBs) have not in general experienced the same digital penetration as those markets where the transition to digital has been driven by a pay-TV operator. What appears to lie behind this outcome are the *relative* costs and benefits of digitising the broadcasting infrastructure.

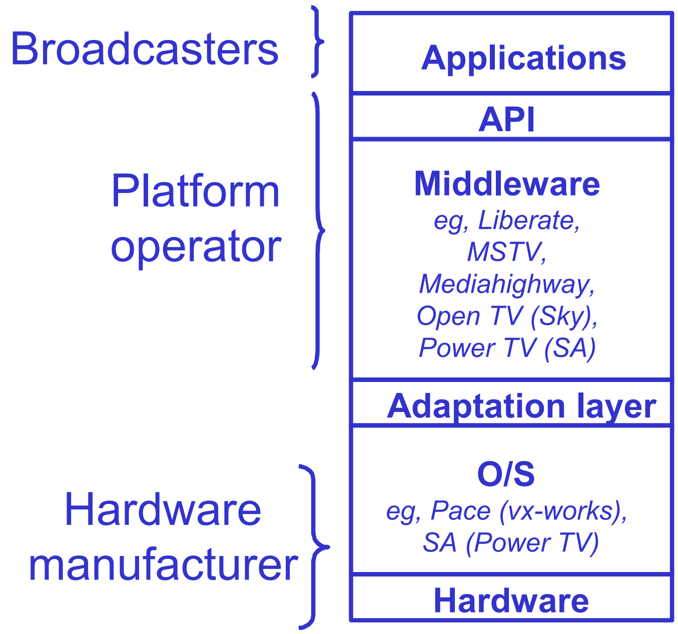
2.2 STB architecture

In order to discuss these issues accurately, it is necessary to be informed about the structure of digital STBs and other technical aspects of digital receiver populations and content delivery. This sub-section provides a brief non-technical overview of the generic structure of STBs, followed by a discussion of the sources of economies of scale in STB production, and an overview of the issues relating to the costs of re-authoring content.

2.2.1 Structure of the STB

A typical STB architecture is shown in Figure 2.4. The hardware sits at the bottom of the stack. The operating system is specific to the STB manufacturer and operates in two directions: downwards, it communicates with the hardware as interfacing with the CAS; and upwards, via the adaptation layer, it communicates with the middleware (although, in older STBs, the middleware may bypass the operating system and communicate directly with the hardware).

Figure 2.4: Generic structure of a set-top box



An application that is being run generates a series of instructions that are interpreted by the API in the middleware into commands that can be understood by the operating system. The adaptation layer sits on the operating system as a translator between the middleware and the operating system and hardware drivers.

Usually an STB manufacturer would have a standard STB architecture that it would sell to many different platform operators or broadcasters. This generic design of an STB would not contain a particular middleware (API), but would be subsequently configured to use the middleware specified by the purchaser. In deciding which STB manufacturer and middleware to use, an operator may test a number of combinations of particular STBs and middleware in order to determine the optimal one for their network.

2.2.2 Software components of the STB

As noted, the decoder or STB has an important role beyond facilitating receipt of audio-visual content transmitted digitally. Three components of the decoder have been identified as potential 'gateways' and these are described below: the CAS, the EPG and the API. In this sub-section the functions of the components are outlined, including a discussion of the role they may play as gateways—ie, presenting opportunities for discriminatory behaviour by incumbents, absent regulatory safeguards. In brief, the CAS is used to unscramble content for the appropriate consumers, while the EPG guides the viewer in terms of content offerings. As noted in the previous sub-section, the API is part of the middleware element of the software stack and is required for running interactive services.

The CAS governs the access of consumers to content. It is generally used to limit access to those who have paid a subscription for access to the specific content. However, it may be used in the FTA sector where copyright laws require access to be restricted—for example, to consumers in a specific geographic area.[30] The CAS is used as the central part of the encryption system, and the subscriber's entitlements are conveyed to the CAS in the STB through an authorisation command in the broadcast stream. Without this authorisation, the subscriber (or consumer) cannot view their selected programming. In the pay-TV business model, authorisations are determined by subscription levels, while, for FTA services, the CAS is often used to overcome DRM problems (for example resulting from a larger broadcast footprint than the underlying rights would allow), or to ensure that consumers receive the correct regional programming.

As a result of the need to broadcast the correct authorisation, the use of a CAS generally implies a direct relationship between the broadcaster (or service supplier) and the consumer. Similarly, as the CAS is the core element of the encryption system used for revenue protection, individual networks tend to have a single, specific, CAS operating on that network.

There are potential competition concerns related to the CAS—in particular, that it could be used to limit access to the installed base of consumers attached to a particular network (ie, it could be used as a 'gateway'). This is mainly a regulatory issue and has been dealt with (at least in theory) by Directive 95/47, which allowed for access to CAS services on FRND terms for service providers. Technical access to the STB or iDTV is via the common interface (CI), or via a simulcrypt solution that allows different CAS to unscramble the same broadcast stream.

A further 'gateway' concern relates to the EPG. Since the EPG controls the presentation of this information, the concern is that platform operators could use the EPG to distort the choice of viewers and hence the market for broadcast content or services. For example, vertically integrated platform operators could display their own content in preference to that of other content providers, or make it much easier to access. Many national governments have introduced regulations that attempt to prevent this potential abuse of the EPG listings.

Similar concerns extend to the case of PVRs, since these operate using the information in the EPG. In particular, they direct consumers' viewing by recording similar programming to that which the consumer frequently watches. This functionality is driven from the same information stream as the EPG, which includes the categorisation of programming into particular genres. Therefore, the same concern about the preferential treatment of

[30] In this case, broadcasting is know as FTV (free to view) rather than FTA (free to air).

particular content as arises with EPGs may apply to PVRs. In principle, however, a similar regulatory approach to that for EPGs could also be adopted.

Another major element in the STB is middleware. DTV receivers, especially those with interactive capability, are essentially computers running sophisticated software. The middleware accepts information from the broadcast stream, from the end-user, and, where relevant, from non-broadcast streams as well (eg, the telephone network). This information is then run with the middleware resident in the box, to produce the desired output. The result is an enhanced or interactive service, as described in section 2.1 above.

In order to deliver the service successfully, the information being broadcast to the box, being input by the customer or delivered in some other way, must be interpreted and operationalised by the box. The API defines what the middleware will understand and what it will do with the information received. The result is that applications (which produce specific audio-visual outputs for consumers) are written to work with a specific API, and cannot be run by a different middleware with a different API. Where service providers or broadcasters wish to deliver the same enhanced or interactive services to different networks with different middleware, the application must be written specifically for each network.

The extent of the re-authoring (and therefore associated cost) required depends on the presentation of the core applications data, and the degree of difference between the APIs concerned. (This is considered further in section 2.2.3.) In addition, if the APIs are different in their functionality, it may not be possible to re-author some services, as the functions required to make the service work in the STB may not exist.

At present, different established digital operators use different APIs in their installed base. Tables 2.2 and 2.3 report the range of APIs in use across Europe.

Table 2.2: API usage across Europe

	AUT	BEL	DNK	FIN	FRA	DEU	GRC	IRL	ITA	LUX	NLD	PRT	ESP	SWE	UK	Total
Betanova	✓					✓										2
Liberate	✓				✓			✓						✓	✓	6
MHEG-5															✓	
MHP				✓		✓										2
MediaHighway		✓	✓	✓	✓				✓		✓		✓	✓		12
Microsoft TV											✓	✓				2
OpenTV	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	22

Note: The total column does not equal the number of ticks, as more than one operator within a country may use a given API.

Table 2.3: API usage by platform across Europe

Member State	Platform	Platform operator	API
Austria	Cable	UPC Telekabel	Liberate
	Cable	Liwest	OpenTV
	Satellite	Premiere World	Betanova
Belgium	Cable	UPC Belgium	MediaHighway
	Cable	Canal Digitaal	MediaHighway
	Cable	Canal+ Numerique	MediaHighway
Denmark	Cable	Stofa	OpenTV
	Cable	Tele Danmark	OpenTV
	Satellite	Canal Digital	MediaHighway
	Satellite	Viasat	OpenTV
Finland	Terrestrial	Digita	MHP
	Satellite	Canal Digital	MediaHighway
	Satellite	Viasat	OpenTV
France	Satellite	Canal Satellite	MediaHighway
	Satellite	TPS	OpenTV
	Cable	Noos	OpenTV
	Cable	NC Numericable	MediaHighway
	Cable	UPC France	Liberate
	Cable	France Telecom Cable	OpenTV
Germany	Cable + satellite	Premiere World	Betanova
	Cable	PrimaCom	OpenTV
Greece	Satellite	Nova	OpenTV
	Satellite	Alpha Digital	OpenTV
Ireland	Cable	NTL Ireland	Liberate
	Cable	Chorus	OpenTV
	Satellite	Sky Digital	OpenTV
Italy	Cable + satellite	Stream	OpenTV
	Satellite	Telepiu	MediaHighway
Luxembourg	Cable	SelecTV	OpenTV
Netherlands	Satellite	Canal Digital Satellite	MediaHighway
	Cable	Casema	OpenTV
	Cable	UPC Digital	Microsoft TV
	Terrestrial	Digitenne	MediaHighway
Portugal	Satellite	TV Cabo	Microsoft TV
Spain	Satellite	Canal Satelite Digital	MediaHighway
	Satellite	Via Digital	OpenTV
	Cable	Aunacable	OpenTV
Sweden	Cable	Com Hem	OpenTV
	Cable	UPC Sweden	Liberate

Member State	Platform	Platform operator	API
	Satellite	Canal Digital	MediaHighway
	Satellite	Viasat	OpenTV
	Terrestrial	Senda	OpenTV
UK	Satellite	Sky Digital	OpenTV
	Cable	Telewest	Liberate
	Cable	NTL	Liberate

As noted above, where the digital networks do not all use the same API, there will be an inherent lack of interoperability or compatibility between the decoders used on different networks. Interoperability of STBs to deliver interactive applications at the level of the consumer is therefore limited by the existence or use of incompatible APIs. This problem is exacerbated by the fact that the middleware is likely to be specifically configured to operate in conjunction with the hardware and operating system of the particular network on which it is being used, and the same API may be slightly different when used on different networks. Similarly, there may be differences in the way in which different STBs function, even though they may have the same API and are on the same network. Therefore re-authoring of applications is likely to be required between networks, even if they are on the same delivery platform (such as cable), and between platforms, even if they operate using the same API.

Depending on the structure of the STB, if an application is run on an API with which it is not compatible, this can trigger a complete failure of the STB (ie, not only does the service in question fail, but the rest of the STB may temporarily cease to operate and basic audio-visual services are affected). A similar outcome can arise if a particular configuration of STB operates in a slightly different manner to others on the same network. For example, an application may cause STBs of one particular type to fail on a network, while the remainder of the installed base can operate correctly. Any such failure would constitute a severe service degradation for the viewer.

Even though the STB is in fact a small computer running technologically sophisticated applications, consumers are likely to be less tolerant of a failure of their audio-visual services resulting from the operation of the applications than they are of similar failure when using their personal computer. Their experience of analogue broadcasting is that the service does not fail in this manner.

It is therefore extremely important that the STB architecture and API are robust, and/or that there is extensive testing of applications before they are transmitted to consumers' equipment. In the context of this report a robust API is defined as one that can cope with incompatible applications without causing a box failure. That is, although incompatible applications may not be displayed fully or correctly, they do not cause the equipment to cease operating.

As a result, there is a significant problem for all digital service providers of managing the network so that interactive services can be delivered without impeding consumers' core linear broadcast content. There are two approaches that can be adopted to address the problem.

In the first approach (adopted largely by pay-TV platform operators), the network operator takes ongoing responsibility for successfully managing the network infrastructure, including the customer's STB. This can be done through a combination of close control of the type of equipment attached to the network by the consumer, and exhaustive testing of all applications (and especially new applications) against all types of equipment connected to the network. The network operator achieves this control by specifying the configuration of the STB and supplying it as part of the pay-TV package (see section 2.4.1). It therefore knows exactly what is connected to its network and can limit this diversity.[31] Using this approach, the middleware and hardware in the STB can be designed with higher *risks* of failure, but with the risks mitigated by extensive, ongoing, active management of the full network.

The other approach is to design the middleware so that it is robust against unexpected inputs, and that the API is sufficiently well defined both in what is expected (in terms of information) and what the middleware does (in terms of service delivery), so that testing against a standard is sufficient to guarantee that the service will work, as expected, on all STBs. Using this approach, the STBs resident on the network require little, if any, ongoing active management, and the network is robust against unexpected information being directed at the STB.

These two approaches have different economics. The first has reduced STB costs for any given level of functionality, but higher ongoing management costs. In addition, because close control of the STB population is required, this approach is inconsistent with a fully developed horizontal market in STBs and for service provision where there is no centralised network operator. The second approach employs more resource-intensive, more 'intelligent' STBs that can be independently produced and tested against a specification. As a result, they are less vulnerable to failure and do not require ongoing management. The API in such STBs is described as 'robust.' However, these STBs require greater computing power and so at present are more expensive than the less sophisticated boxes used in the first approach.

In part, pay-TV operators have adopted the former strategy as a result of the lack of an alternative—it is only in the second half of 2002 that the Digital Video Broadcasting (DVB) multimedia home platform (MHP) specification has begun to be implemented and receiving equipment containing it has actually been made available.[32] Increasingly, however, pay-TV operators will have the choice of moving to the second option and significantly reducing their ongoing network management costs. Some operators, including Canal+, are already considering migrating to MHP. Nonetheless, at present

[31] There are some instances in Europe where consumers have to purchase the STB in order to access pay-TV. The price may or may not be subsidised, but the STB remains specified by the operator.

[32] MHP is an API that has been developed by the DVB, and is designed to be robust while also incorporating a considerable degree of functionality. As discussed below, the degree of functionality has resulted in an API that requires a high level of computer-processing power in the receiving equipment. This results in the equipment to support MHP being more expensive than that required for many other APIs.

there is a legacy installed base of about 32 million STBs across Europe, of which around 1.7 million could be migrated to MHP.[33]

The gateway concern related to APIs is twofold. First, that the specification of the API may not be available to all content developers, limiting the development of interactive applications. Second, that, even if applications are developed for the API of a particular platform, it may still be difficult to get access to the network of installed receivers.

The former relates to whether the API is ‘open’. Given that demand for digital services is a function of the content available (linear broadcast and interactive), middleware providers do not have an incentive to restrict the availability of the API specification.[34] The latter is partly a question of access to the underlying network infrastructure (which can be dealt with through the Access Directive), but is also affected by the manner in which the network management problem is solved, which has a direct bearing on the scale of this problem. The active management solution involves a network operator controlling and testing all interactive applications broadcast to the installed base of STBs, while a network using robust APIs does not have this requirement. Therefore, the gateway problem is potentially significant with active network management, while a robust API would, in principle, allow any interactive application provider to broadcast to all STBs on the network.

2.2.3 Cost drivers

There are two main cost elements in the process of delivering DTV services that vary with the choice and number of APIs used in the market: economies of scale in STB production and re-authoring costs. These are considered in turn below.

Economies of scale

Production costs of both devices and services will be influenced by the existence of economies of scale and by incentives to innovate. Within digital broadcasting services there are complex issues of economies of scale that apply to different parts of the production chain. The principal areas where economies of scale are likely to arise are:

- the core components of STBs;
- software production (ie, API);
- production run(s) of any particular manufacturer’s box;
- testing a particular version of an STB (or equivalent) to ensure that it will perform as required when connected to a particular network; and
- testing applications to ensure that they actually work on all STBs connected to a particular network.

[33] Communication from DG Information Society.

[34] Platform operators may have an incentive to restrict access to the API specification if they produce their own content, but this is a relatively short-sighted strategy, and may limit the attractiveness of their platform to consumers.

In respect of many of the components of STBs, the economies of scale in production are not driven by the demand for a specific STB, specific APIs, or even the demand for digital receiving devices. Rather, many of the components of an STB are the same as those used in a standard personal computer. Therefore, the main economies of scale in their production will be driven by the total demand for all products using the components. For most of these types of component, the additional demand that arises from STBs is relatively small compared with total demand, and thus will not have a great impact on the achievement of economies of scale (and hence unit costs). Indeed, the current production levels of many of these components are such that it is reasonable to consider that most economies of scale have already been achieved. Components to which this applies include, for example, the memory requirements of any STB.

Other components that address the standardised parts of digital broadcasting, but are not common to computer technology, are more likely to have economies of scale with respect to the total demand for STBs (or equivalent). These unit cost benefits can be achieved regardless of whether these STBs have a common API (although there may be an indirect impact on unit costs if a common API increases the total demand for STBs.) An example of this type of component is the MPEG2 decoder. Any hardware *components* that are specific to a particular API will have economies of scale associated with the volume of that API. However, APIs are software rather than hardware, so the link between hardware components and a specific API is likely to be weak.

In common with other types of software, the costs of producing APIs are mainly the fixed costs incurred in the development phase, while the ongoing marginal costs are relatively low. Thus there are significant economies of scale for middleware developers in the production of individual APIs. The more APIs there are, the greater the total costs of API production (in overall social welfare terms) that will ultimately need to be recovered from users.

The complexity of STBs means that a specific implementation of an API in an STB requires considerable research and development, which is costly. These costs are, at a minimum, specific to a particular API and to each network implementation of that API (that is, a general implementation of the API for the network regardless of the individual STB design),[35] while at the extreme each combination of the API and different STB architecture would require detailed development. The more APIs there are, the more possible combinations there are. In other words, there are potentially considerable fixed costs associated with the production of an STB using an API on a specific network. Therefore, the more STBs that are produced of a particular kind, the more units there are over which to spread the fixed cost (and hence the lower the unit costs are).

It has not been possible in the course of this study to identify reliably the level of the costs of implementing an API within a given STB architecture. That is, for a particular pre-

[35] The requirement to optimise and reconfigure for each network on which it is used means that, even if another network used the same API, the need to test the implementation again would not be removed.

existing design of an STB, what are the costs of incorporating a new API and configuring the STB so that it operates correctly? While some equipment manufacturers suggested that these costs were insignificant, others considered that they were sizeable and represented a major drawback of having multiple APIs across Europe. A consensus position could not be determined, and this issue remains one on which the Commission Services should consider further specific technical investigation.

Re-authoring costs

As noted above, applications also need to be modified to run using the API of each network on which the applications are broadcast. This modification, or re-authoring, usually has to be carried out for each API network implementation, or, where a non-robust API is used, for each STB implementation on each network. Therefore, as with STBs themselves, the greater the number of APIs used, the higher will be the total costs of re-authoring. It should be noted, however, that it is not possible to remove re-authoring costs completely; as already discussed, due to the differences in network characteristics, the same API may be implemented in a different way on a satellite as opposed to a cable network. Therefore, even with a single standard API, some re-authoring between platforms would still be necessary, albeit relatively minor.

The alternative approaches to the management of networks identified above have different implications for re-authoring costs. An actively managed network requires far greater and more exhaustive testing of an application, potentially against every configuration of STB on a network, while, for a network with a robust API, it is sufficient for the application to have been tested against the published test suite for the relevant API. Therefore, the former is likely to be more expensive and time-consuming, but pay-TV operators accept this as part of the trade-off they make in order to have lower-specification STBs that are cheaper.

The actual costs of re-authoring may fall exclusively on the application provider, or (in a pay-TV model) may be shared with the platform operator.[36] While both pay-TV and FTA operators have an incentive to encourage attractive content to the network, other considerations outweigh re-authoring costs in determining pay-TV operators' choice of API. On the other hand, FTA systems do not have an operator to contribute to the re-authoring costs, and content (including interactive applications) is essential to attract consumers. Therefore re-authoring costs are considerably more important.

Estimates of re-authoring costs vary, but OXERA understands that the cost of converting interactive applications from one API to another is around 5–15% of the original development costs if the applications have been originally developed using the most sophisticated tools available. The cost of re-authoring an application for a different delivery platform (to that for which it was designed) is of a similar magnitude.

[36] In principle, the costs could also be incurred fully by the network operator, but this is unlikely to occur, not least because of the perverse incentives it signals to content providers.

It should be noted that these costs are estimates from industry players, but there is little consensus between market players on the scale of re-authoring costs, and the costs themselves can vary according to the specification of the application and the relevant platform(s). Furthermore, there is considerable re-authoring between networks using different APIs.

2.3 Theory of standards and market development

The above discussion has outlined the specific market and technological issues in relation to the introduction of DTV in Europe. This section considers in economic terms the factors that influence the successful penetration of new technologies, in the face of network effects. Economic theory has a number of useful insights, drawn from analyses of switching costs, incentives to standardise and the implications of vertical relationships, against a background of network externalities that remove the coincidence between social and private incentives. Here the key lessons from this literature are drawn out—a fuller exposition is found in Appendix 1.

Additionally, the evidence from other industries where standardisation has been successfully achieved (described in detail in Appendix 3) is considered in conjunction with the theoretical discussion in order to identify the market structures that are likely to enhance the development of digital broadcasting.

Most digital broadcasting services will require some investment by consumers, whether in the form of purchasing an STB or by means of a connection charge and subsequent monthly subscription payments. As with all investment decisions, in considering whether to undertake a commitment to digital broadcasting, consumers examine the flexibility of the required investment—in particular the ease with which they could switch suppliers if necessary. If there are likely to be costs in either ceasing to view digital services, or in changing to another operator, these switching costs may inhibit the penetration of a service, particularly where the customer is uncertain about the value of the product or where the price is high.

There are two stages at which switching costs will affect consumers' choices in the case of digital broadcasting. The initial upgrade to digital services requires the acquisition of a digital receiver, and this may represent a switching cost to those consumers who already have an analogue receiver. In addition, once a customer has access to digital services, there may be further costs associated with switching to receive other services.

In both these situations consumers are forced to incur costs to move from their current service to that of an alternative provider. The costs principally derive from an inability to use their current equipment on the new service provider's network,[37] and there are a number of ways in which this can be mitigated:

- minimise the absolute costs of switching;
- share the risk of equipment investment; and
- reduce consumer lock-in by introducing common standards for equipment.

In the rest of this section, each of these alternatives is considered from a theoretical basis, with application to digital broadcasting.

The final aspect of economic theory that is explored in the context of the development of the digital broadcasting market is the benefits of vertical relationships. As noted in section 2.4.1, most pay-TV operators in Europe control their own network and, to that extent, are vertically integrated into STB provision, but the introduction of horizontal markets potentially threatens this operational model. It is therefore important to understand the benefits that can accrue from delivering digital services in this manner in order to evaluate fully the benefits of introducing horizontal markets for the supply of all digital services.

2.3.1 Minimising costs

If consumers are concerned about having to invest in a product that will lock them in to a particular operator, or, indeed, if the absolute cost of the investment deters them from upgrading from an analogue service, the most direct method of addressing the problem is to reduce the cost they must incur. The lower the cost, the less concerned consumers will be if the investment is not worthwhile and they have to discard the equipment. Therefore any incentives to reduce the equipment costs will be beneficial. Particularly effective methods of achieving this are subsidies and the attainment of the available economies of scale. The latter have already been considered in section 2.2.3, and the former are discussed under risk sharing below.

An alternative method of lowering costs is through innovation that facilitates the delivery of a more sophisticated product while the price remains relatively static over time. Incentives for manufacturers and service providers to innovate are likely to increase the more freedom these players have to address consumers directly, and the more competition there is between different manufacturers and different service providers. Hardware innovations are already under way, with Pace announcing the first twin decoder and twin tuner satellite STB ('Puma'), allowing one programme to be recorded while watching another.[38] It is expected that an upgraded product including a PVR will be launched before the end of 2002. In addition, these STBs may enable access to pay-TV channels through the incorporation of a CAS. Such multiple-functionality boxes may increase the

[37] As outlined in Appendix 1, a number of other switching costs can arise; however, in terms of encouraging digital take-up, the issue of receiving equipment is likely to be the most significant.
[38] Pace (2002), 'World's First Twin Decoder from Pace goes into European Distribution', news release, September 13th.

desirability of the product for consumers, enabling them to reduce the number and cost of electronic devices.

In addition, the specification of the receiving equipment will have an effect on the costs of the STBs. While there are benefits to using a high-specification robust API, such as MHP, the additional computing power increases the cost of the equipment, raising the entry costs for new subscribers. Therefore, the potential benefits of the specification should be set against the consequent increased costs (and hence negative impact on consumer take-up).

2.3.2 Risk sharing

Risk sharing is useful when the consumer is uncertain of the value of the product or is credit-constrained. In the case of digital broadcasting, a consumer is likely to be aware of the value of broadcasting, but may be less certain of the additional benefits of digital services. Also, they may be credit-constrained with respect to the initial purchase of the receiver when the price is high.

Risk sharing implies that the up-front costs of the box are subsidised, but the ongoing price of the services delivered over the box are higher. Such practices are commonplace, but do require an after-market—that is, the provider who supplies the box (or offers some form of subsidy) has an ongoing contractual relationship with the customer, in order to recover the up-front cost incurred. As discussed in Appendix 3, mobile telephony uses this sort of a model, with up-front handset subsidies underpinning significant increases in penetration in many markets. There is extensive standardisation of the devices, but constraints on network roaming within the home country and contractual tie-ins ensure that the up-front subsidy is recovered through the ongoing purchase of call and other services from the network provider.

For those parts of the digital broadcasting market where an after-market in content exists (as in the pay-TV environment), the provider can offer tariffs and contractual arrangements that minimise the up-front costs of the hardware and bundle the cost recovery into the ongoing charges for the programming. The analysis of the impact of such pricing patterns on consumer welfare (see Appendix 1) shows that, as long as there are a number of competing providers, such tariffs do not necessarily have negative effects, particularly if consumers have a good understanding of the prices and services that will be offered during the time of any contract.

Such tariff structures can aid consumer choice and penetration by transferring risk to the provider rather than the customer. Consumers incur only limited up-front costs, and can change suppliers at the end of their contract period (often 12 months) without bearing any residual risk on the purchase of their equipment (it is simply returned to the service provider). The service provider in turn is willing to accept the risk, as take-up of its services is increased, and, if the customer remains with the network for longer than the break-even period, there are additional returns available (the tariff charge does not drop once the STB cost has been recovered). Furthermore, the service provider is in a better position to take on the equipment risk, as they can take old boxes back from departing subscribers, recondition them and supply them to new subscribers; in effect the service provider internalises the secondary box market.

Where an after-market for services does not obviously exist (as in the FTA environment), the potential to offer such flexible tariffs is not available to the hardware provider. As a result, consumers must face the full cost of their initial decision to access digital services, as well as the costs of any subsequent change to an alternative platform. The impact of the absence of a subsidy mechanism can be exemplified by the lack of success of digital audio (discussed in section 8). The up-front costs of a DAB tuner are high. Moreover, no market-based subsidy model is likely to arise since no service provider can restrict access to the radio channels and directly charge listeners to offset the initial subsidy.

2.3.3 Standardisation in theory

There are a variety of ways to facilitate interoperability in order to reduce switching costs. The most direct method is through the standardisation of APIs. In the context of DTV, it is useful to understand the social welfare effects of standardisation of APIs and the commercial pressures to standardise or differentiate, in order to understand whether this is likely to arise without formal intervention.

The benefits of standardisation are predominantly related to the reduced switching costs that arise. An API standard in digital receiver equipment would lead to consumer gains through expanded service options, increased choice, reduced cost of components, and less uncertainty about the initial investment (ie, the equipment will not be dedicated to one particular platform). The cost of these has been dealt with above, while the first three are underpinned by gains for the producers of the complementary products (enhanced content and interactive applications) supplied over the receivers as the market increases, and gains through economies of scale for the manufacturers of the hardware.

Direct and/or indirect network effects produce many of these benefits. Where strong demand-side benefits arise in a network, increasing the potential network size through the introduction of a standard will have beneficial welfare effects. If the network effects (either direct or indirect) are sufficiently strong, the market is likely to 'tip' one way or another, with one option becoming the industry standard. The existence of multiple incompatible standards in the presence of strong network effects tends to be unstable.[39]

Appendix 3 discusses these incentives for standardisation in the case of DTV against the background of the experience in other industries. A prime area of contrast is that there are few direct network effects in digital broadcasting, as broadcast communication is not user-to-user, but centre-to-user, in contrast to telephony, or the Windows operating system, which facilitates the interchange of information using common applications.[40]

In digital broadcasting, indirect network effects do arise from a wider range of applications being developed for the standardised installed base, with consistent functionality across users. However, the extent of these indirect effects depends on the costs of re-authoring, since these would be avoided through standardisation. In the computer software market the costs of re-authoring are considerable and the network advantages of others using the same software is high, hence there are strong pressures to

[39] See Appendix 1 for a more detailed discussion of the theoretical literature.
[40] Internet access over television provides direct network benefits.

standardise (see Appendix 3 for further details). By contrast, as outlined in section 2.2.3, the costs of re-authoring interactive applications for DTV may not be so high as to render this practice infeasible—indeed, many platforms currently re-author content that has been developed for different APIs.

The costs of greater standardisation are related to the reduction in the variety of APIs that would be available and the potential resultant loss of non-price competition through innovation. In addition, there may be transition costs involved in moving from the current position of many diverse APIs across European operators to a single standardised API.

The loss of API innovation may also have a negative effect on applications innovation. Creating a standard API would facilitate the development of applications that could, relatively costlessly, be reconfigured for different networks. This greater variety of interactive content may in turn facilitate the take-up of digital services (these are the indirect network effects). However, the functionality supported by the chosen API may be less than that available from the full range of existing APIs, and the dynamic development of the chosen middleware may be slower than if there had been competing innovation between numerous APIs. This may have a further negative impact on applications innovation and variety.

Thus, the overall welfare impact of the emergence of a standard is a balance between the benefits arising from the removal of re-authoring costs (and the positive effect on applications development) and the costs of a loss of API diversity (including the effect of this on diversity in applications) in the consumer welfare function. This is discussed in more detail in section 5.

2.3.4 Market-driven standardisation

The market outcome that results from firms determining their own approaches to standardisation may not correspond to the social welfare trade-off. Manufacturers of devices may have conflicting pressures in determining whether to move towards a standard. Where a participant is large, where it has a cost advantage and where network effects are not significant, it may prefer incompatibility, particularly if this means that it may eventually become the dominant standard. The literature on patent races examines contests to become a market standard, and highlights that the firms involved require control over the proprietary technology (in this context, a hardware manufacturer would need an exclusive licence to a given API) and that the uncertainty about the likely future dominant standard may result in reduced consumer take-up of the product in question, at least for the period of the race.

Given that, in DTV, demand for such hardware is partially a derived demand in order to access the content, it is unlikely that manufacturers of receiving equipment benefit from choosing incompatibility. Unlike other technological products, such as video recorders or video games consoles, the manufacturers of STBs do not control the standards used in the broadcast stream that must be understood by the receiving equipment. Therefore, if a manufacturer produced an STB that was not compatible with the API on a particular network, consumers would not purchase it, as the equipment would not be able to carry out its required functions.

Nonetheless, there are circumstances in the DTV market, especially in relation to the APIs and other standards used by FTA services, where coordination is required and where there is no single organising firm to facilitate this coordination. In this case, considering other industries where standards have developed through market-led coordination is instructive.

DVD development is an example of this. Rival manufacturers did not wish to repeat the VHS/Betamax difficulties and formed the DVD Consortium—now comprised of Hitachi, JVC, Matsushita, Mitsubishi, Philips, Pioneer, Sony, Thomson, Time Warner, and Toshiba. The consortium agreed on the DVD 1.0 specification (interoperability) for recordable and erasable DVD.[41] To manufacture DVD players, a range of patents must be licensed, and this is coordinated through one licensing agent. Without a clear signal to the content providers that there would be coordination to ensure a large enough installed base of hardware, incentives to produce content for this new product would be reduced. In such a situation, any one manufacturer's ability to market its (incompatible) hardware would be substantially reduced. The corollary with DTV is that the FTA services in a particular country may not individually be large enough to attract sufficient content to stimulate mass take-up of the service if its API is incompatible with other FTA (and pay-TV) services across Europe. However, if a number, or all, of the FTA content providers coordinated on a single API, this could produce sufficient critical mass that the indirect network benefits would be great enough to stimulate substantial content development.

Considering further distributors and broadcasters, the theoretical literature predicts that larger firms generally have incentives to make switching difficult, in order to relax the price competition they face in any after-market and because the incompatibility acts as an entry barrier.[42] These incentives increase where the products supplied are very similar. Such analysis is relevant in the broadcasting sector when a firm has an ongoing commercial relationship with the customer, the price of which it is seeking to influence; hence it relates to markets where subscription relationships prevail (ie, for pay-TV operators). Where the broadcaster has no financial relationship with the viewer, either in the initial purchase decision or for access to the content (for example, in the FTA environment), there is limited scope for the firm to exercise such influence.[43]

As discussed in section 2.4 and Appendix 3, there are underlying features of network operation that may push pay-TV operators towards incompatible solutions. Pressures to standardise differ between the pay-TV and FTA sectors in terms of the solutions to network management issues and the achievement of economies of scale in hardware manufacture as a result of standardisation of middleware. These two factors interact in different ways in subscription and non-subscription digital broadcasting, to produce quite different incentives to standardise. Pay-TV operators have largely adopted an active network management approach. Given the requirement to design and configure STBs specifically for each individual network, the potential for achieving greater economies of scale through standardisation is relatively limited.

[41] The process of the development of DVDs was not without difficulty, and for some elements a common standard could not be agreed upon, resulting in the bundling of different formats to overcome the problem.
[42] A large installed base of customers with incompatible hardware hinders entry of other platform operators.
[43] Some incentives may arise around competition for advertising revenue.

In addition, established pay-TV operators have limited commercial incentives to facilitate consumers' ability to move their equipment from one operator to another, as this is likely to reduce customer tenure.

On the other hand, in the non-subscription sector, there is often not a single controller of the network specification, and, where one does exist, this is usually a government or group of operators working for the collective good. There are benefits for all users of the FTA platform from minimising the barriers to the provision of content for the service, and from ensuring that consumers receive the best possible experience without any single entity managing the network. FTA/PSB providers generally are interested in the widest viewership possible. Hence, there is little conflict in enhancing access to other services if this facilitates better access to the FTA channels. In addition, although individual content providers may be in competition with each other, and so have incentives to attempt to introduce incompatibility with rivals' content, in practice no single content provider has the power to achieve this result. It is also likely that the benefits from encouraging consumer take-up through standardisation outweigh the gains from non-interoperability.

These factors produce pressures in the FTA sector to standardise to a *robust* middleware—this is the lowest-cost solution to ensuring integrity of the network without requiring active management of the network of consumers' STBs (which is difficult to coordinate in the absence of a central platform operator).

In order to develop potential solutions to the problem of establishing standards in digital broadcasting, it is relevant to consider other industries where similar issues have been important, but have been overcome. Table 2.4 presents a comparison of the manner in which standards have evolved in three other sectors with the attributes of digital broadcasting (see Appendix 3 for a full discussion).

Table 2.4: Summary of the pressures towards standards across a range of industries

				Digital broadcasting	
Criteria	**Operating systems**	**Mobile telephony**	**Internet**	**Pay**	**FTA/PSB**
Incentive to standardise	High	High	High	Low	High
Private interest in standard choice	High	Low	Low	Medium	Low
Standards process	Competition to determine the standard	Coordination	Imposition	'Private good' case: standard may not arise	Potential coordination
Outcome	Dominant standard	Single standard	Single standard	Co-existence of incompatible technologies	?

In the pay-TV sector, the combination of a low incentive to standardise and a high level of private interest in the choice of standard has been denoted the 'private goods' case.[44] In this case, there *may* still be benefits to standardisation, but the distribution of these benefits will depend on the particular choice of standard.[45] This means that firms will be sensitive to the choice of standard, and each firm will therefore have its own (more or less) entrenched position on the identity of the standard that should be adopted. Absent a dominant firm, a standard is therefore unlikely to come about voluntarily, and participants may not welcome the intervention of an external standards body to coordinate the process.

In general terms, theory suggests that there is a variety of scenarios that may arise in seeking to set an open standard, including the following:

- if coordination is attempted, the process can be hindered as each party tries to promote its favourite (or currently used) technology, or to prevent a different choice being made. This can result in stalemate, with no choice of standard. As a result, the market is characterised by the use of technologies that are simultaneously incompatible;

- a standard may eventually arise through the market mechanism, asserted by a dominant firm. However, the dominant firm may be opposed to its standard

[44] Besen, S.M. and Saloner, G. (1989) 'The Economics of Telecommunications Standards', in R.W. Crandall (ed), *Changing the Rules: Technological Change, International Competition and Regulation in Communications,* The Brookings Institute, Washington DC.
[45] For example, a firm may have invested in authoring content for a particular API and may not wish to incur those costs again.

becoming an open standard if it fears that its rivals will be able to make profits at its expense by making products that are compatible with the standard. It may prefer its dominant technology to remain proprietary;

- government intervention may be able to break the stalemate and 'force' standardisation, but this may itself be a controversial move; and

- there may be no, or reduced, technological advance, owing to the absence of a standard.

This private-good characterisation seems to describe reasonably well the situation in pay-TV digital broadcasting. There is low incentive to standardise on middleware, although there may ultimately be some benefits to the operators in doing so (eg, reduced re-authoring costs). There are industry-driven attempts to create a standard, but the process does not appear to have delivered a solution that pay-TV operators in general can or are willing to implement for the time being. The subscription market is therefore characterised by the co-existence of several incompatible APIs.

In the FTA sector, on the other hand, the incentive to standardise is high, driven by the desire to minimise STB costs through the attainment of economies of scale in the management and testing of a 'standard' box (thereby aiding the proliferation of applications, and ultimately penetration), and by the need to ensure a secure and robust network without active management. Other advantages of standardising the middleware would be the desire to reduce re-authoring costs and to reach as large a target audience as possible (this is particularly relevant to advertising-funded broadcasters).

This high incentive to standardise combines with a low level of interest in the chosen standard based on the economic incentives facing broadcasters (assuming limited existing involvement in producing interactive applications and that the chosen standard meets the requirements for successful delivery of FTA services). The economic analysis suggests that there will be a quite strong incentive to coordinate around one of the already available robust standards, such as MHP or MHEG-5; however, non-economic factors may influence the standard-setting process.

