EBU

OPERATING EUROVISION AND EURORADIO

TR 026

ASSESSMENT OF AVAILABLE OPTIONS FOR THE DISTRIBUTION OF BROADCAST SERVICES

TECHNICAL REPORT

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Summary

Broadcasters are producing a wide range of content and services not only as traditional linear radio and TV but also as time-shifted, on-demand, hybrid content and data services. The audience has at its disposal an increasing range of devices. Home TV receivers are now larger and more capable which in turn feeds user expectations for increased picture quality. Personal computers, smartphones and tablets are increasingly used to access media services. These devices are used either as a second screen to supplement the main TV set, a secondary receiver or even as the main media device, in particular when out of the home.

The audience thus enjoys a wide choice of content and services (both linear and on-demand) that is increasingly available at any time and at any location. Broadcasters naturally seek to deliver the whole range of content and services to all interested users on a device of their choice and in their preferred environment. That requires using a number of different means of distribution, including traditional broadcasting platforms, such as terrestrial, cable and satellite, as well as broadband networks, both fixed and mobile.

This study aims at assessing the distribution options available to broadcasters at present and identifying what distribution means may be required in the future. It was assumed that broadcast content encompasses the entire range of content that broadcasters offer to the audience irrespective of the technical platform across which it is distributed. A broadcast service is an edited selection of broadcast content.

Furthermore, in order to address the current and anticipated future audience behaviour, a concept of use cases was developed. A use case is defined as a combination of a broadcast service, a user environment in which the service is used, and a user device.

Two distinct user environments were considered: a permanent one where a user spends considerable amount of time in the same place and where the vast majority of media use takes place (e.g. home or office), and a transient one (e.g. public place or when travelling) which is becoming increasingly important for media use, in particular on portable devices.

A set of representative types of user devices has been identified without considering their respective functionality and features in any greater detail. Instead, these device categories reflect how services are consumed by the viewers and listeners and not necessarily the technical means of their delivery.

Individual use cases were evaluated in terms of their relevance to broadcasters. In reality, different use cases coexist and are strongly influenced by their context. The following assumptions are made:

- Linear viewing is the primary way of watching TV content and there is currently no indication that this will change in the foreseeable future.
- Time-shifted and on-demand viewing will continue to grow, but this will not significantly erode the overall amount of linear viewing.
- Migration of TV services from SDTV to HDTV will continue. More content will be offered as well, in particular with the introduction of new HDTV services.
- Ultra-HDTV will be introduced and may become the mainstream format in the medium to long-term future on all TV platforms.
- Portable and mobile devices are increasingly used to access media services. Nevertheless, most of the TV viewing will remain on the large screen.
- Majority of the TV viewing, both linear and nonlinear, will continue to occur in the home. Usage in transient environments will become increasingly significant.
- Innovative media services embrace active audience participation in particular through social networks such as Facebook, Twitter, etc.
- Hybrid broadcast-broadband services are becoming commonplace based on broadcast platforms and fixed broadband infrastructure. In the future they may also make use of wireless broadband.

Not all identified use cases are equally relevant from a broadcaster's perspective. The relevance is determined taking into account the current situation as well as the short to mid-term future (e.g. next 5 - 10 years). For instance, a use case is considered highly relevant if it is currently important or if foreseen to

become important in the future. Elements to be considered may include the size of audience, availability of suitable devices or the programme offer.

Once a relevant use case has been identified the question is by which distribution options this use case can be enabled. For the purpose of analysis of distribution options only the highly relevant use cases have been considered. A *distribution option* refers to any technical possibility available to a broadcaster to distribute its services to the audience. This report dealt with terrestrial, satellite, cable, fixed broadband and mobile broadband as distribution options.

For every use case a set of requirements has been defined that need to be fulfilled by a viable distribution option. The requirements are service focused, i.e. defined in such a way as to ensure desired availability and quality of service. Two types of requirements have been defined:

- general requirements which are common to all use cases, and
- specific requirements for each use case

The distribution options are assessed in terms of their ability to satisfy the requirements. The following are the main conclusions:

- The use cases that include linear services are sufficiently well served by broadcast networks except those that target portable devices such as tablets and smartphones.
- Broadband networks are not suitable to enable use cases containing linear TV services because they typically provide only best-effort quality and are, in general, not able to serve large concurrent audiences. This limitation is more pronounced on mobile networks than on fixed.
- The use cases that include on-demand services are only enabled by broadband networks as they provide the required return channel which is not available on broadcast networks.
- A number of use cases are enabled by more than one distribution option.
- No single distribution option can enable all relevant use cases. Therefore, in order to enable the whole range of relevant use cases multiple distribution options need to be employed in a complementary manner.
- Some distribution options may be able to support multiple use cases simultaneously. For example, broadband networks can be used to watch linear TV and access on-demand services at the same time. However, broadband networks may not be able to serve peak demands of all supported use cases simultaneously, even though they may in principle satisfy them individually at different times.
- Some use cases have been identified that are considered highly relevant but cannot be fully enabled by any of the currently available distribution options. For these cases further technical and market developments are necessary.

The abovementioned analysis focuses on individual use cases. However, it is important to recognize that individual use cases taken in isolation do not cover all situations that occur in reality. Combination of use cases, i.e. simultaneous use of different devices and services or consecutive use over time and space, sometimes even including a switch of device, are becoming increasingly important. This kind of user behaviour is described by the term 'usage pattern'.

Only a brief analysis of usage patterns was performed. It revealed that most usage patterns can’t be enabled by a single distribution option. Combination or even cooperation of different options would be required.

Furthermore, this study touched upon some of the ongoing technical developments, noting that all distribution options are evolving and may in the future overcome some of their current limitations. However, it remains to be seen which of the proposed innovative technical solutions will be successful on the market.

The results of the analysis clearly indicate that there will be no ‘one-fits-all’ solution.

The methodology applied in this study can also be used by broadcasters to identify and assess the available distribution options taking into account their own specific circumstances.

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Assessment of Available Options for the Distribution of Broadcast Services

1. Introduction

Broadcasting is subject to profound technological transitions, innovation in service offering, shift in user habits and expectations, changing regulatory environments, and the competitive pressure from on-line media. Viability of terrestrial broadcasting is challenged by the reduction of the amount of available radio spectrum and the prospect of alternative infrastructure for wireless delivery that may exist in the future.

At the same time, the significant development of the Internet and the associated IP connectivity of people have a great impact on the society and businesses alike. The foundations of broadcasting seem to be shaken by this digital revolution. One response by the broadcasting community is to adopt hybrid distribution approaches including both traditional broadcast platforms and IP networks. This enables offering a greater variety of new services to the listeners and viewers.

This report presents a study of distribution options available to broadcasters in terms of their potential to carry future broadcasting services both linear and nonlinear. Conclusions of the preceding Strategic Programme on Terrestrial Broadcasting as contained in EBU TR 013 [1] served as a starting point for the work. This study aims at assessing the distribution options available to broadcasters at present and identifying what distribution means may be required in the future.

Section 2 introduces the concept of uses cases, defines a large number of possible use cases and evaluates them in terms of their relevance for public service media. As a result a set of use cases have been identified that are considered to be highly relevant for broadcasters, now or in the foreseeable future.

Broadcasters, in particular public service media organisations, have a number of requirements that need to be fulfilled in the process of distribution of their content and services. Some requirements are specific for each use case, whereas others are generally applicable to all use cases. These requirements are elaborated in section 3.

In section 4 the currently available distribution options are introduced and evaluated in terms of their capabilities to meet broadcaster's requirements and in particular whether or not they can enable the highly relevant use cases.

Usage patterns are briefly discussed in section 5.

Section 6 briefly touches upon some of the on-going technical developments which may take forward the available distribution options and help to overcome their current limitations.

Results of the analysis are discussed in section 7 while conclusions and recommendations are provided in sections 8 and 9, respectively.

2. Use cases

A starting point in this study was to try and establish a clear picture of future behaviour and expectations of listeners and viewers as well as of the receiving devices used to access broadcasters' content and services. Only if broadcasters know their future targets can they develop compelling services and make optimal distribution choices.

In order to reduce the complexity of the matter individual use cases were examined in terms of their relevance to broadcasters and their potential to be enabled by a particular distribution option. A single use case is the smallest unit treated in this analysis and individual use cases have been considered in isolation. It is recognised that in reality individual different use cases coexist and are strongly influenced by their context.

2.1 Terminology

The terms used in the analysis of use cases are defined as follows:

Broadcast content

Broadcast content encompasses the entire range of content that broadcasters offer to the audience irrespective of the technical platform across which it is distributed.

Broadcast service

A broadcast service is an edited selection of broadcast content.

Linear broadcast service

Linear broadcast service refers to the traditional way of offering radio or TV services. Listeners and viewers tune in to the content organised as a scheduled sequence that may consist of e.g. news, shows, drama or movies on TV or various types of audio content on radio. These sequences of programmes are set up by broadcasters and cannot be changed by a listener or a viewer. Linear broadcast services are not confined to a particular distribution technology. For example, a live stream on the Internet is to be considered as a linear service as well.

Nonlinear broadcast service

Nonlinear broadcasting services refer to any type of broadcast offer which requires action of the listener or viewer beyond the simple selection of service as for linear services. Typically, the user can select individual pieces of content and control, as a minimum, the timing and sequence of the consumption.

Particularly popular nonlinear services are catch-up and time-shifted services. Other forms of nonlinear broadcast services encompass downloading content to local storage for future consumption or on-demand access to audio and video content for immediate consumption. Furthermore, associated offers such as dedicated websites or data services supporting particular programmes fall under the category of nonlinear service, too.

On-demand broadcast service

An on-demand broadcast service is a service where the viewer or listener can access individual broadcasting programmes such as news, shows, and episodes of series or movies, independent of a given schedule.

Hybrid broadcast services

Hybrid broadcast services consist of both linear and nonlinear elements. They are to complement

each other in the sense of enriching the broadcast offer but also in order to interrelate both types of services. This requires a certain level of integration already when producing the content. Examples include slideshows for digital radio or second screen television.

Broadcast data service

A broadcast data service comprises any kind of data content in addition to pure audio-visual content which is provided by a broadcaster. Examples are broadcaster's websites including their *Facebook* or *Twitter* pages, *EPG*s, traffic information or *Teletext*.

Distribution option

A distribution option refers to any technical possibility available to a broadcaster to distribute its services to the audience.

2.2 Composition of use cases

A use case is defined as a combination of a single broadcast service, the user *environment* in which the service is used and a *user device*.

Broadcast services

The following broadcast services are considered in the present analysis:

Table 1: Considered services

TV services	Radio services	
linear TV	linear radio	data services
on-demand TV	on-demand radio	
hybrid TV	hybrid radio	

User environments

Two different user environments are considered:

- *Permanent* – In this environment the user is within a non-public location that they use very regularly, for example the home or an indoor work environment (office, workshop, etc.) and have a high degree of control over the means of access to broadcast services.
- *Transient* – In this environment the user is in a public space that they use occasionally, for example an airport, a train station or a shopping mall, or is travelling (in cars, trains, etc.), where they have little control over the available infrastructure.

User devices

The following user devices are considered to be representative with regard to access to broadcast services:

Table 2: Considered user devices

TV receivers	Radio receivers	Computers and portable devices
stationary TV set	home audio system ('Hi-Fi')	desktop computer
portable TV set	portable ('kitchen') radio	portable ('laptop') computer
TV receiver in a vehicle	radio receiver in a vehicle	smartphone
	small ('pocket') radio	tablet

Figure 1 illustrates in which environment each of the above listed user devices is normally used.

