A Long Term Vision for Terrestrial Broadcast

Study Mission Report of CM-T

November 2015

DVB Document Reference: SB2333

EXECUTIVE SUMMARY

Terrestrial Broadcast is an established technology essential to the delivery of media and entertainment

Terrestrial Broadcasting is the birthplace of radio and TV, and for many years Radio and TV existed only on and through Terrestrial Broadcast infrastructure.

With its evolution to digital, Terrestrial Broadcast is still an essential delivery method for media and entertainment, although alternatives to Terrestrial Broadcast have developed and in certain markets play a significant role, sometimes complementing and sometimes competing with Terrestrial Broadcast.

Currently 250 million European citizens have Terrestrial Broadcast as their preferred means of media consumption[1], and the Terrestrial Broadcast platform covers between 95% and 98% of European citizens. In Europe the Terrestrial Broadcast platforms host about 2,000 TV channels, including the most popular high audience programmes and channels including those that are free to air and/or from public service broadcasters.

Beyond Europe, through different regional standards, Terrestrial Broadcast is also in wide use and some important deployments are in play now (e.g. large deployments of digital Terrestrial Broadcast underway in Africa in conjunction with analogue switch-off).

Terrestrial Broadcast technology is perfectly suited to perform its core purpose – the delivery of linear TV channels. Here it offers high throughput at a very affordable cost[2] with high quality and reliability; it is available at no cost on virtually all TV receivers produced in the world.

It is widely accepted that linear TV will remain a very important form of entertainment, despite significant new propositions in the market and shifts in viewing habits, and that Terrestrial Broadcast will remain a highly efficient and popular infrastructure for the delivery of this core service.

There is a need to plan a mid-term evolution of the Terrestrial Broadcast technology to deal with the forecasted demand and capacity challenge

The demand for Terrestrial Broadcast capacity is expected to grow significantly between now and 2030. The growth will result from the combination of factors: 1) a roughly stable number of linear TV channels, 2) a shift over time to an all HD landscape, 3) the introduction of some UHDTV services as well as 4) the progressive emergence of new applications (e.g. on-demand and mobile media delivery), which could take advantage of the wide reach and high efficiency of Terrestrial Broadcast.

Part of this potentially large increase in demand can be mitigated by the high efficiency gains to be derived from deploying the latest existing DVB-T2/HEVC technologies.

Nevertheless the re-allocation of the 700 MHz band will drastically reduce the available spectral resource; this will mean that meeting the forecasted capacity demand with such reduced resource will require **a significant improvement in technical efficiency, roughly a factor of 1.8.** Such improvements will need to be obtained by a combination of techniques, whether associated with encoding efficiency (using techniques beyond HEVC) or with physical layer efficiency (going beyond the current DVB-T2 performance), and the DVB has already carried out work that leads to promising possibilities in this direction.

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[1] *Source: BNE Infographics 2015*

[2] *Considering the cost per viewer paid either by the viewer (generally none apart from a Television license fee) or by the broadcaster*

Whilst considering such changes it is also the right time to evaluate the possible introduction of an IP based optional alternative to the DVB Transport Stream.

There is not an immediate need to develop new standards because, in the short-term, the required increase in efficiency can be achieved by more widespread adoption of DVB-T2 in combination with HEVC coding in the Terrestrial Broadcast networks. Therefore development and implementation of any new standards should be aimed towards realisation in the medium term – from around 2020.

An opportunity to converge towards global broadcast and global mobile standards

It would be highly advantageous for the DVB to try to combine the introduction of a next generation Terrestrial Broadcast standard with (1) the possible convergence to a **global Terrestrial Broadcast standard** and (2) enabling the **compatibility with mobile standards** of such a global Terrestrial Broadcast standard; a valuable window of opportunity for the latter created by the on-going generation of the 5G standards.

Nevertheless, the relevance of addressing mobile devices with a broadcast network appears to be quite important, given the growth of these devices as media/TV viewing devices and the challenges that it creates for cellular unicast networks, so that that envisaging such convergence already in the context of 4G/LTE would be beneficial and should be encouraged as quickly as possible.

The major challenge for Terrestrial Broadcast platforms is to better serve and connect with new media paradigms

Even more urgent and challenging than the improvement of the technical efficiency of Terrestrial Broadcast is the need to create the conditions such that terrestrial broadcast can better 'connect' or adapt and serve the new media consumption paradigms.