2.3.5 Vertical effects

In the context of this study, the important vertical relationships occur in relation to the pay-TV network operators. They have strong relationships with manufacturers and consumers, and Table 2.5 reports the variety of arrangements for STB pricing that exist between platform operators and their customers across Member States. In most markets, some form of subsidy is present, and rental models are more prevalent than consumer ownership (see Appendix 2 for further details).

Table 2.5: Models of STB ownership across Europe[1]

	AUT	BEL	DNK	FIN	FRA	DEU	GRC	IRL	ITA	LUX	NLD	PRT	ESP	SWE	UK
Purchase (optional)	✓		✓			✓			✓			✓			
Purchase (obligatory)[2]	✓		✓	✓			✓							✓	
Subsidised purchase			✓	✓										✓	
Rental	✓		✓	✓	✓	✓			✓			✓	✓	✓	
Free rental		✓						✓		✓	✓			✓	✓
STB give-away								✓							✓

Notes: [1] Within each country there are a number of operators, each offering one or several of the combinations of STB provision identified. [2] STB purchase is obligatory with Liwest (AUT); Viasat (DEN/FIN/SWE); TDC Kabel TV (DEN); Senda/Boxer (SWE) and all operators in Greece.

Vertical integration between the supplier of a durable good (the STB) and the supplier of services consumed using that good (content) gives the integrated firm an incentive to promote the system as a whole. A vertically integrated firm may want to subsidise STBs in order to reap the benefits through subsequent content sales (at prices that exceed marginal costs and therefore recover the cost of providing cheap equipment to consumers).

Furthermore, in the early stages of establishing a network, a vertically integrated platform operator may want to rent rather than sell the hardware. This can help to boost consumers' confidence in the network since there will be no problem of stranded assets for consumers (the platform operator retains ultimate ownership of the equipment) and the firm is effectively committing itself to not exploiting customers in the software market. That is, if consumers were forced to purchase hardware dedicated to a particular platform, they would face a moral hazard risk[46] where they were captive to that platform. In that situation, the operator could raise prices significantly before consumers would switch, as they have invested in an asset that does not have a value outside of the current network. However, where an operator itself invests in the hardware, the value of the hardware owned by the firm is solely derived from the revenues of customers using it. If the content prices rise too high, far fewer customers would subscribe and the hardware assets would be underutilised.

[46] Moral hazard risk applies to the situation when one person (consumer or firm) invests in or commits to something that is specifically related to a product or service supplied or purchased by another person. In this case a consumer invests in an STB that is dedicated to a particular platform, which produces a switching cost away from the platform (because the investment would be lost). The existence of the switching cost gives the platform operator an incentive to exploit consumers (through increased price or otherwise) because the operator is aware that the consumer is captive until the cost of remaining with the platform operator is equal to or exceeds the value of the consumer's equipment.

Therefore, while the vertically integrated model adopted by most pay-TV providers across Europe is based upon non-interoperable systems, there are discernible consumer benefits that flow from this organisational structure. In particular:

- consumer equipment can be provided at low initial cost, reducing the entry cost of DTV services and minimising the residual risks associated with investing in technology hardware;
- reducing consumer entry costs helps stimulate take-up of digital services, especially when the benefits associated with the new services are uncertain; and
- greater consumer penetration of digital services may encourage the development of interactive applications inter alia (the indirect network effects).

Therefore, vertical integration benefits consumers by reducing the costs associated with initially taking digital services, a very important function for stimulating penetration and facilitating the successful development of all forms of digital services (FTA and pay-TV). However, contractual ties or the rental model mean that the consumer faces switching costs if it wants to access alternative digital services, although, on the other hand, the switching costs are likely to be lower in the presence of subsidies or rented equipment than if consumers had to purchase the hardware themselves. Rental models can be consistent with a developed horizontal hardware market; subsidisation may be problematic without formal contractual tie-ins.

2.4 Development of digital broadcasting and business models

As noted above, the migration from analogue to digital services in the European broadcasting market has been led by the pay-TV operators. This is largely a result of the different incentives faced by pay-TV operators as compared with FTA operators, and the coordination issues that arise in the FTA sector. This section outlines the business models of both pay-TV and FTA operators, and considers the implications of these differences in the context of digital services, interoperability and horizontal markets.

The pay-TV business model is considered first, as it is more complex than that of FTA operators, and the delivery of FTA services can usefully be considered in comparison with the pay model.

2.4.1 Pay-TV operators

All pay-TV operators in Europe use a subscription-based charging model supported by the CAS. Consumers are charged, normally on a monthly basis, for the programming they receive. The charging structure used is generally based on the model adopted from the USA, which involves consumers having to purchase one of a number of initial packages (normally referred to as ‘basic’ packages) and then adding on further (‘premium’) channels. Consumers may also buy additional services such as PPV events or (N)VOD services (as and when the services are introduced).

The price levels chosen by operators are designed to maximise their return from their subscribers, while continuing to encourage new subscribers to join. However, the subscriber acquisition decision is based on a net present value (NPV) calculation over the expected lifetime of the subscriber—that is, the discounted revenue stream exceeds the discounted costs incurred in supplying the customer, including a fixed cost allocation, over the time that the customer remains subscribing. This means that there is likely to be only a proportion of the potential market that will ever subscribe to pay-TV services, as, for some, the price will be too high compared with the relative benefits.

The CAS is vital for the operator to ensure that consumers can access only the services they are entitled to receive (ie, that they have paid for). Consumers' entitlements can normally be updated remotely so that changes in viewing requirements can be processed rapidly.

Most platform operators bundle channels themselves into the basic packages; they negotiate carriage terms (wholesale prices) with channel providers and then incorporate the channels into bundles that are offered to consumers. Some platform operators, such as Canal+ and BSkyB, also produce their own content. In many countries there is only one operator on each platform (cable, satellite or terrestrial). This is particularly the case for cable networks where there may be different operators in different geographic areas, but cable overbuild is rare and most cable networks remain closed to third-party access. In several Member States, such as France and Italy, there is more than one satellite operator. Appendix 2 provides an overview of the digital operators in each Member State and the nature of their product offerings (given the low number of FTA digital services, these are mainly pay-TV operators).

The introduction of digital services has provided all operators and content providers (not just those in pay-TV) with the opportunity to exploit interactive functionality. In principle, interactive services could provide an additional revenue stream for such operators, but at present interactive revenues remain minimal. The most successful applications for which there is a charging structure are games and gambling-related products, while the vast majority of interactive content is provided free of charge as an enhancement to the core broadcast content services. Enhanced content is expensive to provide, but may increase consumers' loyalty to their network, thus reducing churn.

A further aspect of the business model for most European pay-TV operators is the supply of the receiving equipment to their subscribers (see Appendix 2). Platform operators specify the characteristics of the STB and contract for its supply with a manufacturer (often development of a box configuration is carried out by a manufacturer in conjunction with a pay-TV operator). The operator then supplies the STB to subscribers on a rental basis, although some operators offer consumers the opportunity (or in one or two cases require them) to purchase the box.[47] An exception to this is BSkyB in the UK, which provides the STB free of charge to consumers in return for a subscription arrangement. While this supply of the equipment (either by rental or free) is termed a 'subsidy', in all cases across Member States any up-front costs of the box borne by the operator are recovered through the ongoing subscription charges.

Platform operators choose their API mainly on the basis of the API's performance on their network when configured with a particular type of box. As robust APIs become available, pay-TV operators will also factor the network management aspects into their API selection decision. As already discussed, often the API used is modified to optimise

[47] The price of such boxes may or may not be subsidised, but the STB remains specified by the operator.

its performance on a particular network. Thus, even though two platforms or networks may use the same API, it may be slightly different and applications designed for one network may therefore not run perfectly (if at all) on the other network. This means that the STBs are also dedicated to the network in question, which has the additional benefit for the operator of preventing the consumer from using one operator's box on another operator's network, effectively locking them in. However, given that most equipment is provided on a rental basis, this is not a significant switching cost.

The objective of pay-TV operators is to maximise the yield from their network by selling as much content and other value-added services as possible to their subscribers. For this reason, virtually all pay-TV networks are closed—ie, all content has to be distributed by the platform operator. This protects the operator's income stream, as it means that the operator appropriates all available revenue from consumers on its network. In addition, it enables the operator to adopt a less robust API using a cheaper STB, supported by active network management.

Furthermore, as described above, the desire to maximise returns from the network and the installed subscriber base provides pay-TV operators with an incentive to move to a digital network. Digital compression techniques allow greater volumes of content to be transmitted over the same bandwidth, enabling the operator to offer consumers a broader range of content, but also innovative new services (as described above). This maximises the return from any given subscriber, although the costs of upgrading the network to digital and providing new STBs have to be recouped.

Although pay-TV operators have strong incentives to migrate to digital, they have weaker incentives to facilitate the interoperability of APIs or horizontal markets for receiving equipment. Interoperability of any form (see section 1 for a discussion of the types of interoperability) would allow consumers to move to different platforms more easily than at present. While this may have benefits in terms of facilitating the recruitment of new subscribers from rivals' platforms, there are symmetrical risks to each operator's own installed base, so operators are unlikely to incur significant costs in order to achieve interoperability. Horizontal markets may impose upon subscribers the requirement to purchase their own STB, and this would increase the costs of joining a pay-TV network, deterring some consumers that may have subscribed when provided with their equipment by the operator.

The exact impact of moving to a horizontal market would depend on whether rented STBs were still available. In particular the experience in the USA cable industry has indicated that where a rental model is still available consumers (and operators) may be reluctant to rely upon the horizontal market. This has also had a negative effect on the development of the horizontal market itself as manufacturers have been reluctant to supply equipment when the demand remains uncertain and consumers can alternatively receive equipment from their cable operator.

A combination of interoperability and horizontal markets may also prove problematic for active network management. In order to manage a network without a robust API, the network operator must be aware of all types of STB resident on the network and exhaustively test all applications to ensure they are compatible with these STBs. With a horizontal market for interoperable boxes, it would be considerably more difficult, if not impossible, for the network operator to be able to guarantee that an application would not cause a box failure. This is because there would be many more varieties of box (each with a different configuration) that may be attached to the network.

Although, in principle, a test suite could be designed for each box configuration, this would involve considerable expense. There would also be a requirement to test *all* applications against any new box configuration in order to ensure that even those applications already running on other STBs would not cause a problem with the new STB. Therefore, the active management solution would become unwieldy and involve disproportionate testing in an environment with full interoperability and a horizontal market for STBs. For example, if a single subscriber introduced a different type of box to the network, all applications would have to be tested against this box configuration to ensure that the new subscriber did not suffer a loss of service. As a result, the introduction of a horizontal market with interoperability (and potentially even without interoperability) is likely to undermine the current business model of pay-TV operators. Active network management of an installed base of less robust STBs would become very difficult, and involve a considerable increase in the costs and onerousness of testing applications. Pay-TV operators may therefore be forced to move to a robust API, using more expensive STBs.

Such a move would be costly and have potentially serious consequences for operators; an installed base of digital equipment already exists, and consumers would have to change their STB simply to receive exactly the same services as they currently have. The cost of such a move would have to be borne by consumers purchasing in a horizontal market or by the operators providing the equipment on a rental basis. Either option is unattractive—in the first, consumers have to spend a significant sum of money (likely to be several hundred euros) for no appreciable benefit, and, in the second case, the cost burden falls on the operator unless it increases subscription charges, when consumers would again have to pay more to receive the same service.

2.4.2 FTA operators

By definition, FTA broadcasters do not charge for the content they provide to consumers. While the pay-TV operators' goal is one of maximising profits given consumer demand, FTA operators are primarily concerned with reaching as many viewers as possible. This may be either because of the requirements of their public service broadcasting remit, or in order to maximise potential advertising revenues that are linked to audience size and characteristics.

FTA broadcasters essentially segment into two types based on the platforms used: those that can supply their own content as they desire (subject to regulatory constraints on broadcasting capacity) and those that have to supply their content to a third-party platform operator for distribution. The former relates to broadcasters using the analogue or digital terrestrial networks, and in some countries, such as Germany, the satellite distribution platform. The latter principally applies to FTA channels supplied over cable networks that are closed, although, in some cases, it may also apply to other networks (eg, BSkyB's satellite network in the UK).

Where the FTA content is supplied through the incumbent pay-TV or other platform operator (for some cable networks, this could be the telecommunications provider that does not supply any other broadcast content), the FTA channel provider is not in control of its own final distribution. In this sense, the FTA providers are no different from any other content providers, and the issues relating to interoperability and horizontal markets are under the control of the pay-TV (or other) operator rather than the FTA content provider.

Of interest here is the manner in which FTA content is provided outside of a pay-TV or other platform operator. That is, the first case identified above.

The main characteristics of such FTA content provision is the absence of a platform operator to coordinate the delivery of many channels to the consumer. Channel providers must arrange their own transmission independently of other channel providers that may be using the same distribution platform. For interactive equipment and services, the absence of a platform operator means that there is no one to manage the network and ensure that interactive applications conform to the requisite standards.

Further, there is no operator to provide the receiving equipment to consumers; individual channel providers will not incur the cost of doing this because of the free-rider problem where other channel providers could benefit from the supply of the equipment but need not contribute to the cost of supplying it. In addition to the absence of a single platform operator, the FTA situation differs from pay-TV because there is no payment or subscription mechanism that could easily be used to recoup up-front equipment subsidies. In this case, therefore, providing cheap STBs would be an actual subsidy (transfer from the provider(s) of the STB to the consumer) rather than principally a financing mechanism (as in pay-TV). As a result, it is unlikely that individual channel providers would be willing to subsidise equipment. This problem could be solved through a coordination mechanism such as an industry body (for example, as demonstrated with the development of the FUN specification in Germany). However, in the absence of regulatory involvement mandating membership of this body, there would be considerable incentives for operators to free-ride.

This suggests that, unless funded by an external body (such as a national government or the European Commission), there are unlikely to be subsidies for STBs dedicated to FTA services. There are two implications arising from this. First, STB prices may be higher and take-up correspondingly slower for FTA than in the pay-TV environment. Second, the provision of consumer equipment for FTA services is likely to be heavily dependent on the horizontal retail market for the actual supply of receiving equipment to consumers.

However, in both the FTA and pay-TV models, the demand for receiving equipment is largely a derived demand for the content and services that can be accessed using it. Therefore, even though there may be a distinct horizontal retail market for the provision of STBs, the success of that market is closely related to the content that is available. Television is an experience good, and consumers may be unaware or uncertain about the benefits they will derive from viewing before doing so. This factor is particularly important for FTA because consumers are less likely to invest considerable sums of money in purchasing equipment for a service delivering uncertain benefits.

The characteristics of digital receiving equipment supplied into the market may vary considerably, but there are two forms: STBs with interactive capability and those without, known as zapper boxes. Zapper boxes are useful as a method of enabling consumers to gain access to digital services at relatively low cost, potentially providing a way to overcome the experience-good problem highlighted above. Although such boxes do not contain an API, and hence interactive functionality, interactive applications do not appear to be highly valued by consumers at present. If interactivity were important to any particular consumer, they could purchase a more expensive STB that did include an API.

Given the potential damage to STBs (and the consumer's viewing experience) that can arise from interactive applications which do not fully conform to the specification, and given that, for FTA services, active network management is not feasible, it is necessary to minimise the sensitivity of the box. The main way of doing this (as identified in the previous section) is to use an API that is sufficiently robust that it will cope with a broad range of interactive applications without causing box failure. At present, MHP is the only API that claims to be completely robust, although its actual performance is dependent on the manner in which the specification is implemented. MHEG-5 is also fairly robust.

Both MHEG-5 and MHP have specified test suites that are readily available for any interactive service provider. These test suites are essential for providers to ensure that their applications will work properly once the application is broadcast to the installed base of boxes. In the FTA environment, individual-application suppliers have to carry out this testing for themselves, which would be done by the platform operator in a pay-TV network.

However, robust APIs, particularly MHP, require a much more sophisticated STB than is necessary for other APIs. This is a result of the greater memory and processing power required to run the MHP software, and increases the retail price of the box for consumers. At present it is estimated that the MHP STB will be considerably more expensive than a box using alternative software, although this is likely to change as advances in technology reduce the component costs for sophisticated STBs (see the discussion of economies of scale in the previous section).

In principle there should be no restriction on the level of penetration that can be achieved by FTA services, provided the equipment is well-specified and priced at an appropriate level, and the content available from FTA channel providers is appealing to consumers.

The major cost for consumers in receiving FTA services is the initial cost of the STB, as there are no ongoing charges. This means that FTA digital service take-up is likely to be highly sensitive to reductions in the cost of the box, and the exploitation of any potential economies of scale becomes all the more important.

Provided that the cost of STBs can be reduced to a level that is acceptable to consumers, and that the content is sufficiently attractive, full digital switchover is likely to be driven by FTA operators rather than pay-TV platforms, even though pay-TV operators were the first to migrate to digital. It should be noted that, for this to occur, the cost of digital STBs does not necessarily have to approximate the cost of current analogue boxes. This is because digital STBs have greater functionality and so deliver greater benefits to consumers. Correspondingly, consumers may be willing to pay more for them, but there remains an upper limit to the price at which widespread adoption of digital FTA services will occur. No consensus on this price limit across Europe, or even within particular Member States, could be identified during this study.

The additional method by which digital technology could be acquired by consumers is through the purchase of iDTVs. In much the same way as for STBs, consumers will only buy these when the incremental cost compared with a television without the interactive functionality is considered to be value for money. That is, the benefits from having an interactive television outweigh (or at the margin equal) the incremental costs of having the interactivity.

2.5 Horizontal market framework

The preceding sections have outlined various aspects of the research that has been undertaken in this project as an input to the central issue of identifying options to achieve interoperability and/or horizontal markets in DTV in Europe. Much of this has focused on interoperability, although it has been noted in connection with FTA services that the development of a horizontal market in equipment provision will be vital. Therefore this section presents a characterisation of the market structure required for the successful introduction of horizontal markets for the supply of digital receiver equipment.

As in any market, there are both demand- and supply-side requirements for a horizontal retail market: the demand-side issues relate to consumer take-up of the product; the supply-side issues relate primarily to manufacturers' supply to the market. The factors on both the demand and supply sides that influence the success of horizontal markets are discussed below, and form a generic supply and demand framework.

2.5.1 Demand-side issues

Consumers will only purchase a particular product if they gain sufficient benefit from that purchase decision. In a general demand framework, the level of demand for any given product is derived from the individual's utility function. In the simplest model, an individual's demand for product k will depend on the price of the good (P_k), income (y), and the price of other relevant goods—either substitutes or complements (P_1, P_2 … P_n). In other words, an individual's demand for a good is a function of the price of the good in question, the individual's personal income level, and the price of other relevant goods. This can be expressed as:

$$k = f(P_k, y, P_1 \ldots P_n)$$

This captures the inherent trade-offs between the price of different goods and constraints imposed by budgets. In the case of purchasing *durable* goods, the purchase decision is more like an investment decision than consumption, since the good, by definition, is expected to provide a stream of utility over some period of time.

A consumption decision can therefore be formalised into a choice between several products, each rendering the consumer a level of net benefit over its lifetime. The rational consumer chooses that product which produces the maximum benefit (or expected benefit, if future returns are uncertain).

The net benefit of purchasing a single product k is defined as N_{ik}:

$$N_{ik} = U_{ik} - P_k$$

where U_{ik} is the utility benefit derived by consumer i from consuming product k, and P_k is the price of product k. U_{ik} itself is determined by a number of aspects of the product, such as the degree to which the product meets any individual consumer's needs; the value the consumer places on the services available through using the product; the risks attached to buying the product (which will decrease the utility); and the presence of substitute products that may provide similar benefits.

Given a set of competing substitute products, the consumer will purchase the product that offers the greatest net utility, provided that this net utility is positive. If the individual net utility available from all the products (assessed individually) is less than zero, the consumer will not purchase any of the products.

That is, for a consumer to purchase good *k*:

$$N_{ik} > N_{im} \textit{ for all } m \neq k, \text{ and } N_{ik} > 0$$

Using this structure as a guide, the likely components of the decision to purchase technological goods are as follows.

- *Price*—the higher the price, the greater are the benefits required to offset the costs. The price should be compared with the consumer's income level; there may be net benefits from consuming a product, but consumers may still not be able to afford it. Thus, the lower the price, the greater the net benefit to consumers (for a given level of utility), and the more likely it is that a mass market for a product will develop. In addition, the price of a given device relative to the alternatives will be crucial.

- *Quality*—the higher the quality of a product, the more consumers value it, and hence the greater the benefit that is achieved from purchasing it.

- *Product differentiation*—each consumer has an 'ideal' set of characteristics that they seek from a particular product. The closer any single receiver, or group of receivers, is to that ideal, the more benefit consumers obtain. Where consumers are unable to reveal their preferences through purchase decisions (for example, if they have no control over the characteristics of the STB supplied to them by their platform operator), it is less likely that the product will closely match consumers' requirements. Greater product differentiation increases the chances that a particular product meets a consumer's desired specification.

- *Risk*—consumers are sensitive to risk in their purchase decisions, especially where the product in question is durable. The greater is the risk associated with purchasing a particular product, the lower the net benefit from consuming that particular product, reducing the likely take-up of that product. In technological markets, the main causes of risk are obsolescence as a result of technological advance, or stranding caused by changing standards, and the possibility of being 'locked in'.

  - If the dominant standard of a particular product has yet to emerge, or to be determined, consumers will perceive greater risk in purchasing before the standard has been established. This is particularly so where the products available before the establishment of a standard are not compatible (and are not likely to become so). The potential consumer response to this risk is to delay purchase decisions until there is sufficient certainty.

  - The rate of technological advance increases risk for two reasons. First, it increases the possibility that equipment purchased by consumers will be invalidated by technological change, and therefore have no value. Second, technological developments often cause the price of new products to fall rapidly. Both of these forms of risk reduce consumers' discount rates (they value future benefits relatively more, and current benefits relatively less), which again results in delay in purchase decisions.

– Consumers may also be reluctant to purchase a non-interoperable box because they will be 'locked in' to one service provider. Given that demand for the box is a derived demand for access to services over the box, non-interoperability will indicate to the consumer that they will not be able to switch easily to an alternative service provider should they prefer that provider's content. Again, the response may be delay, until it is clear which delivery routes have the most appropriate content to suit their requirements.

- *Complementary product market characteristics*—given that the demand for STB or iDTV equipment is largely a derived demand, most of the value in purchasing an STB is obtained from being able to access the services delivered across the device. These services are complementary to the purchase of an STB. Therefore, the current and future behaviour of the service provider will affect the equipment purchase decision. Factors, such as quality of content available, price and additional services available (eg, interactivity), will all affect both the equipment and service purchase decisions.

2.5.2 Supply-side issues

Production of equipment constitutes the supply side of a market. Consumers cannot purchase equipment unless offered for sale by manufacturers. Therefore, it is crucial to consider the way in which manufacturers would participate in horizontal markets, and the incentives they face.

In the same way that it is possible to formalise the consumer's decision to purchase a product, so it is possible to represent a manufacturer's decision to supply. Ultimately, manufacturers are motivated by profit, and will supply goods where there is an expectation of a positive profit. This leads to a supply decision based on whether an investment is positive on a net present value (NPV) basis:

$$NPV = \sum_{t=0}^{n} \left[\frac{R_t - C_t}{(1+r)^t} \right]$$

where the value to the firm is the discounted sum of expected profits—revenues (R_t) minus costs (C_t)—over the lifetime of the product (here taken to be n years). The discount rate, r, is assumed to be constant throughout the period.

This formulation is based on perfect information and foresight—ie, firms do not face uncertainty about the level of future profits. In reality, investment decisions are often made under conditions of uncertainty. Such decisions may apply to entering new markets or launching new ranges of products in existing markets. If the project is risky, the above formula can be adjusted for *expected* revenues and costs. Expectations of revenues and costs will depend on the likely consumer demand, the maturity of the product class (the newer the class of products is to the market, the greater the risk), and the speed and direction of technological development.

Against this background, the factors that affect the likelihood that manufacturers will enter into the supply of a particular technological product can be deduced as follows.

- *Entry*—where entry into a market is easy (ie, barriers to entry are low), markets are less likely to be concentrated and competition is more likely to develop. The possibility of entry means that firms must constantly guard their position and there may be little scope for maintaining prices above cost.

  Where demand for a product is a derived demand for services delivered through it, there may be a further entry barrier associated with uncertainty in the form of a coordination problem. This problem arises when neither the suppliers of the services, nor the suppliers of the product necessary to receive the services, will move first into the market. This is a market failure resulting from indirect network externalities.

  Entry is facilitated where there are clear standards, as risks to manufacturers are reduced by the introduction of standards that allow a diversity of services and/or consumers to be addressed with the same product.

- *Risk*—uncertainty over the level of future demand may have a substantial impact on suppliers' decisions to produce a particular product. The effect of such risk is to give a significant option value to waiting or starting slowly, particularly where an investment decision is irreversible. This is likely to reduce the volume and range of products supplied by manufacturers until they have sufficient certainty. However, this can produce a vicious circle, significantly delaying the development of the market; the low range of equipment available deters consumers from purchasing, and manufacturers restrict the products they supply since demand is low.

- *Efficiency*—entry into a market will be facilitated where there is scope for cost-enhancing improvements. Such improvements provide the entrant with an incentive to participate where it perceives that its cost advantage will allow a greater portion of the market to be captured. Cost-enhancing improvements may arise from economies of scope or scale.

- *Incentives to innovate*—vibrant markets need innovation (often driven through entry). Successful innovation allows a firm to move ahead of its rivals, at least for a short period—in effect, creating a temporary monopoly. These short-term benefits (until rivals imitate or overtake the successful change) are the return for the investment in the innovation. In the same spirit, investment in R&D that results in a new product is often protected for a certain period by the patent/IPR system. Innovation and market development may be constrained where markets are nascent or existing products exert strong pricing pressures on new products. Allowing rewards for innovation may be in line with the goal of maximising investment and securing long-term sustainable competition.

- *Impact on firm profitability*—notwithstanding the relative attractiveness of any particular product, individual firms will assess the impact of their production decisions on their existing product portfolio. If the introduction of a new product adversely affects the profitability of existing products, the firm will take this into account when deciding whether to proceed.[48] If a number of the firms that are likely to produce the new product all face this decision, the introduction of the new product may be slowed. This is particularly relevant to the situation for STBs; many manufacturers currently have supply relationships with platform operators that would be affected by the introduction of a horizontal market in STBs. If the bilateral contracts with platform operators are expected to be more profitable than the direct consumer market, each manufacturer will be reluctant to produce for a horizontal market. In such a situation, the horizontal market would be slow to develop without regulatory intervention (unless platform operators themselves change the supply model). As long as there are new potential entrants to the market for STB supply, this problem should not be significant.

The foregoing analysis suggests that there are a number of characteristics of products and their development that are critical to the development of a market. In particular, consumer demand is crucial for manufacturers to invest in production and innovation of products, while the price and quality of the products on offer (which are strongly affected by the volume produced and the degree of innovation) are very important for consumer demand to be stimulated.

In addition, consumer demand for STBs is a derived demand that is contingent on the complementary services (content and interactive applications) that can be received over the STB. Therefore, to this extent, hardware manufacturers are also reliant on the platform operators, content providers and applications developers.

This framework for analysing the potential success of a horizontal market can be applied to any product. In this project, it has also been applied to the analysis of display-based formats and digital audio broadcasting (DAB). These are examined in sections 7 and 8 respectively, which highlight the crucial importance of the interdependencies outlined above in the development of markets for different television formats.

2.6 Summary of the main development factors

Digitisation of the broadcast infrastructure will allow the delivery of more, and different, services to consumers. However, it requires a more complex infrastructure, which has higher network control and management costs. In the end, consumers will have to pay for this. If they are to do this voluntarily, it must appear to them to be worthwhile—ie, the benefits must outweigh the costs. From the analysis set out above, a number of

[48] However, often firms are forced to 'cannibalise' their existing product(s) in order to respond to new, more technologically advanced, products offered by rivals or new entrants.

parameters can be identified that are important in achieving interoperability and/or successful horizontal markets in digital broadcasting.

The lower the price that consumers need to pay for hardware and content (linear as well as interactive), the greater will be the take-up of digital services. This can be achieved through:

- *economies of scale in STB production*—this is assisted through standardisation delivering a larger potential market for a given box configuration;
- *increased innovation in the digital devices*, which will mean better value for money for consumers. This may involve bundling products, such as DVDs and STBs, and may include the production of flexible STBs with multiple tuners and multiple CAS to facilitate inter-platform interoperability;
- *a standard API*, which will reduce the need for re-authoring, thereby lowering ongoing costs;
- *a robust API*, which enhances the consumer's experience of the service, minimising the likelihood of box failure, but may lead to higher costs; and
- any developments that *increase the costs of the STB*, which will have a direct negative effect on the take-up of digital services, so this should avoided or minimised where possible.

The benefits of standardisation increase as indirect network effects are greater:

- *lowering re-authoring costs* between platforms for enhanced and interactive services can facilitate the achievement of indirect network benefits (from applications development) in a cost-effective manner;
- *increases in innovation in applications* will raise the benefits that consumers derive from their digital service, and hence promote digital penetration. The more consumers who receive digital services (ie, the higher the penetration), the greater incentive there is for application development;
- *innovation in the capability of middleware* has a complex relationship with the development of the complementary services. Innovation implies the production of new functionality that can facilitate the development of more advanced applications. However, innovation in middleware is stimulated by competition between APIs, which occurs when there is more than one API in the market.

The less uncertainty faced by consumers and manufacturers, the better are the conditions for establishing horizontal markets:

- *increasing the stability of technology* will facilitate confidence on both the demand and supply sides in investing in new technology. Indications that technology is changing rapidly lead to a high value for waiting;

- while it may not immediately reduce uncertainty, *a standard determined by the market* is likely ultimately to produce a more stable market outcome than an imposed standard. Regulatory interventions to determine standards may be undermined by innovation or subsequent product development in a way that a market-driven standard may not.

This breakdown of the market conditions forms the basis for the parameters that are used to evaluate the performance of the policy options. The evaluation tool using the parameters is outlined in section 3, and is then applied to the goals and objectives in section 4, and to the policy options in section 5.

3. Description of the Evaluation Tool

The previous section of the report outlined the important features of the digital market. It is against this background that the options for achieving the *goals* of interoperability and horizontal equipment markets will be developed and critiqued. In addition, any policy option must also be evaluated against the EU *policy objectives* in the area of digital broadcasting, which are to:

- increase consumer welfare;
- promote a non-discriminatory competitive market in Europe;
- promote incentives to invest in innovation;
- ensure relative ease of implementation; and
- remain vigilant concerning security issues.[49]

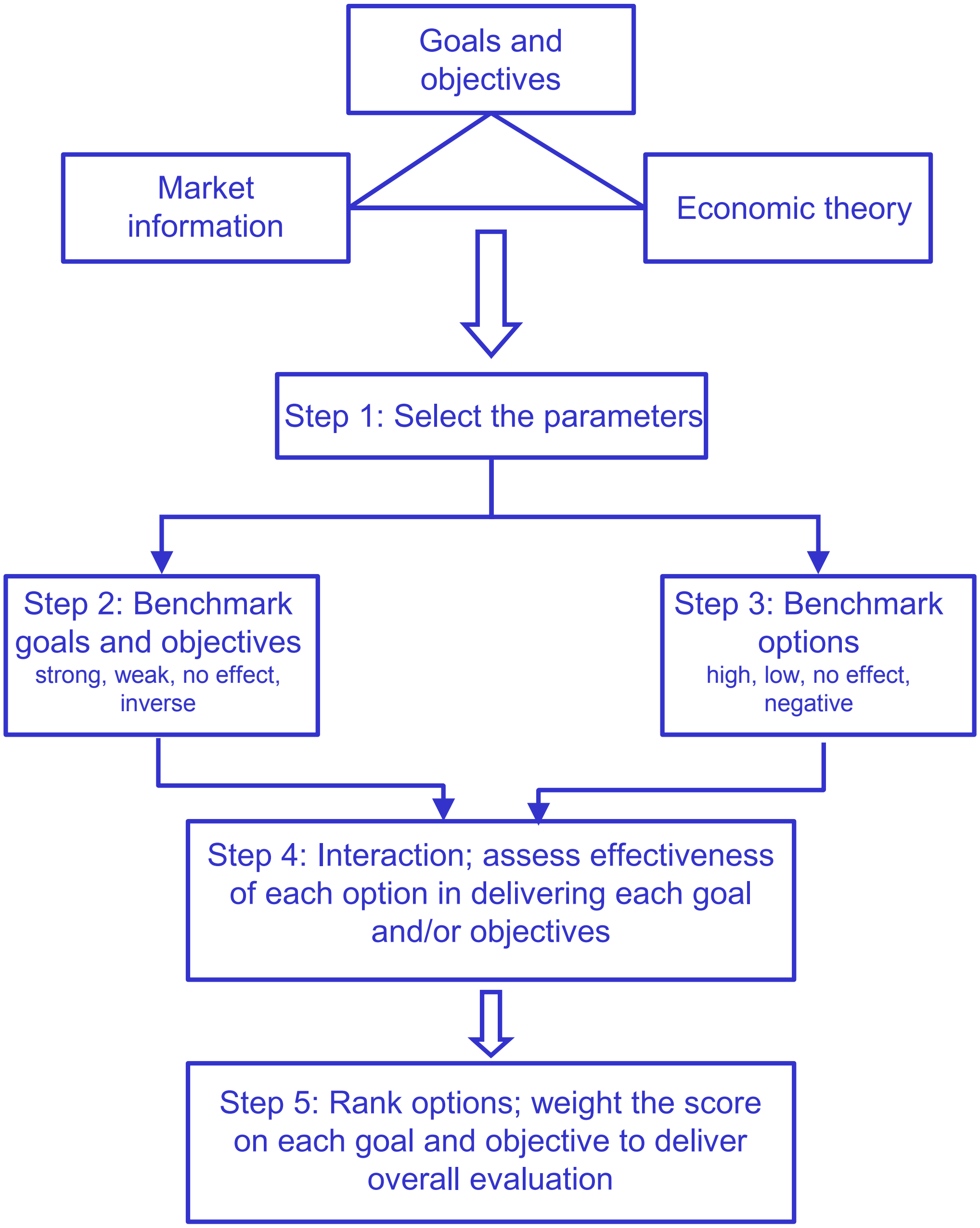
Having examined the options in this manner, guidance can be given about the likely success of any given option in achieving the desired goals, while also meeting the broader policy objectives. Indeed, through the option evaluation process, options can be ranked on their success at meeting these goals and objectives. However, it is clear from the preceding section that the markets in which these changes will take place are complex, with significant competition and differing interests depending on the position in the supply chain.

Each option may well have different implications for different parts of the industry value chain. For example, a policy that mandated the use of a specific API across the industry could have quite different effects on incentives to continue API innovation by middleware developers, and on the level of economies of scale achievable by manufacturers of STBs. Capturing the trade-offs between these effects is essential in order to judge whether a given option will achieve the goals and objectives. Hence, OXERA has developed a framework that enables trade-offs between different interests to be modelled in a transparent manner. In this section, the process is explained in detail before its implementation in sections 4 to 6.

There are five steps in the option appraisal process presented in this report, shown in Figure 3.1 and described in detail thereafter.

[49] These objectives have been ascertained from a variety of EU consultation documents and approaches to related topics, and reflect the drivers of EU policy in this area. As is often the case with broad policy objectives, there is likely to be some inherent conflict between specific policy objectives (for example, between competition and investment). In this case, some judgement may need to be made on the relative importance of different objectives.

Figure 3.1: Option appraisal process



Step 1: Select the parameters

The first step is perhaps the most important in the whole process. Based on the analysis of the market conditions, the theoretical literature and the policy focus of the Commission, a set of characteristics is identified. These characteristics reflect the elements that will be most influential in determining whether the specific goals and broader objectives can be achieved. The range of characteristics is distilled to a set of ten key parameters, simplifying comparison across the broad options and facilitating trade-offs by highlighting areas of conflict where a given option may increase the success of achieving a specific goal but may not deliver one of the broader objectives well. For example, an option that uses a robust API may be more likely to achieve interoperability, but may not be as successful at achieving the broad consumer welfare objective if the cost of the service will need to increase. By classifying the options in terms of these key parameters, it ensures that the analysis focuses on delivering the policy goals and objectives.

Hence, the first step is to specify the appropriate set of parameters that summarises the core aspects of the digital broadcasting market relevant to achieving the goals of interoperability and horizontal markets, as well as the broader EC objectives. The selection is based on the analysis in section 2 and is described fully in section 3.1.

Step 2: Benchmark the goals and objectives

Step 1 identified the relevant core elements most influential in terms of achieving the goals and objectives. These elements are reflected in a set of ten key parameters. Next it is necessary to understand the relative importance of each parameter in achieving each goal or objective. To make the analysis more tractable, each high-level goal or objective is broken down into its constituent parts. This is because the narrower constituent parts are more easily defined and measured. Moreover, in some cases, there may some ambiguity about how a parameter affects a goal or objective, and this can be more easily understood if the high-level goal or objective is broken down (see section 4). Thus, the effect of each parameter on each factor underlying the goals and objectives is marked as strong, weak, no effect or inverse. For example, a market where there is significant innovation in digital receiver equipment will have a 'strong' effect on interoperability at all levels, as it facilitates the development of the appropriate hardware. However, significant innovation in receiver equipment may only have a 'weak' effect on the competitiveness of the market. Section 3.2 discusses this step more fully and section 4 then presents the benchmarking of each goal and objective in detail.

Step 3: Benchmark the options

Each option is also examined to determine the likelihood that it has a positive effect on achieving the core elements, summarised in the parameters. For each option, the effect on the parameters is marked as high, low, no effect or negative. Thus, mandating a robust API is highly likely to contribute to more innovation in applications (marked 'high'), but is likely to reduce innovation in APIs (marked 'negative'). Section 3.3 discusses this step more fully and section 5 benchmarks each option in detail.