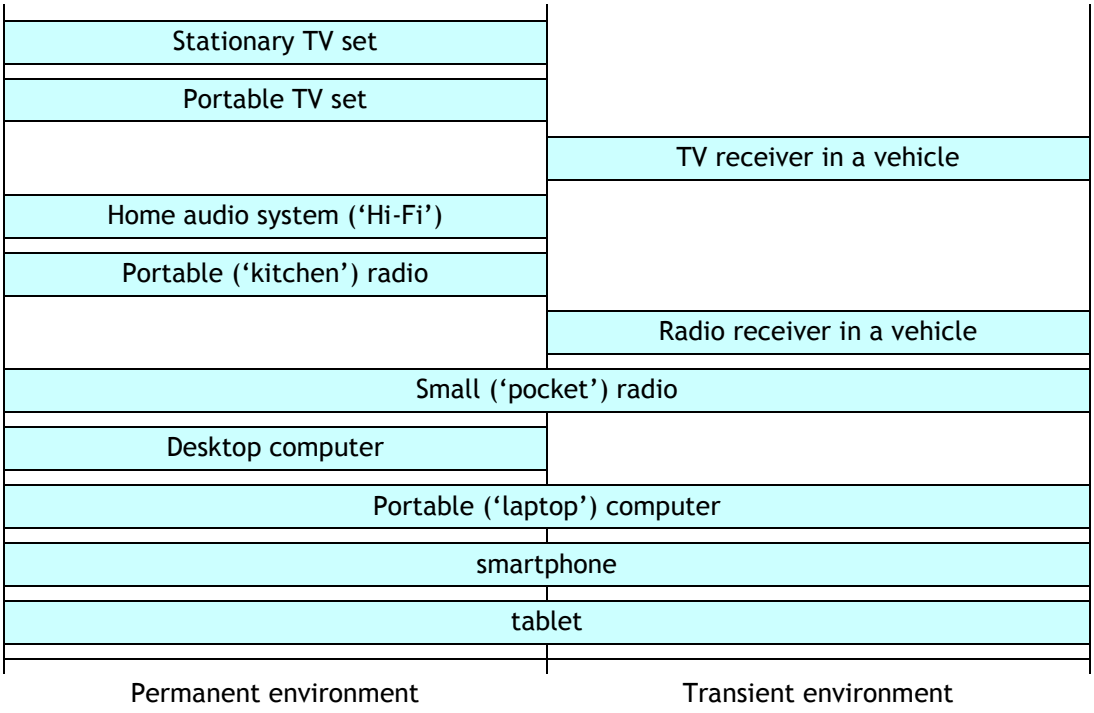

Figure 1: User devices and environments

These device categories describe how services are consumed and not necessarily the technical means of their delivery, i.e. a receiving unit could be integrated in the device or external such as set-top box, game console. In some cases the same user device could include or be connected to multiple receiving units.

2.3 Identification of relevant use cases

The use cases have been evaluated on the basis of the following observations regarding general trends in broadcast services and the associated viewer behaviour which form the basic assumptions for the analysis presented in the report:

- Linear viewing is the primary way of watching TV content and there is no indication that this will change in the foreseeable future. Time-shifted and on-demand viewing will continue to grow, but this will not significantly erode the overall share of linear viewing.
- Migration of TV services from SDTV to HDTV will continue. More content will be offered as well, in particular with the introduction of new HDTV services.
- Ultra-HDTV will be introduced and may become the mainstream format in the medium to long-term future on all TV platforms.
- Portable and mobile devices are increasingly used to access media services. The content consumption will, in addition to linear viewing on TV sets, increasingly include consumption through the Internet and Apps on mobile smartphones and tablets. Nevertheless, most of the TV viewing will remain on the large screen.
- Majority of the TV viewing, both linear and nonlinear, occurs in the home. This will not significantly change with the increased usage of portable and mobile devices, nor with the growing adoption of innovative media services. Nevertheless, usage in transient environments will become increasingly significant.
- Innovative media services include active audience participation in particular through social networks such as *Facebook*, *Twitter*, etc.

- Hybrid broadcast-broadband services are becoming commonplace based on broadcast platforms and fixed broadband infrastructures. In the future they may also make use of wireless broadband.

The principal objective for broadcasters is to deliver the whole range of broadcast services to all interested users on a device of their choice and in their preferred environment.

Combining broadcast services with user environments and devices gives rise to many possible use cases. However, not all identified use cases are equally relevant from a broadcaster's perspective. It is therefore important to identify those use cases that are particularly relevant for broadcasters already now or are expected to become important in the future.

The use cases are categorized according to their relevance into three levels:

High: These use cases are strategically important for broadcasters' position on the market.

Medium: These use cases could enhance broadcasters' primary offer and their market position.

Low: These use cases are of less importance for broadcasters.

The relevance is determined taking into account the current situation as well as the short to mid-term future (e.g. next 5 - 10 years). For instance, a use case is considered highly relevant if it is important already now or it is foreseen to become important in the future. Elements to be considered may include the size of audience, availability of suitable devices or the programme offer.

The evaluation of use cases has been carried out as a consultation process within the EBU community. Therefore, the results including the assessment of relevance for each use case represent a collective view of the European public service media organisations and not necessarily a position of any individual EBU Member. Furthermore, commercial broadcasters and other contributors to the media value chain may have different views considering the relevance of the respective use cases.

Table 3 overleaf shows all the considered use cases. Some combinations of services and user devices are not considered because they do not represent a plausible use case (e.g. delivery of TV services to radio receivers). These combinations are shaded grey in Table 3. Highly relevant use cases are marked in green. More details on the use cases together with the results of evaluation are provided in Annex 1.

For the purpose of analysis of distribution options (see section 4) only the highly relevant use cases have been considered.

Table 3: The matrix of use cases.

Receiving environment	User devices / Services	Stationary TV set	Portable TV set	TV receiver in a vehicle	Home audio system (HiFi)	Portable ('kitchen') radio	Radio receive in a vehicle	Small ('Pocket') radio	Desktop computer	Portable ('laptop') computer	Smartphone	Tablet
Permanent	Linear TV	■	■		Not applicable				■	■	■	■
	On-demand TV	■	■						■	■	■	■
	Hybrid TV	■	■								■	■
	Linear radio				■	■		■	■	■	■	■
	On-demand radio	Not applicable			■	■			■	■	■	■
	Hybrid radio											
	Data services	■	■						■	■	■	■
Transient	Linear TV		■	Not applicable							■	■
	On-demand TV		■							■	■	■
	Hybrid TV		■									
	Linear radio	Not applicable					■	■			■	■
	On-demand radio										■	■
	Hybrid radio											
	Data services			■			■			■	■	■

2.4 Observations about use cases

Some general observation can be made about the highly relevant use cases:

- The majority of highly relevant use cases refer to usage in a permanent environment, while there are also many highly relevant use cases referring to transient usage.
- For radio, highly relevant use cases are linear and on-demand and must be available on user devices capable of supporting them, in particular traditional radio receivers in the home or in the car as well as smartphones and tablets.
- Hybrid radio does not seem to be highly important as it requires a level of continuous interaction. This supports radio being thought as a "listening-while-doing-something-else"

medium.

- All TV service categories investigated are highly relevant for traditional TV sets, both stationary and portable.
- Smartphones and tablets are highly relevant for all TV service categories investigated. This is related to their capabilities such as multi-functionality combined with ease of use, availability and portability.
- Data services represent a very broad category. While they are highly relevant for all devices there may be different data service types associated with different devices.

3. Broadcasters' requirements

For every use case a set of requirements has been defined that need to be fulfilled by a viable distribution option. The requirements are service focused, i.e. defined in such a way as to ensure desired availability and quality of service. Furthermore, they are as far as possible neutral with regard to distribution options, i.e. they do not reflect the current constraints of one or the other distribution technology or user device. The distribution options are assessed in terms of their ability to satisfy the requirements.

Two types of requirements have been defined:

- general requirements which are common to all use cases, and
- specific requirements for each use case

Distribution options have first been evaluated with respect to the general requirements and then for each use case taking into account the respective specific requirements.

Specific requirements have been specified for the highly relevant use cases. Nevertheless, it is assumed that they may also apply to other use cases, as appropriate.

3.1 General requirements

General requirements reflect the basic principles which determine the business model of PSM. The following general requirements are considered relevant for the assessment of distribution options:

- Possibility for free-to-air or equivalent, no additional costs for the viewers and listeners
- Deliver the services of public service broadcasters to the public without blocking or filtering the service offer, i.e. no gate keeping.
- Content and service integrity - no modification of content or service by third parties, e.g. TV content must be displayed on screen unaltered and without unauthorised overlays.
- Quality of service requirements to be defined by the broadcaster, such as
  - QoS when the network is up and running
  - availability of network: robustness, up-time, reliability
- Quality of Service for each user shall be independent of the size of the audience.
- Geographical extent of the service area (e.g. national, regional, local) is to be defined by the broadcaster.
- A distribution option needs to be viable on the market and capable of supporting at least
- a minimum service offer (e.g. a minimum number of programmes) defined by the broadcaster.
- Ease of use - straightforward accessibility of broadcast offer.
- Low barrier for access to broadcasters' content and services for people with disabilities.

- Ability to reach audience in emergency situations

Any distribution option needs to allow implementing these principles in one way or the other in order to be suitable for PSM.

These general requirements implicitly address not only technical issues but also regulatory, market and business related aspects relevant for public service broadcasters.

3.2 Specific requirements

Specific requirements are defined for each use case and they should be fulfilled in addition to the general requirements specified above. The following parameters are specified:

- ***Data rate***

To ensure high quality user experience the average bit rates per programme are specified, while the actual data rate must not at any time drop below certain minimum levels.

For live television content the following data rates are assumed for HDTV signals encoded by means of MPEG-4 / H.264[1]:

average 8 Mbit/s, minimum 5 Mbit/s:	for stationary and portable TV set
average 5 Mbit/s, minimum 2.5 Mbit/s:	for TV set in a vehicle, desktop and portable computer, smartphone, and tablet.

Live content requires real-time encoding while for on-demand content more sophisticated non-real-time encoding algorithms can be employed giving rise to lower required bit rate for the same perceived picture quality.

The typical bit rates for radio services range from 64 - 192 kbit/s depending on the codecs and the type of content to be delivered.

- ***Bit error rate***

The bit error rate has to be controlled and within predefined limits. Typically this is referred to as quasi error free. This means that after decoding the incoming signal, a maximum bit error rate shall not be exceeded. For television a bit error rate of 10^{-11} is considered the required value. For radio a bit error rate of 10^{-4} is typically used.

In the case of streaming audiovisual content over the Internet the bit error rate may not be the proper parameter to describe the quality of the delivered signal.

- ***Targeted peak size of the concurrent audience***

In order to decide if a particular distribution option can enable a use case it is important to understand that the number of concurrent users is not static but varies from one moment to another. Therefore, it is a requirement for the available distribution options to cope with this variation and support the expected maximum number of concurrent users, i.e. a peak demand.

[1] Different values are applicable for other encoding standards (e.g. MPEG-2, HEVC) and picture formats (SDTV, UHDTV, 3DTV, etc.)

In other words, peak demand corresponds to the maximum number of concurrent users for a given use case at a given point in time. To give an example, peak demand for the use case “linear TV/large TV screen/permanent” could be the total number of people watching linear TV in their living rooms on a large flat screen at 20:00 which is usually the peak hour for TV.

For the purpose of this analysis the terms “very large” and “small” are used to distinguish between mass audiences and niche demand.

4. Distribution options

A distribution option refers to any technical possibility available to a broadcaster to distribute its services to the audience.

There are a number of distribution options. However, they are not equal in terms of their capability to fulfil PSM’s requirements. It is observed that many use cases can be enabled by different distribution options, at least in principle. The question is what distribution option (or options) is/are most suitable in practice for a particular use case? This question needs to be answered taking into account the broadcasters' requirements, the viewers' and listeners' habits and expectations, and current and future market conditions as far as they can be anticipated.