Step 4: Interact the options with the goals and objectives

Having identified the likely success of each option with regard to motivating the core parameters, and the influence that these parameters will have on achieving the desired goals and objectives, these two elements are put together. Thus an option that is highly likely to deliver a parameter that has a strongly positive effect on a goal will be judged successful for that goal. An option that has a minimal effect on the same parameter will be judged less successful for that same goal. However, due to its effect on another parameter, the option may nonetheless contribute to achieving the ultimate goal. A scoring approach is used to enable these effects to be aggregated across the parameters. This yields a summary of the effectiveness of each option in achieving each goal and objective. Section 3.4 discusses this step more fully and section 6.2 presents the options evaluated in this way.

Step 5: Rank each option by weighting the importance of the different goals and objectives

Step 4 gives an indication of how likely an option is to achieve each goal or objective. In order to determine the 'best' option, weightings must be given to the different goals and objectives. As presented in the report, the base case for comparison is for each goal and objective to be weighted equally; however, this assumption can be easily adjusted. Section 3.5 discusses this step more fully and sections 6.3 and 6.4 provide the unweighted analysis and a series of scenarios.

3.1 Selecting the parameters

The parameters have been selected on the basis of the analysis in section 2. They are designed to identify the core attributes arising from the digital broadcasting sector that will influence the success of interoperability and horizontal markets for digital receivers, as well as meet the broader policy interests of the European Commission. The parameters identified in section 2 are discussed in more detail here.

- *Economies of scale in STB manufacture*—there are two aspects of economies of scale in digital receiving equipment: those related to the volume of equipment produced; and those arising from additional costs imposed on equipment manufacturers through producing and managing a number of different APIs—known as the 'costs of diversity'. Increased take-up of DTV is likely to generate some volume benefits, while moving towards a single API would reduce the costs of diversity. The degree to which further economies of scale could be achieved by manufacturers (particularly volume effects) is dependent on the minimum efficient scale required for manufacture, and the degree of unit cost reductions that could be achieved by expanding beyond their current production level(s). Volume effects *may* be limited by the extent to which the prices of component parts (such as memory) are independent of demand in digital broadcasting, and are determined by demand in other industries (such as global computing). In this document, the working assumption is that savings or efficiencies through economies of scale related purely to volume effects are minimal, but that economies of scale may be achievable with respect to reducing the costs of diversity.[50]

- *Minimise re-authoring costs*—there are costs to re-authoring an application to enable it to be run on an installed base that incorporates a different API. The removal of this cost is a benefit of moving to a single API. However, even within an environment of a single API, applications are likely to need some re-authoring according to the characteristics of the platform (ie, cable, satellite, DTT, or other). This parameter captures the extent to which total costs of re-authoring are reduced, not that the unit costs are lowered.

- *Equipment innovation*—this refers to innovation in producing digital receiving equipment, both in terms of the core technical abilities of the equipment, but also in the presentation of the product to the consumer. The latter may involve developments such as additional *receiver* functionality, which is important for

[50] This assumption would need to be verified by an independent analysis.

ensuring that the same box can be used on different platforms or in different geographic areas (as opposed to API functionality that is discussed below), or the inclusion of alternative functions (such as DVD capability) within receivers.

- *API innovation*—a benefit of the current market situation with multiple APIs being developed is that there is non-price competition between middleware providers in terms of innovation. Middleware providers in a competitive setting will seek to innovate to distinguish their middleware product. This then facilitates the development of new applications that take advantage of the greater API functionality. Such impetus to innovate is reduced if there are fewer APIs. Within this, however, there is an inherent conflict with respect to the development of applications, since reduced API innovation can also facilitate the proliferation of applications because developers would be sure that the installed base would be able to support their content. This then facilitates take-up of digital services, through a virtuous circle of indirect network effects.

- *Robust API*—section 2 discusses the particular importance to FTA content providers of having a *stable* installed base of receiving equipment to overcome the need to actively manage the network. This implies that the API must be robust—ie, not easily disrupted. Specifically, a robust API implies that it is possible to implement independent production and testing of STBs. As a result, there is a much reduced chance of the STB experiencing problems receiving broadcast content and services. This is a prerequisite for FTA services, as there is no single manager of the network. On the other hand, pay-TV operators do not necessarily require a robust API, provided they are able to control and actively manage the equipment that is used on their network for interactive applications.

- *Applications development/innovation*—consumers only appreciate the benefits of having interactive functionality in their receiving equipment to the extent that it is exploited by the applications delivered by service providers. It is therefore important for consumers that applications innovation and development are motivated within the regulatory regime adopted. As already noted, consumers benefit from increased applications development and the associated network effects when there is more certainty associated with the identity of the API.

- *Stable technology*—for consumers to engage with a horizontal market in digital equipment, it is important that they have confidence that their investment in an expensive consumer durable item will not be rendered useless by technological advance or changed standards. This is known as 'stranding'. Stable technology is also important from the point of view of investment on the supply side (ie, manufacturers). If a firm is choosing whether to invest, uncertainty gives an option value to waiting.

- *Market-driven standard selection*—a standard may be set by the market by industry consensus (for example, GSM) or by a competitive process driven by the market (for example, the establishment of Windows as the dominant operating system). Alternatively, a standard may be set by regulatory intervention. Where a market is likely to 'tip' to a single universal standard because of strong network effects, regulatory intervention is unnecessary. Where the network effects are not as strong, but there is a perceived benefit to standardisation, regulators may need to encourage or impose the setting of standards. There is little theoretical analysis on whether markets or regulation are better judges of appropriate standards, and the empirical evidence is ambiguous. For example, it is widely accepted that the market 'got it wrong' when VHS dominated Betamax. Likewise, regulatory intervention had little success in defining standards associated with HDTV in Europe. Notwithstanding this uncertainty, where the impact of the mode of selection of the standard has an impact on the outcome in terms of the goal or objective, a weakly positive impact has been assigned as the conservative approach. This working assumption builds in a slight bias against imposed standards.

- *Single standard*—the market may be served by a few APIs, or by just one. This parameter captures the impact of the establishment of a single universal standard (regardless of how it is imposed).

- *Increase in STB cost*—the consumer is the focus of the policy option assessment process. The consumer will be highly sensitive to the price of the STB, especially since it is a derived demand for broadcast services.

3.2 Benchmarking the goals and objectives

Section 4 analyses the goals and objectives in detail, presenting them in terms of their underlying constituent parts. This deconstruction of the goals and objectives into component parts is important because there may be conflicting impacts of any parameter on a particular goal or objective. For example, increasing economies of scale is likely to have a positive effect on achieving efficiency in service and product provision (an aspect of competitive markets), but may reduce the prospects for entry (also an aspect of competitive markets). Each of the goals and objectives is examined by considering the extent to which each parameter influences the relevant particular components. For example, how far is inter-platform interoperability (a component part of interoperability) facilitated by the presence of innovation in equipment (a parameter)?

There are four levels of impact that a parameter can have on the goals and objectives:

- *strong* ('S')—the parameter in question has a strong and positive effect on the particular dimension of the objective or goal concerned;
- *weak* ('W')—the parameter in question has a weak but positive effect on the particular dimension of the objective or goal concerned. The weak effect may be indirect;
- *no effect* ('–')—the parameter in question has no effect; and
- *inverse* ('I')—the parameter in question has a negative effect on the particular dimension of the objective or goal concerned.

Thus, continuing the example above, the presence of good incentives for equipment manufacturers to innovate has a strong effect on inter-platform interoperability (and hence the overall goal of interoperability) because such inter-platform interoperability requires manufacturers to bundle tuners and common interface slots into digital receivers. On the other hand, the presence of such incentives for equipment innovation has only a weak effect on encouraging complementary products (one of the elements of delivering horizontal markets). This is because such innovation only indirectly facilitates the development of services over the installed receiver equipment.

3.3 Benchmarking the options

Section 5 presents each policy option in detail (including its definition, likely outcomes and impact on stakeholders), including an assessment of how each option is likely to affect the selected parameters. In each case, the issue is the extent to which the option would, in practice, create an environment where the given parameter would be realisable. As explained in section 3.1, the parameters summarise the market attributes most influential in achieving the goals and objectives.

There are four levels of effect that an option can have on a parameter:

- *high*—the option has a highly positive effect on the identified parameter;
- *low*—the option contributes to some degree (perhaps indirectly) to improving the conditions for that parameter;
- *zero effect*—the option does not enhance or reduce the likelihood of improving the conditions for that parameter; and
- *negative*—the option hinders the emergence of the given parameter.

The options are also directly assessed in terms of their political implementation. ‘High’ indicates a high cost—ie, difficult to implement; zero indicates no cost—ie, easy to implement. ‘Medium’ and ‘Low’ are intermediate points.

When assessing the options both against each other and in terms of the goals and objectives, it is important to bear in mind what would happen if there were no regulatory intervention. Hence the first policy option is the option of ‘non-intervention’. The other options are then assessed using option 1 as a benchmark. In other words, if an option would have no greater impact in a particular dimension than not intervening (ie, option 1) then the same outcome (ie, as for option 1) in terms of the parameter is assigned.

For example, ‘non intervention’ is expected to lead to a ‘low’ outcome with regard to economies of scale for manufacturers. Some convergence on API standards is expected without any intervention, which will lead to some improvement in the economies of scale accessible by manufacturers. However, this convergence is unlikely to be sufficient to enable manufacturers to significantly increase economies of scale by, in particular, reducing the costs of diversity associated with testing. Hence, when option 2a is assessed—the mandation of a single, low-specification API—the effect on economies of scale is now ‘high’, because the single API standard enables manufacturers to produce for a larger potential market and to reduce the costs of diversity.

3.4 Assessing each option’s success in achieving each goal and objective

The next step is to combine the analysis of the previous two stages in order to gain insight into the relative strengths and weaknesses of each option, as illustrated by how well they contribute to achieving the given goals and objectives. The process is described in this section and analysed in section 6.2.

The aim is to understand the impact of a particular policy option on the underlying components of the goals and objectives, through its effect on the parameters. The logic is that implementation of a policy will lead to changes in the market outcome, captured by the parameters. The way an option affects these parameters was assessed in step 3. The success of each parameter in affecting the goals and objectives was assessed in step 2. Combining these two in step 4 reveals the extent to which each option moves towards achieving the goal or objective.

For example, option 1 (‘non intervention’) has a ‘low’ impact on the parameter ‘economies of scale’. A given objective (say intra-platform interoperability) is only ‘weakly’ enhanced by a market situation where economies of scale exist. Therefore option 1 will achieve some (‘low’) economies of scale, which will ‘weakly’ facilitate the achievement of the objective of intra-platform interoperability. The combination is therefore ‘weak–low’.

As shown in Table 3.1, there are 12 possible combinations (given that those where the parameter has no effect on an objective are not worth considering). Each combination of option and goal/objective against each parameter needs to be scored in order to allow the inherent complexities in a given option to be traded off against one another. For example, again considering option 1, it is expected to have a low effect on encouraging innovation at the manufacturing level, which is a strong contributor to the achievement of intra-platform interoperability. Hence this combination is strong–low. The effect of option 1 on a given objective needs to aggregate the effect through all the parameters. This is achieved by giving each combination a score and summing them.

These scores need to be designed to reflect the fact that combinations that move further towards achieving the goal or objective should be given a higher score. Scores that have equal but negative values need to reflect situations with equal but negative impact. Hence strong–high and inverse–high need to be attached to policy impacts with equal, but offsetting, effects.

Table 3.1 shows the 12 combinations of the options’ performance against the effect of the parameters on the objectives, and the way each combination is scored.

Table 3.1: Scoring the combinations

Option performance (on the parameter)	Association between the objective and the parameter	Rating
High	Strong	4
Low		2
Zero		0
Negative		–2
High	Weak	3
Low		1
Zero		0
Negative		–1
High	Inverse	–4
Low		–2
Zero		0
Negative		3

Considering Table 3.1 in detail, in all instances where the option has no effect (ie, 'zero') the rating is '0', and hence the option receives no score. For those cases where a parameter is an important contributor to a goal, scoring zero will therefore lower the option's overall score with respect to that goal or objective.

Where the option has a positive effect on a parameter (ie, 'high' or 'low') *and* the parameter is positively associated with the objective (ie, 'strong' or 'weak'), the outcome combination receives a positive score. Where the association between the objective and the parameter is 'strong', the score for the option is higher for both 'high' and 'low' performances than for the same option performance where the association is weak. That is, the combination 'strong–high' scores more than the combination 'weak–high' (a '4' versus a '3') and the combination 'strong–low' scores more than the combination 'weak–low' (a '2' versus a '1'). This structure allows for differentiation both between how the option performs ('high' or 'low'), and between different associations between the objective and the parameter ('strong' or 'weak').

Importantly, however, a 'weak–high' combination is considered to be better than a 'strong–low' combination (a '3' versus a '2'). This makes it explicit that the analysis considers it better for an option to have a high effect on a parameter that only weakly benefits an objective than to have a low effect on a parameter that is strongly important for an objective.

Where the option performance is 'negative' and the association between the objective and the parameter is positive (ie, 'strong' or 'weak'), the option scores a negative value. The value is more negative where the association between the objective and the parameter is 'strong'. This reflects that 'more' of something negative is worse than 'less' of something negative.

Where the association between the objective and the parameter is 'inverse', this implies that delivery of that parameter by a policy option would be negative in terms of achieving the specific underlying component of the goals and objectives. For this reason, the scale is inverted. 'Inverse–high' is considered to be the exact opposite of a 'strong–high' combination. Similarly, 'inverse–negative' is not as beneficial as the 'strong–high' combination; in this case, two wrongs do not make a right.

Having allocated each combination a score, these combinations need to be aggregated to calculate the effect of each option on achieving each goal and objective (or component part thereof).

The results of these combinations have been rebased to a score out of 10 compared with the theoretical maximum for that option-objective pair. This is because a given pair may have a higher absolute score because this is an objective for which there are many important parameters. Without scaling the absolute score to control for the number of parameters, it may bias the results on a given option.

For every option-objective pair, there are a number of parameters against which the option has been interacted. On each parameter the maximum score that the option could have achieved is 4 for a high–strong outcome (according to the scale above). Therefore, the total an option could score against any objective is the number of relevant parameters (say n) multiplied by 4, giving a total possible of $4n$. The actual score summed across all the relevant parameters for the option against that objective is then divided by $4n$. The result is a score between 0 and 1 indicating the proportion of the total feasible score that the option achieved; this score is multiplied by 10 for ease of presentation and analysis.

As noted above, the assessment of implied political implementation costs was slightly different. There was a specific parameter for this aspect of the implementation objective, so it would be inappropriate to include it in the analysis with the others. Instead, the option's performance in terms of 'high', 'medium', 'low' and 'zero' is presented and the implications of this objective are discussed separately.

3.5 Ranking the options

The final stage of the process is to aggregate across the goals and objectives in order to judge the success of a given option for the full range of policy considerations facing the European Commission. The output of stage 4 is a score out of ten for each component of a given goal or objective. These scores can then be averaged up to the higher-level goals (interoperability and horizontal markets) and objectives (the EU policy objectives). It is at this point that weightings may be applied, to increase or reduce the relative importance of an underlying component of the goals and objectives, or of the individual parameters relative to each sector.

In the central analysis presented in section 6, no judgements have been made with respect to weighting the objectives. Instead, an equal approach has been taken which assigns equal weight to each of the components *within* the higher-level goals or objectives. Thus, an objective, such as increasing consumer welfare, has three components (quality, service diversity and protection from stranding), each of which is given a weight of one-third. If. however, the view was taken that service diversity was less important than the other two aspects, then the weightings could be adjusted to reflect this. The goal of achieving the correct demand-side conditions to facilitate a horizontal market has five components (price, quality, product differentiation, risk of stranding and vibrant complementary services); each of which is given a weighting of 20% in the main results. The policy view may be that price and complementary services are the key drivers of successful take-up of receivers, and the weighting could be adjusted to allow for this.

The result of adjusting these weights may lead to different options being attractive; hence section 6 also includes a number of scenarios where the weightings have been adjusted to reflect different judgements as to the relative importance of certain factors that make up the goals and objectives.

4. Goals and Objectives—Benchmarked against the Parameters

This study clearly needs to be considered within the broader EU policy context. As a result, high-level *policy objectives* in the area of digital broadcasting were identified at an early stage of the process. These have been presented earlier in the document. In summary, the objectives are to:

- increase consumer welfare;
- promote a non-discriminatory competitive market in Europe;
- promote incentives to invest in innovation;
- ensure relative ease of implementation; and
- remain vigilant concerning security issues.[51]

Any option proposed as a means of achieving the *goals* of interoperability and horizontal equipment markets must be evaluated against these objectives as well. Given the goals are seen as the means to the end of good public policy with regard to digital broadcasting, it is important that part of the evaluation and ranking of the policy options involves understanding their impact on these broader questions.

As described, the objectives are very broad. In order to gain a better understanding of the mechanisms by which policy options influence them, and to make the analysis more tractable, each goal and objective is broken down into a number of constituent elements or underlying factors. For example, an objective to ‘increase consumer welfare’ can be broken down into factors that include (but are not limited to) cost-reflective prices, high-quality products, and diversity through innovation. It is easier to gauge the success of an option in moving towards these factors than moving towards the overarching concept of ‘enhancing consumer welfare’. This is both because the concepts are more clearly defined, and because any given policy option or parameter may influence such a broad objective in conflicting ways.

For instance, a change may be good at reducing prices, but may be less good at delivering high-quality products. It is important to understand these different effects in determining how to rank policy alternatives. It is therefore more meaningful to assess the impact of any proposed policy change against these underlying components, and then derive the overall impact on the higher goal or objective from this assessment.

As discussed in section 3.2, this second step of the evaluation judges the importance of the parameters with respect to each one’s contribution to each of the underlying factors that make up the two goals and five EU objectives. In this section, the goals and objectives are broken down in detail, and analysed in terms of their component parts. The

[51] These objectives have been ascertained from a variety of EU consultation documents and approaches to related topics, and reflect the drivers of EU policy in this area. As is often the case with broad policy objectives, there is likely to be some inherent conflict between specific policy objectives (for example, between competition and investment). In this case, some judgement may need to be made on the relative importance of different objectives.

aim is to understand for each element of the goal or objective how important each parameter is in delivering the given element. For example, how far is inter-platform interoperability (a component part of interoperability) facilitated by the presence of economies of scale (a parameter)? Each parameter is determined to have either strong, weak, no or inverse effects on each selected factor underlying the goals and objectives.

4.1 Interoperability

As identified in section 1, there are three aspects to interoperability:

- *intra-platform interoperability*—interoperability of hardware between platforms of the same type that may be achieved in a number of ways: bundling APIs, simulcasting (ie, dual- or multi-illumination), or using the same API;
- *inter-platform interoperability*—interoperability of hardware between platforms of different types. This could be achieved in the same ways as noted above, but would require additional hardware innovation, such as bundling of tuners and (potentially) building FTA STBs with CI slots (to allow for upgrading to pay-TV);
- *geographic interoperability*—this implies that consumers could take their STBs or iDTVs with them when they move country. This could require either inter- or intra-platform interoperability. Achieving geographic interoperability requires any of the solutions to hardware interoperability to be solved in a similar fashion *across Europe*.

The achievement of the different types of interoperability is affected positively or negatively by a given parameter, to very similar degrees.

- *Economies of scale in STB manufacture*—the existence of economies of scale would facilitate all three types of interoperability, as this gives a production incentive to support commonality across STBs. The positive effect on inter-platform and geographic interoperability is relatively stronger because these forms of interoperability increase the size of the potential market substantially, allowing better exploitation of the economies of scale.

- *Minimise re-authoring costs*—if overall re-authoring costs are low, this has little impact on the achievement of interoperability, in and of itself.

- *Equipment innovation*—equipment innovation is required for the development of receivers that can be moved between platforms (tuners) and between FTA and pay-TV on the same platform (the CI module, if the correct CAS is not embedded). Equipment innovation therefore has a strong effect on achieving interoperability.

- *API innovation*—activity in API innovation is negatively related to interoperability of all three types since it makes it harder for market participants to coordinate on a single API; there will be an option value to waiting before standardising to a single API. A high level of innovation in APIs will also dampen incentives to achieve interoperability by bundling or simulcasting.

- *Robust API*—a robust API implies that it is possible to implement independent production and testing of STBs, and that such STBs will be more stable. This would facilitate the implementation of interoperability, but only weakly, since a robust API could be more expensive.

- *Stable technology*—this refers to stable APIs. Interoperability, in general, is facilitated when the API is stable since there is less risk of obsolescence. Manufacturers can invest in hardware which delivers interoperability between platforms and services, and be confident that the optimum technology will not change markedly. Consumers can have similar confidence in their purchases.

- *Market-driven standard selection*—the mode of selection of a standard is not relevant to achieving interoperability.

- *Single standard*—by definition, the establishment of a single API standard would strongly facilitate the achievement of interoperability.

- *Increase in STB price*—an increase in the price of the STB does not directly affect whether interoperability is achieved.

These parameters and their interaction with the three types of interoperability are summarised in Table 4.1.

Table 4.1: Summary of effects of parameters on interoperability

	Relevant dimensions of interoperability		
Parameters	**Intra-platform**	**Inter-platform**	**Geographic**
Economies of scale in STB	Weak	Strong	Strong
Minimise *re*-authoring costs	Inverse	Inverse	Inverse
Equipment innovation	Strong	Strong	Strong
API innovation	Inverse	Inverse	Inverse
Robust API	Weak	Weak	Weak
Applications innovation	–	–	–
Stable technology	Strong	Strong	Strong
Market-driven single-standard selection	–	–	–
Single standard	Strong	Strong	Strong
Increase in STB cost	–	–	–

4.2 Horizontal markets

The component elements that underpin successful horizontal markets were explored in section 2.5. Here these factors are summarised and each is then considered against the parameters, to determine helpful conditions for the development and/or success of a horizontal market in DTV receiver equipment.

As in any market, the prerequisites for successful demand and supply of the product are crucial for a vibrant horizontal retail market. Demand will be influenced by price, quality, and information, and supply will be affected by production technology and costs. The factors on both the demand and supply sides that influence the success of horizontal markets determined above are discussed briefly in turn below, followed by the assessment against the parameters.

4.2.1 Demand-side issues

Consumers will only purchase a particular product if they gain sufficient benefit from that purchase decision. The important elements that they will weigh up in making that decision are:

- price, both absolute and relative;
- quality of the product;
- the extent of product differentiation—ie, how close to an individual's preferred receiver can a product get?;
- minimum risk (in this context, technological risk, or a lack of standards, may result in stranding of the investment);
- availability of complementary services, as digital receivers are a derived demand for the content distributed over them.

Each of these aspects of the demand side in a horizontal market for digital receivers will be differently affected by the presence of the underlying features summarised by the parameters. The impact of the parameters is summarised in Table 4.2.

Table 4.2: Summary of effect of parameters on demand-side factors

	Relevant dimensions of the demand side				
Parameters	**Price**	**Quality**	**Product differentiation**	**Risk of stranding**	**Complementary product market**
Economies of scale in STB	S	–	–	–	–
Minimise re-authoring costs	–	–	–	W	S
Equipment innovation	W	S	S	–	W
API innovation	–	W	W	I	W
Robust API	I	S	W	–	W
Applications innovation	–	–	–	–	S
Stable technology	W	W	W	S	W
Market-driven single-standard selection	–	W	–	–	W
Single standard	W	–	I	S	W
Increase in STB cost	I	W	I	–	I

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

- *Economies of scale in STB manufacture*—the only effect of the presence of economies of scale is in achieving more affordable consumer prices. This assumes that the manufacturer passes the benefits on to the customer.

- *Minimise re-authoring costs*—there is a weakly positive effect in reducing the risk of stranding, since no single API is likely to be 'abandoned' if it is cheap to re-author content. There is a strong positive effect in the complementary market (ie, broadcast services) since it implies that content is more easily converted from one API environment to another.

- *Equipment innovation*—the presence of equipment innovation has an effect on several aspects of the demand side. In terms of price, other things being equal, innovation will reduce prices (as, for example, has occurred in PCs). The effect is only weakly positive, however, as most forms of technological innovation are more directed at quality improvements than price reductions. Quality and product differentiation benefit strongly from an environment when there is innovation in equipment. The complementary market also benefits, since innovation implies the ability to deliver more functionality in the STB. The effect is weak since it is indirect.

- *API innovation*—innovation in APIs does not affect price. There is a weak positive effect on quality and product differentiation. There is also a weak positive effect on complementary services; the variety of services available is likely to increase as developers use the functionality available in new APIs. However, the effect is weak again since it is indirect. The risk of stranding is increased (ie, there is an inverse effect) because more innovation in APIs is likely to generate greater differentiation between the APIs, and increases the risk of stranding.

- *Robust API*—a more robust API is likely to lead to strong improvements in the quality of service. This is because there is less chance of the STB experiencing problems, as a 'robust' API implies independent production and testing. There is a negative impact on the price of the STB, as a robust API requires more expensive components. The other effects are weakly positive on the complementary product market and on product differentiation. The former occurs because it is likely to be easier to ensure that services are delivered correctly; however, it is only weakly positive, as there is a slight downside if a robust API means that the level of functionality (and hence service that can be supported) is reduced compared with other APIs. The effect on product differentiation is positive since the ability to independently produce and test equipment allows more freedom for innovation. The effect is weakly positive, rather than strong, since it would, at present, only apply to the FTA market.

- *Applications development/innovation*—development of applications has a strong impact on the delivery of complementary services. This is a direct effect.

- *Stable technology*—stable technology is relevant to all aspects of the demand side of the horizontal market, since, for consumers to invest in digital equipment, it is essential that they have confidence that their investment will not be rendered useless by technological advance or changed standards. The effect in all of the aspects except for risk of stranding is weakly, rather than strongly, positive. This is because stable technology *can* imply that there is a reduction in innovation. The only exception is the risk of stranding, which benefits directly and strongly from stable technology.

- *Market-driven standard selection*—the importance of the mode of standard selection is only relevant to the aspects of quality and complementary services. The impact is assigned as weakly positive to reflect a conservative analysis of the impact of non-market-selected standards.

- *Single standard*—a single-standard environment would be strongly positive for reducing the risk of stranding, since, by definition, there are no competing standards. It would be positive for the development of complementary services, since all development activity would focus on the single API, but only weakly so, since there is a risk of lower functionality arising from the single API. The effect is weakly positive on price, on the assumption that there are economies of scale to be reaped by having a single API, but that the chosen API may be more expensive. A single standard is negative with respect to product differentiation—ie, there would be less means of differentiation if there were a single standard.

- *Increase in STB cost*—an increase in the price of the STB is clearly negative for the development of the market. This will lead to an inverse effect on price (obviously), on product differentiation and on complementary products. These latter two effects are driven by the risk that the higher cost of producing the box lowers entry in both the manufacturing and applications markets. The extra cost is likely to be accompanied by a positive shift in quality, benchmarked as weak.

4.2.2 Supply-side issues

Production of equipment constitutes the supply side of a potential market. Consumers cannot purchase equipment unless offered for sale by manufacturers. Suppliers participate in a market by considering the long-term viability of the investment required in the product, based on the market opportunities and the incentive they will have to address these opportunities.

Against this background, the factors that affect the likelihood that manufacturers will enter into the supply of a particular technological product can be encapsulated as follows:

- entry barriers must be relatively low, which also requires relative certainty about the future market;
- efficient production processes, with scope for reducing costs, attract entrants;
- incentives to innovate underpin successful development of new products and markets;
- impact on firm profitability—new areas may be difficult to establish when incumbent firms see the new product as a risk to existing profitable business.

Table 4.3 shows these dimensions of the supply side and how they are reflected in the appropriate parameters.

Table 4.3: Summary of effects of parameters on supply-side factors

	Relevant dimensions of the supply side			
Parameters	**Efficiency**	**Entry**	**Incentives to innovate (hardware)**	**Impact on incumbents' profit**
Economies of scale in STB	S	–	W	W
Minimise re-authoring costs	–	–	W	–
Equipment innovation	W	W	S	W
API innovation	–	–	–	–
Robust API	W	S	S	I
Applications innovation	–	–	W	–
Stable technology	W	W	W	I
Market-driven single-standard selection	–	–	–	–
Single standard	S	S	S	I
Increase in STB cost	–	I	W	–

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

- *Economies of scale in STB manufacture*—economies of scale in the production of STBs are positively associated with delivering efficiency in production and incentives to innovate. There is no effect on entry here, unlike the standard theoretical case where economies of scale do constitute a barrier to entry. This is because of the assumption that 'normal' economies of scale associated with volume effects have been largely exhausted, and that economies of scale arising from reduced costs of diversity do not inhibit entry. Achieving economies of scale would have a weakly positive impact on the profits of incumbents (ie, there may be a downside associated with 'cannibalisation' of existing profits).

- *Minimise re-authoring costs*—low re-authoring costs are weakly related to generating incentives to innovate in hardware. There are no other effects on manufacturers' supply incentives.

- *Equipment innovation*—equipment innovation is a positive supply incentive, as reflected in all the dimensions. The association is weak with respect to efficiency, entry and the impact on incumbent's profits because of the derived-demand nature of the product.

- *API innovation*—there is no effect on supply incentives.

- *Robust API*—a robust API would create strongly positive conditions for entry because of the possibility for independent production and testing. Therefore, a robust API is negatively related to incumbent's profits because it enhances incentives to enter. There would be strong incentives to innovate since the requirements for an application would be well specified through the test suite. A robust API is also positively linked to efficiency, but weakly, as it is an indirect effect.

- *Applications development/innovation*—a good environment for applications development creates an incentive to innovate (albeit weak) in hardware because of the spillover effects.

- *Stable technology*—a stable API may have a negative impact on the incumbent's profits, again because of the positive entry incentive generated. The effect on entry is, however, weak compared with the incentive of 'strong' of a robust API already referred to. This reflects the fact that a stable API may not necessarily have all the positive attributes of a robust API—eg, independent production and testing may not be feasible. A stable technology is weakly positive for incentives to innovate and efficiency.

- *Market-driven standard selection*—the mode of imposition of a standard does not affect manufacturers' incentives to supply.

- *Single standard*—a single standard would create strong positive incentives in terms of efficiency, entry possibilities and incentives to innovate. As a result of incentives to enter, the impact on incumbent's profits could be negatively related to the imposition of a single standard.

- *Increase in STB cost—*if the STB were to increase in price, this would deter entry for a given level of risk, but be weakly positively associated with incentives to innovate.

4.3 EU policy objectives

The EU policy objectives have been ascertained from a variety of EU consultation documents and approaches to related topics, and reflect the drivers of EU policy in this area. In this section, each policy option is discussed in more detail and broken down into its component parts, in order for the parameters to be assigned 'values' (ie, strong, weak, inverse, no effect), so as to reflect how far the objectives are facilitated by the parameters.

Many aspects of the EU objectives, particularly of increasing consumer welfare and ensuring non-discriminatory competitive markets, have already been covered by the horizontal market supply and demand framework examined in section 4.2. In this case, the results from the previous section are repeated, but not discussed.

4.3.1 Increase consumer welfare

Consumer welfare will be protected and enhanced by ensuring:

- provision of innovative and high-quality products and services at cost-reflective prices, providing consumers with freedom of choice;
- affordable access for all to the Information Society to prevent any social exclusion resulting in a society of information 'haves' and 'have nots' (ie, a 'digital divide');
- proliferation of innovative and diverse services to meet consumer needs;

- where possible, that early adopters of technology are not unduly disadvantaged by subsequent technological development.

These concepts of consumer welfare may be grouped into components that reflect price, quality, protection from stranding and service diversity. Quality and protection from stranding were also part of the horizontal supply and demand framework. The effect of these parameters is repeated in Table 4.4. Cost-reflective pricing is best delivered through competitive markets, for which there is a separate objective—addressed below. In this context, service diversity refers specifically to the delivery of services other than TV programmes to the television screen in a convergent world. Examples of diverse services include the Internet and *e*government services.

Freedom of choice and access are important components of consumer welfare, but are captured in the concepts of delivery of diverse services and cost-reflective prices.

Table 4.4: Summary of the effect of parameters on consumer welfare

	Relevant dimensions of consumer welfare		
Parameters	**Quality (high)**	**Service diversity**	**Risk (protection from stranding)**
Economies of scale in STB	–	–	–
Minimise *re*-authoring costs	–	–	W
Equipment innovation	S	S	–
API innovation	W	W	I
Robust API	S	W	–
Applications innovation	–	S	–
Stable technology	W	W	S
Market-driven single-standard selection	W	–	–
Single standard	–	W	S
Increase in STB cost	W	I	–

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

Service diversity is better delivered where there is innovation in both equipment and applications, since it is these that have a direct impact on the ability to deliver a wider range of services. There are also positive effects, although they are weaker, from an environment that results in API innovation (this will feed through to applications development, but is assigned 'weak' because increased API innovation could actually fragment the market), a robust API (services are less likely to fail, but there is the possibility of lower functionality being supported), stable technology (uncertainty is reduced), and a single standard (again, uncertainty is reduced and there is a potentially larger market). There is an inverse relationship with the cost of the STB, as a more expensive STB hinders penetration and hence makes entry into the product areas reliant on an installed base of receivers more difficult.

4.3.2 Promote a non-discriminatory competitive market in Europe

Promoting an open and competitive market is essential for:

- ensuring efficiency in service and product provision;
- ensuring a level playing field conducive to entry and dynamic progress;
- ensuring appropriate (affordable) product and service pricing;
- increasing the range of product and service offerings (both at the platform and equipment levels) available to meet consumer needs;
- ensuring that the market does not become distorted; and
- contributing to consumer welfare.

As was the case with consumer welfare, there is overlap between the components of promoting competitive markets and the horizontal supply and demand framework. This reflects the fact that an objective to encourage a horizontal market is similar to promoting a competitive market in devices. All the underlying features of promoting non-discriminatory competitive markets in Europe have already been covered: efficiency, entry, appropriate pricing and the complementary product market services. Ensuring that a market does not become distorted is part of the framework of promoting competition and is backed by competition law. Underlying factors relating to contributing to consumer welfare are dealt with by that specific objective.

The components and the effects of the parameters are repeated in Table 4.5 for convenience.

Table 4.5: Summary of effects of parameters on competitive markets

	Relevant dimensions of competitive markets			
Parameters	**Efficiency (service/ product)**	**Entry**	**Appropriate pricing**	**Complementary services**
Economies of scale in STB	S	–	S	–
Minimise re-authoring costs	–	–	–	S
Equipment innovation	W	W	W	W
API innovation	–	–	–	W
Robust API	W	S	I	W
Applications innovation	–	–	–	S
Stable technology	W	W	W	W
Market-driven single-standard selection	–	–	–	W
Single standard	S	S	W	W
Increase in STB price	–	I	I	I

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

4.3.4 Promote innovation and investment

Investing in innovation is helpful to ensure non-discriminatory and competitive markets, and to promote consumer welfare. It is important that any regulatory intervention (for example, setting standards) does not distort investment by restricting the opportunity to innovate in DTV markets. For instance, an overly restrictive use of standards in television might result in investment activity focusing on alternative technologies where there is greater freedom to innovate, such as PC-oriented initiatives, to the extent that these may be able to deliver similar outputs.

Investment and innovation should lead to better products being available to European consumers at all levels of the supply chain in DTV. The policy options will affect each of the levels differently:

- *platform operators*—these are the pay-TV network operators, such as BSkyB and Canal Plus. They are sometimes also directly involved in content provision; however, many operators purchase all content from upstream suppliers. Incentives to invest in innovation by platform operators refer to investment in the network infrastructure and installed base;
- *manufacturers of hardware*—this group includes companies such as Pace and Philips. Innovation by hardware manufacturers has been referred to above, and relates to additional receiver functionality such as extra tuners (as opposed to API functionality), or the inclusion of alternative functions (such as DVD capability) within receivers;
- *middleware providers*—this group includes such companies as OpenTV and Liberate. Innovation by these companies refers to the continued development of the embedded APIs upon which applications rely;
- a*pplication developers—*in this context, these are third parties that develop digital consumer products and services for the broadcasting industry. The term 'application developer' could in some cases refer to content providers or platform operators (where they are involved in content provision), but that is not the sense in which it is used here; and
- *content providers*—this group includes both the FTA broadcasters and pay-TV operators who develop broadcast content.

Table 4.6 shows how each of the identified parameters affects the incentives to invest and innovate of these participants in the broadcasting value chain.

Table 4.6: Summary of effects of parameters on innovation and investment at each stage of the value chain

	Innovation and investment incentives in the value chain				
Parameters	**Platform operators**	**Manufacturers of hardware**	**Middleware developers**	**Applications developers**	**Content providers**
Economies of scale in STB	–	W	–	–	–
Minimise re-authoring costs	–	W	S	S	W
Equipment innovation	–	S	–	W	–
API innovation	–	–	S	W	–
Robust API	–	S	–	W	–
Applications innovation	W	W	S	S	S
Stable technology	W	W	I	S	W
Market-driven single-standard selection	–	–	–	W	W
Single standard	W	S	I	S	S
Increase in STB cost	–	W	-	I	I

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

- *Economies of scale in STB manufacture*—this parameter has a weak positive effect on manufacturers' incentives to invest and innovate. Achieving economies of scale means that it is possible to produce more output cheaply; doing so better than a rival implies more profits.

- *Minimise re-authoring costs*—an environment of low re-authoring costs has a strongly positive effect on middleware and applications developers. Middleware developers are motivated to innovate since, if re-authoring costs are low, there are fewer costs associated with moving content over to a new API, thereby increasing the likelihood that a manufacturer will upgrade the API technology. Applications developers will respond positively since low re-authoring costs imply that an application written for one API potentially has a much larger audience across platforms using different APIs at low additional cost. Content providers and manufacturers of hardware would also both respond positively, but the effect is weaker. Content providers may be motivated to introduce more enhanced interactive content if it is cheap to re-author; hardware manufacturers may respond positively since low re-authoring costs imply that there is likely to be a wide range of complementary products available for any API selected.

- *Equipment innovation*—an environment that is conducive to equipment innovation will motivate manufacturers. It may also motivate applications developers, through the possibility of wider audiences from the increased interoperability between platforms driven by innovation in hardware (ie, integrating multiple tuners). This is a weaker, indirect effect.

- *API innovation*—middleware developers will be strongly motivated by API innovation since this is their field of expertise. As discussed in the demand-side analysis, there is a certain ambiguity over how an environment of innovation in APIs affects the incentives of applications developers. Innovation in APIs motivates developers to create new and innovative applications for consumers, hence API innovation has a (weak) positive effect also on complementary services. However, API innovation may reduce the development of applications if the potential market for any one API becomes too small. To ensure a conservative analysis of the impact of API innovation, the effect on applications developers has been assigned as weakly positive (as before).

- *Robust API*—an environment of a robust API, particularly the fact that it allows for independent production and testing, would result in positive effects on innovation by manufacturers, who would be able to follow independent production and testing regimes and would be freer to innovate; and on innovation by applications developers, although this could be restricted by the robustness itself. Hence, the impact is weakly positive.

- *Applications development/innovation*—an environment of applications development and innovation is positive in terms of the investment incentives of all the participants. The effect on manufacturers is weakly positive, since it works through the derived demand for complementary services. The effect on platform operators is also weakly positive, working through the derived demand for a better product, thereby increasing the size of the possible market. Middleware developers, applications developers and content providers would all respond in a strongly positive way to an environment where there were applications development and innovation.

- *Stable technology*—stable API technology is not consistent with high levels of innovation, which would dampen incentives for middleware developers. For the other industry players, an environment of stable technology works to reduce uncertainty and increase confidence in investing, partly as a reflection of increased consumer confidence in the market where there is little chance of stranding. The effect is strongest for applications developers, since it is a direct effect.

- *Market-driven standard selection*—the mode of selection of any standard is only relevant to applications developers and content providers, since the identity of the standard is most important to them.[52] As before, the parameter is assigned as weakly positive to reflect a conservative analysis of the impact of non-market-selected standards.

- *Single standard*—middleware developers would be negatively affected and would be less likely to innovate. All innovation would be within the context of the selected middleware, and this constraint is likely to shrink this market. Platform operators would be weakly positively affected in terms of incentives to innovate, since competition may be strengthened by the existence of a standard. Investment may therefore be necessary as an alternative way of distinguishing a platform and persuading consumers to subscribe. Manufacturers of STBs, applications developers and content providers would all be positively motivated since it removes uncertainty and re-authoring costs, and allows for the potential market to be larger.

- *Increase in STB cost—*an increase in the price of the STB would reduce the incentives for content providers and applications developers to provide content, if they believe that a more expensive box will shrink the market. Manufacturers of hardware would respond positively, but the effect is weak since the level of demand for an increased price may be reduced.

4.3.5 Ensure relative ease of implementation

A policy may meet many other criteria, but its ease of implementation will be critical to its success. An important policy objective would therefore be to ensure:

[52] This is form the demand-side perspective. Obviously the suppliers of APIs, middleware providers, have a strong interest in the chosen standard!

- *practical* ease of implementation, which will depend on issues such as the degree to which take-up among the public can be fostered, and the degree to which there can be continuity across hardware and software systems;
- *political* ease of implementation—the evaluation of, and consultation with, the different stakeholders will be an important input into this objective; and
- the *legal* ease of implementation.[53]

The political issues related to the implementation of particular options are not the primary focus of this study, and so this element of the implementation objective is not assessed against the parameters. Rather each option is analysed directly in section 6 in terms of its ease of implementation.

Table 4.7 shows how the parameters affect the achievement of a practical ease of implementation. The analysis is based on an assessment of whether the characteristics of the market identified by the relevant parameter would facilitate an easy implementation of an option.

Table 4.7: Summary of effects of parameters on practical ease of implementation

Parameters	Practical ease of implementation
Economies of scale in STB	–
Minimise re-authoring costs	W
Equipment innovation	W
API innovation	–
Robust API	I
Applications innovation	S
Stable technology	S
Market-driven single-standard selection	S
Single standard	I
Increase in STB cost	I

Note: 'S' should be interpreted as strongly positive effect, 'W' as weakly positive and 'I' as an inverse effect. '–' implies no impact.

- *Economies of scale in STB manufacture*—achieving economies of scale will not affect the difficulty of implementing an option.

[53] Note that an analysis of the legal ease of implementation is outside the scope of this study, and the political assessment will be limited to the stakeholder analysis.

- *Minimise re-authoring costs*—reducing re-authoring costs would provide a stimulus to applications development, and provide direct benefits to those firms currently incurring such costs. Therefore this parameter would have a weak–positive effect on implementing any given option.

- *Equipment innovation*—improving the likelihood of equipment innovation will produce benefits for consumers and stimulate general developments in the technology, providing positive incentives for the horizontal market to develop. As these are beneficial developments, they will ease the implementation of any particular option, but only weakly.

- *API innovation*—increasing API innovation has a positive effect on the functionality available to consumers, but makes interoperability harder to achieve (by increasing the losses from moving to a single or standardised API). As these are offsetting impacts and there is no particular rationale for considering one to be more significant than the other, this parameter is given a neutral, no effect rating.

- *Robust API*—introducing a robust API is likely to have considerable impacts on DTV operators, especially pay-TV. The implementation of such an option would be difficult, hence the impact is inverse.

- *Applications development/innovation*—an environment that encourages applications development will produce tangible benefits for consumers, and help stimulate the take-up of all digital services, particularly FTA. This will considerably ease the implementation of an option generating this outcome, so there is a strongly positive effect.

- *Stable technology*—stable API technology provides consumers with greater certainty, and thus is positively related to the penetration of digital receiving equipment. This is a strong effect.

- *Market-driven standard selection*—imposing any standard or regulation that fundamentally alters the development of a market. Therefore, allowing the market to determine the appropriate standard reduces the difficulties of implementing any given regulatory initiative.

- *Single standard*—as with a robust API, introducing a single standard implies substantial impacts on existing market players, and so would involve a considerable degree of difficulty in implementation.

- *Increase in STB cost*—similarly, increasing the cost of STBs has a negative impact on consumers and DTV operators. Therefore, any option resulting in this effect would face considerable difficulties in gaining acceptance for its implementation.

4.3.6 Remain vigilant concerning security issues

Security issues are of concern at many different levels within the DTV supply chain. The aim of this objective is to ensure:

- a high level of data protection and privacy for citizens;
- the appropriate delivery of DTV content to subscribers and reduced opportunities for piracy (including hacking);
- copyright protection; and
- technical network security.

Citizens are already well protected in law, in terms of data protection and privacy issues. The achievement of the other dimensions is best reflected by the contribution of the policy option to robust network management.

5. Outline and Assessment of the Policy Options

This section presents the policy options that have been identified for achieving interoperability and/or horizontal markets in the European DTV market. In section 6, each option is assessed using the evaluation tools developed in section 3 against the two goals referred to, and against the overarching EU objectives. To allow this, it is necessary to gauge the impact of each policy option on the important attributes of the market, summarised in the parameters of the evaluation tool developed in sections 2 and 3.

The policy options have been determined through a consideration of the DTV market in Europe, an understanding of the technical aspects of DTV delivery, consideration of the ways in which similar problems have been addressed in different countries and industries around the world, and application of the relevant economic theory (see appendices for summaries of the conclusions from each of these component areas of research). The options fall into two broad groups: policies that *impose* a required outcome; and policies that *influence* the market to arrive, by itself, at the 'desired' outcome.

The advantage of imposing a regulatory requirement is that the identified goal is, by definition, directly achieved. Where there are two goals, as in this case, the policy may still exert influence in terms of achieving the second, non-imposed goal. Policies that directly impose an outcome fall into two sub-groups: those that impose the way that an outcome is reached on some or all of the market, and those that require a specific outcome by a specific time, but let the market choose how to reach that outcome. It should be noted that no legal analysis has been conducted in relation to the feasibility of these objectives, especially with regard to state aid.

Policies in the first sub-group could be those, for example, that require interoperability to be facilitated by imposing a standard API. There are disadvantages associated with such policies, including the considerable risk of 'picking' the wrong standard, or of picking it at the wrong time. Either of these outcomes could have negative effects on the development of the market. Policies in the second sub-group could be those that require some level of interoperability and/or horizontal markets, but do not specify how this is to be achieved.

Policies that seek to influence the desired outcome rely upon the market to respond to a set of incentives that is created through policy intervention. The outcome is therefore sought indirectly. This may still be open to the same potential problems of pre-selected standardisation if a clear incentive to move to a specific, predetermined standard is created, for example through subsidisation of content written to a specified API. In addition, as the policy only influences the outcome through incentives, the incentives introduced may not be strong enough to overcome the existing market dynamics and to achieve the objective without intervention. The range of identified options involves a mix of all these types of option, and is as follows:

- *impose* interoperability (and thus influence the development of horizontal markets):

  option 2 mandate a single, specific API;
  option 3 mandate that all digital receivers be 'interoperable', by a specified date;

option 4 mandate the use of mark-up languages or some other method of removing the need to have compatibility between applications and APIs;

- *impose* horizontal markets (and thus influence the development of interoperability):

option 5 mandate that all digital receiver equipment must be bought or rented at the retail level with no subsidies;

- *influence* the development of interoperability and/or horizontal markets:

option 6 influence the market towards interoperability using subsidies.

In the sections that follow, each policy option is analysed in the same way: the option is defined; its probable outcome is outlined; and the likely impact on stakeholders is discussed. The relevant stakeholders are content providers, platform operators, middleware providers, manufacturers, applications developers and consumers.[54] Finally, the option is benchmarked against the parameters identified in section 3. In some cases, the policy option could be implemented in several different ways, hence these variations are also analysed.

When assessing the options both against each other and in terms of the goals and objectives, it is important to bear in mind what would happen if there were no regulatory intervention. Hence, the first policy option that is considered (option 1) and assessed in terms of the parameters is the option of 'non-intervention'. The other options are then assessed using 'non-intervention' as a benchmark. In other words, if an option would have no greater impact in some dimension than 'non-intervention', the same outcome in terms of the parameter is assigned.

A final option, option 7, is given consideration at the end of the section. This is the option to influence the market towards interoperability and horizontal markets through analogue switch-off. The political and practical implications make it unlikely that this would be implemented prior to there being a critical mass of digital services established in the market, and a significant level of penetration. The other six options are aimed at achieving these pre-conditions. Thus, the option is discussed in more general terms and is not evaluated using the same framework.

[54] Platform operators refer to pay-TV only, as there is no single operator in an FTA environment, rather there are simply content providers.

5.1 Option 1: non-intervention

5.1.1 Option description

This option is for the market to be allowed to develop of its own accord, and represents the least interventionist approach. There would be no regulatory intervention to move the industry to a single common API or to introduce horizontal markets, although either or both of these outcomes may naturally arise in all or part of the market.

5.1.2 Option outcome

In the short to medium term, current digital pay-TV operators are likely to continue to operate with their existing APIs. In the absence of any incentive, pay-TV operators are unlikely to change their business model. This is in line with the economic theory—the incentives for these players to introduce compatible systems are muted, particularly where this may increase their costs.

Theory and experience suggest, however, that it may be possible for the FTA sector to agree upon a single robust standard (allowing for 'passive' network management and the achievement of any economies of scale in production through larger runs). There is already evidence of a number of FTA country groups adopting the same API. Due to their technical robustness, this is generally either MHEG-5 or MHP.[55] It is likely that new FTA services being developed will follow this trend and adopt one of these APIs in order to take advantage of the implementation experience of other operators and the availability of appropriately authored interactive content.

It is unclear whether greenfield pay-TV operators will implement a similar API to that established in the FTA sector, or whether they will adopt an alternative API (which may well already be used by other pay-TV operators). This choice is likely to be based on a number of factors, including the cost differential of the STBs (assuming a vertical model), the relative availability of applications on the different APIs, and ownership links. Ownership links relate to the commonality of APIs across large media groups; in general, firms such as Canal+ have adopted the same API throughout their networks.

Overall, market pressures and other pressures notwithstanding, the FTA sector is likely to coordinate around a single standard. Pay-TV operators are likely to retain their vertical business models, supplying the STB on a rental basis, or for free. This will allow them to simplify the management of their network, and retain existing APIs, even if they are not robust. New pay-TV operators may follow this model, particularly where initial pay-TV adoption may need to be stimulated. The vertical model allows them to incentivise by subsidising hardware acquisition costs for consumers, which is particularly important when the value of pay-TV to consumers is uncertain. Whether these new operators pick the same API as that used in the FTA sector will depend not only on the factors outlined

[55] As already noted, these are not equivalent options, as MHP requires a considerably more complex, and at present more expensive, STB than MHEG-5. It appears that it may be possible to download MHEG-5 into existing boxes used for other APIs.

above, but also on their views on how fast the market will develop. New pay-TV operators may want to be able to take advantage of consumers upgrading from the FTA installed base.

In terms of interoperability, the same API in FTA markets would facilitate geographic and national intra-platform interoperability for consumers, and would mean that more content is available at less cost because of reduced re-authoring costs. The development of inter-platform interoperability will depend on the incentives to innovate in equipment and produce STBs with duplicated parts to overcome the technical differences between platform types (eg, dual band tuners).

In terms of horizontal markets, on the supply side the incentive for manufacturers to innovate and bring a variety of high-quality, affordable equipment to the market will be increased if the sector can coordinate around a single acceptable API (and in so doing reduce uncertainty). On the demand side, consumer engagement depends on the cost (and availability) of receiving equipment, and the available services. The more attractive are the services available through digital reception as compared with analogue, the more likely consumers are to purchase digital receiving equipment.

Development of a successful horizontal market in digital receivers in the FTA part of the market *could* affect the pay sector, and create further incentives for interoperation between the two sectors. Pay-TV operators may be interested in accessing the installed base of digital receivers that had been purchased by consumers for FTA reception. If these STBs were built to allow for conditional access (ie, they incorporate a CI slot or have multiple embedded CAS) then there would be no need to subsidise or provide equipment for these new subscribers, were they to upgrade to pay-TV services (provided the API was appropriate). This creates an economic incentive for pay-TV operators to broadcast their services in a format that can be understood by the installed base of STBs acquired by consumers for FTA services—ie, to broadcast using the API chosen by the FTA broadcasters. However, the inclusion of CI slots or CAS would have to occur at manufacture and increase the cost of the STB. Therefore, the decision to purchase a digital receiver with this capability would involve extra cost, and would ultimately depend on the consumer's valuation of the future option to subscribe to pay-TV services without needing a complete, new, STB.

The development of more applications and services that run on a particular API may further increase the likelihood of convergence over time towards the single (or a small number of) API(s) in both FTA and pay-TV services.

This analysis therefore predicts that, under the 'non-intervention' scenario, the market *could* motivate the emergence of either a small number of APIs (with just one in the FTA sector), or a common API across both sectors. Such a result depends upon the development of horizontal markets in consumer hardware, on the development of compelling content in the FTA sector, and the concomitant pressure on pay-TV operators to interoperate with the established base in the FTA sector.

A downside is that the timeframe for such a result may be relatively long, and the outcome is uncertain. Although the incentives for the FTA sector *not* to coordinate around a single API are weak, the sector could fragment into using multiple, incompatible, APIs. Nonetheless, the incentives to coordinate are not particularly strong, and it is hard to predict what other pressures may become important and cause the market to deviate from coordination between FTA broadcasters across the European market. A benefit from coordination would be that, if either or both the FTA and pay-TV sectors did converge on a single API, this API would have been determined by the market, obviating the risks attendant on intervention (particularly in artificially picking a 'winner' API).

5.1.3 Stakeholder impact analysis

The impact of the option 'non-intervention' on the stakeholder is set out in Table 5.1.

Table 5.1: Option 1—stakeholder impact analysis

Stakeholder	Impact
Manufacturers	In the short term, there would be little change. Benefits will arise, however, if the FTA sector can engage consumer interest and grow, and if a single, robust API standard can establish itself in the FTA sector, allowing more freedom to innovate in equipment. Further benefits will develop if pressure to interoperate develops within the pay-TV sector.
Application developers	No immediate change. Applications development will benefit from the emergence of a single, robust API standard in the FTA sector, reducing uncertainty about which API to write for. As the market grows and as innovation in equipment increases, this would also be positive for applications developers.
Content providers	Again, no immediate change, but benefits should emerge as the result of the (probable) establishment of a robust, common API in the FTA sector.
Platform operators	The potential of the market to tip to interoperability across the two sectors depends on the incentives that platform operators face. Some may choose to continue current practice—as isolated, proprietary networks that subsidise the consumer equipment. Others may prefer to interoperate with the FTA sector in order to take advantage of the installed base of STBs that has developed based upon FTA content and supported by the horizontal market. Depending on the speed with which platform operators decide to interoperate, and on how it is accomplished, there will be some cost to a transition.
Middleware providers	Middleware developers are negatively affected when there is a reduction in demand for diverse middleware. This option has no immediate impact, however, as there would be continued competition to innovate in APIs, up to the point at which the total market converges to a single API (if it does). If the FTA sector establishes a single API, as predicted could happen, the competition between different middleware will be confined to the pay sector. However, if, as is likely, the API chosen by the FTA sector is open, there will continue to be competition in the implementation of the chosen API.
Consumers	The broadcasting environment for consumers will develop slowly. Pay models will continue to innovate and to seek to persuade subscribers to join. Consumers will switch to FTA digital as the content becomes sufficiently persuasive (in the absence of a forced switch). If the total market converges to a single API, there should be consumer benefits in terms of innovation in applications development and manufacturing, but this could be at the cost of (potentially) more expensive STBs in the pay-TV sector. A mitigating cost factor could be the achievement of economies of scale as the market grows, centred around a standard API.

5.1.4 Option assessment—most likely outcome

Table 5.2 assesses the performance of this option against the parameters developed in sections 2 and 3. The analysis in the table considers the impact of the option in terms of the changes in the market that are stimulated, as reflected in the attributes. As already mentioned, option 1 is being taken as a base case, or the market outcome that would occur were there no intervention in the market. In order to assess the benefits of policy intervention, it is necessary to understand whether the relevant policy options improve, have no effect, or worsen delivery of the parameters compared with the base case.

However, as described above, option 1 does not determine an outcome. The present analysis indicates that the most likely outcome is that FTA broadcasters converge on a single API, and that, at least in the medium term, pay-TV operators continue with their propriety, and non-interoperable, APIs. This is the outcome that is taken as the base case.

Overall, the option does not produce strong results in many of the areas, except that the market chooses the API. This reflects the fact that market players are able to migrate to a single API at their own pace (which may be never), and the identity of that API is determined by the market. There is also no strong incentive on pay-TV operators to alter their vertical business models in favour of horizontal ones.

However, the cost of this limited impact is that the policy goals of total interoperability and full horizontal markets are achieved only slowly, if at all. The timetable is not clear, and uncertainty persists on both the supply and demand sides of digital broadcasting (with respect to the right API to integrate in STBs and the risk of obsolescence). As a result, the benefits of interoperability, such as increased application development or the stability of technology, are not fully achieved.

**Table 5.2: Assessment of option 1: non-intervention—
most likely outcome, taken as the base case**

Parameter	Option performance	Outcome
Economies of scale in STB	Economies of scale depend on the size of the market and on reduced costs of diversity. Some economies of scale will be achieved, as the FTA market converges on a single API. The size of the market will depend on the broadcasters' ability to convince the public that the additional content is worth the higher costs. This may lead to uncertainty for manufacturers.	Low
Minimising re-authoring costs	Little impact on the re-authoring cost environment while multiple APIs exist. However, within the FTA sector using FTA platforms, re-authoring costs are low because of the adoption of a common API.	Low
Equipment innovation	As the FTA sector coordinates around a common and robust API, manufacturers are likely to perceive less risk and more upside to investing. In fact, this is already happening to an extent—for example, with the advent of equipment with multiple CAS and tuners.	Low
API innovation	There is initially no impact on API innovation. There may be some reduction if the whole market moves to a single API.	Zero
Robust API	This option results in a robust API in the FTA sector because of the requirement to solve the network management issue in that way.	High
Applications innovation	Innovation in applications is unlikely to be affected until a single API reaches some critical mass. Given the uncertainty of this option, it may take a little time, even in the FTA sector.	Zero
Stable technology	There would be little change in the perception of the stability of the technology until critical mass is reached in the FTA sector.	Zero
Market-driven standard selection	The option requires that any standards are picked by the market.	High
Single standard	There may be some impetus towards the establishment of a single market across all output, although this depends on how fast the FTA sector develops, and then on how the pay-TV sector responds.	Low
Increase in STB price	The option will not have a direct impact on the price of STBs.	Zero

5.1.5 Option assessment—the FTA market does not coordinate

For the reasons set out above, option 1 does not have a very deterministic outcome. It seems probable that the FTA sector would coordinate around a single API, but this is not guaranteed. If the coordination does not happen, the outcome is rather different to that presented above. The major differences are mostly negative:

- fewer economies of scale would be realised;
- re-authoring costs would be higher;
- equipment innovation would be less; and
- applications innovation would be likely to suffer.

Perhaps one positive outcome would be more innovation in APIs. However, even here, the loss of a large customer base may have a negative impact on the incentives to innovate, given the difficulty of recovering costs of interactive services in the FTA sector.

In evaluating the options against option 1, the possibility of the outcome described directly above needs to be taken into account.

5.2 Option 2: mandate a single API

At a superficial level, this policy option seems straightforward. It demands that, from a certain date, all interactive services must be written to a common API *at least,* and that all new STBs must support the common API *at least*. However, such a policy could be implemented in a variety of ways. These options could all be ultimately achieved (with varying levels of cost) via some kind of migration strategy.

In all the permutations below, the API that is imposed is assumed to be 'robust'. As has already been discussed, FTA services require a robust API to minimise post-purchase equipment management problems and to obviate the need for active network management. Such an API also allows for independent product testing against tight specifications. A potential downside of a robust API is that it may need more sophisticated receiver equipment than is currently found in most pay-TV installed equipment bases, and in many consumer homes.

Options that address the application of a single, robust API across both sectors are:

- option 2a: mandate a single, low-specification API (delivering a limited set of potential services); and
- option 2b: mandate a single, high-specification API (delivering a richer set of potential services).

Establishing a single API across the whole market could have significant implications for the pay-TV business model. In order to take advantage of the opportunities arising from the installed base resulting from a viable horizontal market, pay-TV operators would be likely to offer lower ongoing tariffs to those consumers providing their own equipment.[56] This would highlight the degree of apparent subsidy provided to subscribers taking their equipment from the operators. Depending on consumers' preferences, pay-TV providers may need to minimise this differential (through rebalancing the tariff offerings) if they cannot prevent consumers taking the 'subsidised' STB and using it to access competitors' service offerings directly.[57] This would be likely to reduce the level of subsidy available to subscribers taking the equipment; such subsidy reduction could come in the form of greater up-front charges, or a higher rental component of the monthly bill.

[56] If there were no differential in the ongoing monthly subscription rate, consumers might still prefer to take equipment from the pay-TV provider. Therefore the pay-TV operator would not materially reduce its capital hardware costs, nor actually take advantage of the horizontal market.

[57] This assumes that there is a maximum contracted tie-in period that consumers will accept, and that this is not long enough for the full up-front subsidy to be recovered. Operators therefore effectively rely on continued consumer loyalty beyond the tie-in in order to recoup the subsidy.

As a result, if FTA services use the same API as the pay-TV sector, it is unlikely that pay-TV operators will subsidise boxes to the same extent as they do currently. Practices where operators (such as BSkyB in the UK) provide free STBs, which subsequently belong to the consumer, would be likely to cease. As noted in the previous footnote, the contractual tie-in period may be insufficiently long to recoup in full the subsidy, and the presence of a common API would present consumers with considerable alternatives to those pay-TV services from the operator providing the box. Therefore, there would be a greater risk of failure to recoup the subsidy, leading to a reduction in the level of subsidy or its withdrawal altogether.

For those pay-TV operators offering subsidised equipment rental (the vast majority in Europe), the subsidy could decrease for similar reasons. If subsidised rental from one operator can be combined with services from operators who are not contributing to the subsidy, the subsidy becomes unstable, and rental rates would have to increase to cover the full costs of the equipment. While other pay-TV operators (or even FTA operators) would be under no obligation to accept interoperable equipment onto their network, there is likely to be an incentive for them to do so, as it reduces their costs, as noted above.

Variations on the full immediate mandation of the single API for all operators include:

- option 2c: mandate a single API only in the FTA sector;
- option 2d: mandate a single API in FTA and greenfield pay-TV developments; option 2e: mandate a transition to a robust API via an interim lighter version.

Since the first two of these options (2c and 2d) only apply to a subset of operators, it is important to consider the effect, if any, on the other players. For the whole market to tip to a single API and therefore facilitate (increased) interoperability, the right incentives must be created for the pay sector, as a result of the commonality of API in the FTA sector. Specifically, the outcome of the option in terms of stimulating attractive FTA content and consumer interest in digital services would need to be sufficient to convince the pay operators that there would be net benefits for them in migrating to the same API, and thus facilitating interoperability across the two sectors. Were the market to tip, the impact and consequences of introducing a common API would be as described in the first two sub-options (2a or 2b, where a single, specific API applies across the whole market).

5.2.1 Option 2a: mandate a single, low-specification API

All broadcasters and operators would be forced to move to a common API that would be robust, but would not have all-embracing functionality. All other things being equal, a low-specification STB is likely to be cheaper than a high-specification one, although it has lower functionality. An example of such an API would be MHEG-5. It is assumed that this API, although of low specification, would still be robust, and therefore reasonably stable, and allows for the possibility of independent production and testing.

In addition, a relatively low-specification, but robust, API may be downloadable into some, if not all, of the existing STBs currently attached to the digital broadcasting infrastructure. If this is the case, this outcome is relatively cheap to implement, as it re-uses much of the existing infrastructure.

Option outcome

This option, by definition, facilitates the achievement of interoperability (both inter- and intra-platform). However, as the common API would be a low-specification version, there may be a degradation of service for those consumers currently receiving interactive services based on a more advanced API. This prospect would be likely to make the option difficult to implement, and may dampen incentives to develop inter-platform and geographic interoperability.

Stakeholder impact analysis

The analysis of the option of mandating a single, low-specification API is set out in Table 5.3.

Table 5.3: Option 2a, mandate a low-specification API— stakeholder impact analysis

Stakeholder	Impact
Manufacturers	This option is quite positive for manufacturers relative to the base case. Incremental benefits arise from the increased incentive to innovate in applications, the establishment of a robust API and of a stable technology. There are increased incentives on the part of manufacturers to invest due to the existence of a single standard that operates across all markets. A potential negative impact for manufacturers might be if the market size is limited by the functionality that the low-specification API can support, and as a result consumers find the whole digital package less attractive, making them less likely to purchase receiving equipment.
Application developers	Applications developers would also benefit relative to the base case. There would be a reduction in re-authoring costs, and a more stable, robust, standard technology. Applications and equipment innovation should increase within the capabilities of the API, but applications developers would be negatively affected by the reduction in functionality of the API. The imposition of an exogenously determined standard could also have costs.
Content providers	Content providers will benefit from the establishment of a common, robust API standard. Re-authoring costs fall and there is an incentive to develop more applications. However, content providers could also be negatively affected by the lower functionality of the API. There is a potential cost where the market does not set the standard.
Platform operators	Relative to the base case, some platform operators fare slightly better, while others fare slightly or significantly worse. The stabilisation of a uniform API is likely to increase applications development, and hence the range and diversity of service providers, but the limited functionality limits the range and diversity of potential services. Platform operators currently using high-specification, but non-robust, APIs in their network infrastructure see a reduction in the quality of service they can offer. If the chosen API cannot be downloaded into existing STBs, they also face the cost of replacing the existing installed base of boxes, which their customers may be unwilling to pay for.
Middleware providers	Most middleware providers will be negatively affected by such an option, relative to the base case, as those providing any API other than the chosen one are likely to see their market shrink or disappear. However, those middleware providers supplying the chosen API will see their market expand. There may also be a general reduction in API innovation which is a negative welfare outcome.
Consumers	Consumers will benefit from the single standard, as competition in applications development increases, manufacturers innovate more and the decoder can be used on different platforms. There is, however, the potential cost of the interactive applications offering only a low level of functionality.

Option assessment

Table 5.4 outlines the performance of this option against the parameters (and compared with the base-case option, 'non-intervention').

The option has a positive impact on several of the parameters. The single standard should allow economies of scale in STB production across the entire market through reduced costs of diversity and a larger potential market. Part of this effect is driven by the fact that the robust nature of the API allows for independent production and testing of STBs, and the option reduces uncertainty around the stability of the technology.

The incentives for equipment and applications innovation are affected positively; however, the low-specification nature of the API means that certain desirable applications innovations are curtailed and thus the impact is 'low' rather than 'high'. For both attributes, the impact is stronger than was the case in the 'non-intervention' option.

API innovation is negatively affected as a direct impact of the option, as it is not a 'market-driven standard'.

There are likely to be some transition costs associated with this option. The practical implementation involves swapping out all the existing APIs, and possibly some or all existing STBs on existing networks. Politically, this option is likely to meet with resistance on several fronts; in particular few broadcasters or platform operators will want to be forced to migrate to an API that could curtail their future development of applications.

Table 5.4: Assessment of option 2a—single, low-specification API

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	High	Low
Minimising re-authoring costs	High	Low
Equipment innovation	High	Low
API innovation	Negative	Zero
Robust API	High	High
Applications innovation	Low	Zero
Stable technology	High	Zero
Market-driven standard selection	Negative	High
Single standard	High	Low
Increase in STB price	Low	Zero

5.2.2 Option 2b: mandate a single, high-specification API

This is the same as the previous option, except that the mandated API has a high specification that is both robust and able to support the greatest level of functionality. At present the only API of this type is MHP.

Option outcome

As for option 2a, interoperability is facilitated by the imposition of a single API. The key difference is that a high-specification API, in addition to allowing for independent production and testing, allows for greater innovation and development in applications and in equipment. This is a result of the nature of the API. A significant downside, that might limit the market, is that the higher-specification API could lead to an increase in the price of STBs and other decoders. In addition, it is less likely that such an API could be downloaded onto all existing STBs, and is therefore more likely to require a large number of STBs to be swapped out.

Stakeholder impact analysis

The impacts of option 2b (mandate a high-specification API) would be very similar to those of option 2a (low-specification API) shown in the table above. However, the incentives to innovate by manufacturers and applications developers would be greater due to the higher level of functionality offered by the API. Consumers would benefit from this greater potential for applications development relative to option 2a, but there would potentially be a cost associated with a more expensive STB (due to the higher specification of the API) and the need to swap out a considerable amount of installed receiving equipment.

Option assessment

The specific differences arising from specifying a high-level API have already been referred to. The effect on applications innovation would be more positive as a result of greater functionality of the API. This might have some impact on the market potential for STBs, and lead to a second-order impact on equipment innovation, but this effect is not included in the analysis. The STB is likely to be more expensive than option 2a, due to the nature of the API. For pay-TV operators this option is likely to be more expensive than the base case. The practical and political cost of implementation would be higher than was the case in option 2a, due to the higher specification of the API and associated extra cost.

The results of the option in terms of the parameters are shown in Table 5.5, and compared with the base-case option ‘non-intervention’.

Table 5.5: Assessment of option 2b—single, high-specification API

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	High	Low
Minimising re-authoring costs	High	Low
Equipment innovation	High	Low
API innovation	Negative	Zero
Robust API	High	High
Applications innovation	High	Zero
Stable technology	High	Zero
Market-driven standard selection	Negative	High
Single standard	High	Low
Increase in STB price	High	Zero

5.2.3 Option 2c: mandate a single API, but only for FTA services[58]

In this option, a (robust) API would be mandated for FTA but not for the pay sector. Pay-TV operators would continue to select their own API and be free to operate according to their business models.

Option outcome

By definition, interoperability across the FTA sector would be significantly facilitated. Intra-platform interoperability (and possibly geographic portability within platform type) for FTA services could be achieved immediately; inter-platform and full geographic interoperability is likely to occur as manufacturers respond to incentives to innovate, within a regime of independent production and testing. This would increase the chances of the horizontal equipment market being successful, and hence improve the likelihood of the eventual migration of pay-TV to the FTA API. However, where FTA services are provided over networks run by pay-TV operators (eg, UK satellite services and the cable services in many Member States), interoperability problems could still arise, and some FTA services might need to be dual-illuminated (see below) to ensure that STBs designed for FTA and those designed for a specific pay-TV network could both deliver FTA services provided via a pay-TV infrastructure.

Stakeholder impact analysis

The analysis of the option of mandating a single API for the FTA sector only is set out in Table 5.6. Essentially, the impact on stakeholders will be very similar to that in the 'non-

[58] This refers to FTA content provided outside of pay-TV bouquets—ie, stand-alone FTA content. However, this option is not straightforward where FTA content is transmitted using the CA system of a pay-TV operator, for example as in the UK. The implications of mandating an API for FTA are that the FTA content may no longer use the same API as the pay-TV system, and consumers wishing to obtain all the available content on such a platform would need to acquire two STBs, or one containing both APIs. While this may inconvenience consumers in the first instance, it may contribute to a faster adoption by the pay-TV operators of the common FTA API.

intervention' option, although the market may converge to a common API more rapidly since there would be a common API imposed on the FTA sector. The impact would not be as great as for the imposition of an API on the whole market (especially option 2b, the imposition of a high-specification API). However, this option may be easier to implement both politically and practically, as it applies to the FTA sector only, where there is already significant activity aimed at establishing a single standard.

Table 5.6: Option 2c, treating FTA as a separate market—stakeholder impact analysis

Stakeholder	Impact
Manufacturers	Relative to the base case, manufacturers benefit because of the establishment of a robust, stable technology that allows for reduced uncertainty.
Application developers	Applications developers are not affected significantly differently by this option relative to the base case. There are some positive benefits associated with the establishment of a stable technology and associated applications development in a shorter timeframe. There is a possible negative impact associated with the risk of the wrong standard being imposed, but this would only arise if the externally chosen standard were different from the standard arrived at in the base case.
Content providers	Relative to the base case, content providers benefit from the more stable technology.
Platform operators	Platform operators would experience both positive and negative effects, relative to the base case. Some FTA operators may be forced to abandon their existing API earlier than they would if the coordination was purely market-driven, and some FTA broadcasters using pay-TV platforms may need to dual-illuminate (depending on the precise way the API was mandated). However, the stabilisation of the technology and the reduction in uncertainty in the FTA sector are likely to benefit FTA operators as a whole through the effect on service supply and equipment supply.
Middleware providers	The outcome for middleware would be similar to the base case although this negative impact on middleware developers would occur slightly faster.
Consumers	There would be a greater initial benefit to consumers compared with the 'non-intervention' scenario, as the immediate common API environment in FTA should motivate more applications development and innovation on the part of manufacturers. However, consumer interest may be limited and therefore take-up slow if the retail STBs are very expensive as a result of the chosen API being more expensive than the market-driven API that FTA operators would otherwise coordinate around (effectively, the API that would arise in option 1.) Over the longer term, a quicker move to a common API in the FTA sector may increase the motivation for the pay-TV sector to align, and hence increase the probability (and speed) with which this might occur. Thus the consumer benefits from this development are slightly more likely to arise compared with the base case.

Option assessment

This option is very similar to the base case. However, as the common API for FTA is established sooner, both the positive and negative effects also arrive sooner.

The most significant difference between this option and option 1 is that it eliminates the possibility of the FTA market developing in a fragmented way. Given that there is a non-negligible probability that FTA operators do not coordinate around a single standard under option 1, option 2c has significant benefits.

There are, however, some costs associated with this option compared with the base case. These are associated with a slightly more difficult practical implementation, since the

FTA sector is being directed towards a specific API; as the market is not selecting the standard, the usual problems(costs) associated with ‘picking’ a standard apply. On the positive side, this option creates more certainty about the stability of the technology than in the ‘non-intervention’ scenario. It has less of an impact than for either of the scenarios where an API is imposed on the whole market (2a and 2b), since it only applies directly to the FTA sector. Similarly, FTA services (and potentially the whole market) would benefit from the imposition of a robust API rather more quickly than in the ‘non-intervention’ scenario, where the market is left to tip by itself. There is also an increase in incentives for applications innovation for similar reasons—imposition of a robust API induces more consumer confidence in the market and the increased potential audience motivates developers to write more applications for the FTA sector.

As in the ‘non-intervention’ scenario, the market would gain from a single standard applied to at least part of the market. Market growth could stimulate equipment innovation by manufacturers, leading to an increased chance that intra-platform interoperability could be achieved.

This option differs from options 2a and 2b (application of a low- and high-specification API across the market respectively), in that a single API is not created for the entire market, so there is relatively less impact on applications and content innovation, and the greatest reduction in re-authoring costs is not achieved (at least until pay-TV follows suit later, if ever). On the other hand, the practical and political costs of implementation are likely to be lower for 2c than either 2a or 2b.

The impact of the option is summarised in Table 5.7, compared with the ‘non-intervention’ base-case scenario.

Table 5.7: Assessment of option 2c—single API for FTA

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	Low	Low
Minimise re-authoring costs	Low	Low
Equipment innovation	High	Low
API innovation	Zero	Zero
Robust API	High	High
Applications innovation	High	Zero
Stable technology	Low	Zero
Market-driven standard selection	Negative	High
Single standard	Low	Low
Increase in STB price	Zero	Zero

5.2.4 Option 2d: mandate a single API, for FTA services and greenfield pay

This is the same option as above, but the API that is mandated for FTA services is also applied to greenfield pay-TV services.

Option outcome

The impact of this option on stakeholders will be as for the previous option (2c, single API for FTA), except that, in time, there may be more pressure on pay-TV operators to migrate, as the common API will cover greenfield pay-TV operations as well as FTA operators. Thus this option increases the probability of the emergence of a common API covering the entire market, and, if it does emerge, the speed with which it arrives.