The following distribution options have been considered:

- Terrestrial broadcast
- Satellite broadcast
- Cable broadcast
- Fixed broadband
  - managed service mode
  - best effort service mode
- Mobile broadband

Broadband services can take a form of managed or best effort services. Managed services are capable providing guaranteed QoS to the users. IPTV is an example of a managed service delivered over a broadband network based on a business model similar to that of cable broadcast networks. Best effort services are delivered over the Open Internet without the network operator's involvement in ensuring QoS. This is often referred to as 'over the top (OTT)'. WiFi is considered as an extension of a fixed broadband network.

Fixed broadband can be provided via xDSL, cable/DOCSISx or optical fibre networks. Mobile broadband networks are considered to be best effort networks for the purpose of this analysis. Managed services on mobile networks are not presently available. A technology such as eMBMS could be used in this context. However, for the time being its capabilities are not fully known [2].

It is recognised that not all distribution options are universally available nor can each of them serve all user devices. An in-depth analysis of the individual distribution options is beyond the scope of the present document. Assessment of distribution options has been carried out on the basis of general requirements specified in section 3.1 and the specific requirements for each use case as indicated in section 3.2. This analysis focuses on the highly relevant use cases shown in Table 3 in section 2.3.

The following colour code has been used to indicate the potential of a given distribution option to satisfy general requirements or to facilitate the highly relevant use cases, respectively:

The distribution option is already fully capable of satisfying a general requirement / enabling a use case

The distribution option could satisfy a general requirement / use case but with constraints (e.g. because of high costs, limited availability)

The distribution option cannot satisfy the general requirement / use case

Not known

It is recognized that there is equipment on the market which can be connected to computers and mobile devices in order to enable reception from broadcast networks, e.g. USB sticks containing DTT receivers. However, the impact of such devices is rather limited and therefore was not taken into account in assessing the distribution options.

Furthermore, it has to be noted that the analysis presented in Tables 4 and 5 was based on the information available at the time of writing this report.

4.1 Assessment of distribution options with respect to general requirements

The assessment of specific requirements of different use cases with respect to whether a distribution option can enable a use case has been carried out on the basis of its technical characteristics as of today, e.g. the lack of return channel capabilities of broadcast options as well as limitations of broadband in serving large audiences.

Table 4: Assessment of distribution options with respect to general requirements

	General Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort	Mobile broadband best effort	Remarks
1	Possibility for free-to-air or equivalent, no additional costs for the viewers and listeners			1a	1b	1b 1c	1b 1c	1a Minimum subscription fee required in many European countries. 1b At least an Internet subscription required 1c Data volume limitation may apply
2	Deliver the services of public service broadcasters to the public without blocking or filtering the service offer, i.e. no gate keeping.	2a	2a	2a	2a	2b	2b	2a May be subject to commercial agreement and legal obligations 2b FRND & Net Neutrality needs to be respected
3	Content and service integrity - no modification of content or service by third parties, e.g. TV content must be displayed on screen unaltered and without unauthorised overlays.							
4	Quality of service requirements to be defined by the broadcaster, such as: QoS when the network is up and running availability of network: robustness, up-time, reliability	4a	4a	4a	4a			4a Subject to commercial agreement

	General Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort	Mobile broadband best effort	Remarks
5	Quality of service for each user shall be independent of the size of the audience					5a	5a	5a Concurrent users share the available network capacity.
6	Geographical extent of the service area (e.g. national, regional, local) is to be defined by the broadcaster.		6a	6b 6d	6b	6c	6c	6a Satellite footprint is difficult to constrain to regional or local coverage areas. 6b Networks may not be universally available. 6c Service areas can be constrained to national areas by means of geo-blocking. It is not common practice to use geo-blocking on a regional or local basis. 6d Networks may not match geographical requirement of broadcaster
7	A distribution option needs to be viable on the market and capable of supporting at least a minimum service offer (e.g. a minimum number of programmes) defined by the broadcaster.							
8	Ease of use - straightforward accessibility of broadcast offer					8a	8a	8a It is generally more complex to access broadcast services over the open Internet than via dedicated broadcast technologies.
9	Low barrier for access to broadcasters' content and services for people with disabilities							
10	Ability to reach audience in emergency situations							

4.2 Assessment of distribution options with respect to specific requirements for each use case

All use cases are identified by their individual labels as given in Annex 1. Table 3 in section 2.3 highlights those use cases which have been identified as the highly relevant ones. Only these have been assessed with respect to their ability to satisfy the specific requirements of broadcasters.

The assessment of the highly relevant use cases, i.e. the attribution of green, yellow or red entries, was based on the following considerations:

- Portable broadcast receivers may be suited to cope with high data rates which can in principle be delivered by satellite, cable or managed services over fixed broadband. However, these distribution options would require connecting the portable receiver to the fixed access point thereby losing its defining characteristic which is portability.
- Best effort broadband networks, both fixed and mobile, are in general not able to provide a sustained minimum quality of service to a large audience. This limitation is more pronounced on mobile networks than it is on fixed. Furthermore, it can be expected that the cost of delivery of broadcast content, i.e. large amounts of data, over mobile broadband is very high. Best effort broadband in a permanent environment and for a small audience is currently considered to be able to deliver video at a sustained bit-rate of 5 Mbit/s, but not necessarily at 8 Mbit/s. In the transient case (e.g. in public places) the capacity will generally not be sufficient to deliver the same sustained bit-rate.
- Some distribution options target particular applications. Managed networks offering IPTV

require a special receiver box / set top box which usually cannot easily be connected to a computer. Even though there may be workarounds for such cases they are not taken into consideration here.

- Neither a broadcast network (terrestrial, satellite or cable) nor a best effort broadband network on their own will be able to offer hybrid TV to large audiences, but a combination of a broadcast network and a best effort broadband network will be able to offer such services. Managed broadband networks may be able to offer hybrid services.

The assessment of the highly relevant use cases also took into account the capabilities of devices to receive and make available audiovisual content:

- Currently available TV sets are equipped with tuners for terrestrial, satellite and cable reception or are attached to a set top box. Furthermore, TV sets are capable of connecting to the internet or are attached to a separate device for this, e.g. a game console.
- TV sets in a vehicle are equipped with a tuner for terrestrial reception and may be connected to mobile broadband.
- Radio receivers in a vehicle are equipped with a terrestrial tuner. It is assumed that they cannot be connected to mobile broadband.
- It is recognized that there is equipment on the market which can be connected to computers and mobile devices in order to enable reception from broadcast networks, e.g. USB sticks containing DTT receivers. However, the impact of such devices is rather limited and therefore was not taken into account in assessing the distribution options.
- Some smartphones also contain an FM receiver. However, this is not generally the case. On the other hand, smartphones with a DAB receiver are not available. Therefore this way of accessing radio programmes was not taken into account in assessing the distribution options.

The table containing a complete set of assessment results for all highly relevant use cases is given in Annex 2. Use cases containing linear and on-demand TV are given here as examples in Table 5.

Table 5: Assessment of distribution options with respect to specific requirements for use cases - examples for those use cases that encompass linear and on-demand TV.

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort	Mobile broadband best effort
T 01	linear TV permanent stationary TV set	Data rate: av. 8 Mbit/s, min. 5 Mbit/s Concurrent Audience Size: very large						
T 02	linear TV permanent portable TV set	Data rate: av. 8 Mbit/s, min. 5 Mbit/s Concurrent Audience Size: very large						
T 04	linear TV permanent desktop computer	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 05	linear TV permanent portable computer	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 06	linear TV permanent smartphone	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 07	linear TV permanent tablet	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort	Mobile broadband best effort
T 10	linear TV transient TV in a vehicle	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 13	linear TV transient smartphone	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 14	linear TV transient tablet	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 29	on-demand TV permanent stationary TV set	Data rate: av. 8 Mbit/s, min. 5 Mbit/s Concurrent Audience Size: small						
T 30	on-demand TV permanent portable TV set	Data rate: av. 8 Mbit/s, min. 5 Mbit/s Concurrent Audience Size: small						
T 32	on-demand TV permanent desktop computer	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 33	on-demand TV permanent portable computer	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 34	on-demand TV permanent smartphone	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 35	on-demand TV permanent tablet	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 38	on-demand TV transient TV in a vehicle	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 40	on-demand TV transient portable computer	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 41	on-demand TV transient smartphone	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						
T 42	on-demand TV transient tablet	Data rate: av. 5 Mbit/s, min. 2.5 Mbit/s Concurrent Audience Size: small						

5. Usage patterns

Analysis of individual use cases is not sufficient to address all possibilities that may be of interest to broadcasters. Combinations of use cases are becoming increasingly important. This kind of user behaviour is described by the term 'usage pattern', as opposed to a single use case.

A usage pattern involves more than one use case. This can be a transition from one use case to another thereby generating a usage sequence in space and time or a situation where multiple use cases occur simultaneously (e.g. second screen). These two types of usage patterns can be described as follows.

- The first type refers to a temporal succession of the use cases defined in section 2. This implies a situation where there is a change of the service consumed, a change of the receiving device or a change of the distribution platform by which broadcast content is

delivered.

- The other type of usage pattern comprises concurrent use cases. This means consuming one service on a given device while enjoying another service on another device. The services may not be linked at all, e.g. watching linear TV while chatting at the same time on a tablet, or they may be linked in which case one can talk about a hybrid service.

Figures 2 and 3 illustrate these different aspects of usage patterns.

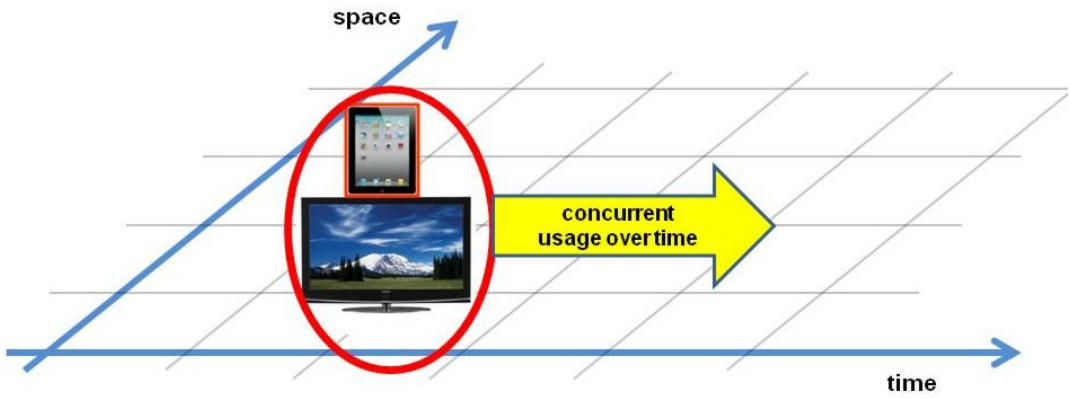

Figure 2: Usage pattern representing concurrent usage of two use cases over time.