Stakeholder impact analysis

The impact on the stakeholders will be largely the same as for option 2c, hence a separate table is not supplied here. The major difference is in the impact on greenfield pay-TV operators, who lose their ability to choose their own API. If there is a significant cost disadvantage for them—because active network management using a non-robust API is cheaper—they are likely to object, as the requirement would put them at a cost disadvantage compared with existing pay-TV operators. There may also be a knock-on negative effect on middleware developers, as there would be no new APIs being implemented for new pay-TV operators, and a more positive impact on manufacturers through increased economies of scale. Content providers and applications developers will also benefit from more of the market being covered by the same API. However, as the pay-TV sector already has the mechanism in place to charge customers for services, the additional impact of a single API in part of this market may be muted.

Option assessment

A difference with respect to the previous option of specifying the API in the FTA sector only is that there is likely to be a greater benefit to having a single standard, since the same standard will apply in all developing greenfield operations—both pay and FTA. There is thus a greater chance of other pay-TV services migrating towards this API. A further difference is that there is likely to be a greater political cost associated with this option, since an API is imposed on new private-sector initiatives.

The outcome is summarised, alongside the base-case option, in Table 5.8.

Table 5.8: Assessment of option 2d—single API for FTA and greenfield pay

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	High	Low
Minimise re-authoring costs	Low	Low
Equipment innovation	High	Low
API innovation	Zero	Zero
Robust API	High	High
Applications innovation	High	Zero
Stable technology	Low	Zero
Market-driven standard selection	Negative	High
Single standard	Low	Low
Increase in STB price	Low	Zero

5.2.5 Option 2e: mandate a single, high-specification API via an interim lighter version

Moving directly to a robust API may well imply significant transition costs from swapping out the existing installed base—see option 2b above (single, high-specification API across the market). An alternative, which this option presents, would be to move to an *interim* API now that is consistent with the identified robust, high-specification, API, but which has less onerous hardware requirements. This would be applied to both pay-TV and FTA sectors.

An example of such an API pairing might be MHEG-5 and MHP. MHEG-5 could be imported into much of the existing equipment after some development (including that on the pay-TV networks), and new STBs could be manufactured with MHP and an MHEG-5 plug-in. Applications written in MHEG-5 would then run on the installed base of decoders, and on all new decoders. The final conversion to MHP is likely to take some time, as applications authored in MHP could only be received on MHP receivers. Therefore, the authoring of all applications in MHP would have to wait until there was a fully MHP-compatible installed base, or the proportion of receivers that would be rendered obsolete by such a transition would be relatively small.

Option outcome

The outcome of this option is very similar to option 2b above, the imposition of a high-specification API across both market sectors. The main difference is that a migration path is specified. The practical implementation is therefore potentially eased in comparison with moving directly to the high-specification API, but the political implementation is of the same order of magnitude of difficulty. Furthermore, the impact on the total costs of STBs, while still positive when compared with the base-case scenario, is less abrupt than with the direct imposition of the high-specification API. This is as a result of allowing for the positive migration path and designing this migration so as to minimise the costs. However, as for option 2a (single, low-specification API across the market), there is likely to be a short-term service degradation on networks where the current API has greater functionality (but may not be robust) compared with the initial API to be imposed.

Stakeholder impact analysis

The long-term impact on stakeholders would be very similar to the outcome for option 2b above (single, high-specification API across the market), hence a separate table is not included here. The main difference is in the short-term impact of an increase in the STB costs, which has more of an impact in scenario 2b. Since the interim solution is a low-specification API, the short-term impact on STB costs is relatively lower. Further, given that component costs of STBs are likely to fall, the delay in moving to a high-specification API may keep these costs low overall relative to option 2b.

Option assessment

The analysis of the option of mandating a single, robust, high-specification API via an interim lighter version against the parameters is set out in Table 5.9. The base case is also shown.

The key differences with respect to mandating a robust, high-specification API from the outset are, as already mentioned, a slight easing on the practical implementation cost, and not such an abrupt cost in terms of increase in STB costs (assuming the low-specification API can be downloaded into existing STBs).

Table 5.9: Assessment of option 2e—single robust API via a lighter interim API

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	High	Low
Minimise re-authoring costs	High	Low
Equipment innovation	High	Low
API innovation	Negative	Zero
Robust API	High	High
Applications innovation	High	Zero
Stable technology	High	Zero
Market-driven standard selection	Negative	High
Single standard	High	Low
Increase in STB price	Low	Zero

5.3 Option 3: mandate that all digital receivers and all content be 'interoperable', by a specified date

5.3.1 Option description

This 'mandation' option specifies interoperability as the outcome, but does not specify the means of achieving it. In other words, broadcasters and platform operators could use different migration methods. The option could result in a single API outcome across both sectors. Equally, however, it is possible that the market may never move quite that far. Rather, the methods of achieving interoperability without a single, universal API in place may prove insufficient to result in the tipping of the whole market to a single standard.

In addition, the type of interoperability that emerged would depend on the level required by the regulator. If this option only directly facilitates the achievement of intra-platform interoperability, then the development of inter-platform and geographic interoperability would still depend upon the incentives for manufacturers to develop equipment with the relevant characteristics (eg, multiple tuners), in order to overcome the intrinsic differences in the technology used on different platforms.

Although this option leaves the means of achieving interoperability up to the industry, the number of options in practice is limited. To achieve interoperability with multiple APIs, there are essentially two approaches:

- make each STB capable of dealing with every API that could possibly be broadcast to it; or
- supply every service in a way that allows every STB connected to the network, no matter what the API, to support the service.

Given the number of APIs in existence, and the existing population of STBs, neither of the above two approaches is practical in achieving full interoperability of existing STBs. However, the combination of variants of each of the options could be practical:

- every STB is made capable of decoding a common API in addition to the API currently being used on the network to which it will be (initially) attached (bundling APIs);

combined with

- every service is delivered using two APIs, the original one for its network and the common API that is being installed in all STBs (dual illumination).

If existing STBs could have two APIs downloaded into them then full interoperability could be achieved quickly. However, this is unlikely to be universally possible. Thus, this option does not overcome the problems of options 2a and 2b where some, or all, of the existing population of STBs would need to be swapped out.

If interoperability is only mandated for STBs acquired after a certain date then those STBs could be fully interoperable by being supplied with two APIs. This is likely to increase the cost of the STB, but it is technically feasible. However, even under these conditions, all broadcasters would need to dual-illuminate, so as to ensure that migrated dual-enabled STBs would work on their network. Given that dual illumination has a cost, a network operator would have little incentive to require that STBs had dual APIs—just the common API would be sufficient. As this is likely to result in a cheaper STB, the most likely outcome is that new STBs would only have the common API installed.

Therefore the outcome is similar to option 2b (single, high-specification API), where the common API would need to be robust and of high specification in order that all (or nearly all) services were deliverable to all customers, irrespective of their type of STB. As a result, this option has the same problems associated with choosing a single, high-specification API to be mandated on all operators (option 2b). The difference is that there is a migration path that allows existing STBs to continue on their existing networks (ie, a population of non-interoperable STBs) while the population of inter-operable STBs is established (ie, all new boxes supplied after a given date).

The costs of this migration strategy are largely borne by the broadcasters or platform operators, who would have to dual-illuminate their services, or swap out STBs that do not have the common API. As a result, the entire market would end up with the common API.

Thus, just mandating interoperability and leaving it to the industry to sort out how to achieve this is equivalent to requiring the industry to decide on a single, common API. To be credible, this approach would also imply that the government or regulatory authority mandating interoperability would mandate the API if the industry could not agree. The outcome of this option is therefore the same as option 2b (mandate a high-specification API across the industry). As a detailed analysis of this option would just repeat the analysis of option 2b, this has not been done here.

5.4 Option 4: mandate the use of mark-up languages or some other method of removing the need to have compatibility between applications and APIs

5.4.1 Option description

This option would reduce the importance of the choice of API on any particular network. It would entail requiring all APIs to be capable of understanding a common set of instructions—a kind of common language between APIs. Applications written to be understood by the common language would be largely transportable between different networks. At present this could be achieved using a mark-up language (such as HTML or XML).

However, a drawback with this option is that the functionality of the mark-up language is likely to be lower, possibly considerably so, than that of all or most of the underlying APIs. Thus there would be a reduction (which might be severe) in the available functionality if STBs were to be fully interoperable. Further, the incorporation of the mark-up language in the receiving equipment may be very complex.

It is not envisaged that platform operators would be restricted to only providing services that exclusively use the common functionality, so some platform operators may continue to exploit existing APIs fully, while only some of these services would be available to consumers with STBs with a different API.

5.4.2 Option outcome

The benefit of this solution is that some degree of interoperability might be achieved, but all operators and equipment providers could continue to use their existing APIs.

If the limited degree of interoperability that this option might achieve were satisfactory to consumers, it is possible that STBs designed for FTA networks could be moved to pay-TV networks (if they had a CI slot, and the pay-TV network provided CA modules). If the limited functionality were not acceptable to consumers, this option would be unlikely to produce operational interoperability between STBs and networks with different APIs. However, it might reduce re-authoring costs, as there would be a common core to some applications.

5.4.3 Stakeholder impact analysis

The impact of this option on stakeholders, assuming that consumers do find that the common functionality provides an acceptable level of interoperability, is set out in Table 5.10. If consumers do not find the limited interoperability acceptable, there is very little change from the base case, except that re-authoring costs might decline slightly.

Table 5.10: Option 4, remove the need for compatibility between APIs and applications—stakeholder impact analysis

Stakeholder	Impact
Manufacturers	No major change.
Application developers	Applications using only the common functionality would have a wider audience without significant re-authoring, but could only use the limited common set of interoperable functions. Otherwise, there would be no significant change. The use of full functionality might be inhibited if STB populations became heterogeneous (with respect to the underlying APIs).
Content providers	There would be easier access to the complete market for content, making use of the common functions, otherwise no significant change.
Platform operators	There would potentially be easier access to an existing population of STBs, as long as applications exploit common functionality.
Middleware providers	Middleware providers would have to include the common functionality within their APIs; otherwise, no significant change
Consumers	Consumers would benefit from a limited form of interoperability, reducing the risk of stranding. However, this limited form of interoperability would be bought at the price of a more limited set of applications.

5.4.4 Option assessment

This option does not perform particularly well against the 'non-intervention' scenario. It is unlikely to reduce the incentives on FTA operators to move to a common API, so the outcome is similar to the base case. However, for some applications, re-authoring costs could decline, and there would be a core of reasonably stable technology. These outcomes are summarised in Table 5.11.

Table 5.11: Assessment of option 4—removing the need to have compatibility between applications and APIs

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	Low	Low
Minimise re-authoring costs	High	Low
Equipment innovation	Low	Low
API innovation	Negative	Zero
Robust API	Low	High
Applications innovation	Negative	Zero
Stable technology	High	Zero
Market-driven single standard selection	Zero	High
Single standard	Low	Low
Increase in STB price	Zero	Zero

5.5 Option 5: mandate horizontal markets

5.5.1 Option description

For this option it would be mandated that consumers had to acquire equipment through an independent horizontal equipment market. In effect, this option would prohibit the platform operators from acting as gatekeepers of STBs and only allowing certain manufacturers to provide STBs for their networks. Absent the ability to have tight control over the STB specification and then actively manage the network, network management would have to be achieved through the use of a robust API. Hence this option would effectively mandate that all operators used a robust API that allowed independent testing of equipment for compliance with the API specification. Platform and network operators would then have to allow any certified equipment on to their network. In addition, any subsidy offered to consumers, by platform operators, on the acquisition of STBs (or similar) would have to be made available in a non-discriminatory way, so as to avoid distortion of the horizontal market.

Given that this is how FTA equipment is likely to be supplied, this policy option in practice would affect pay-TV operators only. The requirement to apply any subsidies on a non-discriminatory basis is likely to mean that there would be a wider separation of the function of equipment supply and the supply of pay-TV services.

5.5.2 Option outcome

For FTA providers, this option does not have a significant impact, except to the extent that incentives are created for pay-TV operators to converge on the same API as in the FTA sector, given that they are likely to have to change their API anyway.

For the pay sector, the major outcome of this option would be the requirement to use a robust API that allowed independent testing and certification. This limits their freedom to choose a non-robust API (which may have lower total costs), and may raise security issues, as STBs with CI slots would have to be accepted on all pay-TV networks.

However, even within these constraints, there are several possible outcomes. Platform operators could be willing to continue with their systems more or less as currently configured, and oblige subscribers to acquire STBs that were non-compatible with other networks. Consumers would still be 'locked in', but this is a choice the consumer would be able to make *ex ante* and is only relevant where switching costs are high. Alternatively, the consumer may be willing to subscribe to a rental model, where residual risk of equipment obsolescence remains with the provider. However, as the option renders active network management impractical, the advantages to pay-TV operators of not using the robust API deployed by FTA operators decrease.

Pay-TV operators may still choose to subsidise STBs, albeit at a lower level or on a rental basis only (if this were still allowed), and this is more likely if they retain non-interoperable APIs. However, the greater the level of FTA take-up (and the number of consumers wishing to upgrade to pay-TV services), the more there will be an incentive for pay-TV operators to switch to the common API. This in turn will diminish the incentive to subsidise STBs.

5.5.3 Stakeholder impact analysis

The impact of this option on stakeholders is set out in Table 5.12.

Table 5.12: Option 5, mandate horizontal markets–stakeholder impact analysis

Stakeholder	Impact
Manufacturers	The impact on manufacturers would, in general, be reasonably positive compared with the base case. Platform operators would have less control over manufacturers. However, the market for pay-TV STBs could remain fragmented, although, if the pay-TV market did tip, the outcome would be close to option 2b (mandate a high-specification API). There would be a more positive impact in terms of incentives to innovate in equipment.
Application developers	The impact on applications developers is largely neutral if the pay-TV market does not tip. If it does tip, they are likely to see a larger, unified market for which to develop applications.
Content providers	The effect on content providers is reasonably neutral if the pay -TV market does not tip.
Platform operators	Pay-TV platform operators would be more negatively affected by this option than under the 'non-intervention' option, as STB costs on their networks would be likely to rise as a result of the requirement to implement a robust API. However, there may be some advantage arising from the range and scope of services available if the market tips to a single API. In addition, they might gain if they decide to reduce or remove subsidies for STBs, although this might affect their level of penetration.
Middleware providers	Given the requirement to move to robust APIs, middleware providers would be likely to benefit in the short run. However, if the pay-TV market tipped to the FTA API, the alternative middleware providers would be negatively affected.
Consumers	Consumers would benefit from increased equipment and applications innovation, and from the establishment of a robust API. However, if this option also eliminated all apparent STB subsidies by pay-TV operators, consumers might be negatively affected. This is because the entry price of pay-TV services might rise and welfare-enhancing price discrimination by pay-TV operators might be ruled out.

5.5.4 Option assessment

The outcome of option 5 is uncertain along a number of dimensions, particularly on the choice of the robust API made by pay-TV operators. Table 5.13 sets out the outcomes if pay-TV operators *do not* opt for the FTA API, but continue with non-interoperable APIs.

Table 5.13: Assessment of option 5—mandate horizontal markets

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	Low	Low
Minimising re-authoring costs	Low	Low
Equipment innovation	High	Low
API innovation	Zero	Zero
Robust API	High	High
Applications innovation	Low	Zero
Stable technology	Zero	Zero
Market-driven single standard selection	High	High
Single standard	Low	Low
Increase in STB costs	High	Zero

The main difference with the base case is that manufacturers have more freedom to innovate, because all of the market is open to them through independent testing and certification, which flows from the requirement to use a robust API. However, this option does represent a significant intervention in the market place, is likely to increase the costs of pay-TV operators through higher STB costs, and there may be both political and practical problems with implementing such a policy, compared with the base case.

Moreover, if the pay-TV market tips to the FTA API, additional benefits arise, as the outcome is a single API across the entire market. In particular, more economies of scale become available, re-authoring costs are minimised and incentives for applications innovation increase. However, STB subsidies may be reduced or eliminated, producing a potentially negative welfare impact for consumers.

5.6 Option 6: influence the market towards interoperability using subsidies

- option 6a: subsidise equipment for a particular API; or
- option 6b: subsidise content written for a particular API.

5.6.1 Option 6a: subsidise equipment for a particular API

In this option, the Commission or national government would subsidise the retail sale price of equipment available through the horizontal market that contained a particular API. This API would in effect be the common API, as determined by the funding body. The subsidy would be applied for a defined period of time.

Option outcome

Assuming that the API chosen were the same as that which the FTA operators would otherwise adopt, subsidising consumer equipment would provide a considerable boost to the development of FTA digital take-up. This option effectively increases the probability of the FTA market coordinating around a single API, and the chances of the pay-TV market following suit. However, as it does not mandate a specific API (just subsidises it), if the API chosen were significantly sub-optimal, it would still not be implemented. As a result, compared with options 2a to 2e, it reduces (slightly) the problems that would arise if a poor choice of API were made. There may also be an effect on the pay-TV operators, as the opportunity to take advantage of cheaper equipment might provide them with an additional incentive to move from a vertical to a horizontal equipment provision model. To do this, they would also have to adopt the common API used in this equipment. If they were to do so, additional economies of scale could be reaped across the industry.

Therefore, the overall effect of the subsidy might be to encourage the development of a horizontal market for both FTA and pay-TV equipment focused on a single API, but in a relatively market-driven manner. The main intervention (which would nonetheless be substantial) would be for the funding body to choose the API for which a subsidy would be available.

Stakeholder impact analysis

The analysis of the option of subsidising equipment for a particular API is set out in Table 5.14.

Table 5.14: Option 6a, subsidising equipment—stakeholder impact analysis

Stakeholder	Impact
Manufacturers	Subsidising equipment would provide more certainty for manufacturers that there were value in the end market. Manufacturers would benefit in terms of the increased incentive to innovate and the quicker establishment of a robust API.
Application developers	Applications developers would also benefit from an increased incentive to develop applications as a result of the increased certainty of which API would be implemented in practice. A negative effect compared with the base case would be that the API would be exogenously determined—as in options 2a and 2b. In all three cases, there would be a negative impact if a sub-optimal API were chosen.
Content providers	Content providers gain from the increased certainty over the API that is likely to be implemented, but the standard would not be picked by the market. However, there would be scope for dissent if the chosen API is not regarded as appropriate.
Platform operators	FTA operators would benefit, as the taxpayer would be paying some of the consumers' costs of acquiring receiving equipment. The additional certainty over the API would be likely to produce benefits as well, as content and applications innovation would be enhanced. Pay-TV operators could also benefit indirectly from the equipment subsidy if they adopted the same API.
Middleware providers	There would be no significant change from the base case, although, if the market were to tip to a single API, the impact could be substantial on alternative middleware providers.
Consumers	Consumers would benefit initially from the subsidy on equipment, and this would be augmented by a proliferation of applications. Consumers would also benefit to the extent that the subsidy aids penetration and market development, increasing the likelihood of innovation necessary for the delivery of other, diverse, services. However, taxpayers who do not want to consume digital broadcast services lose out.

Option assessment

The performance of this option in terms of the parameters is set out in Table 5.15.

Table 5.15: Assessment of option 6a—subsidising equipment for a particular API

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	Low	Low
Minimise re-authoring costs	Low	Low
Equipment innovation	High	Low
API innovation	Zero	Zero
Robust API	High	High
Applications innovation	Low	Zero
Stable technology	Low	Zero
Market-driven standard selection	Negative	High
Single standard	Low	Low
Increase in STB price	Zero	Zero

This option has a reasonably positive impact, compared with the base case, on many of the parameters that are necessary for digital penetration achieved through horizontal markets. Specifically, externally subsidising consumer equipment is positive for consumers in terms of price, and assists the establishment of the market. Moreover, even if the entire market does not tip to a single API, there may still be a quicker realisation of economies of scale. The incentive for the FTA market to tip quickly to a single API is beneficial in terms of reducing uncertainty, establishing a more stable technology and increasing innovation in applications. On the more negative side, the standard is not set by the market, and the option could be quite costly, in terms of the actual level of subsidy required to bring about the desired market effect, as well as in terms of political and practical implementation.

5.6.2 Option 6b: subsidise content written for a particular API

Another option for encouraging market-led take-up of a common API would be to subsidise content written for a particular API. The subsidy could apply solely to new content, or it could apply to re-authoring of existing applications and content to the common API.

Option outcome

This option would expand the potential consumption spillovers for the relevant API by encouraging the provision of content. This in turn should provide more incentives for consumers to switch to digital, and service providers to migrate to the common API, particularly for FTA content.

If the consumption spillovers are strong enough, or these in turn stimulate the success of the FTA digital market, there may be incentives for pay-TV operators also to migrate to the common API. However, the effects of subsidising content are likely to be weaker and take longer to produce a discernible effect than that which arises from subsidising equipment.

Stakeholder impact analysis

The analysis of the option of subsidising content written for a particular API is set out in Table 5.16.

Table 5.16: Option 6b, subsidising content–stakeholder impact analysis

Stakeholder	Impact
Manufacturers	Manufacturers would benefit from this compared with the 'non-intervention' option, but mainly through the indirect effect of additional content tending to tip the FTA market to a specific API slightly faster, and possibly because the additional content available would expand the market.
Application developers	Applications developers would benefit from the direct content subsidy, and from the reduction in the uncertainty over which way the FTA market is likely to tip. Concerns similar to those highlighted in options 2a and 2b arise with regard to the choice of API.
Content providers	Content providers would benefit from increased applications development and the reduction in risk as the technology becomes more certain; however there could be counterbalancing negative effects if the API chosen for subsidy is the wrong one.
Platform operators	FTA platform operators would do slightly better in this scenario than in the 'non-intervention' scenario, as the additional availability of content should enhance FTA digital take-up. Unless pay-TV operators also adopt the subsidised API (ie, existing operators switch from their current API), they receive no benefit.
Middleware providers	There would be no significant change from the base case, unless the market does tip to a single API.
Consumers	Consumers would benefit relative to option 1 as the subsidy would increase the probability of FTA operators coordinating around a single API. They would also be likely to benefit from greater availability of services as a direct result of the availability of the subsidy.

Option assessment

The outcome of this option in terms of the parameters is summarised in Table 5.17. The outcome is close to the base case, where the 'non-intervention' option results in the FTA market tipping to a single API. In addition, however, this option would stimulate more applications development and bring about a more stable technology more quickly (ie, it would reduce uncertainty). This option also reduces the probability of the FTA market fragmenting, a possibility under the 'non-intervention' option.

**Table 5.17: Assessment of option 6b—
subsidising content written for a particular API**

Parameter	Outcome	Outcome—non-intervention
Economies of scale in STB	Low	Low
Minimise re-authoring costs	Low	Low
Equipment innovation	Low	Low
API innovation	Zero	Zero
Robust API	High	Low
Applications innovation	High	Zero
Stable technology	Low	Zero
Market-driven standard selection	Negative	High
Single standard	Low	Low
Increase in STB price	Zero	Zero

5.7 Option 7—influence the markets by switching off analogue services

This option would force all consumers to take digital services, either by subscription (pay-TV) or FTA. In order for this solution not to result in chaos in the market and generate a severe negative reaction from consumers of analogue services, it is essential that digital services are sufficiently developed in all Member States to which it would apply. There would also need to be a sufficient supply of receiving equipment to cope with the sudden increase in demand resulting from the analogue switch-off.

The identification and adoption of a common API are not directly affected by the option, nor is the successful development of a horizontal market. The extent to which this option can result in these outcomes probably lies in its use as a signal. If the Commission or individual Member State governments can credibly indicate that analogue television signals will be switched off at a certain date, regardless of the state of the market, this may serve as an incentive to accelerate the development of digital services. For reasons already mentioned, this development relies upon the FTA market, which would need to have a robust API in place, as well as a horizontal market to supply the receiving equipment. However, by using analogue switch-off to force consumers to acquire digital receiving equipment, a functioning horizontal market in equipment would almost certainly be created or strengthened. As FTA broadcasters would probably coordinate around a single API, interoperability of FTA equipment would also be likely.

Thus, this option is actually quite likely to deliver both interoperability of FTA STBs and a horizontal market. However, it is doubtful whether this option could be used to stimulate these market conditions. The credibility of the decision to switch off the analogue signal is crucial to the success of the option. In practice, it may only be politically acceptable to switch off analogue broadcasting once these conditions are already established and a high proportion of the population is *already* connected to the digital broadcasting infrastructure.

There are already examples of national governments setting optimistic deadlines for switch-off, only having to capitulate in view of domestic political pressure and under-development of the market. A series of non-credible threats is unlikely to help, and may even be counterproductive, as it may just raise the general level of policy and market uncertainty.

6. Assessment and Analysis of the Policy Options against the Goals and Objectives of the Study

The previous sections have built an understanding of the goals and objectives of the study and the central attributes of the market that will contribute to achieving them successfully. These attributes are summarised in the parameters of the evaluation tool.

Predicting the take-up of new technology, where critical mass and compatibility are important aspects of the problem, is not straightforward. This is particularly the case in a complex industry such as DTV with many different interactions between a wide variety of stakeholders. The incentive structures are such that many different elements have an impact on a particular outcome, and there may be a number of potential effects arising from a given market situation.

Theoretical analyses of incentives in these markets usually predict several possible equilibria; understanding the criteria that move a market *towards* a desired outcome is the most useful conclusion that can be drawn from the economic literature. This will provide an indication of the most *likely* outcome, although certainty is virtually impossible to achieve.

In this section these elements (the components of the goals and objectives, and the nature of the market interactions) are brought together in order to assess the performance of the options identified in section 5 against the goals and objectives. In analysing the options presented, the task is to understand the details of how an option contributes towards the achievement of the full range of goals and objectives, particularly where some of these are conflicting. By understanding how each option moves the market towards a particular outcome, and knowing how each outcome contributes to achieving the desired goals, it is possible to identify the relative strengths and weaknesses of each option.

The evaluation tool outlined in section 3 is based upon an economic judgement of the way in which the goals, objectives and options all perform against the parameters, which were themselves identified through a consideration of the market characteristics and interactions. Every effort has been made to produce an objective assessment of the policy options, but the limitations of the approach should nonetheless be borne in mind when considering this section.

The ranking of the evaluation of the options depends on how the component elements of the evaluation process are weighted. For example, the balance between the parameters can be changed by weighting some differently from the others, and the relative importance of the objectives can be altered by choosing different weights. The different weightings could be based on factors such as relative importance within overall policy objectives, or views about the likelihood of particular market outcomes (such as the size of potential economies of scale). The default case adopted here is where all components of the evaluation are weighted equally.

Therefore, for the default case, within each high-level goal or objective (seven in total), the component parts are assigned equal weight. Each goal is then equally weighted to derive an overall score.

An important issue for the Commission to consider when using this analysis is the relative weights that should be assigned to different goals and objectives in order to make appropriate trade-offs. The aim of determining the weights would be to understand the trade-offs implicit within particular options across the goals and objectives. For example, although one approach may be highly successful in achieving interoperability, if it is costly in terms of innovation incentives, it may harm the overarching goals of the Commission. An option that is less successful in directly achieving interoperability may still perform well on horizontal markets and may meet the broader goals more closely. It is for the Commission to determine the relative importance of (in this case, for example) achieving interoperability as opposed to innovation or horizontal markets, and weight these goals and objectives accordingly. By exposing these trade-offs, informed policy choices can be made.[59]

Section 6.1 presents the results from sections 4 and 5, summarising the structure of the evaluation tool and the manner in which it operates. In section 6.2, default outputs from this process are presented in the form of a table that ranks the performance of each option against the goals and objectives, assuming equal weightings, and considers the impact on stakeholders of the highly ranked options. Section 6.3 then illustrates a variety of scenarios that could be developed based on different assumptions about DTV policy and market developments. The scenarios shown in this section are neither exhaustive nor meant to be predictive of the scenarios that the Commission Services might employ; rather, they provide worked examples of how the framework developed in this report might be used.

As a reminder, the options presented in section 5 are summarised in Table 6.1.

[59] It should be noted from section 4 that each goal and objective has differing numbers of parameters that are relevant to its component elements. This has an effect on the scoring (as noted below). However, as the number of relevant parameters is determined by the *objective* (or goal) concerned and not by the options, this effect does not alter the *relative* comparison of the options and therefore does not skew the results.
Where a goal or objective has more parameters that are relevant, implicitly each one is weighted relatively less, compared with a goal or objective with fewer component parts. This means that the parameters are not equally weighted across the goals or objectives, with their relative weight within any particular component of an objective or goal being dependent on the number of parameters that apply to the particular goal or objective.
For example, the parameter for a robust API scores 3 in both the intra-platform aspect of interoperability and the efficiency aspect of horizontal markets. The former has seven relevant parameters while the latter has only five. In order to illustrate the effect of the different number of relevant parameters on the impact of the individual parameters, consider the case where all the parameters have the same score, 2. Thus, intra-platform interoperability has a score of 14, and efficiency a score of 10. Doubling the weighting of the robust API parameter relative to the others will increase the intra-platform interoperability score to 16 (a 12.5% increase), while the efficiency score increases to 12 (up by 20%). Therefore, any given change in the weighting of the parameter(s) will have a proportionately greater effect on those components of the objectives and goals that have fewer relevant parameters.

Table 6.1: Summary of the policy options

Option	
1	Do nothing
2a	Mandate a low-specification API
2b	Mandate a high-specification API
2c	Treat FTA as a separate market
2d	Treat FTA and greenfield pay-TV together
2e	Mandate a transition to a full robust API via an interim lighter version
3	Mandate interoperability, without specifying how
4	Remove the need for compatibility between APIs and applications
5	Mandate horizontal markets
6a	Subsidise equipment for a particular API
6b	Subsidise content written for a particular API

As noted in section 5, option 7 (analogue switch-off) is not fully evaluated since it is not considered to be a realistic option in the short term.

6.1 The goals, objectives and policy options, described in terms of the parameters

As described in section 3, the objective of the evaluation is to gauge how far each policy option achieves the goals and objectives of the study. Section 3 outlines the structure of the evaluation tool and the scoring that is used to determine the relative performance of the various options. The benchmarking of the underlying component parts of each goal and objective against the parameters is carried out in section 4, while section 5 does the same for each of the options.

The output from section 5 was a matrix showing the effect the options have on facilitating achievement of the parameters. The results are summarised in Table 6.2.

Table 6.2: Summary of the policy options assigned against the parameters

Option	1	2a	2b	2c	2d	2e	3	4	5	6a	6b
Economies of scale in STB	Low	High	High	Low	High	High	High	Low	Low	Low	Low
Minimise re-authoring costs	Low	High	High	Low	Low	High	High	High	Low	Low	Low
Equipment innovation	Low	High	High	High	High	High	High	Low	High	High	Low
API innovation	Zero	Neg	Neg	Zero	Zero	Neg	Neg	Neg	Zero	Zero	Zero
Robust API	High	High	High	High	High	High	High	Low	High	High	High
Applications innovation	Zero	Low	High	High	High	High	High	Neg	Low	Low	High
Stable technology	Zero	High	High	Low	Low	High	High	High	Zero	Low	Low
Market-driven standard	High	Neg	Neg	Neg	Neg	Neg	Neg	Zero	High	Neg	Neg
Single standard	Low	High	High	Low	Low	High	High	Low	Low	Low	Low
Increase in STB cost	Zero	Low	High	Zero	Low	Low	High	Zero	High	Zero	Zero

Note: 'Neg' indicates negative.

For each option, there is therefore an indicator assignment rating for the interaction of its impact on a specific parameter, together with the association of the components of the goals and objectives with that parameter. These separate ratings are then interacted to produce a score for each objective component and parameter pairing. Summing these scores over the objective and goal components, and then across all the components of each goal and objective, produces a total score for each goal and objective against each option.

As outlined in section 3.4, in order to facilitate comparison of any single option's performance on different objectives, and to give a context for the rating of each option-objective outcome, the results of the parameter interactions have been rebased to a score out of 10.

6.2 Option evaluation

As mentioned in the introduction to this section, the default for assessment of the options involves equal weighting of the different elements of the scoring process.

Table 6.3 presents the default appraisal of the success of the different options in achieving the direct goals of the study—interoperability and horizontal markets. Table 6.4 then indicates how each option performs in terms of achieving the EU objectives. Comparing these two tables then allows the options to be assessed.

Table 6.3: Summary of option outcomes on the study goals (default)

	Interoperability				Horizontal markets	
	Intra-	Inter-	Geographic	Average total	Demand	Supply
Option						
1	2.86	3.18	3.18	3.07	2.00	2.03
2a	10.00	10.00	10.00	10.00	5.02	5.39
2b	10.00	10.00	10.00	10.00	4.80	5.47
2c	5.71	5.91	5.91	5.84	3.36	3.90
2d	6.67	6.82	6.82	6.77	3.53	4.95
2e	10.00	10.00	10.00	10.00	5.16	5.58
3	10.00	10.00	10.00	10.00	4.80	5.47
4	6.19	6.36	6.36	6.36	3.64	2.61
5	4.76	5.00	5.00	4.92	2.41	3.35
6a	5.71	5.91	5.91	5.84	3.22	3.72
6b	4.76	5.00	5.00	4.92	2.60	2.80

Table 6.3 ranks options 2a, 2b and 2e (and by default option 3) equally as the best means of achieving interoperability, with each achieving a maximum possible score of 10—this is because they mandate interoperability directly. However, Table 6.3 also shows that option 2e performs best in encouraging horizontal markets, the other primary goal of the study. Further, Table 6.4 identifies that option 2e ranks first in terms of meeting the EU objectives of consumer welfare, competitive markets, incentives to innovate and practical implementation, with options 2a, and 2b close behind. Options 2c and 2d also perform reasonably well.

Table 6.4: Summary of option outcomes on EU objectives (default)

	EU objectives					
	Consumers	Competition	Innovation	Practical implementation	Average total	Political implementation
Option						
1	2.46	2.57	2.35	0.37	1.94	Low
2a	6.74	6.39	4.54	0.00	4.42	Medium
2b	7.07	5.84	5.46	0.00	4.59	High
2c	4.41	4.60	3.85	0.37	3.31	Low
2d	4.28	4.43	3.73	0.00	3.11	Medium
2e	7.03	6.57	5.66	0.37	4.91	Medium
3	7.07	5.84	5.46	0.00	4.59	High
4	4.44	3.76	2.18	0.37	2.69	Medium
5	3.92	2.80	3.15	0.00	2.47	High
6a	4.12	4.43	2.74	0.00	2.82	Medium
6b	3.78	3.58	3.71	0.00	2.77	Low

However, options 2a, 2d and 2e have medium political implementation difficulties, while option 2b has a high degree of difficulty, but 2c has only low difficulty. Of these options, 2c and 2e also score best on practical implementation, although 2c performs poorly on achieving the goals of the study. Similarly, 2b does very well on the goals (as noted above), but is the worst for implementation due to the high costs involved in introducing a high-specification API.

Of note is the low score for option 5 on horizontal markets, even though it mandates this outcome. The reason is that the goal is the *successful development* of horizontal markets, and this involves more than just forcing pay-TV operators to abandon their vertical model. Without other developments, such as the stimulation of applications development or the achievement of economies of scale through expansion of the FTA sector, the horizontal market may not be successful. The assumption that pay-TV operators do not opt for the FTA API (see section 5.5.4) significantly diminishes these effects. The outcome for option 5 would be better if this assumption were relaxed.

This analysis is discussed further below, examining in turn:

- how far the goals of the study are achieved;
- how far the EU objectives are achieved; and
- the cost of implementation of an option.

6.2.1 Assessing the options against the goals of the study

In this section, the degree to which the options achieve the goals of interoperability and horizontal markets is assessed. Table 6.5 shows the options ranked by their overall average interoperability score, along with the score for achieving intra-platform interoperability.

Table 6.5: Ranked options outcomes for interoperability

Option		Intra-platform interoperability	Interoperability (average)
2a	Mandate a low-specification API	10.00	10.00
2b	Mandate a high-specification API	10.00	10.00
2e	Mandate a transition to a full robust API via an interim lighter version	10.00	10.00
3	Mandate interoperability, without specifying how	10.00	10.00
2d	Treat FTA and greenfield pay-TV together	6.67	6.77
4	Remove the need for compatibility between APIs and applications	6.19	6.36
6a	Subsidise equipment for a particular API	5.71	5.84
2c	Treat FTA as a separate market	5.71	5.84
5	Mandate horizontal markets	4.76	4.92
6b	Subsidise content written for a particular API	4.76	4.92
1	Do nothing	2.86	3.07

The first three options all achieve interoperability by mandating a particular API (low- or high-specification). The other option that mandates intra-platform interoperability directly is option 4, but it is only ranked in the middle of the options on the overall interoperability score. This is because interoperability that is broader than the same platform depends on incentives to innovate in STBs and other related equipment, such that the appropriate hardware is manufactured. Ultimately, such developments will be driven by digital content, since this drives the size of the market. Despite being an option that mandates the outcome of interoperability, option 4 achieves it in a way that is unlikely to stimulate the market further. In particular, the option does badly on the attributes of reducing re-authoring costs (it is unlikely to result in a reduction) and of bringing about equipment innovation. This latter element is a necessary component of further interoperability.

Options which do not mandate action across the whole sector that do reasonably well are 2d (treat FTA and greenfield together), 6a (subsidise equipment for a particular API) and 2c (treat FTA as a separate market). In particular, 2d does relatively well, as it induces a substantial proportion of the firms involved in the provision of DTV to move to a single API, thus stimulating the achievement of economies of scale, and applications development.

Table 6.6 shows the ranking of the options for achieving horizontal markets.

Table 6.6: Ranked options outcomes for horizontal markets

Option		Horizontal markets (average)
*2e	Mandate a transition to a full robust API via an interim lighter version	5.37
*2a	Mandate a low-specification API	5.21
*2b	Mandate a high-specification API	5.13
*3	Mandate interoperability, without specifying how	5.13
2d	Treat FTA and greenfield pay-TV together	4.24
5	Mandate horizontal markets	2.88
2c	Treat FTA as a separate market	3.63
6a	Subsidise equipment for a particular API	3.47
*4	Remove the need for compatibility between APIs and applications	3.13
6b	Subsidise content written for a particular API	2.70
1	Do nothing	2.01

Note: * denotes the options that mandate interoperability across the market

The performance of option 5 has already been discussed above. As is expected, many of the options that score well on interoperability also rank highly in the development of horizontal markets. All the options that mandate interoperability (marked with a *), except for 4 (remove the need for compatibility between applications and APIs), do well in terms of supporting horizontal markets.