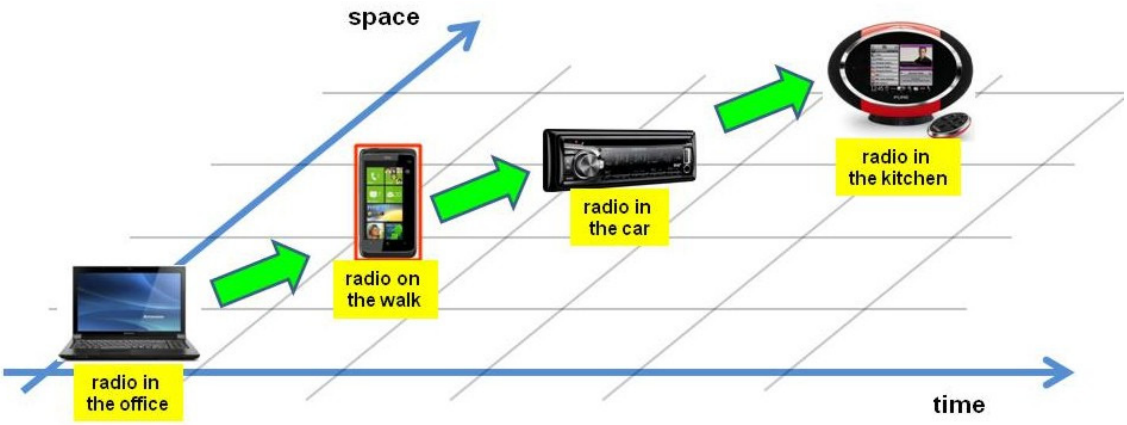

Figure 3: Usage pattern representing a temporal and spatial change from one use case to another.

The following situations are examples of usage patterns:

Example 1: Listening to linear radio

A typical situation is getting up in the morning and switching on radio to listen to a linear radio service using a portable radio receiver which could be a kitchen radio. Then one leaves the house to go to work or school still listening to the same linear radio service, however, using another device such as a smart phone or a tablet. Following the structure given in section 2 such a usage pattern involves a change from use case R04 to R10 (see Annex 1).

Example 2: Transition from linear to time-shifted TV

A simple situation where such a usage pattern occurs is when a person is watching a linear TV service in the living room on a large screen and at a certain point in time there is some event that leads the viewer to stop watching. At a later point in time viewing is resumed at the point where it was stopped. This corresponds to going from use case T01 to use case T09 (see Annex 1).

Example 3: Watching a football match on the way from work to home

Someone may start watching a football match on the way home from work using a tablet or computer while sitting in a train. Walking from the train station to the home he or she will continue watching while after having arrived at home the large screen in the living room is then used.

It is clear that usage patterns in most cases will not be enabled by a single distribution option. Combination or even cooperation of different options would be required. This may require interaction between different networks on one side and the receiving devices on the other side. Furthermore, hand-over between different types of distribution would be required and hence synchronisation between the corresponding networks becomes crucial.

6. Developments with regard to distribution options

The five different technical options which are available to distribute TV and radio programmes to users, i.e. terrestrial broadcasting, satellite, cable, fixed and mobile broadband networks, offer different possibilities to broadcasters but also come with their individual characteristics and constraints. This has been discussed in detail in section 4 in relation to their potential to enable relevant use cases.

All of the available distribution options are developing, even though at a different pace. It remains to be seen whether or not this may change the assessment given in section 4.4. However, there are some current developments which may be interesting for broadcasters. Some of them are briefly touched upon here.

6.1 Integrated broadcast receivers in handheld devices

Personal devices such as smartphones and tablets are increasingly used to access media services. Tablets are especially important for long-form audiovisual media and TV services because of their convenient form factor /size, long battery life and high quality display. In terms of their reception capabilities tablets normally come with a WiFi connectivity (based on the IEEE 802.11 standards) and sometimes also with mobile broadband capabilities (based on 3G or LTE standards by 3GPP).

However, these devices currently cannot receive directly from any of the broadcast platforms, with some exceptions in Asia (e.g. in Japan and Korea) and some pay TV services in the UK and US[2]. Similar possibilities are not common in most European countries.

As a consequence, media services are delivered to smartphones and tablets almost exclusively via broadband networks, i.e. either fixed broadband access extended by WiFi or mobile broadband. While there is growing acceptance of such broadband delivery in the market, it currently utilises only unicast connections, which come with a number of constraints, such as:

- Only best effort quality, no possibility for assured quality of services;
- Broadband networks cannot support the delivery of linear TV services to mass audiences;
- Distribution costs for broadcasters generally increase with the size of audience;
- The user's costs are determined by data allowances defined by the ISPs; and
- The ISPs potentially have a 'gate keeping' role.

The above mentioned constraints could be overcome if personal devices were equipped with a

[2] Tablet TV (http://www.motivetelevision.co.uk/english/tablet-tv/); Dyle TV (http://www.dyle.tv)

broadcast receiver. This would in particular enable those use cases that involve linear radio and TV services which are already provided over terrestrial broadcast networks to stationary receivers. However, in order to provide the same coverage for handheld reception as for fixed roof-top reception the terrestrial networks would have to be upgraded.

In that respect a distinction shall be made between radio and TV services. The upgrade effort to reach smartphones and tablets with broadcast radio signals would be less than in the case of TV because the networks for radio are already targeting portable or mobile reception. In contrast, TV networks are designed in most cases for fixed roof-top reception.

6.2 LTE

LTE is the current state-of-the-art technology for mobile broadband and is increasingly used to access media services on handheld devices. LTE networks have a potential to enable some use cases, in particular those that involve smartphones and tablets. A detailed consideration of the delivery of broadcast content and services over LTE networks is available in the EBU Technical Report 027 [2].

6.2.1 eMBMS

Audio-visual services are normally delivered over LTE networks by means of unicast connection. However, in some cases the same content may be requested by multiple users within a mobile cell at the same time. In these cases it may be more efficient to employ multicast or even broadcast technology, instead of unicast. For that purpose a Multimedia Broadcast/Multicast Service (MBMS) was standardized and since 3GPP Release 9 it is called 'evolved MBMS' or eMBMS. eMBMS traffic is time multiplexed with unicast traffic within an LTE network. This provides additional benefits because it enables the delivery of on-demand services in addition to broadcast.

From a technical point of view, the examined use cases and free-to-air delivery could in principle be enabled by LTE eMBMS, noting that further developments to the standard are required. However, there is currently no business model for eMBMS deployment that would ensure free-to-air delivery, which is a core value for public service media and the consumers.

Furthermore, it has been identified that regulatory constraints, business and operational models including free-to-air, costs and availability of user equipment need to be better understood to finally judge on the viability of delivering broadcast content via LTE.

6.2.2 Low-Power-Low-Tower LTE

Typically, LTE networks are deployed as cellular networks that consist of a large number of base stations with an inter-site distance in the range between a few hundred metres (i.e. in dense urban areas) and about 10 km (in rural areas). As the transmitted power levels and the antenna heights are rather low, this type of network is usually called a low-power-low tower (LPLT) network.

The LPLT configuration is optimised for wireless unicast communication and handheld user devices. In order to achieve universal LPLT coverage with sufficient capacity for the delivery of audio-visual services to large audiences the networks would need to be significantly upgraded. The main concern is that this would make broadcast service delivery prohibitively expensive.

6.2.3 High-Power-High-Tower LTE

Broadcast networks typically consist of a limited number of high-power transmitters with large antenna heights for the main coverage. They may be complemented by a larger number of medium and low power gap fillers. This type of network is usually called a high-power-high-tower (HPHT) network.

In principle, LTE eMBMS networks could be deployed on the basis of HPHT architecture, similar to the current DTT networks. The networks could be built for fixed roof-top reception, or could be extended to provide a stable robust signal indoors for stationary devices and outdoor coverage for mobile devices.

However, the current LTE eMBMS specification does not allow for HPHT deployment. Appropriate modifications of 3GPP specifications would be required (e.g. larger cyclic prefixes to enable large inter-site distances). Furthermore, significant investments would be required to roll-out eMBMS networks with a coverage equivalent to the current broadcast networks.

Even if technical modifications to enable HPHT LTE networks would be made, it remains unclear whether eMBMS networks could deliver a QoS comparable to that of existing broadcast platforms.

6.3 Tower Overlay

The Tower Overlay concept, also proposed by TU Braunschweig [3], is a particular way of combining broadcast and broadband delivery. To this end, a HPHT network is cooperating with a cellular LPLT network. The HPHT network is used to deliver audio-visual services to a mass audience across large areas, while the cellular network is meant to satisfy individual requests for content.

One of the options to implement the Tower Overlay concept would be to use a HPHT DVB-T2 overlay network together with an LTE cellular network. A feature in the DVB-T2 standard called 'Future Extension Frames' could be used to reach LTE terminals.

Similar to the HPHT LTE variant, modifications to the LTE specifications would be required in order to make the implementation of Tower Overlay possible.

6.4 Content Distribution Networks (CDN)

When delivering broadcast content and services over the Internet there is always a risk of network congestions leading to poor user experience. This risk increases when a large number of viewers try to access the same content at the same time, leading to a peak in the Internet traffic. One approach to reduce the risk of network congestion is to implement a Content Distribution Network (CDN).

The core function of CDNs consists of caching content in dedicated servers as close to the end users as possible, e.g. within the network infrastructure of Internet Service Providers (ISP).

Broadcasters often use multiple CDN providers. This allows them to maintain their services even if congestions occur in some parts of the Internet. CDNs are most useful for the most popular content. Network analytic tools allow the content providers to determine in real time what content is demanded by the viewers and where. This in turn makes it possible to optimise the delivery, taking into account the network conditions, capabilities of the servers and user devices.

The concept of caching the content as close as possible to the viewer could be extended perhaps even into the home network.

6.5 Dynamic Broadcasting

Dynamic Broadcasting [3] is a concept proposed by Technical University of Braunschweig. It combines broadcast and broadband delivery with extended storage capabilities of user devices. Broadcast delivery is used for live programmes and pre-produced programme content expected to be viewed by a large number of concurrent viewers. A broadband connection is used to deliver less popular pre-produced content to smaller audiences. The broadband connection is also necessary to identify the media consumption patterns of the viewers in order to determine the most efficient

way of delivering the content.

A variety of content is stored in the receiver. This content may have been delivered in non-real-time. Dynamic service guides are transmitted in order for the receiver to be able to identify which content is delivered via which network, or whether it is already stored in the device.

Switching between different delivery mechanisms can be done dynamically and is transparent to the viewers. This implies dynamic adjustment of multiplex configurations, transmission parameters, etc.

Dynamic Broadcasting would provide additional flexibility to broadcasters and network operators, while potentially improving the user experience.

6.6 Adaptive streaming

If a streaming service requires a constant bandwidth this would imply that a minimum bandwidth would have to be available end-to-end (e.g. from the server to the end user) in order to ensure the required quality of service. However, the Internet is a best effort network which means that the available bandwidth to any user is not constant but fluctuates. As a consequence, the quality of service of a requested audio-visual service can be neither predicted nor guaranteed.

Alternatively, a sufficiently long initial buffering time could prevent deterioration of the QoS, but may nevertheless impair the user experience.

A solution is to adapt the coding and the delivered bitrate for a service to the network conditions in real time. This approach is known as adaptive streaming. Adaptive streaming involves producing several instances of a source media file and making them available to the user device. These different instances correspond to different QoS levels and have different data rates. Depending upon the available bandwidth, the processing power of the device, and the buffer status, adaptive streaming technologies can switch between streams when necessary to ensure continuous playback or to improve the experience.

MPEG-DASH (Dynamic Adaptive Streaming over HTTP) is a state-of-the-art open standard streaming format [4].

6.7 Multicasting in fixed networks

Multicast enables one-to-many and many-to-many communication over an IP network. When a service is requested by a user, the packets are transmitted from one multicast node in the network to another, while being replicated along the way and finally delivered to the receivers. The content is transmitted between any two nodes only once.

Multicast has historically been restricted to managed IP networks, where congestion and packet loss can be controlled. However, it has not been widely adopted across the public Internet. Perhaps the main reason is that for a successful use of multicast in an IP network the multicast functionality must be enabled everywhere from source to receiver and this is not the case on the Internet. In addition, there are issues with ensuring a resilient and sustained quality of service.

If multicast were enabled on the Internet, this would allow broadcast services to be delivered to larger audiences without an excessive use of the network capacity, provided that quality-of-service issues are addressed.

7. Discussion

7.1 Use Cases

The approach taken in this report to analyse potential developments in programme distribution is based on four different elements. Firstly, users can choose to consume many different types of audiovisual media services. Secondly, they may make use of a variety of different receiving and display devices. Thirdly, media consumption may take place in difference environments. For each of these three elements several possibilities have been identified. A particular combination of service, device, and environment defines a use case for the purpose of this study.

Prominent use cases are for example the combinations "*linear TV + stationary TV set + permanent environment*" or "*on-demand TV + tablet + transient environment*". The possibilities shown in Figure 4 give rise to a total of 154 different combinations but only some of them constitute a meaningful use case. Some use cases are more relevant for broadcasters than others.

Once a relevant use case has been identified the question is by which of the six distribution options this use case can be enabled. Thus, a distribution option constitutes the fourth important element of the analysis.

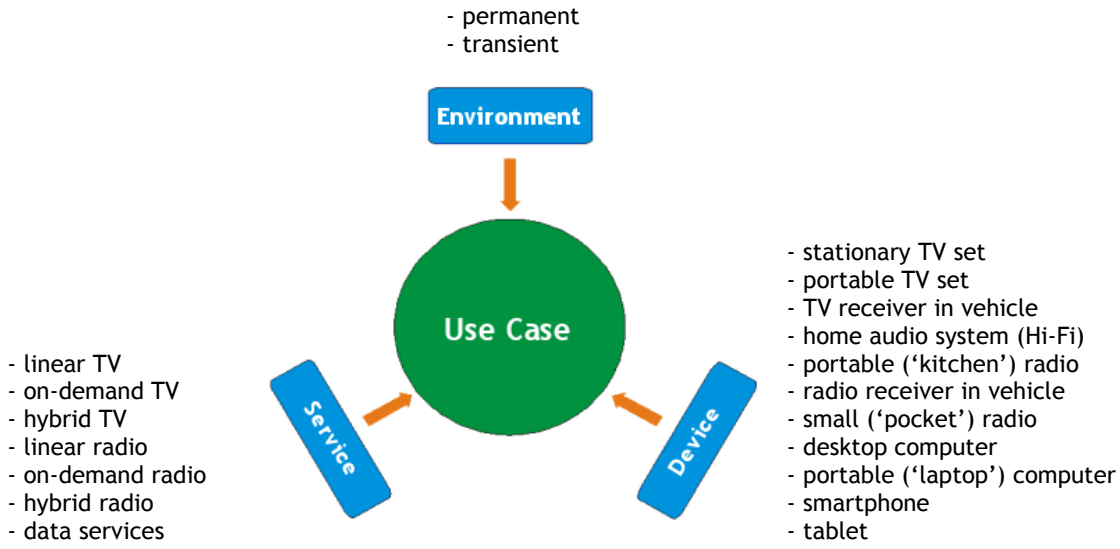

Figure 4: Definition of a use case.

The analysis was carried out in two steps. The first step was to identify the relevant use cases and the associated broadcasters' requirements. In the second step the available distribution options have been evaluated on the basis of these requirements. In order to determine to what extent is a particular distribution option able to support a specific use case it was assessed whether or not the requirements can be met. There are two kinds of requirements:

- *General requirements* that any potential distribution option must fulfil, for example the possibility to provide free-to-air services and
- *Specific requirements* that may differ from one use case to another, such as the required data rate to ensure satisfactory service.

This approach provides a methodology that allows broadcasters to carry out their own analysis. The assessment of distribution options in section 4 has been limited to those use cases which were considered relevant for EBU Members.

7.2 Assessment of distribution options

Broadcasters want to provide different types of content and services, both linear and nonlinear, to different kinds of user devices and in different environments.

The analysis in section 4 clearly shows that:

- The use cases that include linear services are sufficiently well served by broadcast networks except those that target portable devices such as tablets and smartphones (see section 7.5).
- Broadband networks are not sufficiently suitable to enable use cases containing linear TV services because they typically provide only best-effort quality. In general, they are not able to ensure a sustained minimum quality of service to a large concurrent audience. This limitation is more pronounced on mobile networks than on fixed.
- The use cases that include on-demand services are only enabled by broadband networks as they provide the required return channel which is not available on broadcast networks.
- A number of use cases are enabled by more than one distribution option. In those cases broadcasters seek to utilize a distribution option that best meets their requirements (see section 7.3).
- When a single use case can be enabled by multiple distribution options this normally leads to the situation where the audiences are distributed across different options. Hence, it is never the case that a single distribution option must satisfy the whole peak demand. For example, most of the audience for linear TV is distributed between terrestrial, satellite, cable and IPTV networks.
- No single distribution option can enable all relevant use cases. Therefore, in order to enable the whole range of relevant use cases multiple distribution options need to be employed in a complementary manner. This becomes even more obvious when usage patterns are considered as they include a combination of different use cases, as described in section 5 (also see section 7.4).
- Some distribution options may be able to support multiple use cases simultaneously. For example, broadband networks can be used to watch linear TV and access on-demand services at the same time. However, broadband networks may not be able to serve peak demands of all supported use cases simultaneously, even though they may in principle satisfy them individually at different times.
- Some distribution options operate as a closed system targeting dedicated, often proprietary user devices. For example, IPTV or cable TV requires a dedicated receiver box. Access to these options is normally subject to subscription and contract with the platform operator (see section 7.7).
- Some use cases have been identified as highly relevant but cannot be fully enabled by any of the currently available distribution options. This can be either because a suitable technical solution is yet to be developed, for example linear TV services on smartphones and tablets, or such a solution exists but is not enabled or sufficiently rolled-out, such as:
  - on-demand TV and hybrid TV services in a vehicle
  - hybrid TV services on stationary and portable TV sets

For these cases further technical and market developments are necessary.

7.3 Selection of a distribution option

In those cases where multiple distribution options are available broadcasters seek to utilise a distribution option that best meets their requirements. An obvious example is the use case T1 (i.e. linear TV in a permanent environment on a large screen) that is enabled by terrestrial, satellite TV, cable TV, IPTV and live streaming over the Internet).

These options are not equal in terms of being able to satisfy broadcaster's requirements as defined in section 3. They differ for example with respect to the achievable coverage, the amount of programmes offered and the QoS which can be guaranteed for a large concurrent audience. As a consequence, broadcasters make use of several distribution options simultaneously to overcome their individual limitations. Furthermore, as no single distribution option is capable to enable all relevant use cases a combination of them has to be used anyway.

The question which distribution to employ and which to ignore depends on many factors which may differ from broadcaster to broadcaster. Coverage, reach, QoS and costs are certainly important issues in this respect. Also regulatory obligations may play an important role. In some countries in Europe broadcasters are subject to regulatory obligations to use a terrestrial broadcasting network to provide full area and/or full population coverage. In other countries, even though public service broadcasters also have to fulfil universal coverage obligations, this constraint is interpreted differently. For example, in Germany the requirement for universal coverage is met as long as the population can get access to PSM content by any of the available distribution options.

Another very important aspect with regard to selecting the best suited distribution platform is certainly the costs. Actually, there are two sides to it. Firstly, the cost of distribution under the conditions broadcasters have to adhere to is crucial. This is currently one of the most challenging issues in connection with the debate whether LTE can replace DTT in the long run. Currently, it seems that the mere distribution costs exceed those for DTT by up to an order of magnitude. Secondly, costs for users are decisive, in particular for public service broadcasters which have to provide their services free-to-air.

As of today, broadcasters are employing several distribution options simultaneously. The primary reason is that the audience is spread across the different available distribution options and hence broadcasters do not have a choice if they want to reach the entire population. Also, selection of distribution options is influenced by the legacy situation.

7.4 Complementary or cooperative use of distribution options

As no single distribution option is capable of enabling all relevant use cases one possibility to overcome this limitation would be to use multiple options in a complementary or cooperative way.

The straightforward interpretation of complementary use refers to using different distribution options to reach different segments of the audience. Within a single use case, different parts of the population can be served by different options in order to achieve universal coverage. As mentioned above, the use case T1 (i.e. linear TV in a permanent environment on a large screen) is enabled by terrestrial, satellite TV, cable TV, IPTV and live streaming over the Internet. In most cases any one of these distribution options alone would not be able to provide universal coverage and consequently two or more need to be used in a complementary manner.

Furthermore, by utilizing different distribution options simultaneously it should be possible to enable all relevant use cases. For example, enabling all use cases that involve linear TV is currently only possible by combining broadcast and broadband networks; broadcast networks to serve traditional TV receivers and broadband networks to reach PCs, smartphones, and tablets.

Another way of looking at complementary usage of distribution options would be to extend the reach or the functionality of a given option by switching to another one. Two important possibilities can easily be identified:

- Unicast vs. Broadcast, i.e. making use of broadcast distribution options for large audiences while niche audiences are exclusively served by unicast technologies.
- Mobile vs. fixed + WiFi, i.e. using terrestrial distribution for outdoor consumption only while indoor coverage is enabled by combining fixed reception (broadcast or broadband) with WiFi to provide full portable indoor coverage.

The latter case of complementary use of different distribution options seems to be very promising. It provides indoor coverage by means of re-transmission of broadcast services via WiFi signals. Constructing terrestrial networks that are able to provide (deep) indoor coverage is usually expensive. However, a simple solution to cope with indoor coverage is to follow the philosophy "pick-up and re-transmit". The TV signal is picked up from a terrestrial or satellite TV antenna, or from cable TV, or a broadband network; it is then transcoded to IP and re-transmitted inside buildings over the WiFi network. Figure 5 illustrates this. Broadcast-to-IP converters are already commercially available but their mass market adoption is yet to take place.

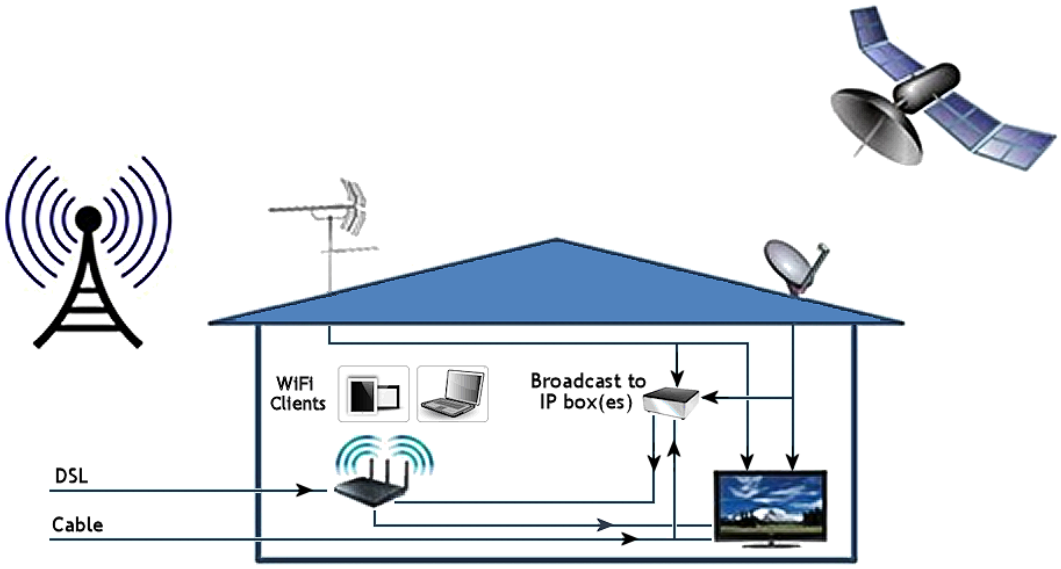

Figure 5: Indoor coverage by means of picking-up and re-transmitting TV signals.