The other options that do well in terms of horizontal markets, 2d (treating FTA and greenfield as one market), 6a (subsidising equipment for a particular API) and 2c (treat FTA as a separate market), also do reasonably well in terms of interoperability, while stopping short of full mandation. In addition, option 3 does well on stimulating horizontal markets, and, by definition, also does well on interoperability, as it mandates it.

Therefore, the set of options that perform best in terms of both goals is:

- 2a mandate a low-specification API;
- 2b mandate a high-specification API;
- 2c treat FTA separately from pay-TV;
- 2d treat FTA and greenfield pay-TV together, but separate from existing pay-TV;
- 2e mandate a transition to a full robust API via an interim lighter version;
- 3 mandate interoperability, without specifying how;
- 6a subsidise equipment for a particular API.

6.2.2 Assessing the options against the objectives of the study

In this section, the performance of the options against the EU objectives is presented. The summary information for the EU objectives of enhancing consumer welfare, stimulating competitive markets, facilitating innovation, and ensuring the ease of implementation of the appropriate policy option is presented in Table 6.7. The ease of implementation from the political perspective has not been a focus of the study (as the study is an economic analysis of the issues), but an overview of the likely political difficulty in implementing the various options is also presented in the next sub-section.

Table 6.7: Ranking by the EU objectives of consumer welfare, competitive markets, incentives to invest in innovation and the practical ease of implementation

Option		EU objectives (average)
^2e	Mandate a transition to a full robust API via an interim lighter version	4.91
^2b	Mandate a high-specification API	4.59
^3	Mandate interoperability, without specifying how	4.59
^2a	Mandate a low-specification API	4.42
^2c	Treat FTA as a separate market	3.31
^2d	Treat FTA and greenfield pay-TV together	3.11
^6a	Subsidise equipment for a particular API	2.82
6b	Subsidise content written for a particular API	2.77
4	Remove the need for compatibility between APIs and applications	2.69
5	Mandate horizontal markets	2.47
1	Do nothing	1.94

Note: ^ denotes options that performed well in terms of achieving both the goals

The three options mandating API(s) (options 2a, 2b and 2e) score highly on meeting the EU objectives; these also performed well in achieving both horizontal markets and interoperability. Options 2d and 2c both did relatively well on meeting the goals and EU objectives, with option 2c being the best of the two.

Options 6a and 6b—subsidy options—do not deliver the broader objectives; however, 6a did relatively well on meeting the goals of interoperability and horizontal markets. Options 4, 5 and 1 perform quite poorly in terms of the EU objectives, and were also not particularly good at delivering the goals.

Table 6.4 shows the performance of the options on each separate objective. Examining this indicates whether the conclusions are sensitive to the averaging process. As the issues relating to both forms of implementation are considered together in the next sub-section, they are not considered in the analysis below.

- Options 2b, 2e and 2a (and option 3, although this is a mirror of 2b) are consistently ranked the top three for each individual objective. 2e is best for encouraging competitive markets and innovation incentives, and 2b is best for consumer welfare. This latter result is driven by the fact that 2e allows market participants a smoother transition, slowing the introduction of the beneficial API.

- Option 5 makes virtually the least contribution to encouraging competitive markets (just above option 1 of non-intervention). Thus, mandating horizontal markets alone is poor at achieving the EU policy objectives, but this is because it is focused solely on horizontal markets and contributes poorly to interoperability, which is a key element of policy in this area. As noted above, this is partly a result of the assumptions used in constructing option 5.

- Options 2c and 2d produce reasonably good results on all three objectives, although they are not ranked very highly on any of them.

- Options 4, 6a and 6b overall do not perform well on any of the three objectives.

Comparing these rankings with those in the previous section, it is clear that the variants on option 2 seem the most successful in meeting the goals and the major objectives of EU policy in this area. The other option that was highly ranked for the achievement of the goals, option 6a, is not so effective at achieving the objectives. Through subsidising STBs with a particular API, this option drives the market towards interoperability and supports horizontal markets, but only has average performance on the broader objectives.

6.2.3 Implementation analysis

The final means of assessing the options is their ease of implementation; an option that appears to have excellent results may not be suitable as a policy approach if it is likely to involve considerable costs, take a long time to introduce, or meet with substantial resistance. At the least, the governments and/or regulatory bodies implementing the desired policy option(s) should be aware of the issues with regard to implementation. The stakeholder effects of each option have been outlined in section 5 and are summarised here through the assessment of ease of implementation.

Table 6.8 ranks the options by their practical ease of implementation, which can be deduced (albeit approximately) from the analysis in the study. The scale of political implementation costs is also given qualitatively for each option; as these were not the focus of the study, it is not possible to be precise about this objective.

Table 6.8: Ranking of the options by ease of implementation

Option		Practical ease of implementation	Political implementation costs
1	Non-intervention	0.37	Low
2c^	Treat FTA as a separate market	0.37	Low
4	Remove the need for compatibility between APIs and applications	0.37	Medium
2e^	Mandate a transition to a full robust API via an interim lighter version	0.37	Medium
2a^	Mandate a low-specification API	0.00	Medium
2b^	Mandate a high-specification API	0.00	High
2d^	Treat FTA and greenfield pay-TV together	0.00	Medium
3^	Mandate interoperability, without specifying how	0.00	High
5	Mandate horizontal markets	0.00	High
6a^	Subsidise equipment for a particular API	0.00	Medium
6b	Subsidise content written for a particular API	0.00	Low

Note: ^ denotes options that performed well in terms of achieving both the goals

The first point to note about Table 6.8 is that there are several options that score zero on practical implementation, even though they might have been expected to have substantial costs of implementation (for example, options 2b and 5). This result occurs because all the options have positive as well as negative attributes with respect to implementation, and these (by coincidence) cancel out when all parameters are equally weighted. For example, option 2b eases implementation by increasing applications innovation and facilitating predictability and stability in the technology. These aspects balance the difficulties of introducing a single standard that increases the STB cost. As can be seen below, if the parameters are weighted in different ways, the practical implementation scores change. Similarly 2d mandates an API on greenfield pay-TV as well as FTA, resulting in a faster switch to a common API than in option 2c, and hence it has a greater cost of implementation.

Many of the options have at least some degree of difficulty in implementation and so none performs particularly well. The low score on the non-intervention option (option 1) reflects the difficulty for the Commission or Member State governments of failing to introduce incentives to achieve the market conditions that are considered important for stimulating the development of FTA services. These largely outweigh the benefits from not introducing radical measures that would be difficult to implement.

Option 5 also does relatively poorly, although it does not involve changes to existing STBs and so does not do as badly as the other mandating options. 2d is more costly than 2c, as it results in a quicker adoption of a robust API which would have an effect on the existing installed base of STBs. Furthermore, option 5 results in higher STB costs, but these can be directly passed on to the customers, rather than necessarily being borne by platform operators. Nonetheless, there is interference in the commercial relationship that operators have with manufacturers and customers. This may cause significant resistance, despite the fact that this model does work in the GSM market. Consumers may also view the option as unpopular if it results in higher up-front costs for subscription services, despite the fact that ongoing charges should fall. Hence, this option is also one with a high political implementation cost.

The least-cost options are 1, 2c, 2e and 4. Option 4 (removing the need for compatibility between APIs and applications) has a low cost because, like 2c and 1, it does not significantly affect existing STBs. However, it produces reduced functionality and does not perform well against the objectives. Option 2e does well because it generates the positive benefits of 2b, but allows for a smoother (less costly) introduction of the high-specification API. This transition phase also means that there are expected to be only medium political implementation costs.

Of the options that are the easiest to implement, 2c and 2e perform best against the objectives, with 2c having lower political costs. This is because 2c involves mandating a particular API (and therefore potentially some changes to existing equipment), but only for FTA operators, who may welcome the certainty that this brings.

As discussed in section 6.2.2, options 2a and 2b are two of the more successful options in meeting the range of goals and objectives set in the study. They are, however, both relatively interventionist. In both options, costs are imposed on platform operators through requirements to upgrade the STBs on their network. In option 2b, these costs could be significant, given that it could require the upgrading of the existing installed base to boxes with higher memory and computing power to support the higher-functionality API.[60]

All the options that mandate an API are likely to be unpopular with middleware providers, since it significantly curtails their market opportunities. The worst of these is option 2b. Successful implementation of this option relies on manufacturers, applications developers and content providers responding well to the new standard, with the result that STBs are more customer-friendly and a wide range of innovative services is available over them. This latter point, in particular, will drive consumer interest in taking up the new technology. As such a high degree of coordination between disparate parties would be a difficult exercise to perform successfully, the option is considered to have a high political cost.

Options 6a and 6b have relatively low implementation costs, as neither option forces pay-TV operators (who constitute the largest existing DTV operators) to change their existing APIs. However, they may affect the operation of the pay-TV sector through the provision of cheap equipment, potentially skewing the market; this may be a politically difficult

[60] It should be noted that, as outlined in the option assessment in section 5, it has been assumed that a low-specification API, such as MHEG-5, could be introduced into existing STBs designed for other non-robust APIs, such as Liberate or Open TV, and that this could be achieved remotely through a download operation. The implications of this are that the implementation costs of options 2a and 2e are lower than 2b, but the benefits are also lower (hence a zero score when all parameters are equally weighted). However, if such a procedure is not possible, the implementation costs for 2a and 2e would increase and would be rated in the same way as 2b against the relevant parameters.

outcome to introduce. As option 6a does this more indirectly, it has a lower political implementation cost.

6.3 Sensitivity tests

Sensitivity testing of the results was undertaken in order to verify the evaluation process. This was done by individually re-weighting some of the parameters and objectives, and by constructing a full scenario based on a series of weights that would be consistent with a particular view of the potential market outcomes.

The objective of these tests was to check the robustness of the results to different weights that could be applied. In particular, the aim was to ensure that the evaluation mechanism was neither too sensitive to one particular assumption, nor too inflexible to produce a range of solutions given different weighting profiles. A wide variety of tests was used, but only a small subset are reported below; these are the tests that may also be of interest to the Commission Services, as they address key areas of uncertainty, using the approach of the study.

6.3.1 Individual parameter and objective testing

The sensitivity tests were carried out by taking the equally weighted model used for the results obtained in section 6.2, and then changing one or more of the elements to an alternative value, such as 2 or 0.5. Therefore, the weights detailed below should all be considered in comparison to 1 for the other parameters or objectives. The tests included the following weights:

- 0.5 for economies of scale;
- 2 for economies of scale;
- 0.5 for re-authoring costs;
- 2 for re-authoring costs; and
- 2 for implementation within the average EU objectives.

The first four of these options relate to the main areas of uncertainty in the research of this study, the exact magnitude of economies of scale in STB production and the level of re-authoring costs. The sensitivity tests involved setting first the economies of scale parameter and then re-authoring costs to weights of 0.5 followed by 2, with all other parameters set to 1. That is, initially economies of scale were set to 0.5, implying that there are not considered to be many economies of scale available from expanding STB production, with all other parameters (including re-authoring costs) set to 1. Subsequently the economies of scale parameter was set to 2, then the same process was carried out for re-authoring costs.

Finally, all the parameters were given equal weighting, but the implementation objective score was weighted at 2 (compared with 1 for the other objectives) in the calculation of the average total EU objectives score. This would represent the situation where the costs of practical implementation were considered to be of particular concern in assessing the options.

The results of the sensitivity tests for the average total interoperability, horizontal market and EU objectives scores are shown in Tables 6.9, 6.10 and 6.11. As the implementation test relates to the weighting within the average total EU objectives score, the scores for interoperability and horizontal markets are unaffected and reflect the equal weight default presented above.[61]

Table 6.9: Average total interoperability scores in sensitivity tests

	Average total interoperability score				
	Equal weighting (default)	Economies of scale (0.5)	Economies of scale (2)	Re-authoring costs (0.5)	Re-authoring costs (2)
Option					
1	3.11	2.99	3.29	3.09	3.13
2a	10.00	10.00	10.00	10.00	10.00
2b	10.00	10.00	10.00	10.00	10.00
2c	5.54	5.62	5.41	5.68	5.30
2d	7.16	6.93	7.53	7.41	6.75
2e	10.00	10.00	10.00	10.00	10.00
3	10.00	10.00	10.00	10.00	10.00
4	6.80	6.96	6.55	6.60	7.14
5	4.73	4.74	4.70	4.82	4.58
6a	5.54	5.62	5.41	5.68	5.30
6b	4.73	4.74	4.70	4.82	4.58

It can be seen from Table 6.9 that, although the absolute and relative scores change, the ranking of the options in terms of interoperability does not alter. However, the direction of the changes is different between options, depending on the option's performance with regard to economies of scale.

Those options that mandate interoperability are unaffected by the weighting of economies of scale as they score the maximum on all relevant parameters, so their proportionate score is unaltered. The results for the other options depend on the relative importance of the economies of scale parameter in the total parameter score for the option; re-weighting the parameter affects both the actual option score and the maximum possible score, and the effect of this on the total option score depends on the relative importance of the parameter score in the option score.

[61] In considering all of the sensitivity tests presented in this section, it should be remembered that the total score for all the parameters is a proportion of the sum of the total possible scores for those parameters (eg, a score of 10 for three parameters each rated 'strong' for the goal or objective produces a total score of 10/12, as each parameter has a total possible maximum score of 4—this score is then multiplied by 10 to give the final score). Therefore, if the weight of the parameter is altered, this will also affect the total possible maximum score for each option against the goals and objectives.

In a similar way, altering re-authoring costs does not affect the mandating options, but has a varying impact on the interoperability score of the other options.

Table 6.10 shows the results for the average total horizontal market score. Economies of scale are positively related to the achievement of horizontal markets, as the stimulation of economies of scale would reduce the price and increase the volume of STBs supplied, and thus contribute towards the establishment of horizontal markets (especially in the FTA sector). Therefore, in the sensitivity tests, it is to be expected that those options that are most successful at generating horizontal markets would be most affected by the re-weighting of the economies of scale parameter. This is observed by considering options 2a, 2b and 2e that are particularly successful in contributing towards the take-up of FTA digital services.

On the other hand, re-authoring costs are not greatly related to horizontal markets, so it is expected that there would be only minor changes to the horizontal market score as the weights on re-authoring change. As noted above, the direction of these changes will depend on the relative importance of the re-authoring parameter in the overall score. These results are produced by the evaluation mechanism, as shown in Table 6.10.

Table 6.10: Average total horizontal market scores in sensitivity tests

	Average total horizontal market score				
	Equal weighting (default)	Economies of scale (0.5)	Economies of scale (2)	Re-authoring costs (0.5)	Re-authoring costs (2)
Option					
1	2.01	1.87	2.22	1.98	2.06
2a	5.21	4.93	5.63	5.16	5.29
2b	5.13	4.85	5.55	5.10	5.20
2c	3.63	3.55	3.75	3.65	3.60
2d	4.24	3.95	4.69	4.29	4.17
2e	5.37	5.09	5.78	5.33	5.43
3	5.37	5.09	5.78	5.33	5.43
4	3.13	3.01	3.30	3.01	3.31
5	2.88	2.78	3.03	2.88	2.89
6a	3.47	3.38	3.60	3.48	3.46
6b	2.70	2.56	2.90	2.71	2.69

Finally, the impact of the tests on the average total EU objectives score can be considered (Table 6.11). As noted above, the impact of changing only the parameter weights has a straightforward scaling effect on the average total objectives score, although the relative difference between the options changes. The rank order is unaffected. The results do operate as expected, although with a positive relationship between both economies of scale and re-authoring costs, and the average total interoperability score.

The effect of increasing the importance of the practical costs of implementation in the total objectives score will depend, however, on the underlying weighting of the parameters. As shown in Table 6.4, when all the parameters are weighted equally, the implementation scores are either low or zero for all the options. In this case, altering the weight of implementation in the calculation of the average EU objectives score will have a significant impact on the nominal scores, but the small differences between the implementation scores for the individual options means that there is no change in rank order.

Table 6.11: Average total EU objectives scores in sensitivity tests

	Total EU objectives score					
	Equal weighting (default)	Economies of scale (0.5)	Economies of scale (2)	Re-authoring costs (0.5)	Re-authoring costs (2)	Implementation (2)
Option						
1	1.94	1.90	2.00	1.87	2.05	1.62
2a	4.42	4.37	4.49	4.21	4.76	3.53
2b	4.59	4.54	4.67	4.39	4.92	3.67
2c	3.31	3.30	3.32	3.27	3.37	2.72
2d	3.66	3.58	3.76	3.62	3.71	2.85
2e	4.91	4.86	4.98	4.72	5.21	4.00
3	4.91	4.86	4.98	4.72	5.21	4.00
4	2.69	2.68	2.70	2.43	3.10	2.22
5	2.47	2.44	2.51	2.41	2.56	1.97
6a	2.82	2.81	2.83	2.76	2.92	2.26
6b	2.77	2.74	2.80	2.72	2.85	2.21

6.3.2 Complex scenario test

The tests described above all involve varying only one element of the evaluation mechanism at a time. However, that is a relatively unrealistic outcome—in practice, it is likely that many different elements of the mechanism will need to be weighted in such a way as to reflect accurately beliefs about the market and the realities of EU policy choices.

There are a number of elements within the evaluation tool that can be weighted:

- the parameter weights (as above);
- the weights of the components of each objective (section 4 identified that each of the objectives had a number of component parts); and
- the importance of each objective in the total objectives score (also discussed above).

In order to test the operation of the evaluation tool, a complex scenario was created that replicates a potential situation that the Commission Services might wish to evaluate. The scenario has the following components.

- Intra-platform interoperability is the most important element of all the forms of interoperability.

- The greatest concern for policy is the development of FTA services supported by a horizontal equipment market. In order for this to arise, the equipment must be at the lowest possible price, and the development of complementary services, especially interactive applications, will be vital. Confidence in the standard and stability of technology will also be important.

- It is not believed that there are significant economies of scale that could be exploited further by manufacturers, and re-authoring costs are currently low, so reducing them further is not particularly important.

- Minimising the costs of implementation is the most important objective, as they may adversely affect the take-up of digital services.

This structure for the scenario produces the parameter, goal and objective weightings shown in Tables 6.12 and 6.13.

Table 6.12: Weightings of goals and objectives in the scenario test[1]

Goal	Component	Weight	Objective	Component	Weight
Interoperability	Intra-platform	0.5	Consumer welfare	Quality	0.22
	Inter-platform	0.25		Service diversity	0.44
	Geographic	0.25		Protection from stranding	0.33
Horizontal market (Demand)	Price	0.29	Competitive market	Efficiency	0.18
	Quality	0.14		Entry	0.18
	Product differentiation	0.14		Appropriate pricing	0.36
	Risk of stranding	0.14		Complementary services	0.27
	Complementary market	0.29	Innovation and investment	Platform operators	0.2
Horizontal market (Supply)	Efficiency	0.25		Manufacturers	0.2
	Entry	0.25		Middleware developers	0.2
	Incentives to innovate	0.25		Applications developers	0.2
	Impact on incumbent profit	0.25		Content providers	0.2
			Total	Consumer welfare	0.2
				Competitive market	0.2
				Innovation and investment	0.2
				Implementation	0.4

Note: [1] Implementation is not included under the individual objectives, as there is only one element (practical implementation) that is quantitatively scored, so weighting is not appropriate. Implementation can, however, be weighted in the total average objectives score, as noted above.

Table 6.13: Weightings of parameters in the scenario test

Parameter	Weight
Economies of scale in STB	0.5
Minimising re-authoring costs	0.5
Equipment innovation	1
API innovation	1
Robust API	1.5
Applications innovation	2
Stable technology	1.5
Market-driven standard selection	1
Single standard	
Increase in STB price	3

Tables 6.14 and 6.15 display the results of this scenario when the weights shown in Tables 6.12 and 6.13 are applied in the evaluation mechanism. As might be expected, the ranking of the options for interoperability is virtually unaltered by the scenario structure, and options 2a, 2b and 2e (and by default 3) perform the best on average.

The ranking of the options in terms of the average horizontal market score shows some sensitivity. In particular, option 2c has increased its ranking due to the relatively reduced importance of aspects such as economies of scale, and the greater weighting for increasing the STB cost. For similar reasons, options 5 drops significantly in the ranking.

Table 6.14: Interoperability and horizontal market scores in scenario test

	Interoperability			Horizontal markets		
	Average total	Original rank	New rank	Average total	Original rank	New rank
Option						
1	2.73	11	11	1.30	11	10
2a	10.00	1=	1=	3.46	2	2
2b	10.00	1=	1=	3.11	3=	3=
2c	5.96	7=	7=	2.96	7	5
2d	7.17	5	5	2.77	5	6
2e	10.00	1=	1=	3.74	1	1
3	10.00	1=	1=	3.11	3=	3=
4	6.80	6	6	2.24	9	8
5	4.75	9=	10	1.12	6	11
6a	5.96	7=	7=	2.68	8	7
6b	5.15	9=	9	2.22	10	9

However, the performance of the options against the objectives is radically altered. Option 2e remains the best, as it gains all the benefits of mandating a single high-specification API, but does so in a lower-cost way than option 2b. The second ranked option is 2c. Both these results are consistent with the structure of the scenario that was created.

The scenario emphasises the importance of the FTA market and the need for applications to support this market's development. Further it place weight on having an option with low implementation costs, while reducing the importance of economies of scale and re-authoring costs.

The performance of option 2b is particularly reduced by the relative sensitivity in this option to increased STB costs, and the lower benefits that are gained from increasing economies of scale and reducing re-authoring costs.

Table 6.15: EU objectives scores in scenario test

	EU objectives		
	Average total	Original rank	New rank
Option			
1	0.98	11	10
2a	2.42	4	3
2b	2.33	2=	4=
2c	2.62	6	2
2d	2.11	5	7
2e	3.10	1	1
3	2.33	2=	4=
4	1.48	9	9
5	0.40	10	11
6a	1.94	7	8
6b	2.26	8	6

These results are in line with prior expectations. Therefore, overall, the evaluation mechanism appears to be operating correctly, and produces economically sensible results that are in line with expectations, given an understanding of the European DTV market.

6.4 Conclusion

Determining the preferred option depends crucially on the weighting given to the different goals and objectives. A variant of option 2 is consistently the highest ranked option using the neutral weightings presented in the default. If implementation costs were not important, option 2b, or 2b via a migration path, 2e, would seem to be appealing policy choices. These options meet exactly the goal of interoperability at all levels of the market, and are also the best at developing successful horizontal markets. However, these options would be difficult to implement, and easier options that also perform well against the goals are 2c and 6a.

The benefit of 2c is that it is one of the least interventionist options, mandating a specific API only for FTA services, and leaving pay-TV operators to determine their own choice of API. Therefore, although it is not the best at achieving the goals, it is relatively good at meeting the objectives of increasing consumer welfare, stimulating a competitive market and providing adequate incentives for innovation, while also being relatively easy to implement.

If an option that does not require mandating is desired, then option 6a would be a potential candidate. It performs reasonably well against the goals, but less well against the first three objectives; its overall score on objectives is substantially increased by the fact that it is one of the easiest to implement.

As identified in section 6.4 when discussing the sensitivity tests, the evaluation tool is very tractable, and the weights of a considerable number of the elements can be altered. In addition to the Commission's policy concerns that will drive the weightings (see below), there are two aspects of the assessment above that need further investigation. These are economies of scale and re-authoring costs. As outlined in section 2.2.3, there is a considerable amount of uncertainty about the extent of these, and they could alter the outcomes of the analysis above by reducing the importance of their relevant parameters. For example, if economies of scale are limited, or only of a particular type, the economies of scale parameter should be given a relatively lower weighting than other parameters.

This section of the study has presented an economic evaluation of the issues relating to interoperability and horizontal markets in DTV, but has not considered the appropriate *policy* that should be adopted. Trading off the various aspects of policy, and determining the appropriate weights for the areas of concern is the task of the Commission. This part of the report, and indeed the whole study, is designed to assist in the process by providing a framework for balancing the conflicting pressures that arise from the different options available to the Commission, Member State governments or regulatory agencies.

7. Innovation in Display Formats

If the *market* is to deliver the full range of digital services (rather than through imposition by the Commission or national governments), then consumers must be offered new and well-differentiated services that are sufficiently attractive to persuade them to purchase the necessary equipment, or to pay in some other way for the costs of upgrading the infrastructure. Such differentiation is particularly important where the incentives to upgrade to digital are dampened by the existence of multi-channel analogue television. As already noted, the main DTV services (in Europe) are multi-channel television which increases consumer choice, and interactive television which should allow the delivery of new types of service over the television (and related equipment). These advantages result from the digitisation of the broadcast infrastructure, together with the acquisition of suitable STBs by the consumer.

In addition, digitisation can facilitate some improvement in picture quality, although this may also be achieved by changing other parameters in the broadcast system. This section discusses the impact of the introduction and take-up of more advanced-display formats that offer better pictures in a digital environment. The primary issue is whether display formats that offer the potential for better quality pictures (in terms of resolution and the impact and realism delivered to the television viewer) are likely to be successful in the market. A further issue that is touched upon is the extent to which this would aid switchover from analogue to digital broadcasting.

An analysis of the set of circumstances in which a (generic) new display would be successful in the market is undertaken, focusing on, how different incentives shape the market for these new display technologies. The discussion identifies factors that may hinder take-up of these improvements. Where appropriate, specific examples are used.

The generic supply and demand model developed in section 3 is used, focusing on the net benefit that the consumer may derive from a purchase of an improved television or other display device. The role of risk and uncertainty in limiting both supply-and demand-side participation in the market turns out to be crucial, and motivates the discussion of two key issues: first, the issue of coordination between supply-side players (both content providers and manufacturers), and, second, the closely related issue of compatibility between broadcast and receiver formats.

This approach illuminates reasons as to why a market in improved display equipment may not grow very fast, if at all. Essentially, where the consumer can perceive no (probabilistic) net benefit to investment, then the market in such equipment is unlikely to develop. If there is an external objective to move consumers and broadcasters to the new format(s)—ie, there is a perceived social welfare benefit from the new format—intervention in the market may be necessary. Typically, such intervention should take the form of mitigating the perceived risk to either or both of the supply and demand sides.

The section is organised as follows: the business model for display-based formats is set out, in section 7.1; the supply and demand framework of section 3 is revisited in section 7.2, with application to display formats in general. Section 7.3 considers the three display formats, and section 7.4 provides a summary and recommendations

7.1 Business models for display-based formats

In general, television display format innovations seek to improve picture quality and/or increase the functionality of the television screen. There may or may not be a broader impetus behind the development of the technology, such as the political motivations behind the original HDTV technology in Europe, and there may or may not be a prevailing standard developed before the technology is launched in consumer products. For example, while the 16:9 format was standardised in advance of its application with a considerable degree of cross-industry involvement, other consumer electronics standards such as the VHS video format have developed in a more haphazard way. This was a proprietary technology developed in competition with other formats, and all the available technologies competed in the market place to become the *de facto* industry standard.

Regardless of the manner in which the technological innovation is developed, there is no guarantee that it will be successful in the consumer market. The majority of technological innovations have straightforward business models—the technology is developed into a consumer electronics product, and that product is sold to consumers through the standard retail outlets (or some other sales route). Some products such as the Tivo brand of PVR also entail ongoing service contracts, but these are no different to those found in other product markets. The consumer has a straightforward trade-off: is the improvement worth the increase in price?

The European Commission may have concerns that products embodying apparently worthwhile or beneficial standards are not being taken up by consumers in the market. However, it is difficult to force consumers to adopt products that they do not feel are beneficial. Products acquired by consumers will only coincide with those that the European Commission (or other government or regulatory agency) may consider as most beneficial if the products offer attributes that appeal to consumers at a price that they are willing to pay. This is a standard consumption decision outlined in the demand-side analysis of the generic horizontal market framework.

Similarly, firms will only produce goods embodying the new technology if it can be developed into a quality consumer product that the firms consider will be successful. Frequently, firms themselves get this innovation and development wrong, and products are either unsuccessful, or do not prove to have a long life. In much the same way as for consumers, firms make their own decisions as to whether to develop a particular technology into a product. These decisions are unlikely to be influenced by external regulatory policy concerns about overall consumer welfare. The conditions required for firms to introduce new products in technology markets (or enter an existing market) were also identified at a general level in the supply-side part of the generic horizontal market framework.

A further issue is that the demand for televisions is derived from the content available to be viewed on it, and the television and content are not sold as a single bundled product. This means that there may not be incentives for the different players on the supply side to coordinate their actions for their mutual benefit, and it also means that the consumer is dependent upon two sets of supply-side participants (content providers and manufacturers of television sets). As a result, there is a complex set of interdependencies that can move together in a positive way, creating a virtuous circle; on the other hand, the interdependencies may also result in inertia that is exacerbated by investment risk. In this latter position, entry decisions on the part of all market participants are limited.

It is difficult for any regulatory agency to act indirectly to *guarantee* that a beneficial technology is adopted. It is possible that the only way to guarantee a particular outcome would be to mandate a particular standard or technology, and, if existing services in the existing format are still seen as demand-side substitutes to the new service/format, to ban the old format.

An alternative to imposing a standard is to seek to influence the market indirectly in order to produce the desired outcome. An example of this form of intervention is the Widescreen Action Plan (discussed below), which was designed to provide a financial subsidy to help overcome the supply-side coordination problem between content providers and manufacturers (the stand-off problem)—ie, to reduce the risk to content providers by subsidising the additional costs of widescreen production, thus encouraging the broadcasting of widescreen content. In turn, this should stimulate demand for widescreen televisions, thereby reducing manufacturing uncertainty. A virtuous circle should ensue.

7.2 Supply and demand framework and display formats

This section revisits the generic supply and demand framework set out in section 3, and applies it more specifically to the penetration of display format innovations. This facilitates the process of identifying potential obstacles to the development of a particular horizontal market. The focus is on the net benefit that the consumer may derive from a purchase.

As already noted, the supply and demand framework is relevant to any product market. However, analysing technology markets such as broadcasting has an additional complication, since demand for the good in question is derived from demand for access to the underlying content. This means that there are effectively two key supply-side participants: content providers and manufacturers of television sets. In order that a market may exist, there must be coordination between supply-side participants, such that there is appropriate content available on compatible television sets that consumers want to buy. Typically, there are two closely related coordination problems that exist on the supply side in these markets, the free-rider problem and the stand-off problem, which limit the development of the supply side of the market. These issues are discussed in section 7.2.1.

A major factor that links and limits both the demand and supply sides is risk, which arises when a new format standard has yet to become established for either production and transmission of content or for manufacturing. This risk has the effect of delaying consumer purchase decisions and exacerbating the supply-side coordination problems.

A further complication in these markets, also related to the element of risk, is that there is likely to be a transition period, when different sets of broadcasting and receiver standards are in use at the same time. This transition period may last indefinitely, or it may 'tip' at some point as one format establishes itself as the universal industry standard.

The introduction of new formats will inevitably involve a transition period and this highlights issues of compatibility between standards, especially when receiver formats and broadcast formats are different. The way in which the transition period impacts upon consumers is important to the eventual success of the product—if the transition period implies a net cost to the consumer, then the consumer will be unlikely to participate. The transition period may be lengthened or further complicated by the fact that television is an 'experience good'—ie, consumers may be unaware or uncertain about the benefits they will derive from viewing television until they have done so. These effects of risk are discussed further below in section 7.2.2.

7.2.1 Supply and demand framework

Consumers will purchase any individual product when their net benefit from the purchase is both positive and greater than the benefit from any other alternative products available.

As outlined in section 2.5, the net benefit of a purchase decision is a trade-off between those factors that increase the likelihood of purchase (benefits) and those that reduce it (costs). The benefit factors are quality, product differentiation, and complementary product market characteristics (ie, content), while the cost factors are price and risk. Having balanced these factors to generate the net benefit, the net benefit available from the potential substitutes products is also determined. The product with the highest net benefit of all the available choices is purchased (assuming that the net benefit is positive). Where a consumer already has a particular product (as is most likely the case when considering the purchase of television sets), this is also evaluated, as it is a potential substitute. The eventual consumption decision might be to retain the existing product and not purchase anything new; in this case the existing product has a price of zero, and may have a better risk profile, but could be offering lower benefit (for example, if it was not as technically sophisticated as the new product or was of a different format).

Thus, positive net benefit for any given product is more likely to arise, and so convince the consumer to engage in the market, when the benefit factors are high *and* when the cost factors are low. However, the consumer will place different weights on each factor and make implicit trade-offs. Thus, consumers could still achieve a net benefit from a product even if, for example, the price is considered high, provided this is balanced by particularly compelling content, or, if the quality is low but so is risk.

Demand-side analysis

Price, quality and product differentiation are important factors in determining the level of benefit associated with a particular product. However, these three factors are largely determined by the level of competition in, and the effectiveness of, the horizontal market. The influences on this are considered further below under the supply-side conditions.

The primary complementary product for television screen formats is the content that is displayed on the screen. The difficulties in stimulating the provision of content are the stand-off effect (outlined in section 7.1 above), where there is a supply-side coordination problem between content providers and manufacturers, and the fact that content provision is subject to network externalities which imply that the level of content is related to the volume of receivers of the relevant format in the market. Network externality effects arise when the consumption of a product by one consumer generates benefits to others, and the value of this benefit may be difficult to capture in the price mechanism.

Consumer purchase of television sets exhibits *indirect* network effects based upon content, since the demand for televisions is derived from the underlying content that can be accessed.[62] As the consumer take-up of a specific receiver format grows, there are greater incentives for providers to create content and applications that exploit this receiver format and hence reach these consumers.[63] Therefore the social value of an additional consumer purchasing a television of a particular format is the sum of the private benefit to the individual plus the additional incentive provided to suppliers to create more content and applications.

For established formats with sizeable installed bases of products, the latter effect is likely to be negligible. However, when the display format is becoming established, there may be considerable incentives for content providers as penetration grows, so the social benefit of a purchase is greater than the private benefit. If this effect were captured through the price mechanism, early adopters would pay a low price, and the price would gradually rise as more consumers purchased the product (reflecting the decline in indirect network benefits as take-up increased).

In general, however, the price structure suggested above is the reverse of what happens, and new format televisions are priced high (mainly for other supply-side reasons such as low volumes) and then decline as the market becomes more established. There is therefore a market failure in the pricing of new screen format televisions. There are two possible outcomes:

- the market failure may slow the market development, but is ultimately overcome; or
- the market failure may permanently inhibit development of the market.

If the screen format in question is considered to be important for social welfare reasons, some form of regulatory intervention may be appropriate to ensure that the market failure is overcome.

The remaining demand-side factor is the risk associated with investing in a given display standard (in terms of both the receiver and the way content is designed and made available to the consumer). This relates to the possibility that the receiver format that the consumer purchases will not become the accepted or dominant standard, and so the consumer will be left with a worthless piece of hardware (ie, a stranded asset). The impact of such risk can be mitigated by consensus standards determination by industry bodies or governments (including regulators) and by the provision of content using the appropriate standard.

[62] Telephony is the classic example of *direct* network effects, since each individual's potential to use a specific telephone network increases as more people join. This means that the social benefit from an individual joining a network is greater than the private benefit derived by the individual—others benefit from now being able to call the person that has joined the network.

[63] This is similar to the indirect network effects exhibited by the Windows operating system. See Appendix 3.

As noted above, the supply of content is subject to indirect network effects, but, for the market for a particular receiver format to become established, content needs to be available in that standard, as this will increase consumers' confidence in the permanence of that standard (thereby reducing risk).

Furthermore, the standard used in the content may have a direct impact on the level of benefit derived from the content itself (regardless of the nature of the content). Simply acquiring a receiver using a new display format is not necessarily sufficient to allow the consumer to realise the better viewing experience. Content would ideally be broadcast in a standard that is the same as the receiver format—ie, there is total compatibility—allowing the functionality of the receiver to be exploited to the full.[64] An example of the need for compatibility between broadcast and receiver format standards might be PALplus, where full advantage of a widescreen television set with a PALplus decoder may only be realised when watching PALplus transmissions.

At any point in time the factors discussed above together produce a level of net benefit for a particular television set using a particular display format, and this is compared with the net benefit offered by all the potential substitutes.[65] In other words, the probability of purchasing a particular product is dependent on the benefit derived from the competing options, and in terms of television sets (as noted above) these are likely to include the consumer's existing set. Thus the closer the consumer's existing set is to the new product they are considering, the less likely the consumer is to purchase the new product.

To make this point clearer, consider a consumer who is considering buying a widescreen plasma display. The consumption decision depends on their starting point:

- if the consumer is comparing the potential purchase opportunity to their existing standard cathode ray tube television, the benefit derived from the existing set is likely to be considerably lower than the new plasma screen, and there is greater likelihood of purchasing a new set;

- if, on the other hand, the consumer already has a large widescreen television, the decision is much less clear. The level of benefit derived from the widescreen television is likely to be much higher, reducing the likelihood that there is an incremental benefit from the plasma screen. This may be the case, despite any superior characteristics of the plasma screen This is particularly the case when it is considered that there is a cost to buying a new television, while there is none for the existing widescreen set (it has been purchased in the past, so no cost needs to be incurred to continue using it).

[64] As mentioned elsewhere, compatibility may also be achieved where standards are interoperable.
[65] The net benefit from all relevant products would be calculated in the manner outlined above.

As a result, *ceteris paribus,* in the first option the consumer is likely to make a purchase; in the second, the same consumer is much less likely to upgrade. The likelihood of purchasing new screen format television could therefore be enhanced not only by improving the new equipment, but also by degrading the quality of service achievable using the existing equipment in some way.

For example, all content on both analogue and digital platforms could be broadcast in a widescreen picture format. Those with standard format (4:3) television sets would see a letterbox shaped image with black panels, a distorted image, or one that was cropped. All of these would be worse than watching the same broadcast on a widescreen set, and likely to be worse than viewing the same material prepared and broadcast in 4:3 on a 4:3 set. Hence, the likelihood that the net benefit to the consumer of upgrading to a widescreen television (in this example) is greater than that derived from keeping their existing 4:3 set has increased, through the degradation of the existing service. An extreme example of this would be the switch-off of all analogue broadcasts, significantly reducing (to zero) the benefit available from analogue substitutes to digital services.