For all the cases of complementary usage described so far, the different distribution options are independent from each other. On the contrary, cooperative use assumes that there is a degree of active interaction between different distribution options. The ultimate incarnation of cooperative use would be the development of a universal purpose network. Clearly, both broadcast and unicast modes would form part of the technical delivery option of such a network. Furthermore, it should be possible to dynamically reconfigure the network to switch from one transmission mode to another depending on demands due to requested services, location and number of simultaneous users.

Some features of such general purpose networks are being addressed for example under the umbrella of 3GPP, but also the activities in the broadcasting sector within DVB Project, FOBTV or ATSC 3.0 could be seen as examples. However, at the moment it is not clear when they will be ready to be rolled out and in particular if they will cover broadcasters' general and specific requirements. Further information on some of the concepts can be found in section 6.

7.5 Integrated DTT receivers in handheld devices

One of the most challenging tasks for broadcasters is to enable use cases involving linear TV targeting smartphones and tablets. For the time being, these devices allow accessing linear TV content only by means of employing broadband networks. As long as these networks do not make use of broadcast modes, serving a concurrent mass audience is not feasible. A straightforward way to overcome this problem would be to offer smartphones and tablets which can access both terrestrial broadcast and mobile networks as a standard. This would enable delivery of linear and nonlinear content to these devices with the help of terrestrial broadcast and mobile networks.

Integration of multiple access technologies is already reality today to some extent. TV receivers for the living room usually contain DVB-T, DVB-C and DVB-S receivers together with the possibility to

connect to the Internet via cable or WiFi. On the mobile network side the terminals contain different mobile technologies such as GSM, UMTS and LTE. At the same time they are able to connect to WiFi and incorporate Bluetooth.

Outside Europe there are already smartphones and tablets on the market that contain a DTT receiver. There are smartphones with ATSC, ISDB-T or CMMB receivers for markets in the US, Japan and China. What seems to be missing is smartphones with DVB-T/T2 receivers for Europe. On the other hand there are tablets with integrated DVB-T in the European market. The technology that allows the general incorporation of broadcast receivers in smartphones and tablets is available on the market[3]. However, this is not a mass market phenomenon, rather it is niche business yet driven sometimes even by regulators to support the national industry, as apparently in Japan.

In Europe mobile device markets were dominated by the mobile network operators by virtue of subsidizing terminals. This way they decided which features were integrated and which not. However, the situation seems to be changing. In mobile markets such as Germany the market share of unlocked terminals has risen in recent years from marginal to almost 50%. Putting a mobile terminal on the market which features a DTT receiver thus may give manufacturers a competitive advantage. Integration of DVB-T/T2 receivers in smartphones and tablets would open a direct possibility to get linear and nonlinear content into these devices.

In order to enable universal availability of broadcast services on handheld devices, broadcast networks would need to be adapted to provide the necessary coverage.

7.6 Storage and push services

After all these aspects there is another issue to be considered which is related to the term “linear” broadcast content. “Linear” and “live” are quite often used synonymously even though care should be taken. Linear content refers to content which is offered in a sequential way organized by the editing departments of broadcasting companies. It typically consists of news, information programmes of various types, sports and entertainment. The user tunes in to such content and apart from zapping for example from one TV channel to another there is no possibility to influence the flow of content. Live content is basically the same with the additional condition that what is offered on TV or radio is happening at the same time at another location and is broadcast directly.

Analysing the content of typical broadcast channels it turns out that only a fraction of the entire programme offer may have to be broadcast on a live basis. A large part of many broadcasters’ offer is movies or series which need not necessarily be transmitted live. In principle, such content could be pre-recorded on the user devices and then replayed from there. This does not say that this content cannot form part of the broadcaster’s programme schedule. If a given episode of a series is stored on the device it can be replayed from there at the time when the programme schedule foresees this content. For the user this would make no difference as the look-and-feel would be the same. However, from a distribution point of view there might be a dramatic difference. In an environment where different networks are cooperating available capacity on a network could be used to pre-load content to user devices such as DTT receivers equipped with storage and corresponding software.

The technical aspect of pushing content to user devices seems to be manageable as most of the technology – maybe apart from the cooperation of networks – is already available today. However, pushing content to user devices may have other severe impacts such as content right protection, the need to prevent acts of piracy, and ensuring the content is age relevant to the user.

[3] http://www.siano-ms.com/

7.7 Upcoming platforms

In recent years another issue has become very important for broadcasters, which has not been addressed in this report. A plethora of online platforms has emerged which are operated by globally active companies such as Apple, Google and Amazon. These platforms normally operate outside national and even European content regulation that applies to traditional broadcasters and other content providers, while competing for the same audience.

They offer a great variety of audio-visual content over the Internet in combination with particular user hardware and software which allows them to control access to this content. *Apple TV*, *iTunes*, and *Google Chromecast* are examples of such platforms. The common feature of all these platforms is that they are available only on broadband and not on broadcast networks. With the growing popularity of the Internet as a source of audiovisual content the impact of these platforms on broadcasters' business case may significantly increase.

Furthermore, TV screens whose generic purpose is to watch broadcast content delivered via broadcast networks can also be used to display audiovisual content from non-broadcasting sources. This possibility is exploited by TV receiver manufacturers who are developing their own audiovisual platforms as a new field of business. As most TV receivers on the market today come with the ability to connect to the Internet, manufacturers are implementing their own proprietary user interfaces intended to direct the viewers to their own web portals and content offers instead of broadcast TV channels. In some cases graphic overlays are introduced on the screen, thereby undermining the integrity of broadcast services.

For broadcasters these platforms pose a big challenge as they lie beyond their influence. Indeed, they change the traditional value chain of broadcasting by inserting an additional 'gatekeeping point' between broadcasters and the viewers, either at the level of service aggregation or at the point of reception. Figure 6 illustrates the situation.

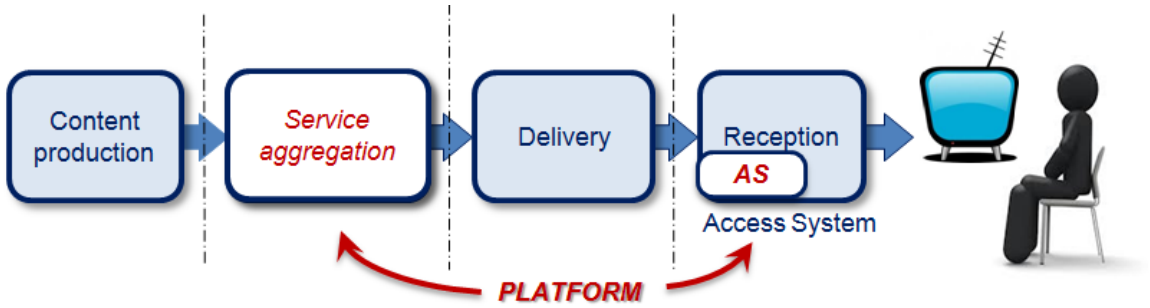

Figure 6: The impact of platforms on the traditional broadcasting value chain.

Broadcasters have a possibility to offer their programmes via these platforms. However, it is up to a company that controls the platform, such as Apple, Google or a device manufacturer, to decide which content is included and under what conditions. The choice is typically made on a purely commercial basis and they have no obligation to grant privileged access to PSMs.

Typically, content offers are organized in a particular way, e.g. in the form of an electronic guide containing a list of programmes. The position of broadcaster's programmes in such lists then becomes a vital issue. It is very likely that a prominent position in such a list could only be obtained by paying significant fees to the platform owner.

8. Conclusions

The principal objective for broadcasters is to deliver the whole range of broadcast content and services to all interested users on a device of their choice and in their preferred environment.

In this study it was assumed that broadcast content encompasses the entire range of content that

broadcasters offer to the audience irrespective of the technical platform across which it is distributed. A broadcast service is an edited selection of broadcast content. A distinction was made between linear, nonlinear including on-demand, hybrid, and data broadcast services.

Furthermore, it was necessary to assess future audience behaviour and expectations. Only if broadcasters know their future target audiences they can develop compelling services and make optimal distribution choices. To this end, a concept of use cases was developed. A use case is defined as a combination of a broadcast service, a user environment in which the service is used, and a user device.

Individual use cases were examined in terms of their relevance to broadcasters. In reality individual different use cases coexist and are strongly influenced by their context.

The use cases have been evaluated on the basis of the following assumptions:

- Linear viewing is the primary way of watching TV content and there is currently no indication that this will change in the foreseeable future.
- Time-shifted and on-demand viewing will continue to grow, but this will not significantly erode the overall amount of linear viewing.
- Migration of TV services from SDTV to HDTV will continue. More content will be offered as well, in particular with the introduction of new HDTV services.
- Ultra-HDTV will be introduced and may become the mainstream format in the medium to long-term future on all TV platforms.
- Portable and mobile devices are increasingly used to access media services. Nevertheless, most of the TV viewing will remain on the large screen.
- Majority of the TV viewing, both linear and nonlinear, will continue to occur in the home. Usage in transient environments will become increasingly significant.
- Innovative media services embrace active audience participation in particular through social networks such as *Facebook*, *Twitter*, etc.
- Hybrid broadcast-broadband services are becoming commonplace based on broadcast platforms and fixed broadband infrastructure. In the future they may also make use of wireless broadband.

Not all identified use cases are equally relevant from a broadcaster's perspective. The relevance is determined taking into account the current situation as well as the short to mid-term future (e.g. next 5 - 10 years). For instance, a use case is considered highly relevant if it is important already now or it is foreseen to become important in the future. Elements to be considered may include the size of audience, availability of suitable devices or the programme offer.

Once a relevant use case has been identified the question is by which *distribution option* this use case can be enabled. For the purpose of analysis of distribution options only the highly relevant use cases have been considered. A *distribution option* refers to any technical possibility available to a broadcaster to distribute its services to the audience. This report dealt with terrestrial, satellite, cable, fixed broadband and mobile broadband as distribution options.

For every use case a set of requirements has been defined that need to be fulfilled by a viable distribution option. The requirements are service focused, i.e. defined in such a way as to ensure desired availability and quality of service. Two types of requirements have been defined:

- general requirements which are common to all use cases, and
- specific requirements for each use case

The distribution options are assessed in terms of their ability to satisfy the requirements. The following are the main conclusions:

- The use cases that include linear services are sufficiently well served by broadcast networks except those that target portable devices such as tablets and smartphones.
- Broadband networks are not suitable to enable use cases containing linear TV services because they typically provide only best-effort quality and are, in general, not able to serve large concurrent audience. This limitation is more pronounced on mobile networks than on fixed.
- The use cases that include on-demand services are only enabled by broadband networks as they provide the required return channel which is not available on broadcast networks.
- A number of use cases are enabled by more than one distribution option.
- No single distribution option can enable all relevant use cases. Therefore, in order to enable the whole range of relevant use cases multiple distribution options need to be employed in a complementary manner.
- Some distribution options may be able to support multiple use cases simultaneously. For example, broadband networks can be used to watch linear TV and access on-demand services at the same time. However, broadband networks may not be able to serve peak demands of all supported use cases simultaneously, even though they may in principle satisfy them individually at different times.
- Some use cases have been identified that are considered highly relevant but cannot be fully enabled by any of the currently available distribution options. For these cases further technical and market developments are necessary.

The above mentioned analysis focuses on individual use cases. However, individual use cases taken in isolation do not cover all situations that occur in reality. Combination of use cases, i.e. simultaneous use of different devices and services or consecutive use over time and space, sometimes even including a switch of device, are becoming increasingly important. This kind of user behaviour is described by the term 'usage pattern'.

A brief analysis of the usage patterns clearly shows that most of them cannot be enabled by a single distribution option. Combination or even cooperation of different options would be required.