Supply-side analysis

On the supply side, manufacturers will enter the market when there is an expectation of positive profit, a function of the identified supply-side factors: barriers to entry (including investment risk); efficiency; incentives to innovate; and impact on the company's profitability.

The key factor on the supply side is barriers to entry. Given that the fundamental technology for the manufacture of different screen format television is relatively well known, the main barriers to entry in this market are consumer demand and uncertainty (or risk) relating to standards (entry is facilitated where there are clear standards). Uncertainty may also relate to the derived-demand characteristic of television displays in the form of a coordination problem. This problem arises when neither the suppliers of the services, nor the suppliers of the product necessary to receive the services, will move first into the market. This is a market failure resulting from indirect network externalities.

The former is clearly dependent on the demand conditions discussed above. In the context of the supply side, uncertainty about standards may inhibit the development of new products, or the entry of new firms, in much the same way as such risk can deter consumers from purchasing products. Firms are concerned that they will invest in developing a product that does not become a success and, therefore, they will not recoup their capital expenditure.

Similar concerns will adversely affect the level of innovation in a market; as noted in section 2.5, innovation incentives are particularly fragile in nascent markets and where there are strong existing competing products. Both these characteristics could apply to the development of different screen formats.

The efficiency of producers is largely endogenous to a competitive market—ie, the greater the competition, the more the pressure on firms to improve their efficiency. Therefore, if the market for any particular screen-based format could be developed successfully, there should be competition, and thus the firms in the market are likely to be efficient. Any problems regarding the absence of competition are best dealt with through the prevailing competition regime.

The final element of the supply-side analysis is the impact on firms' profitability. This relates specifically to the impact of producing a new good on a firm's existing portfolio of products. However, in terms of television formats, this is a minor concern. There are already low margins on sales of existing 4:3 sets, and the market is largely saturated; most consumers already have a 4:3 television and there is intense competition. Therefore, introducing a new product based on a different screen format is likely to be beneficial for a manufacturer, as it could provide additional (or higher-value) sales, and may contribute to stimulating the market overall.

Table 7.1 summarises this discussion of the demand and supply sides for the horizontal market for screen formats. It shows that many of the important elements of both sides of the market are unlikely to impede the development of the market.

Table 7.1: Summary of demand- and supply-side analysis of horizontal market for display-based formats

Demand side	Concern?	Supply side	Concern?
Product differentiation	No—competitive market should provide adequate incentives	Barriers to entry	Yes—uncertainty (over consumer demand) and potential market failure (for content)
Complementary products (content)	Yes—potential market failure	Incentives to innovate	Yes—uncertainty (standards)
Quality	No—competitive market should provide adequate incentives	Efficiency	No—competitive market should provide adequate incentives
Price	No—competitive market should provide adequate incentives	Impact on profitability	No—existing market saturated
Risk	Yes—potential market failure		

However, there are several factors that may require regulatory intervention in order to ensure that the market develops correctly. These can be distilled to two key factors that must be addressed in order for successful markets in display-based formats to arise:

- widespread supply of compatible content; and
- determination of standards.

Both these issues are considered further in the following sub-section.

7.2.2 Risk, content and coordination problems

Risk over standards and content availability have therefore been identified as the two crucial factors that are relevant to the development of the market for a new, technologically advanced television receiver. Risk itself exacerbates the market failure that may exist due to indirect network effects based upon content availability. Since content availability is important as a driver of the demand for televisions, there is a (negative) feedback loop between the supply and demand sides of the market:

- consumers perceive the standards risk associated with purchasing a new type of television to be significant, and as a result may fear being left with a stranded asset. They see little benefit from purchasing the equipment when there is little content available that exploits the full functionality of the display; and

- the uncertainty over consumer demand exacerbates manufacturers' and content providers' concerns about the appropriate standard, and so less equipment and content is supplied.

Underlying this interdependency are two coordination problems:

- the requirement for content to be both created and broadcast (or otherwise made available) in the relevant display format; and
- the need for consumers' receiving equipment to be compatible with the screen standard(s) used by the broadcaster.

In general, innovative screen formats are best exploited by having content that is both created and broadcast in the format on which it is intended to be displayed.[66] To benefit from any content delivered using an improved format, consumers would also need to have a receiver that is compatible with the broadcast format. Commitment by the supply side to (investing in and) employing the relevant screen format may provide a positive signal to consumers over the permanence of the standard, and increase confidence in purchasing the receiving equipment.

However, there is a coordination problem between the manufacturers of television sets and content providers that must be solved before full delivery of content can be achieved. This is the stand-off problem outlined previously: as the full benefit of an innovative screen format can only be appreciated by consumers if both elements of the supply side coordinate together, neither supply-side participant is willing to risk investing in the new format if they do not have a guarantee that their counterparty will also commit. That is, either manufacturers wait for content to be provided in the new format before manufacturing such equipment, or vice versa.

This problem is exacerbated by the atomised nature of content provision; there are many different suppliers of content and it will be difficult to coordinate them to ensure that sufficient content is produced to overcome the stand-off problem. In particular, as adopting the new format involves both an investment cost and a risk (that there will not be enough equipment for consumers to appreciate the benefits of the format), there is an incentive for content providers to free-ride on the investment of others. Some content providers may rely upon others to invest first and ensure the success of the market before committing to invest themselves. Clearly, however, if all content providers did this, none would ever actually invest and the new screen format would not develop at all.

This problem was identified in the Widescreen Action Plan as hindering the achievement of a critical mass in widescreen programming:

[66] This is particularly the case for widescreen and HDTV, but the benefits of such full coordination are minimal for progressive scanning.

> In a number of countries, private broadcasters acted like 'free riders'; they waited for public channels and pay-TV operators to contribute to the development of an installed base of receivers before launching their own commercial services. The result of this policy was that critical mass was often difficult to achieve by relying solely on the efforts of public broadcasters and pay-TV operators.[67]

The second element above—the need for compatibility between consumers' equipment and the broadcast display format—is generally not a problem that arises in a static market environment (that is, one where the display standard has been set and there is a substantial installed base of compatible equipment). The current analogue 4:3 situation is an example. However, in moving to a new display format, coordination on the supply side and subsequent consumer market penetration will only occur over time. Therefore, there may be a period of transition as the old broadcasting and receiver formats are replaced by the new ones. This transition period could persist indefinitely if only some consumers experience enough of a net benefit to be willing to upgrade (and there is some backwards compatibility so that consumers using the new format can access content in a previous format), or it could end as the market tips on the establishment of a critical mass of penetration of the new format.

It is also possible for the transition period to be crucial to the success of the new format if the transition path were to imply a loss or degradation of service to consumers through lack of compatibility (either backwards or forwards). Thus, the success of a particular display format depends in part on how the consumer's viewing experience is affected during the transition period. Where the consumer perceives the transition as a poor experience, participation will be limited. Transition problems may be minimised by the co-existence of several interoperable standards, where technology allows this.

The way in which compatibility issues are dealt with will affect incentives on both the supply and demand sides. This is illustrated in the matrix in Table 7.2, which shows the impact on the consumer of the set of possible combinations of broadcast content and receiver format. The basis for comparison is the existing format receiver display and existing broadcast content format, termed the base case.

[67] IDATE (2000), 'Final Evaluation of the 16:9 Action Plan', November.

Table 7.2: Matrix showing the impact of combinations of content formats and display formats

Broadcast format	Receiver type	
	Original	**New**
Original	Starting position (base case)	Potentially the same, better or worse ('backwards compatibility')
New	Potentially the same, better or worse ('forwards compatibility')	Better[1]

Note: [1] This is an underlying assumption of this section.

The representation is simplified, but the general idea is clear. The viewing experience represented by 'new–new' is assumed to be a better outcome for the consumer than the initial position, 'original–original' (the base case). In this case, the market is much more likely to develop, subject to the other factors that have been identified as affecting the net benefit to consumers.

The relative benefit to the consumer is unclear when the receiver display and the broadcast formats are not the same (either the broadcast or display formats can be 'new'). In both such instances the consumer could be worse-off, better-off, or experience no difference to the base-case position, depending on how the transition problem is dealt with.

However, there is a difference between the incompatible outcomes. When the broadcast signal (and content) has been upgraded, but the consumer's equipment has not, and this results in a degraded experience for the consumer, this may provide the consumer with an incentive to purchase the new equipment to restore (or enhance) their viewing experience. On the other hand, when the consumer has purchased equipment in the new format and is then made worse-off by the transition process (ie, they cannot even fully use or experience the functionality embodied in their old equipment), the net benefit to the consumer is reduced and consumer demand is limited. In this case, the interdependencies between consumers, manufacturers and content suppliers identified above are likely to result in the market development of the new format being impeded.

7.3 Analysis of the display formats

This section builds on the foregoing analysis to discuss take-up of three specific display formats: widescreen, progressive scanning and high definition. The objective is to understand the issues that are relevant to consumers' decisions regarding whether to purchase advanced-display format televisions. This applies the conceptual discussion of the previous sub-section to details of the three display formats.

A detailed technical explanation of these technologies is not given here, however some understanding is necessary to proceed with the analysis. In brief, widescreen (or 16:9) refers to the shape of the screen (the ratio of width to height). The wider aspect ratio increases a television programme's impact on consumers, offering a more pleasing and comfortable viewing experience. It also allows broadcasters and programme-makers more creative opportunities. In addition, it may be a way of differentiating DTV from the standard television content that consumers are used to. In particular, the widescreen aspect ratio ensures that films (the most expensive type of programming after football rights) appear in a compatible format. This takes advantage of the association that many consumers make between widescreen and movies.

Scanning in relation to consumer equipment refers to methods of displaying images on the television screen; these determine the information required, and its sequence, to create the images delivered to the viewer. Interlacing is the traditional method used for television broadcasting and display (ie, traditional televisions have interlaced displays); the issue under consideration is a change that would allow televisions to display images using progressive scanning (typically used by computer screens). In the PAL system using 576 lines, the difference between the scanning methods is that interlaced displays scan the odd and then the even lines (ie, line 1, then lines 3, 5, 7, 9 … 575, then lines 2, 4, 6 8 … 576), of the picture, while a progressive scan picture would scan the lines sequentially (lines 1, 2, 3 … 576).

Progressive scanning has advantages over interlaced when trying to display static images requiring high resolution, particularly text that is designed to be read on screen, such as Internet content. It is this potential to view the Internet through a television that creates the possibility that a television (incorporating progressive scanning capability) could be used to address the digital divide. However, as noted below, there are drawbacks associated with *broadcasting* progressive scanning material, notably in terms of bandwidth utilisation in the broadcast signal. There are few progressive scanning television sets currently available, and these tend to be widescreen as well. Most PC monitors are progressive scanning, although they tend to use the 4:3 aspect ratio rather than widescreen (monitors using the latter are available, but are expensive).

High definition refers (generally) to higher-definition, better quality visual presentation due, among other factors, to the delivery of spatial resolution that is approximately 4–5 times that of standard definition television. Beyond this general definition, there is no widely accepted definition in Europe, in terms of the number of lines and scanning format.

In general, the greater the number of lines that can be displayed on a screen, the greater the potential resolution of the image (subject, in general, to the screen being fed with sufficient information to populate all the potential lines available). In practice, high-definition televisions are also likely to incorporate the widescreen aspect ratio.

It should be noted that PC monitors are generally higher-definition than standard television screens. In terms of the equivalent number of lines, PC monitors usually have over 1,000, but, as indicated above, they are not generally widescreen.

All three changes to the broadcasting infrastructure are possible in an analogue system, but they also have a cost in terms of bandwidth—ie, to deliver the same amount of content, more bandwidth would be required. Alternatively, to stay within a bandwidth constraint, less programming could be broadcast. The implications of this constraint are:

- content providers have to compete harder for capacity where there is considerably less bandwidth;
- broadcasters and network operators have fewer channels to differentiate their service and attract customers;
- the customer is offered less choice and range of content.

This is the case in both a digital and an analogue environment, but is more critical in analogue, where bandwidth utilisation is much less efficient. Compression techniques mitigate the problem somewhat in the digital environment and therefore increase the feasibility of introducing advanced-display formats from an economic standpoint. In addition, the transition process, where the broadcasters and consumers move to the new standard at different times, is easier in a digital broadcasting system—see section 7.4.2 below.

In most countries the majority of consumers still watch television that is broadcast over an analogue infrastructure on a standard format (4:3) television set. For most consumers, therefore, this is the context for comparison of the net benefit offered by an upgrade in display format.

For the purposes of this analysis, it is assumed that the net benefit associated with the purchase of an advanced-display television is achieved within a *digital* broadcasting system, as this is the most likely transition path that will be undertaken.[68] This is a reasonable assumption, given the advantages of using a digital signal compared with analogue. Digital broadcasting is more efficient in its use of bandwidth, and the use of a digital broadcast stream enables the consumer's receiving equipment to alter the display format to match the format of the television on which it is to be displayed. As the analogue broadcast stream does not easily facilitate such manipulation of content,[69] any move to an advanced-display format within an analogue broadcast structure could disenfranchise those consumers without television sets that are able to handle the new broadcast format.

Given these characteristics of the three display formats, there are different benefits that can be derived from each technology, and these are considered further in the first sub-section below, together with a discussion of how this may affect consumer purchase decisions. Section 7.4.2 addresses the issue of the impact on the consumer of transition between technologies that could arise as the new display formats are introduced.

7.3.1 Benefits of advanced-display technologies

The first important consideration in the context of the potential consumer purchase of a technologically advanced receiver is the benefit that each display format offers. Many of these are common across the three display formats, and some will depend on consumers' individual preferences. The following list identifies the main benefits that new display formats could offer relative to existing 4:3 receivers:

- improved aspect ratio;
- improved resolution;

[68] There are no apparent plans in Europe to move to high-definition, progressive-scanned broadcast, or any further expansion of widescreeen broadcasts within the analogue infrastructure.
[69] It is possible for newer television sets to manipulate images received over an analogue infrastructure, but not to the same extent as for images received over a digital infrastructure.

- ability to translate to a big screen; and
- access to more non-broadcast content (eg, Internet web pages).

Each of these benefits is discussed below.

The underlying assumption in this section is that each change to the display format offers an improvement of the viewing experience over the existing 4:3 display, given appropriate content. However, each display format may offer improvements along different dimensions to the others, making comparison *between* innovative formats complex. For example, widescreen affects picture shape, while high definition display formats (with widescreen or not) improve the picture resolution.

The widescreen display format alters the aspect ratio, increasing the potential impact of a programme or film, and offering a more pleasing and comfortable viewing experience.[70] The other two technologies, when incorporated into a television set, *may* include the widescreen aspect ratio, but this is not intrinsic to the technological change.

Resolution has two dimensions: vertical resolution is defined (in television displays) according to the number of lines displayed (576 lines in the 625 line standard in Europe, and historically, high definition has been defined at over 1,000 lines). Horizontal resolution relates to the maximum definition along each line, and the degree of vertical and horizontal resolution should be of similar degrees—increasing the resolution in one dimension without increasing it in the other has little beneficial effect. In general, computer screens have better resolution along both dimensions, with more vertical scanning lines (1,000 or more) and greater horizontal resolution within each line.

The resolution of a digital signal on a widescreen display is not significantly better than either analogue 4:3 content on a 4:3 television, or analogue PALplus transmissions on a widescreen, PALplus set. This is because widescreen displays do not have any more lines than standard format televisions. The same is true of progressive scanning, which removes the visual flicker associated with standard, interlaced pictures and can make the picture smoother to the human eye (particularly hard-edged horizontal lines), but does not improve the theoretical resolution of the picture.[71] On the other hand, high-definition televisions can display more vertical lines, and therefore present a clearer, sharper picture (as noted above, this also requires more bandwidth to broadcast).

Both progressive scanning and high resolution technologies address the way the picture is painted on the screen. Progressive scanning reduces or removes flicker and other artefacts associated with interlaced images, while high definition overcomes the limits of the resolution of the picture being displayed that can be obvious with larger screens (the

[70] Widescreen has an aspect ratio, or ratio of width to height, of 16:9; standard size pictures have a ratio of 4:3.
[71] Where a progressively scanned display is receiving twice as much information as the equivalent interlaced display, the visual quality of the picture can be improved slightly.

picture appears to be grainy). Widescreen alone does not add anything in terms of picture quality on a larger screen.

However, the incremental consumer benefit of moving to both these types of display formats (assuming the appropriate broadcast input is available) is somewhat lessened by the availability of 100Hz television technology displaying standard broadcasting input. This technology allows for each broadcast frame to be shown twice, which effectively reduces flicker. Again, however, resolution is not increased when displaying standard broadcast images. 100Hz technology is not an explicit feature of widescreen, but many widescreen sets (especially the larger ones) incorporate it.

As already indicated, content is a key driver for the take-up of new technology, and it is expected that (most) consumers will switch to digital infrastructure over the next few years. In a digital environment, televisions and STBs are much more intelligent and diverse devices than was the case for analogue broadcasting, and greater volumes of information can be sent in a digitally compressed format. However, there is still a trade-off between bandwidth and the amount of information that can be sent.[72] In particular, broadcasters will prioritise the importance of different content or information, and there is little incentive to broadcast additional display-based information if most or all of the display devices receiving the signal are not capable of effectively using these data.

In some countries, in particular the UK, the widescreen format is a standard feature of *digital* broadcast content. Thus, one of the main coordination problems identified in section 7.2 has been largely overcome, as there is content of the appropriate format readily available for widescreen televisions used on a digital network. This was probably due to coordination among UK content providers driven by the BBC. This is not the case so far, in Europe, for either progressive scanning formats or formats with higher definition, which suggests that take-up of receivers using these formats is likely to be slow until the coordination problems are overcome.

However, consumers need not necessarily rely upon broadcast content in order to exploit the functionality of new display format receivers, as they can also view content pre-recorded on different media (eg, DVDs). Widescreen sales in particular have benefited from the association with DVDs, as much of the original content for DVDs (ie, films) was originated in widescreen. DVD players themselves can handle the problems of coordination between the aspect ratio of the display device and the content, allowing the same source (information on the disk) to be optimised for both display aspect ratios (16:9 and 4:3). As already discussed in section 2.3, the coordination of manufacturers of DVD players and content suppliers has been achieved through industry groups.

Other sources of such content that have yet to be fully developed could include the Internet, for example downloading films and other programming. As a result, there is

[72] The bandwidth constraint will be absolute at some point, absent a relaxation of the constraint via more advanced compression techniques or more bandwidth being made available.

likely to be increasing competition for viewing hours between broadcast and other content. The availability of these alternatives to broadcast material increases consumer choice and decreases the consumers' dependence on *broadcasters* and *network operators* for appropriate content by decoupling the viewing experience from the supply-side issues in broadcasting (particularly the coordination problems). Further, the competition between the two types of content may stimulate a faster conversion of broadcast content to the new formats than would otherwise have occurred. These developments are likely to reduce consumer risk and uncertainty over availability of content, and it *may* help reduce risk associated with standards if the alternative content is compatible with, and can exploit, the functionality of the new display formats. Availability of non-broadcast content therefore has the potential to be a strong driver for take-up of new technology.

In addition to widescreen, which has benefited from DVDs, non-broadcast content is also possible for progressive and high-definition formats. Some DVDs already contain sufficient information to provide an increase in picture quality if displayed on a progressive-scanned screen, and DVD players with a progressive-scanned output are becoming available in Europe. (DVDs played on PCs already exploit this capability, as the PC monitor is progressively scanned.) As yet, the inherent resolution of DVD material is insufficient to deliver a significantly improved image on a high-definition television compared to a standard definition television, but this is likely to change with technical improvements to DVD technology.

Creating DVD output that could exploit high-definition television displays would still require some intra-supply-side coordination. In general, however, it is more straightforward than supplying appropriately configured broadcast content because fewer elements of the supply chain need to be configured. It is possible that non-broadcast content could create, or support, a niche demand for high-definition and/or progressive-scanned televisions that might develop in advance of changes to the whole broadcast chain. This could be a more economically viable and efficient way of overcoming the problems identified in section 7.2.2 and developing an initial installed base of consumer equipment.

A further benefit of the new display formats is the ability to view computing graphics and other data over the television screen. As noted above, the use of a common household product, such as the television, to obtain access to the Internet and any other Information Society applications and services could significantly contribute to reducing the digital divide.

However, as already indicated, computer graphics or similar material are not well presented using standard interlaced scanning displays that televisions typically use—graphics and text are poorly defined and unattractive. Such material requires progressive scanning at high field rates on monitors that offer good vertical and horizontal resolution. Computer monitors typically have a refresh rate of around 75 Hz or greater, and the resolution for a typical 15″ monitor might be 1,024 (pixels) by 768 lines. In addition, computers use progressive scanning which reduces horizontal line flicker, which becomes more important when the individual sits near the screen and when the picture being displayed has lots of horizontal, or near-horizontal, lines (which is typical of text and static graphic displays).

Together, these features (progressive scanning, higher refresh rates and higher resolution) facilitate a good presentation of static text and graphics, and allow individuals to sit close to the monitor. In order to achieve the same (or similar) result on television, the television display would need to have finer resolution in both the horizontal and vertical dimensions, progressive scanning, and a refresh rate of more than 50 Hz *for the complete picture*.

Of the formats considered here, widescreen technology does not offer this functionality. Progressive-scanned and high-definition screens have the potential to deliver resolution akin to a computer screen, but this depends on them being able to deliver a higher field refresh rate than is the case for the optimal viewing of standard definition television, and to use more highly defined screens than is necessary to extract the best definition from current *broadcast* signals.

Finally, the penetration of any good is enhanced by consumer comprehension of its functionality and the benefits that might be derived from purchase. To this extent, widescreen benefits from the fact that the concept is familiar—its association with the cinema helps, plus the fact that the concept has been accessible to consumers for a number of years. Progressive-scanned and high-definition formats are much harder products and technologies to explain and 'sell' to the consumer—the visual benefits are much less obvious on 'normal'-sized television sets, than is the case with widescreen. Therefore, without detailed explanation, the benefits of these innovations may not be perceived by consumers, and demand may be reduced.

The key benefits considered in this sub-section are summarised in Table 7.3.

Table 7.3: Summary of benefits offered by widescreen, progressive-scanned and high-definition display format technologies

Benefits	Widescreen	Progressive scan	High definition
Improved aspect ratio	✓	– [1]	– [1]
Improved resolution	X	X	✓
Translates to a big screen	X	✓	✓
Non-broadcast content	✓	– [2]	– [2]
Potential to view computer data	X	depends on refresh rate	depends on refresh rate
Already understood by consumers	✓	X	x

Notes: This table reflects the benefits of each technology individually. '✓' indicates that the benefit is associated with that format; 'x' indicates that the benefit is not, or not yet, associated with that format. [1] Progressive-scanned and high-definition technologies do not *in themselves* offer the benefit of a wider aspect ratio. It is likely, however, that both a progressive-scanned television and one capable of more lines of resolution would incorporate a wider aspect ratio. [2] Non-broadcast content should become increasingly available to the public. DVD players that can supply either progressive- or interlace-scanned output are currently available, and high-definition output is technically possible and may enter consumer markets. Similarly, compression technology allows DVDs to contain content optimised for one, or a combination of, different formats.

Impact on consumer consumption decision

Having considered the potential benefits that might be derived from the different display formats, it is necessary to consider their impact on consumers' purchase decisions. As discussed in section 7.2, this will be driven not only by the benefits of a particular product but also its cost, and the net benefit available relative to competing substitute products.

While there are some consumer benefits attached to progressive-scanned and high-definition formats when these are coordinated throughout the broadcast chain, the incremental benefit of a purchase of one of these displays compared to widescreen is not very significant. The formats offer improved aspect ratio and resolution, but there is also risk and uncertainty over content availability and standards that will inhibit purchase of the products. From the consumer perspective, this risk is greater with respect to the purchase of a progressive-scanned or high-definition television than for a widescreen set, particularly as widescreen content is more readily available in both broadcast and non-broadcast forms.

This suggests that, in a market where progressive-scanned and high-definition (also usually widescreen) televisions are more expensive than standard widescreen, there will be only a limited (if any) net benefit to purchasing them. Furthermore, there is much more potential confusion over the progressive-scanned and high-definition technologies, and consumers may not value accurately the associated benefits, whether immediately or potentially available. This in turn would reduce the likelihood of purchase.[73]

There is some possibility that non-broadcast content could act as a driver for take-up of progressive-scanned displays and screens capable of displaying more lines of resolution. However, this is likely to be limited for as long as standard widescreen sets are cheaper (hence offering greater net benefit) and while the non-broadcast content is not exclusive (and compelling) to progressive-scanned and/or high-definition monitors. This situation is exacerbated by 100Hz technology, which is built into many widescreen sets and mimics true progressive scanning reasonably well. This improves the image for standard and current widescreen broadcast input, but the improvement in the display itself is not, as yet, really sufficient to enable computer pages to be displayed adequately. This is because 100Hz cannot 'add in' resolution that is not there.

An alternative driver of progressive-scanned and high-definition television penetration could be the ability to access the Internet. However, the price of home PCs is falling rapidly, while the required format televisions remain very expensive. One of the reasons for this is that the size of the display needed for comfortable television viewing (ie large), when combined with the high-quality display needed to view Internet (or similar) content, results in a high cost display device, whether it is called a TV or a PC monitor.

It appears that, as these high-quality screens increase in size, their cost increases proportionately more than the relative increase in screen size. For example, standard 15″ CRT monitors can be purchased from €100, but 21″ CRT monitors (ie, smaller than most television screens) are quite significantly more expensive, starting at around €600 in the UK. This would suggest that televisions that are suitable for the Internet are unlikely to reduce considerably in price in the foreseeable future.

[73] However, it should be noted that these developments may come about as a by-product of other technological developments. In particular, progressive images are the output on thin screens using plasma and similar technologies, even when the input is interlaced.

Further, as the Internet content can be accessed through relatively cheap computers (without having to upgrade the household television), using a television to access the Internet is not a particularly attractive alternative.[74] In terms of the analysis in section 7.2.1, the net benefit from televisions suitable to display the Internet is low, if not negative (due to the high price), and is likely to be less than the net benefit from the combination of the existing household television plus a computer (ie, the closest substitute).

7.3.2 Impact of transition between technologies

As noted in section 7.2.2, a further important consideration in the context of take-up of new and advanced-display formats is the impact of transition between standards—ie, where there is a potential loss of compatibility between the consumer's equipment and the broadcast stream.

It has already been noted in Table 7.2 that the form of (in)compatibility can have an effect on the incentives faced by the consumer. These can be summarised by considering a consumer about to invest in new technology from a position where their existing receiver is compatible with the existing broadcast stream. There are two possibilities:

- the broadcast stream is compatible with the new technology—there is an incentive to invest in a new technology receiver; and
- the broadcast stream is not compatible with the new technology—the incentive to invest in a new technology receiver is limited.

In the transition stage, the broadcast or other content may not be able to exploit fully the functionality of the new receivers that consumers can purchase, and this will reduce the incentive for consumers to invest, even if the new technology will ultimately provide a significant benefit. On the other hand, if the broadcaster causes a degradation of service for consumers by upgrading in advance of the installed base of technology, there are likely to be negative consequences for the broadcasters, both commercial and political. This is despite the fact that, in *economic* terms, such a move would provide the best incentive structure to stimulate consumers to upgrade.

To consider the impact of the transition issues, it is instructive to look at a recent example of an attempted transition. This illustrates the importance of compatibility between standards, and how consumers react if the compatibility is incomplete.

Widescreen television sets have been available since the early 1990s. In an attempt to reduce the supply-side coordination problems, the Widescreen Action Plan[75] (the 'Plan)

[74] A further aspect to note in this regard is that traditional usage patterns have differed significantly between television screen and computer monitors. The computer monitor is more of a 'lean forward' tool that consumers are used to interacting with, while the television is more of a passive 'sit-back' experience. However, these may change if consumers become used to a more active involvement with the television through interactive content.

[75] Council Decision No 93/424/EEC on an *Action Plan for the Introduction of Advanced Television Services in Europe*

put in place subsidies for the making and broadcasting of widescreen content. The Plan was technologically neutral. Funded transmission standards included D2 MAC and the PALplus transmission standard.[76] Such subsidisation is a way of reducing the risk associated with investment under uncertainty on the supply side. The Plan may not have wholly achieved its goals within its life (1993–97), but it raised the profile of the widescreen concept, increased confidence in it, and helped make it a viable DTV format.

A primary reason for the initial lack of success of widescreen may have been the poor compatibility that the *analogue* environment could provide. There was a variety of receivers that consumers could use with the widescreen broadcast format, which produced different viewing outcomes:

- a *widescreen television set (including a PALplus decoder)* could properly support a PALplus transmission, and viewers could see a full widescreen-size, undistorted, extended-resolution picture;

- a *non-PALplus widescreen set* would produce an image with reduced resolution owing to a reduced number of lines of information being used and the size of the screen;

- a *standard (4:3) television set* would receive a PALplus widescreen transmission as a letterbox image; standard 4:3 sets were able to display an image that filled the screen and had the correct resolution only for 4:3 PAL transmissions;

- a new *PALplus television* would either display a 4:3 image with black-side curtains filling up the screen, or the set may be able to manipulate the picture to fill the screen at lower resolution, plus possible distortion, and/or picture loss.

As a result, even though PAL and PALplus are compatible, if widescreen transmissions were mixed with standard transmissions using an analogue signal, there was a degradation to the viewing experience for most consumers for at least some of the time (ie, owners of standard 4:3 televisions). In some Member States, viewing audiences would not accept drama in a letterbox format, and in others, broadcasters were unwilling to use the format for broadcasting football. The inability to view the widescreen content perfectly on a standard widescreen television, as would be achieved with a digital widescreen signal (where the STB necessary for digital decoding would deal with matching the output to the television's format), impeded the take-up of widescreen televisions. The conversion to widescreen in the broadcast stream was also not complete, so those consumers with widescreen sets (with or without PALplus) received a service that was no better than they would have achieved on (cheaper) standard TVs; this was a

[76] PALplus is basically the analogue widescreen version of PAL—it has a 16:9 aspect ratio and uses a digital signal to indicate to receivers that the broadcast has a widescreen aspect ratio. The two standards are compatible.

further incentive not to upgrade. On the other hand, it may be the broadcast stream that converts to the new format first, but it takes time for consumers to upgrade their television sets. An example of the positive incentive effects of this structure is the UK, where all digital (pay-TV) broadcasters adopted widescreen in 1998, and the BBC committed to making all of its output in this format. This has considerably helped stimulate a high penetration of widescreen receivers in the UK, although forwards compatibility was also facilitated as the broadcast stream was digital, so STBs could manipulate the signal to overcome any lack of coordination with 4:3 televisions.

The precise compatibility issues that may arise in the transition stages to each of the three display formats are now considered in more detail.

Widescreen

The impact on the consumer's viewing experience of the transition path from 4:3 to widescreen display of content delivered by a digital signal is summarised in Table 7.4.

Table 7.4: Backwards and forwards compatibility in the transition to digital widescreen

Broadcast format	Display type	Impact on the consumer	Outcome
4:3	4:3	Standard picture	base case
4:3	16:9	Variety of possibilities, all of which stretch or crop the picture, or leave black panels	–/X
16:9	4:3	Choice of displays that manipulate the picture, including shallow 14:9 letterbox. However, black lines at the top and bottom and/or picture distortion and/or picture loss may occur	X
16:9	16:9	Full, sharp widescreen image	✓

Note: '✓' represents a positive effect; 'X' represents a negative effect.

The matrix implies that there is a positive benefit to consumers from upgrading to widescreen when the source material is widescreen. Viewing is at full resolution, undistorted, fills the screen and allows for realisation of all the benefits of widescreen. Forwards and backwards compatibility is not perfect, but, as the UK case demonstrates, if the supply side can move together and commit to the format, then consumers are willing to upgrade to obtain the benefits. Also, as noted, DVD content has had a strong effect, mostly because direct access to content allows the consumer more autonomy in exploiting the new receiver.

Progressive scanning

The impact on the consumer's viewing experience of the transition path to progressive scanning broadcasting in a digital world, compared with the starting position, is summarised in Table 7.5.

Table 7.5: Backwards and forwards compatibility in the transition to digital progressive scanning

Broadcast format	Display type	Impact on the consumer	Outcome
Interlaced	Interlaced		Base case
Interlaced	Progressive	Potential for some negative impact on viewing if the conversion is not good quality Benefit in terms of DVDs and possibility of accessing the Internet[1]	-/X[2]
Progressive	Interlaced	Most viewers would not be able to see any images without either a new television or the STB acting as a signal converter	–/XXX[3,4]
Progressive	Progressive	Improvement on visual quality of the image; potential for reduced output, however, due to bandwidth constraints Benefit in terms of DVDs and possibility of accessing the Internet[1]	✓ [4]

Note: [1] This assumes the necessary computing functionality is resident in the STB, the screen is of sufficient resolution and that the screen refresh rate is sufficient. [2] There are some cases where the visual image is improved if the original material is film and the conversion in the display device is of high quality. [3] If the STB can convert the signal the consumer will see the same output as the base case. If the STB cannot, then the consumer will see no output at all. [4] If the broadcasting system is bandwidth-constrained, total output will need to be reduced, which would have a negative impact on consumers.

The two cases of non-compatibility both generally show degradation to the viewing experience for the consumer. Where the display is progressive and the broadcast content is not (requiring backwards compatibility), the degradation is likely to be minimal (if at all), as the (new) television will have an interlaced-to-progressive format conversion built into it. However, the conversion is not itself problem-free and poor-quality conversion can result in a degraded image. This conversion already takes place when television is viewed on a PC monitor.

In addition, non-CRT display technology may already require a progressive rendering of the image as a result of the technical characteristics of the display. These displays, when used for TV broadcasts, will already have an integrated-to-progressive conversion installed. Modifying the equipment in manufacture to accept a progressively scanned source would be relatively inexpensive, especially compared with the (current) price of the displays (upwards of €3,000).

This may be a minimal detriment compared to the ability to take advantage of other, non-broadcast content, but, as noted above, there is currently not very much of this type of content available. However, DVD players are being sold in the consumer market with the ability to produce output in both types of scanning. Where the source material is originally film, the progressive output is very close to a true progressive rendering of the original image, even if the conversion to the digital encoding on the disk is optimised for an interlaced output (ie, normal television).

Where broadcast content is progressive and the television is interlaced (ie standard TV), the consumer would require a converter in order to be able to view an image. Thus, if the broadcast stream converts ahead of consumers, all consumers would be compelled to invest in such a device. As this conversion can be achieved relatively simply for a digital signal, the digital *STB* may be capable of undertaking such a conversion and providing a non-progressive-scanned input for the television. This implies that the format of the installed base of television becomes irrelevant and could form a forwards-compatibility path for broadcasters. However, given the likely bandwidth constraint, it is not clear that there is any significant benefit to *broadcasters* in broadcasting content in a progressive-scanned format. Even when the population of televisions is fully compatible, the increased quality for typical television images is limited.

In summary, the net benefit (ie after taking into account the increased costs) to the consumer from buying a progressive-scanned receiver for improved reception of progressively scanned broadcast content is likely to be low (or negative), even in the digital environment. There may be other reasons for purchase, such as viewing of DVDs, or access to Internet content and services. There may be some advantage in the picture rendering of interlaced broadcast sources if the interlaced-to-progressive conversion is of sufficient quality, and the net benefit under these circumstances may be positive (as the costs of upgrading the broadcasting infrastructure are avoided). Some receiver types may already incorporate the progressive-scanning format as a by-product of the technology they use.

However, DVD output is already high-quality on standard widescreen sets, and Internet access is unlikely to be an additional compelling benefit for those individuals who can afford a progressive-scanned screen (they are likely to already have a computer). Therefore, turning to a progressive-scanned television broadcasting system as a means of addressing the digital divide is unlikely to be cost-effective, given the current state of display technology.

High definition

The impact on the consumer's viewing experience of the transition path from 4:3 to high definition with a digital signal is summarised in Table 7.6.

Table 7.6: Backwards and forwards compatibility in the transition to digital high definition

Broadcast format	Display type	Impact on the consumer	Outcome
Standard	Standard		base case
Standard	High definition	Same as for base case (fuzzy compared to a true high-definition image)	–
High definition	Standard	Assuming the STB is capable, then the base-case image is extracted	–
High definition	High definition	Full, sharp (and almost certainly widescreen) image	✓✓

There are no obvious compatibility problems. This is because MPEG-2 (the digital compression algorithm decoded in the STB) uses technology[77] in its coding that allows it to decode the bit stream to any resolution. If there is not sufficient detail coded in the signal for the desired resolution (ie, standard signal and a high-definition receiver—backwards compatibility) then the picture could look grainy. On the other hand, a signal with more lines can be decoded to a standard television format signal by the STB. As a result, the compatibility positions are:

- if the consumer upgrades to an advanced television set that can display more lines than a standard set, but the broadcast signal is of standard resolution, then the image viewed is likely to be as for the base case;
- if the broadcast is high-definition, but the consumer has a standard television, then the image will again be as for the base case.

The new coordinated position is the most attractive outcome, when the consumer owns an appropriate television set, the broadcast is high-definition and the signal is good. In such a situation, the consumer will be able to take full advantage of the extra resolution and detail that high definition allows. From a consumer perspective, there are no obvious degradation effects during the transition period that might deter purchase, but are also only limited benefits that can be achieved from having such an upgraded television unless there is broadcast (or other) content of the appropriate format. Therefore the coordination problem identified in section 7.2.1 may impede the development of high-definition format systems—consumers' net benefit is significantly dependent on the upgrading of the broadcast stream, but broadcasters are reluctant to invest without being relatively confident that there will be sufficient volume of receivers that will be able to benefit from this development.

In addition to the uncertainty for broadcasters as to whether they upgrade the broadcast infrastructure, content suppliers will be cautious about producing content in the high-definition format. A critical mass of content produced in high-definition format available for broadcast would provide incentives for both broadcasters and ultimately consumers to convert. However, as noted in section 7.2, there may be a problem of coordination between content suppliers where some suppliers free-ride on the efforts (and risk-taking) of others. This will reduce the likelihood of a critical mass of content being achieved, and may need some form of intervention in order to produce more output corresponding to high-definition formats.

In the absence of broadcast content using the high-definition formats, complementary products, such as DVDs, may provide a stimulus for the demand for high-definition televisions. Indeed, the conditions may already exist in the market for DVDs to provide a solution to the coordination problems of the transition phase.

[77] 'Spatial Frequency Transform'

DVDs are already viewed on high(er)-definition screens when displayed on PC monitors, so there *are* some immediate advantages to producers or consumers to upgrading, and neither is completely dependent on the actions of the other. The existence of a large installed base of high(er)-definition PC monitors could provide an incentive for manufacturers to produce DVD players with sufficient functionality to exploit the capabilities of these screens. However, the difference is only obvious on large monitors, which are also considerably more expensive. The same form of output from the DVD players could also then be displayed on a high-definition television, providing a relatively cheap method for consumers to access a range of content.

Given sufficient net benefit from high-definition televisions (in particular, total *additional* benefit derived from the format compared with the incremental price), consumers could purchase high-definition sets along with a suitable DVD player, and see an immediate benefit. Once an installed base of high-definition televisions exists, there is (some) motivation for broadcasters to broadcast sufficient information to exploit the capabilities of high-definition TVs, even if broadcasters cannot coordinate among themselves to get to the same position.

7.4 Summary and recommendations

Through application of the supply and demand framework to the supply of display formats in general, the study has identified two central aspects of weakness in the market that may impede consumer take-up of innovative display format televisions:

- consumers perceive a standards risk associated with purchasing a new format television, and so are reluctant to invest; and
- there is uncertainty over consumer demand that reduces the incentives for the supply side (manufacturers and content providers) to adopt the new format(s).

It has further been identified that there are two coordination problems that are central to the interdependency between consumers and producers:

- the requirement for content to be both created and broadcast (or at least available through an alternative delivery mechanism) in the relevant display format; and
- the need for consumers’ receiving equipment to be compatible with the screen standard(s) used by the broadcaster.

In a dynamic environment, these two problems are also interrelated—consumers’ consumption decisions will be driven by the content available as well as the display results that could be achieved from upgrading to the new format. However, the volume of content available is partly dependent on the size of the installed base of televisions of the appropriate format.

Further, the compatibility between the broadcast stream and consumers’ equipment is dependent on the speed with which content providers and broadcasters adopt the new format. In the process of upgrading, however, there may be negative effects on consumers before the transition phase is complete.

The analysis above has also highlighted the importance of non-broadcast content in potentially stimulating take-up of the different display formats. Widescreen, in particular, has benefited from the popularity of DVDs that can be displayed correctly on 16:9 aspect televisions. Take-up of the progressive-scanned format is likely to be increased by the availability of, and access to, Internet content on the television. However, as noted above, it is not clear that this will become consumers' primary means of access to such content.

Despite the current developments in the market, there may still be market failures (for instance, the presence of indirect network effects in content provision) and uncertainties in the provision of innovative display formats that need to be overcome. Section 7.1 highlighted the fact that it was difficult for any agency, including the Commission, to intervene directly in consumer markets such as that for televisions. Therefore, more indirect intervention focused on providing the appropriate incentive structures, and where necessary, addressing market failures, is required.

A range of options for stimulating the development of alternative display formats is detailed below, along with a link to the market problems that they might contribute to overcoming. The options range in their effect on the market and their difficulty to implement. The choice of option(s) to be implemented (if any) will depend on the relevant policy issues and the relative difficulty of each option. This is an issue for the Commission or Member States to determine. Further, it should be noted that no legal analysis has been conducted in relation to the feasibility of these objectives, especially with regard to state aid.

- *Subsidise the cost to consumers of the specific television format*—this lowers the cost to consumers, reducing the risk of investment and increasing the likelihood that the net benefit is positive (and greater than the substitutes);

- *Subsidise the supply side (as for the Widescreen Action Plan) for producing and broadcasting content in the specified format*—this contributes to overcoming the market failure caused by indirect network effects in the supply of content;

- *Subsidise research and development costs for manufacturers*—this may stimulate greater innovation and investment in the specified format. It may also help to reduce the price of the sets, increasing the likelihood that consumers purchase them.

- *Mandate that a certain number of hours are broadcast in the specified format*—this would increase the volume of content available, thus addressing one of the consumer risk factors.

- *Mandate that all television sets conform to a number of formats, including the existing standard*—this may help to solve the transition problem by removing issues of backwards and forwards compatibility, and may reduce the risk for both consumers and content providers.

- *Specify that other content (DVDs, Internet downloads) be available in the specified format*—this could be important if it is believed that demand for non-broadcast content and services will be important in stimulating consumer purchase of a particular format.

- *Specify that STBs have the ability to convert between a variety of formats*—as consumers will need STBs anyway to receive a digital signal, this is potentially a low-cost method of reducing risk for both consumers and suppliers.

- *Encourage broadcasters, other content providers and manufacturers to work together to reduce the effect of coordination problems*—increased information on the benefits of the new formats, and the perception of coordination on the supply side may reduce consumers' risk and increase their valuation of the format(s).

- *Mandate that all digital services must use particular screen format(s)*—innovative display formats are easiest to manipulate, and cause the fewest concerns in relation to bandwidth, when used with a digital signal. This option would also significantly increase consumer confidence on the format(s), reducing their perceived risk.

- *Switch off all analogue signals*—forcing consumers to move to a digital broadcast environment significantly reduces the transition problems for new display formats, and may also cause consumers to upgrade their televisions.

Of note by its absence among the options above is the use of the Internet (and Internet-related content and services). As identified in 7.4.2 above, for the foreseeable future delivery of the Internet over a progressively scanned television does not appear to be a cost effective alternative to personal computers. Progressively scanned displays of a size large enough to be incorporated into a television remain expensive, particularly when compared to the cost of purchasing both a basic computer and television.[78]

[78] In fact, unless the consumer actually *needs* to purchase a new television, the relevant incremental cost is of a computer alone, and this would be available at a considerably cheaper cost currently than a progressive scan television.

8. DAB

Most radio broadcasters consider digital radio as the only route to ensure survival in the long term. They argue that, while audio services will always exist, digitisation of content and the existence of multi-purpose receivers could squeeze out the possibility of having a dedicated radio platform with its own players, services and listeners.[79] In this section, the focus will be on obstacles to digital radio take-off, assuming that digital radio is indeed desirable. Section 8.1 outlines the key findings from the Commission's benchmarking exercise. Section 8.2 examines the current state of the market for digital radio in Europe. Section 8.3 identifies the major obstacles to the successful take-up of digital radio, and section 8.4 offers some recommendations for overcoming the obstacles.

8.1 The Commission's benchmarking study

The European Commission is only indirectly involved in forming a European policy on digital radio via the Digital Broadcasting Expert Group (DBEG). The reason for this delegation is that the legal competence for radio broadcasting is essentially national, not European. DBEG is thus merely a forum for discussion. In the discussions of DBEG, national delegations have so far expressed their concerns about the successful take-up of digital radio, and DBEG agreed that a comparative overview of the situation in the Member States would be useful. Digital radio was the subject of various DBEG documents[80] and was discussed at DBEG meetings during 2001 and the beginning of 2002. The following three-step strategy for DBEG work on digital radio was agreed by DBEG at its meeting on January 31st 2002:

a) gather information and identify issues relevant for a more successful take-up of digital radio;
b) focus on issues under the responsibility of public authorities—ie, regulatory framework, licensing and political strategies on the subject. Compare differences in national approaches and draw the European picture;
c) identify best practice regarding the relevant issues identified under a) and possibly propose recommendations.

The benchmarking study is relying on a questionnaire focusing on three main areas: regulatory framework; licensing; and political strategy/encouragement measures. 15 Member States replied to the questionnaire and the broad conclusions are as follows.

The benchmarking study identified three groups of countries depending on the type of legal framework in place. A first group, which has specific regulation on digital radio; a

[79] Digital radio is not necessarily limited to terrestrial DAB broadcasting. It is also possible to use its satellite version (S-DAB). Other technologies are also in the process of being developed, such as web radio and mobile networks (UMTS). This raises the question of profitability of the traditional business model of radio, but it may also be considered as an opportunity to introduce new models and new revenues.
[80] ONP-DBEG 01–07, 15, 15rev, 16, 27, 27rev and 02–12, 13.

second group, which has digital radio covered by general media/communications regulation; and a third group, which has no legislation on digital radio at present. Table 8.1 categorises the Member States into the three groups.

Table 8.1: Legislative measures on digital radio

No specific legislation[1]	Specific legislation[1]	Foreseen specific legislation[1]
France	Sweden	Belgium (Flanders–additional)
Austria	Spain	Austria
Ireland	Portugal	Luxembourg
Norway	Italy	
Finland	UK	
Netherlands	Belgium (Flanders)	
Luxembourg	Denmark	
	Germany	

Note: [1]The columns show the countries where there is or is not current no legislation, and those countries where legislation is anticipated. In Belgium *further* legislation is expected in Flanders.
Source: European Commission, DG Information Society, ONP-DBEG 02-13.

With respect to the licensing process, there is also much variation across the Member States. A specific licensing regime is only in place in the UK, Spain and Portugal, and is foreseen in Italy. Moreover, the lengths of licences and their characteristics vary greatly. Overall, the benchmarking study has thus revealed that only about half of the Member States have already established specific regulatory and licensing regimes.

Finally, the benchmarking study revealed that there are no existing or foreseen public promotion schemes, subsidies or other support measures in most countries. Denmark, the UK and Spain expressed that they consider the successful take-up of digital radio to be a market-led process. However, most countries noted that they would welcome a coordinated action at EU level. Only Portugal was in favour of industrial policy to implement a mass-market production of digital radio receivers.

8.2 Current state of the market

Digital radio technology is operational and has been commercially available since 1995. Contrary to DTV, a standard has emerged within digital radio. DAB (the commercial name for the digital radio standard developed under the Eureka 147 project)[81] is now a recognised world standard, operational or in development in over 40 countries worldwide. Over 285m people around the world can now receive more than 550 different DAB services. The DAB standard is a reference for digital terrestrial radio in Europe, Canada and some countries in Asia. USA is the only major market to follow a different track.

[81] Eureka 147 is a consortium of partners from the broadcasting and consumer electronics industries. DAB is recognised as a standard by ETSI, see http://www.etsi.org

Overall, the roll-out of DAB in Europe is much slower than expected. The following three sub-sections look at the current coverage, the supply of DAB receivers and broadcasting services, and the estimated market potential. It was an intention of the Commission's benchmarking study to gather information on market aspects. However, the available information is largely incomplete and difficult to compare across countries. Therefore, the following sections rely largely on data from WorldDab Forum.[82]

8.2.1 Coverage

Commercial licences have been granted in many European countries, but DAB technical coverage is still quite heterogeneous: from 19% in Austria to 98% in Belgium. Table 8.2 shows the current coverage and targets set for the 15 countries in the EU.

Table 8.2: Current coverage and targets for coverage

	Population (million)	Current coverage (%)	Target coverage
Austria	8.1	19	
Belgium	10.8	98	100% by 2002
Denmark	5.5	65	80% by 2002
Finland	5.1	40	
France	60.4	25	
Germany	82.0	65	90% by 2003
Greece	10.5	n.a.	
Ireland[1]	3.7	0	
Italy	57.5	30	60% by 2004
Luxemburg	0.4	n.a.	
Netherlands	16.0	45	100% by 2003
Portugal	10.8	70	100% by 2004
Spain	9.9	50	80% by 2004
Sweden	8.8	85	100% by 2004
UK	58.7	80	85% by 2003

Note: [1] A network is in place, but RTE has stopped its services as it awaits the production of low-cost receivers.
Source: www.worlddab.org.

It is important to note that technical coverage does not imply that actual digital broadcasts have begun. Moreover, even when digital broadcasting is effective (as, for example, in the UK), the audience may still be negligible. Coverage is thus merely a first step in reaching actual penetration of digital radio. The second step is a viable supply of digital broadcasting services and receivers, and the final step is consumers buying DAB receivers.

[82] WorldDAB Forum is an international non-governmental organisation whose objective is to promote, harmonise and coordinate the implementation of digital radio services based on the Eureka 147 DAB system.

8.2.2 Supply of DAB receivers and broadcasting services

No accurate figures are available on the sales of DAB receivers, although an estimated 200,000 such radios have been sold in Europe, either as car-radios, home receivers or PC cards.[83] Penetration of digital radio is thus very low at the moment.

A selection of DAB receivers has been available to consumers since 1999, when manufacturers, Arcam and Cymbol, brought the first DAB digital radio tuners onto the market. These two manufacturers have since been joined by a number of other manufacturers, and DAB tuners are available in models for the home, the car and as PC cards.[84] Table 8.3 provides the complete list of manufacturers that are currently marketing DAB tuners, with retail prices (in €) shown in parenthesis.

Table 8.3: Manufacturers of DAB receivers (prices in €), August 2002

Hi-fi system	Portable	Car radio	PC card
Arcam (1040, 1585)	PURE (160, 800)	Blaupunkt (560)	Terratec (810)
Cymbol (1585)		Clarion (765)	Modular Technology (150)
Sony (970)		Grundig (480)	
Acoustic Solutions (205)		JVC (940)	
Kiiro (560)		Kenwood (730)	
Terratec (810)		Panasonic (800)	
PURE (400, 525, 599)		Pioneer (480, 1400)	
TAGMcLaren (3600, 3675)		Siemens (970)	
Technics (800)			

Source: www.worlddab.org.

Table 8.3 shows that there are a significant number of manufacturers in the market. Nine manufacturers are currently selling DAB hi-fi systems, eight manufacturers are selling DAB car radios, and two manufacturers serve the niche market for DAB PC cards. Only the market for portable DAB receivers is currently lacking horizontal depth. Table 8.3 also shows the retail prices of the available DAB receivers. Prices of DAB hi-fi receivers range from €205 to €3,675 and prices of DAB car receivers range from €480 to €1,400.

It is difficult to compare prices of DAB receivers with prices of analogue receivers as product specifications vary greatly. Some DAB receivers are also able to receive analogue signals, for example. Moreover, not all digital radios are available in all European countries, so the supply of DAB receivers listed in Table 8.3 is not available to any single consumer. From the perspective of consumers, the relevant market information is the relative prices of DAB and analogue receivers available in a given market. Table 8.4 illustrates price levels of available analogue and DAB hi-fi tuners in the UK market.

[83] *Source*: European Association of Consumer Electronics Manufacturers.

[84] DAB home radios currently on the market are separates that plug into existing hi-fi systems or are stand-alone. While some manufacturers have developed DAB-only tuners, others have developed combined DAB/FM/AM units.

Table 8.4: Price comparison of analogue and DAB hi-fi tuners (€)

	Analogue hi-fi tuners (40)	DAB hi-fi tuners (8)	Price ratio, DAB:analogue
Cheapest	115	395	3.43
Second cheapest	133	411	3.09
Third cheapest	140	427	3.05
…			
Third most expensive	442	553	1.25
Second most expensive	632	679	1.07
Most expensive	785	743	0.95

Source: www.pricerunner.com

Two observations can be made from Table 8.4. First, the range of analogue hi-fi tuners available is five times greater than that for DAB tuners. Forty analogue tuners are available, while only eight digital hi-fi tuners are available. Second, low-cost DAB tuners cost three times more than low-cost analogue receivers. This is likely to be an important explanation of the slow take-up of digital radio. The current supply of DAB receivers forces consumers to make a significant investment in a newly introduced product with no proven track record. A recent special promotion in the UK market offering a portable DAB receiver for £99 was almost immediately sold out, proving that demand exists for low-cost receivers.

Most digital stations are simulcasts of existing analogue services, but unique digital radio stations do exist. Table 8.5 summarises the supply of digital broadcasting services in the major European countries.

Table 8.5: Supply of broadcasting services

	Maximum number of digital stations in a region	Digital-only channels
Austria	4	n.a.
Belgium	8	2
Denmark	7	n.a.
Finland	8	n.a.
France	24	1
Germany	12	n.a.
Italy	7	0
Portugal	5	n.a.
Spain	18	n.a.
Sweden	7	n.a.
UK	52	n.a.

Note: n.a. means that no information is available on the number of digital-only channels.
Source: www.worlddab.org.

Table 8.5 reveals that digital radio stations are currently broadcasting in several European countries. However, the number of stations that broadcast unique digital content is relatively low. The value-added of digital radio, with regard to actual content, is thus limited as the majority of stations are also available as analogue services.

Many digital stations only broadcast in a region of the country, typically in major cities. Table 8.5 shows the supply of broadcasting services in the region with most services available. While the total number of stations in a country may be large, the number of stations available in a given region is not necessarily large.

Overall, this section has showed that, while a horizontal market for DAB receivers exists in Europe, prices of DAB receivers remain high relative to analogue receivers, and the majority of digital stations also broadcast analogue signals, as is discussed above. The incentive to invest in DAB receivers is thus limited at the moment.

8.2.3 Market potential

WorldDAB Forum has conducted a pan-European market potential study[85] across six of the countries that have been most active in developing DAB (France, Germany, Italy, Netherlands, Sweden and the UK). Of the 88m (non-pensioner) households in these countries, an immediate market potential of 33m households was identified as early adopters for DAB. Table 8.6 summarises the survey.

Table 8.6: Households interested in DAB

	Number of households (m)	%
Number of households	88	100
'Very interested' in acquiring DAB for car or home	33	37
'Very interested' in acquiring DAB for car	18	21
'Very interested' in acquiring DAB for home	25	28

Source: www.worlddab.org.

Table 8.6 shows that the immediate market potential for digital radio in Europe is 37% of all households. This indicates a substantial potential group of early adopters for this technology. Of all the households interested in buying a DAB receiver, different reasons were given for this interest. In general, audio enhancement was the main reason for acquiring a DAB receiver. Table 8.7 shows the results.

Table 8.7: Reason for acquiring DAB

	Car (% of all car drivers)	Home (% of all households)
Audio enhancement	29	21
Audio-related features	19	13
Screen-based information	10	7
One or more of these features	35	28

Source: www.worlddab.org.

85 WorldDab (1997), 'The Market Potential for Digital Audio Broadcasting (DAB)', July.

It is thus the audio-enhancement features of DAB that attract the most interest at present (eg, interference-free reception, CD-quality sound, and, for cars, no retuning while driving).

The survey also asked those 'very interested' in DAB about their willingness to pay for different features. Consumers are willing to pay most for screen-based information, including, for example, news headlines and weather forecast. Audio enhancement is, for example, interference-free reception, CD-quality sound and no need to retune while driving, whereas audio-related features are, for instance, displaying the title or artist being played. However, these results show that, even among the most interested consumers, the willingness to pay for digital radio is at most 55% higher than the price of analogue radios. This is reported in Table 8.8.

Table 8.8: Willingness to pay for digital radio receivers (%)

	Car	Home
Audio enhancement	+30	+35
Audio-related features	+40	+45
Screen-based information	+50	+55

Source: www.worlddab.org.

8.3 Obstacles to consumer take-up of digital radio

Given this background, the development of DAB can be analysed using the same approach as that outlined in the previous sections. From this, a number of key obstacles to digital radio penetration can be identified. While some obstacles may be harder to overcome than those for digital TV, other features specific to the digital radio market could facilitate take-off of the market.

As already noted, the demand and supply framework of thought is relevant for analysing the likely success of any new product market. Section 7 outlined in detailed that, in broadcasting, the additional problem that demand for a receiver is actually a derived demand for access to the underlying content, means there is a potential coordination problem between content and hardware providers. This problem was characterised as having two elements—free-riding and stand-off. Both lead to reduced entry incentives on the supply-side, which then delays consumer purchases, even of existing services. In addition to these difficulties in establishing the new service, there may be problems arising from the transition from one combination of content and receiver to a new one, although, in digital radio, the issues of re-authoring and content compatibility with receiver type do not arise.

The preceding sub-sections have identified seven key characteristics of the market for digital radio that can be interpreted in the above analytical framework to explain why ensuring successful take-off of digital radio has proved to be difficult.

- There is a Europe-wide recognised standard, DAB.
- Technical coverage of DAB is above 50% in several countries.

- There is a supply of DAB broadcasting services, although most services are also available as analogue services.

- A horizontal market for DAB receivers does exist.

- The current market potential of digital radio services has been estimated at 33 million households in Europe.

- DAB receivers remain expensive relative to analogue receivers. Few low-price DAB receivers are currently available on the market and prices of low-cost DAB receivers are three times as high as low-cost analogue receivers.

- Consumers' additional willingness to pay for digital services is in the range of 30-55%.

Despite the established standards and the existence of a number of manufacturers of the product, take-up has been limited. The demand framework gives insight into why this is the case. Consumers will only purchase a digital radio receiver if they gain a sufficient benefit from that purchase decision. That is, the net benefit from a purchase is positive and greater than the net benefit from the alternatives. At the moment, DAB receivers do not meet these requirements. The benefits are restricted to some additional features and some improvement in sound quality; however there is little true differentiation of content. Coverage is also restricted, so a consumer will not be certain that they will get uniform service, if on the move. Low cost DAB receivers are approximately three times as expensive as low cost analogue receivers. This exceeds the willingness to pay of even those consumers most interested in the additional features of digital radio, who consider a premium of 35%-55% appropriate for the additional functions that arise from a digital radio receiver. Without better differentiation of services, consumers are not willing to pay significantly more for the receiver. Looking forward, consumers still see considerable uncertainty over the future of digital radio. Coverage is still poor in many countries and there is no evidence of new applications exclusively designed for the digital platform. Thus consumers see benefits from delaying purchase decisions until there is a clearer view of market developments.

From the supply-side, there is already a reasonably well-established horizontal market in DAB tuners, except for portable models. Price is expected to fall if the market grows, although the extent to which there are economies of scale to be exploited is not clear. The difficulties arise because of the coordination problems between content providers, broadcasters and manufacturers.

There is little incentive for the supply of innovative complementary services across the digital radio platform. The additional functionality does not, as yet, dramatically change the radio experience. The ability for content providers to invest in innovative radio products is hampered by the lack of ability to charge for the specific service provided. Given the likely low audience at present because of poor penetration, it will also be difficult to attract advertising revenue. Hence the business case for investing in these services is poor.

In other markets, service providers might subsidise initial receiver purchases to ensure a sufficient installed base is developed to underpin complementary products; however, given radio is exclusively FTA, there is no business model for providing subsidies. As discussed in section 2, this form of risk-sharing can be an important way of assisting a new technology market to develop; however it requires an ongoing commercial relationship for the product supplied over the device to offset the up-front subsidy.

There are also problems through transition, since digital radio will replace analogue radio. The key element of this transition problem is the coordination problem between content and equipment since a digital radio signal can only be received on digital receiver equipment. Thus a dual function receiver requires two tuners and broadcasters must consider simulcasting while there remains a considerable proportion of analogue-only listeners. This simulcasting is costly in terms of bandwidth, and is difficult to insert in existing radio-bands. As a consequence, it may require allocating new bands or the release of existing radio bands (termination of some analogue radio services). Table 8.9 illustrates this transition difficulty.

Table 8.9: Transition to DAB

Broadcast format	**Receiver type**	
	analogue	**digital**
analogue	Starting position (base case)	No service
digital	No service	Somewhat better now with potential to improve

With this structure of transition incentives, with high costs from incompatibility, both receiver manufacturers and broadcasters are likely to be reluctant to move to digital-only services. Content providers then also see limited benefits from investing in digital-only content. The driving force to encourage greater penetration will be that consumers see the benefits from the new format and upgrade themselves. Given that transition incentives limit the differentiation of the new digital services and that there is only limited willingness to pay for service differences perceived to be small, consumers are also reluctant to change.

Without the possibility of up-front subsidies to bring the upgrade costs into line with consumers' willingness to pay at this early stage of development, a critical mass of listeners cannot be established. If such a critical mass existed, the stand-off problem would be reduced for content providers, the differentiation between analogue and digital services would increase, and more consumers would consider the upgrade worthwhile. Thus, the indirect network externalities are working against the effective establishment of a viable DAB service market.

8.4 Recommendations

Based on the preceding discussion, policy recommendations for improved digital radio take-up can be categorised as either reducing the cost of the equipment to bring it within the range of interest of the early adopters, or improving the available content to expand the base of listeners who would be interested in upgrading to digital radio. It should be noted that no legal analysis has been conducted in relation to the feasibility of these objectives, especially with regard to state aid.

Reducing the cost of DAB receivers

- One option is to subsidise directly consumer purchases of DAB receivers. This subsidy would have to be financed through taxation, as there is no ongoing commercial relationship between manufacturers and consumers to sustain a subsidy otherwise.

- A second option is to encourage car manufacturers to include DAB tuners in new cars. Since the price of a car radio is small compared with the full price of the car, consumer price sensitivity will be lower. By increasing consumer understanding of the benefits of digital tuners through experience in new cars, this may directly increase penetration of other digital tuners. A similar pattern of take-up was observed in RDS, now a relatively standard feature of most radio tuners. If economies of scale are substantial, take-off of DAB in car radios could spill over to decrease the price of other tuners as well.

Improving DAB content

- One option is to subsidise digital-only channels. This would increase the relative benefit of owning a DAB receiver compared to analogue receivers. If content on analogue and digital platforms are more or less identical as now, consumers are not likely to buy the more expensive receiver, DAB. There is some willingness to pay for digital radio, and if unique content become available, this willingness to pay may increase further.

- Some existing pay-TV operators offer digital radio over their platforms (eg, ntl and Sky). Further support for this activity would ensure an immediate audience for any new digital radio content, facilitating investment in services. Through increasing general consumer awareness of the potential for digital radio, this could help overcome the current problem of attaining a critical mass of audience and service providers.

A final option is to subsidise geographical coverage. This would ensure more reliable services from the point of view of consumers. At present, consumers cannot be sure that a wide selection of digital channels is available in their area. Consequently, DAB may be viewed as an inferior service relative to analogue radio, which has full coverage.

The Commission's own benchmarking study did also contain some recommendations facilitate the transition from analogue radio to digital radio. In particular it was noted that EU-wide coordination on the implementation of regulatory regimes at the national level would help reduce the current uncertainty in the market. A clear and stable regulation and licensing regime for digital radio could help the involved parties to develop viable business models with credible prospects of return on investment. Compared to the subsidies suggested above, this option is relatively cheap.

Glossary of Terms and Terminology

16:9	see ‘widescreen’
ABA	Australian Broadcasting Authority
ABC	Australian Broadcasting Corporation, in the Australian context
ABC	American Broadcasting Corporation, in the American context
ACA	Australian Communications Authority
ACATS	Advisory Committee on Advanced Television Service
ACTE	Association des Télévisions Commerciales Européennes (association of commercial European broadcasters)
ADSL	asynchronous digital subscriber line: software technology allowing broadband communication on traditional telephone copper lines in the local loop. While ADSL already delivers mainly high-speed Internet, other xDSL technologies can compete with digital cable to deliver VoD
AFC	Australian Film Commission
API	applications programming interface
ARD	German PSB
ARPU	average revenue per user (or subscribing home). Used with reference to pay-TV
ASP	application service provider
ATSC	Advanced Television Systems Committee. US body responsible for overseeing the digital HDTV standards
ATV	advanced television
BBC	UK PSB
BIOS	basic instruction operating service
box	see ‘STB’
BREMA	British Radio & Electric Equipment Manufacturers Association; trade association of consumer electronics manufacturers
BSkyB	British Sky Broadcasting: operator of various bouquets of digital pay-TV services, based in the UK
BTBS	British Telecom Broadcast Services
CA	conditional access (see ‘CAS’)
cable countries	countries in which cable reception is today the predominant television delivery mechanism. Germany, Belgium, Luxembourg and the Netherlands fall into this category
CAS	conditional access system: a system that comprises a combination of scrambling and encryption to prevent unauthorised reception
CATV	community-antenna television
CBS	Columbia Broadcasting System
CDMA	coded division multiple access
CE	consumer electronics (ie, the goods)
CEA	Consumer Electronics Association
CI	common interface (see entry below)
closed standard	the term ‘closed’ is used to denote a standard that is not freely available to third parties
CSA	common scrambling algorithm
COFDM	coded orthogonal frequency-division multiplex: the modulation system for the digital terrestrial broadcasting transmission system specified by the Digital Video Broadcasting project
common interface	connection for plug-in computer card into the digital receiver, designed to carry the conditional access subsystem. Part of the multicrypt approach to CA
consumer equipment	see ‘decoder’
CRT	cathode ray tube
CP/M	control program for microcomputers
CPS	cable programming service
CPU	central processing unit
D2-MAC	analogue TV broadcasting system used for services from DTH satellites in accordance with Article 2 of Directive 95/47/EC

DAB	digital audio broadcasting
DBS	direct broadcast satellite
DCITA	Department of Communications, Information Technology and the Arts (Australia)
decoder	see ‘STB’
DigiTAG	Digital Terrestrial Action Group
Digital	refers to all binary encoded information. Once encoded, the information can be compressed and transmitted on a variety of networks to a variety of terminals
digital divide	the division that exists between those who have access to digital networks and those who do not
D-ILA	digital image light amplifier
Directive 95/47	Directive of the EU to establish a regulatory regime adapted to the start-up phase of DTV services, while also providing adequate continuity with the earlier regulatory environment for advanced television services based on analogue technology
DLP	digital light processing
DRAM	dynamic random access memory
DRM	digital rights management
DTG	Digital Television Group
DTH	direct-to-home. Refers to direct satellite reception with individual dishes (as distinct from cable TV (in which head-ends are fed by satellite transmission), or SMATV, which is direct satellite reception but with a collective dish
DTP	desk-top publishing
DTT	digital terrestrial television
DTV	digital television
durable good	consumer good, such as a car or washing machine, which yields services or utility over time
DVB	Digital Video Broadcasting. The group behind the development of many digital standards (DVB-T, DVB-S, DVB-C, DVB-J)
DVB-RC	DVB return channel for interactive services on cable networks and LMDS
DVB-T	Digital Video Broadcasting—the DTT standard
DVD	digital versatile disc—ie, multimedia storage system
EBU-UER	European Broadcasting Union/Union Européenne de Radiodiffusion (Association of European PSBs)
ECCA	European Cable Communications Association
ECM	entitlement control message
economies of scale	factors that cause the average cost of producing a good to fall as output rises. For example, when output can be doubled with a less than commensurate increase in costs
economies of scope	factors that make it cheaper to produce a range of related products than to produce any of the individual products on its own
EMM	entitlement management message
EPG	electronic programme guide: interactive on-screen display of broadcast information about available services
ETSI	European Telecommunications Standardisation Institute
experience good	a good whose value and attributes are only discernible on experiencing it
externality	consequences for welfare or costs not fully taken into account in the pricing mechanism. Pollution is an example of a negative externality because its effects are rarely treated as a cost to the polluter; similarly, those affected are rarely compensated
FCC	Federal Communications Commission: national regulatory authority in the USA
free-rider problem	this arises when a firm is unable to inhibit rivals from taking advantage of its investment in a product or service. As the rivals cannot be compelled to contribute towards the investment cost, they have an incentive not to do so, and to free-ride on the investment by the original firm. Frequently, the outcome of such a situation is that none of the firms engages in the required investment
FRND/FRAND	fair, reasonable and non-discriminatory
FTA	free-to-air television: television services for which access is not based on a subscription. Includes all television that constitutes a basic package of programmes for which the consumer does not *in general* make a conscious purchase decision. Also includes all television financed by a licence fee and all PSB transmissions. Can be broadcast on any platform type

FTV	free-to-view television: encrypted FTA (for copyright reasons). A smartcard is needed for conditional access
GE	General Electric
GSM	global system for mobile communication: the network compatibility standard for second-generation (2G) digital cellular communications
GUI	graphical user interface
HBO	Home Box Office
HDTV	high-definition television
head-end	central distribution point for a cable network, where programmes are received from satellite and VOD films storage
horizontal markets	see section 1.2.1
HSD	home satellite dishes
HTML	hypertext mark-up language: a text description language that is used for electronic publishing, especially on the World Wide Web
ICT	information and communication technology
IDATE	audio-visual consultants, based in France
iDTV	integrated digital TV receiver—ie, with a built-in digital tuner, and either a built-in CAS or a CI slot
IETF	Internet Engineering Task Force
Information Society	refers to a widespread citizen access to information technologies (Internet, mobile telecommunications, DTV, etc), which would trigger dramatic changes in the society (access to information and learning, electronic democracy) and in the economy
interoperability	see section 1.2.2
IP	Internet protocol
IPR	intellectual property rights
IRD	integrated receiver-decoder: see ‘STB’
ISP/IAP	Internet service provider, Internet access provider
LCD	liquid crystal display
LCoS	liquid crystal on silicon
LMDS	local to multipoint distribution system
MAC	multiplexed analogue components: a family of transmission standards for DBS and cable
market failure	a situation in which economic efficiency has not been achieved due to imperfections in the market mechanism. Resources are therefore distributed appropriately. Sources of market failures are asymmetries of information between market participants, market power and externalities
MHEG	Multimedia & Hypermedia Experts Group
MHP	multimedia home platform: a DVB standard for middleware, based on a Java virtual machine
middleware	non-operating system software that exposes APIs to applications developers. In the context of digital broadcasting, API and middleware are generally used interchangeably
migration	in the context of APIs, migration refers to the process of moving from a legacy API to a situation where that legacy API is no longer in use
MMDS	multi-channel multipoint distribution system (refers to wireless cable television)
modem	modulator/demodulator. A device that transforms a typical two-level computer signal into a form suitable for transmission over a telephone line. It also functions in the reverse direction—transforms an encoded signal on a telephone line into a two-level computer signal
MPEG	Moving Picture Expert Group. This group defines standards, such as the MPEG-2 standard that is used for compression in DTV and incorporated into DVB standards
MS-DOS	Microsoft disk operating system
MSO	multiple systems operator. A cable operator running several local networks (as opposed to local operators of local networks). All major cable operators are MSOs
multicrypt	part of the two approaches to conditional access allowed for in Directive 95/47. Multicrypt is an open system which makes use of the common interface to allow competing CA systems, subject only to the requirement that the service provider

	must transmit entitlement messages for each CA provider
multiplex	a UHF channel that is used to carry digital signals. By means of compression, several services can be carried in the same channel
MVPD	multi-channel video programming distributors
NBC	National Broadcasting Corporation
network externalities	these arise when the value of a service increases with the number of users. For instance, a mobile telephony service is of little value when there are few subscribers
non-proprietary standard	a standard that is not ‘owned’ by a private body, but has been set through the consensus of a representative body
non-subscription television	see FTA
NRA	national regulatory authority
NTSC	National Television System Committee (US analogue television standard or the organisation that developed this standard, currently in use in the USA, Canada, and Japan)
NVOD	near video on demand: impulse PPV with higher flexibility (eg, a new screening session starting every 20 minutes)
OCAP	OpenCable application platform
OEM	original equipment manufacturer
open standard	a standard that is available to third parties either free of charge or on an FRND basis, regardless of ownership
operating system	computing software that controls the allocation and use of the main computer hardware resources, and supports the functions of applications software programs
operator	usually refers to the operator of some kind of pay-network, be it television or mobile telephony
packet-switched transmission	method of transmission of digital information in small packets which are then reassembled at the destination. This method allows a safer transmission and a much more efficient use of the network’s bandwidth than the traditional method, especially for point-to-point communications
PAL	phase alternate lines: one of two analogue colour-TV transmission standards in Europe (the other being SECAM)
PALplus	analogue widescreen transmission standard, an extended version of PAL, with sharper pictures and better quality sound
pay-TV platform	package of TV channels and other services available on a subscription basis
pay-TV	television consumption that the consumer has made a conscious decision to subscribe to and pay for, above and beyond the basic services available to everyone for a minimum fee
PBS	public broadcasting system
PC	personal computer
PC	Productivity Commission (Australia)
PCMCIA	personal computer memory card international association: specifications of compact interface used for example to enable peripherals to be connected to portable PCs. Used in the common interface
POD	point-of-deployment modules
platform	used to denote the *communications* platform—cable, satellite, terrestrial, ADSL, etc
PPV	pay-per-view service
proprietary standard	used to denote private ownership of a standard. Such a standard may be open or closed
PSB	public service broadcaster
PSTN	public switched telephone network
public good	a public good is a good that would typically be undersupplied by the private sector since the benefits are hard to appropriate exclusively. Some form of public-sector involvement is usually the solution. A classic example of a public good is national defence spending
PVR	personal video recorder
RCA	Radio Corporation of America
re-authoring	changing an application that has been developed for one middleware to make it function with a different middleware
receiver	generally refers to the television receiver, unless preceded by ‘digital’, in which

	case, see 'STB'
ROM	read-only memory
SBS	special broadcasting service
SECAM	sequential colour and memory: one of two analogue colour-TV standards in Europe (the other being PAL)
SI	service information: machine-readable details of available services to update the EPG or other navigator
simulcrypt	simultaneous transmission of one programme with the conditional access messages corresponding to several different CAS
smartcard	card needed in some STBs to complete the decryption of the broadcast stream
SMATV	satellite master antenna television system
SMS	subscriber management systems
STB	set-top box: consumer hardware necessary for the consumption of broadcast digital services. It contains the necessary software and conditional access. With respect to an analogue television, the decoder will be housed externally to the television set, most likely in an STB or PVR. With respect to an iDTV, the decoder is integrated into the television set. Also known as 'integrated receiver-decoder' or 'box'
stranded asset	an asset that is no longer supported or upgraded
subscription television	see 'pay-TV'
switch-off	termination of analogue transmission
switchover	the gradual replacement of analogue transmission and reception by digital transmission and reception
TCP/IP	transmission control protocol/Internet protocol—the Internet protocol suite
transcontrol	transfer of control from one CAS to another, notably where CATV operators take over control of pay-TV services relayed by satellites from pay-TV operators
UIB	united independent broadcasters
UCSD	University of California at San Diego
VoD	video-on-demand service—interactive video delivery
widescreen	television programming that has an aspect ratio of 16:9 (width to height), compared with the traditional ratio of 4:3. The term can also be applied to television sets with the same meaning, but referring to the screen size
WYSIWYG	what you see is what you get
X-DSL	X-digital subscriber line: generic name for broadband systems which carry digital signals, including television signals over the PSTN