In addition, as all distribution options are evolving some of the relevant technical developments have been presented that may help to overcome their current limitations. However, it remains to be seen which of the proposed innovative technical solutions will be successful on the market.

The methodology applied in this study can also be used by broadcasters to identify and assess the available distribution options taking into account their own specific circumstances. There will be no one-fits-all solution.

9. Recommendations

The following recommendations have emerged from the analysis carried out in this report:

1) This report puts forward a methodology to define use cases, identify those that are relevant for broadcasters, and assess the available distribution options in terms of their ability to enable the relevant use cases. While this study remains at a general level, broadcasters are encouraged to carry out their own analysis taking into account their

own specific conditions and constraints. The proposed methodology can be applied and, where necessary, adjusted for that purpose.

2) As no single distribution option can enable all relevant use cases, broadcasters need to use multiple distribution options in parallel. This normally incurs higher distribution costs and potentially inconsistent user experience across different services and devices. Therefore, broadcasters should carefully investigate which combination of distribution options suits their needs best, given their specific conditions and constraints.

3) Linear TV on smartphones and tablets belong to a group of use cases for which at the moment there is no viable distribution option available. As many broadcasters consider these use cases to become crucial in the future they may need to consider getting engaged in corresponding developments. This refers in particular to paving the way for DTT receivers in smartphones and tablets.

4) Use cases incorporating hybrid TV services can only be enabled under the conditions in particular public service broadcasters have to adhere to, by making use of broadcast and broadband networks in parallel. Better and seamless cooperation between networks is a crucial factor thereto. Hence, broadcasters may need to increase their engagement with broadband network operators to ensure satisfying service offers.

5) The EBU should further study different aspects of content distribution, such as:

- Relevance of different distribution options and their evolution in terms of reach, quality, free-to-air access, and market position of PSM organisations.
- The evolution of audience behaviour so that future requirements for media distribution in terms of capacity, availability, and QoS can be discerned.
- The impact of delivery models such as Netflix, YouTube, Chromecast and hybrid approaches (e.g. HbbTV, YouView) on the market position of PSM organisations, including possible economic and regulatory implications.
- Regulatory prerequisites for evolving media delivery over fixed and wireless broadband networks, incl. multicasting in fixed and wireless networks.

10 References

[1] EBU Technical Report 13: The Future of Terrestrial Broadcasting, November 2011 http://tech.ebu.ch/docs/techreports/tr013.pdf

[2] EBU Technical Report 026: Delivery of Broadcast Content over LTE Networks, July 2014

[3] Reimers, U., EBU Technical Review, DTT Quo Vadis – Germany as a case study, Q1 2013 https://tech.ebu.ch/docs/techreview/trev_2013-Q1_DTT_Reimers.pdf

[4] EBU Tech-i, Issue 12, 2012, https://tech.ebu.ch/docs/tech-i/ebu_tech-i_012.pdf

Annex 1: List of use cases

Label	Service	Environment	Device	Relevance	Remark
T01	linear TV	permanent	stationary TV set	high	This use case includes other situations where linear TV is delivered to stationary TV sets, such as public indoor spaces, outdoor public viewing, etc.
T 02	linear TV	permanent	portable TV set	high	
T 03	linear TV	permanent	TV receiver in a vehicle	N.A.	
T 04	linear TV	permanent	desktop computer	high	
T 05	linear TV	permanent	portable ('laptop') computer	high	- less convenient than smartphones and tablets - in the home laptops are not the first choice devices for linear TV
T 06	linear TV	permanent	smartphone	high	- Increasingly important device in the future due to its large number and easy usability - High relevance because e.g. in the home smartphones can be connected to a large screen.
T 07	linear TV	permanent	tablet	high	- Provided that tablets will be widely used in the future this is an increasingly important device due to its capabilities and size of screen - Marketing and demographic aspects
T 08	linear TV	transient	stationary TV set	N.A.	
T 09	linear TV	transient	portable TV set	low	
T 10	linear TV	transient	TV receiver in a vehicle	high	
T 11	linear TV	transient	desktop computer	N.A.	
T 12	linear TV	transient	portable ('laptop') computer	medium	- with the increased usage of smartphones and tablets laptops may be perceived as unpractical for watching TV on the move
T 13	linear TV	transient	smartphone	high	- For short programmes such as news
T 14	linear TV	transient	tablet	high	- Provided that tablets will be widely used in the future this is an increasingly important device due to its capabilities and size of screen - Marketing and demographic aspects
T 15	time-shifted TV	permanent	stationary TV set	high	
T 16	time-shifted TV	permanent	portable TV set	high	
T 17	time-shifted TV	permanent	TV receiver in a vehicle	N.A.[4]	
T 18	time-shifted TV	permanent	desktop computer	high	
T 19	time-shifted TV	permanent	portable ('laptop') computer	high	
T 20	time-shifted TV	permanent	smartphone	high	- Increasingly important device in the future due to its large number and easy usability - High relevance because e.g. in the home smartphones can be connected to a large screen.
T 21	time-shifted TV	permanent	tablet	high	- Provided that tablets will be widely used in the future this is an increasingly important

[4] N.A. 'Not Applicable' - this combination does not represent a valid use case.

Label	Service	Environment	Device	Relevance	Remark
					device due to its capabilities and size of screen - Marketing and demographic aspects
T 22	time-shifted TV	transient	stationary TV set	N.A.	
T 23	time-shifted TV	transient	portable TV set	low	
T 24	time-shifted TV	transient	TV receiver in a vehicle	medium	
T 25	time-shifted TV	transient	desktop computer	N.A	
T 26	time-shifted TV	transient	portable ('laptop') computer	medium	- with the increased usage of smartphones and tablets laptops may be perceived as unpractical for watching TV on the move
T 27	time-shifted TV	transient	smartphone	medium	
T 28	time-shifted TV	transient	tablet	medium	
T 29	on-demand TV	permanent	stationary TV set	high	
T 30	on-demand TV	permanent	portable TV set	high	
T 31	on-demand TV	permanent	TV receiver in a vehicle	N.A.	
T 32	on-demand TV	permanent	desktop computer	high	High relevance because of a growing market for catch-up TV services via personal computers.
T 33	on-demand TV	permanent	portable ('laptop') computer	high	See T32
T 34	on-demand TV	permanent	smartphone	high	See T20
T 35	on-demand TV	permanent	tablet	high	See T21
T 36	on-demand TV	transient	stationary TV set	N.A.	
T 37	on-demand TV	transient	portable TV set	low	
T 38	on-demand TV	transient	TV receiver in a vehicle	high	
T 39	on-demand TV	transient	desktop computer	N.A	
T 40	on-demand TV	transient	portable ('laptop') computer	high	
T 41	on-demand TV	transient	smartphone	high	
T 42	on-demand TV	transient	tablet	high	
T 43	hybrid TV	permanent	stationary TV set	high	
T 44	hybrid TV	permanent	portable TV set	high	
T 45	hybrid TV	permanent	TV receiver in a vehicle	N.A.	
T 46	hybrid TV	permanent	desktop computer	medium	
T 47	hybrid TV	permanent	portable ('laptop') computer	medium	- could be used as a companion screen but this is not common
T 48	hybrid TV	permanent	smartphone	high	- as a companion screen
T 49	hybrid TV	permanent	tablet	high	- as a companion screen
T 50	hybrid TV	transient	stationary TV set	N.A.	
T 51	hybrid TV	transient	portable TV set	low	
T 52	hybrid TV	transient	TV receiver in a vehicle	high	
T 53	hybrid TV	transient	desktop computer	N.A	
T 54	hybrid TV	transient	portable ('laptop') computer	medium	
T 55	hybrid TV	transient	smartphone	medium	
T 56	hybrid TV	transient	tablet	medium	
R 01	linear radio	permanent	stationary TV set	low	
R 02	linear radio	permanent	portable TV set	low	

Label	Service	Environment	Device	Relevance	Remark
R 03	linear radio	permanent	home audio system ('Hi-Fi')	high	
R 04	linear radio	permanent	portable ('kitchen') radio	high	
R 05	linear radio	permanent	radio receiver in a vehicle	N.A.	
R 06	linear radio	permanent	small ('pocket') radio receiver	high	
R 07	linear radio	permanent	desktop computer	high	This use case also includes other situations where linear radio services are delivered to computers, such as an office environment.
R 08	linear radio	permanent	portable ('laptop') computer	high	This use case also includes other situations where linear radio services are delivered to computers, such as an office environment.
R 09	linear radio	permanent	smartphone	high	
R 10	linear radio	permanent	tablet	high	
R 11	linear radio	transient	home audio system ('Hi-Fi')	N.A.	
R 12	linear radio	transient	portable ('kitchen') radio	low	
R 13	linear radio	transient	radio receiver in a vehicle	high	
R 14	linear radio	transient	small ('pocket') radio receiver	high	
R 15	linear radio	transient	desktop computer	N.A.	
R 16	linear radio	transient	portable ('laptop') computer	medium	
R 17	linear radio	transient	smartphone	high	
R 18	linear radio	transient	tablet	high	
R 19	time-shifted radio	permanent	home audio system ('Hi-Fi')	low	time shifted radio does not seem to be a successful service proposition
R 20	time-shifted radio	permanent	portable ('kitchen') radio	low	
R 21	time-shifted radio	permanent	radio receiver in a vehicle	low	
R 22	time-shifted radio	permanent	small ('pocket') radio receiver	low	
R 23	time-shifted radio	permanent	desktop computer	low	
R 24	time-shifted radio	permanent	portable ('laptop') computer	low	
R 25	time-shifted radio	permanent	smartphone	low	
R 26	time-shifted radio	permanent	tablet	low	
R 27	time-shifted radio	transient	home audio system ('Hi-Fi')	N.A.	
R 28	time-shifted radio	transient	portable ('kitchen') radio	low	
R 29	time-shifted radio	transient	radio receiver in a vehicle	low	
R 30	time-shifted radio	transient	small ('pocket') radio receiver	low	
R 31	time-shifted radio	transient	desktop computer	low	
R 32	time-shifted radio	transient	portable ('laptop') computer	low	
R 33	time-shifted radio	transient	smartphone	low	

Label	Service	Environment	Device	Relevance	Remark
R 34	time-shifted radio	transient	tablet	low	
R 35	on-demand radio	permanent	home audio system ('Hi-Fi')	high	
R 36	on-demand radio	permanent	portable ('kitchen') radio	high	
R 37	on-demand radio	permanent	radio receiver in a vehicle	N.A.	
R 38	on-demand radio	permanent	small ('pocket') radio receiver	medium	
R 39	on-demand radio	permanent	desktop computer	high	- This use case also includes other situations where linear radio services are delivered to computers, such as an office environment. - listening to radio on a computer happens very likely while doing something else on the computer
R 40	on-demand radio	permanent	portable ('laptop') computer	high	- This use case also includes other situations where linear radio services are delivered to computers, such as an office environment. - listening to radio on a computer happens very likely while doing something else on the computer
R 41	on-demand radio	permanent	smartphone	high	
R 42	on-demand radio	permanent	tablet	high	
R 43	on-demand radio	transient	home audio system ('Hi-Fi')	N.A.	
R 44	on-demand radio	transient	portable ('kitchen') radio	low	
R 45	on-demand radio	transient	radio receiver in a vehicle	medium	
R 46	on-demand radio	transient	small ('pocket') radio receiver	low	
R 47	on-demand radio	transient	desktop computer	N.A.	
R 48	on-demand radio	transient	portable ('laptop') computer	medium	
R 49	on-demand radio	transient	smartphone	high	
R 50	on-demand radio	transient	tablet	high	
R 51	hybrid radio	permanent	home audio system ('Hi-Fi')	medium	Hybrid radio requires a display which may present a constraint on some home audio systems.
R 52	hybrid radio	permanent	portable ('kitchen') radio	medium	
R 53	hybrid radio	permanent	radio receiver in a vehicle	N.A.	
R 54	hybrid radio	permanent	small ('pocket') radio receiver	low	Hybrid radio requires a display which may not be available on small radio receivers.
R 55	hybrid radio	permanent	desktop computer	medium	This use case also includes other situations where linear radio services are delivered to computers, such as an office environment.
R 56	hybrid radio	permanent	portable ('laptop') computer	medium	This use case also includes other situations where linear radio services are delivered to computers, such as an office environment.
R 57	hybrid radio	permanent	smartphone	medium	
R 58	hybrid radio	permanent	tablet	medium	
R 59	hybrid radio	transient	home audio system ('Hi-Fi')	N.A.	
R 60	hybrid radio	transient	portable	low	

Label	Service	Environment	Device	Relevance	Remark
			('kitchen') radio		
R 61	hybrid radio	transient	radio receiver in a vehicle	medium	
R 62	hybrid radio	transient	small ('pocket') radio receiver	low	Hybrid radio requires a display which may not be available on small radio receivers.
R 63	hybrid radio	transient	desktop computer	N.A.	
R 64	hybrid radio	transient	portable ('laptop') computer	medium	
R 65	hybrid radio	transient	smartphone	medium	
R 66	hybrid radio	transient	tablet	medium	
D 01	data services	permanent	stationary TV set	high	High relevance because of EPG and Teletext. Usability for accessing other data services is limited because of the constraints of the remote control (e.g. absence of appropriate keyboard and mouse). This could be overcome by using smartphones or tablets as remote controls.
D 02	data services	permanent	portable TV set	high	High relevance because of EPG and Teletext. Usability for accessing other data services is limited because of the constraints of the remote control (e.g. absence of appropriate keyboard and mouse). This could be overcome by using smartphones or tablets as remote controls.
D 03	data services	permanent	TV receiver in a vehicle	N.A.	
D 04	data services	permanent	home audio system ('Hi-Fi')	medium	Data services require a display which may present a constraint on some home audio systems.
D 05	data services	permanent	portable ('kitchen') radio	medium	
D 06	data services	permanent	radio receiver in a vehicle	N.A.	
D 07	data services	permanent	small ('pocket') radio receiver	low	Data services require a display which may not be available on small radio receivers.
D 08	data services	permanent	desktop computer	high	This use case also includes other situations where data services are delivered to computers, such as an office environment.
D 09	data services	permanent	portable ('laptop') computer	high	This use case also includes other situations where data services are delivered to computers, such as an office environment.
D 10	data services	permanent	smartphone	high	
D 11	data services	permanent	tablet	high	
D 12	data services	transient	stationary TV set	N.A.	
D 13	data services	transient	portable TV set	low	
D 14	data services	transient	TV receiver in a vehicle	high	High relevance because of EPG and Teletext. Usability for accessing other data services is limited because of the constraints of the remote control (e.g. absence of appropriate keyboard and mouse). This could be overcome by using smartphones or tablets as remote controls.
D 15	data services	transient	home audio systems	N.A.	
D 16	data services	transient	portable ('kitchen') radio	low	
D 17	data services	transient	radio receiver in a vehicle	high	- RDS, TPEG

Label	Service	Environment	Device	Relevance	Remark
D 18	data services	transient	small ('pocket') radio receiver	low	
D 19	data services	transient	desktop computer	N.A.	
D 20	data services	transient	portable ('laptop') computer	high	
D 21	data services	transient	smartphone	high	
D 22	data services	transient	tablet	high	

Annex 2: Assessment of use cases with respect to specific requirements

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
T 01	linear TV permanent stationary TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: very large							
T 02	linear TV permanent portable TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: very large		2a	2a	2a			2a: connection to the access point is needed
T 04	linear TV permanent desktop computer	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 05	linear TV permanent portable computer	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 06	linear TV permanent smartphone	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 07	linear TV permanent tablet	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 10	linear TV transient TV in a vehicle	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 13	linear TV transient smartphone	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
T 14	linear TV transient tablet	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 29	on-demand TV permanent stationary TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: small							
T 30	on-demand TV permanent portable TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: small				30a			30a: connection to the access point is needed
T 32	on-demand TV permanent desktop computer	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small				Note 2			
T 33	on-demand TV permanent portable computer	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small				Note 2			
T 34	on-demand TV permanent smartphone	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 35	on-demand TV permanent tablet	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 38	on-demand TV transient TV in a vehicle	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 40	on-demand TV transient portable computer	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small				Note 2			
T 41	on-demand TV transient smartphone	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
T 42	on-demand TV transient tablet	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 43	hybrid TV permanent stationary TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: very large				?			Note 3
T 44	hybrid TV permanent portable TV set	Data rate: average 8 Mbit/s, minimum 5 Mbit/s Concurrent Audience Size: small		44a	44a	44a			Note 3 44a: connection to the access point is needed
T 48	hybrid TV permanent smartphone	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 49	hybrid TV permanent tablet	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small							
T 52	hybrid TV transient TV in a vehicle	Data rate: average 5 Mbit/s, minimum 2.5 Mbit/s Concurrent Audience Size: small						Note 3	
R 03	linear radio permanent home audio system	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 04	linear radio permanent portable radio	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large		5a	5a	5a			5a: connection to the access point is needed
R 06	linear radio permanent small ('pocket') radio	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small		6a	6a	5a			6a: connection to the access point is needed
R 07	linear radio permanent desktop computer	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small				Note 2			

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
R 08	linear radio permanent portable computer	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small				Note 2			
R 09	linear radio permanent smartphone	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 10	linear radio permanent tablet	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 13	linear radio transient radio in a vehicle	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 14	linear radio transient small ('pocket') radio	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 17	linear radio transient smartphone	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 18	linear radio transient tablet	Data rate: 64 – 192 kbit/s Concurrent Audience Size: very large							
R 35	on-demand radio permanent home audio system	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
R 36	on-demand radio permanent portable radio	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
R 39	on-demand radio permanent desktop computer	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small				Note 2			

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
R 40	on-demand radio permanent portable computer	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small				Note 2			
R 41	on-demand radio permanent smartphone	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
R 42	on-demand radio permanent tablet	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
R 49	on-demand radio transient smartphone	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
R 50	on-demand radio transient tablet	Data rate: 64 – 192 kbit/s Concurrent Audience Size: small							
D 01	data services permanent stationary TV set	Data rate: up to 500 kbit/s Concurrent Audience Size: small	1a	1a	1a				1a: Only data services for “all”, i.e. no individual services
D 02	data services permanent portable TV set	Data rate: up to 500 kbit/s Concurrent Audience Size: small		02a	02a	02a			02a: connection to the access point is needed
D 08	data services permanent desktop computer	Data rate: up to 500 kbit/s Concurrent Audience Size: small				Note 2			
D 09	data services permanent portable computer	Data rate: up to 500 kbit/s Concurrent Audience Size: small				Note 2			
D 10	data services permanent smartphone	Data rate: up to 500 kbit/s Concurrent Audience Size: small							

Label	Use case	Specific Requirements	Terrestrial broadcast	Satellite broadcast	Cable broadcast	Fixed broadband managed	Fixed broadband best effort (Note 1)	Mobile broadband best effort (Note 1)	Remarks
D 11	data services permanent tablet	Data rate: up to 500 kbit/s Concurrent Audience Size: small							
D 14	data services transient TV in a vehicle	Data rate: up to 500 kbit/s Concurrent Audience Size: small	14a						14a: Only data services for “all”, i.e. no individual services
D 17	data services transient radio receiver in a vehicle	Data rate: up to 500 kbit/s Concurrent Audience Size: small	15a						15a: Only data services for “all”, i.e. no individual services
D 20	data services transient portable computer	Data rate: up to 500 kbit/s Concurrent Audience Size: small							
D 21	data services transient smartphone	Data rate: up to 500 kbit/s Concurrent Audience Size: small							
D 22	data services transient tablet	Data rate: up to 500 kbit/s Concurrent Audience Size: small							

Note 1: Best effort broadband networks, both fixed and mobile, are in general not able to provide a sustained minimum quality of service to a large audience. This limitation is more pronounced on mobile networks than it is on fixed. Furthermore, it can be expected that the cost of delivery of broadcast content, i.e. large amounts of data, over mobile broadband is very high. Best effort broadband in a permanent environment and for a small audience is considered to be able to deliver video at 5 Mbit/s sustained bitrate, but not 8 Mbit/s. In the transient case (public places) the capacity will generally not be sufficient to deliver the same sustained bitrate.

Note 2: Some platforms target particular applications. Managed networks offering IPTV requires a special receiver box/set top box which usually cannot easily be connected to a computer. Even though there may be work-around for such cases they are not taken into consideration here

Note 3: Neither a broadcast network (terrestrial, satellite or cable) nor a best effort broadband network on their own will be able to offer hybrid TV to large audiences, but a combination of a broadcast network and a best effort broadband network will be able to offer such services. Managed broadband networks may be able to offer hybrid services.

Note on devices:

- TV sets are equipped with tuners for terrestrial, satellite and cable reception or are attached to a set top box. Furthermore TV sets are capable of connecting to the internet or are attached to a separate device for this, e.g. a game console.
- TV sets in a vehicle are equipped with a tuner for terrestrial reception and may be connected to mobile broadband.
- Radio receivers in a vehicle are equipped with a terrestrial tuner. It is not considered to be connected to mobile broadband.
- It is recognized that there is equipment in the market, e.g. USB sticks containing DTT receivers, which can be connected to computers and mobile devices in order to enable reception from broadcast networks. However, the impact of such devices is rather limited and therefore was not taken into account in assessing the distribution options.
- Some smartphones also contain an FM-receiver. However, this is not generally the case and smartphones with a DAB-receiver are not available, and therefore was not taken into account in assessing the distribution options.

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Annex 3: List of Acronyms

Acronym	Definition
ATSC	Advanced Television Standardisation Committee
CDN	Content Distribution Network
CMMB	China Multimedia Mobile Broadcasting
DAB	Digital Audio Broadcasting
DASH	Dynamic Adaptive Streaming over HTTP
DOCSIS	Data Over Cable Service Interface Specifications
DSL	Digital Subscriber Line
DTT	Digital Terrestrial Television platform
DVB	Digital Video Broadcasting
eMBMS	Evolved Mobile Broadcast Multicast System
EPG	Electronic Programme Guide
FM	Frequency Modulation
FRND	Fair reasonable and Non-Discriminatory
GSM	Global System of Mobile Communications - the 2nd generation of mobile systems
HDTV	High Definition TV format
HEVC	High Efficiency Video Coding
HPHT	High-Power-High-Tower network configuration
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet protocol
IPTV	TV over an IP network - the term commonly used for a managed TV service, as opposed to OTT
ISDB-T	Integrated Services Digital Broadcasting - Terrestrial - Japanese standard for digital TV
ISP	Internet Service Provider
LPLT	Low-Power-Low-Tower network configuration
LTE	Long Time Evolution
MPEG	Motion Picture Experts Group
OTT	Over-The-Top delivery model
PC	Personal Computer
PSB	Public Service Broadcasting
PSM	Public Service Media
QoS	Quality of Service
SDTV	Standard definition TV format
UHDTV	Ultra-High Definition TV format
UMTS	Universal Mobile Telecommunications System - the 3rd generation of mobile communications systems
USB	Universal Serial Bus
WiFi	A trademark for products compliant with the IEEE 802.11 family of standards for wireless local area networks (WLAN)
3DTV	3-Dimensional TV format
3G	Third Generation mobile communications systems
3GPP	Third Generation Partnership Project