The digital and media entertainment landscape which is surrounding TV and Terrestrial Broadcast is evolving at a rapid pace, with powerful waves of changes, in end user preferences as well as in commercial models, technology, networks and regulations. The most prominent changes being the trend to on-demand viewing on top of classical linear viewing; the need to feed several screens connected on a home network; the growing habit to consume media on mobile devices whilst on the move; the aspiration to personalized media experiences.

It is not unrealistic, and could be considered to be quite necessary to envisage that the power of terrestrial broadcast, possibly combined with other technologies and networks, is leveraged to support these new use cases. In many circumstances, unicast networks are facing or will face significant limitations such as capacity or coverage constraints, which are less of a problem for broadcast based solutions.

In practice, the following adaptations of Terrestrial Broadcast are considered to be of a high importance to keep it fully integrated with, and "friendly" to new use cases emerging in the broader media consumption context of today/tomorrow.

- A strong and smooth integration of Terrestrial Broadcast in the **Home Networks.**
- The possibility to perform a **local service rebuild**, where a Terrestrial Broadcast receiver will be capable of re-assembling, on the basis of end user choices/preferences or remotely transmitted instructions, the individual services and programmes (for instance a premium UHDTV sequence) to be consumed by the individual receiver.
- The tight association and utilization of **return channel data** (of technical or commercial nature transmitted on another network) with Terrestrial Broadcast services.
- The possibility that files and content intended for **on demand** viewing (e.g. VOD, replay) can be transmitted over Terrestrial Broadcast, in association with pre-load and discovery mechanisms.
- The abilities of Terrestrial Broadcast networks and services to operate in highly **dynamic service plans**, where the allocation of Terrestrial Broadcast capacities to services can be reconfigured very quickly with the appropriate notice to Terrestrial Broadcast receivers.

- Although this remains quite speculative, one could also consider a better association of Terrestrial Broadcast with **IoT**, with on one hand, a Terrestrial Broadcast device making use of new IoT capabilities, and on the other hand, some IoT traffic and protocols being hosted as supplemental services in a Terrestrial Broadcast transmission system.
- Finally, the necessary steps shall be taken to ensure that Terrestrial Broadcast is associated with a high level of **security**, so that end-users, content creators and editors are fully comfortable in having valuable information and content distributed over Terrestrial Broadcast.

DVB cannot drive alone the future of Terrestrial Broadcast; it requires concrete action by the Terrestrial Broadcast community at large

Achieving these evolutions is key to the future of Terrestrial Broadcast, but it is very likely to **require action over and above the traditional DVB action** of generating new standards. Standards enabling these evolutions may already exist, in or outside of DVB, and as it has been seen in the past, a good standard is not sufficient to guarantee widespread adoption of a technology.

This constitutes a key question and maybe even a challenge to the Terrestrial Broadcast community at large, of which DVB is a key member; **how can it be assured that these evolutions take place?**

It becomes quite clear that the process should not be limited to, nor initiate with the generation of a standard. On the contrary, it may have to start the other way around with the Terrestrial Broadcast community identifying new use cases, then prototyping and developing solutions with the relevant standards being developed later, as needed.

There is a danger that in the absence of significant progress along those themes, Terrestrial Broadcast would become a high performance but isolated delivery solution, with several adverse consequences;

- the homes and broadcasters relying on Terrestrial Broadcast would be put at a disadvantage in terms of the services, comfort and user experience they access or provide

- this would be a waste of Terrestrial Broadcast's excellent technical efficiency for delivering high throughput digital content, in a market that is so hungry for content yet always seems to be potentially on the edge of the available capacity

- and the companies who provide services and products to the Terrestrial Broadcast ecosystem would be negatively affected.

From this point of view, it is advisable that the DVB and DVB members share the findings of this report as much as possible with other institutions and parties, with a view to jointly identifying, or creating, the place where this work would be best undertaken.

Tips for a fast reading

A reader who would like to quickly capture first the main messages of the Report is advised to refer to;

- *List of 20 Key **Context Factors** (page 10)*
- ***Context Wrap-Up** (Page 41)*
- *Conclusions of the **Supply & Demand Model** (page 47)*
- *Conclusions of External **Survey** (page 55 & 56)*
- ***Vision – 14 Predictions for Terrestrial Broadcast** (Page 59& 60)*
- ***14 Recommendations** (Page 61 & 62)*

INTRODUCTION AND ACKNOWLEDGMENTS

Context and Objectives of the Report

Terrestrial Broadcasting is the birthplace of radio and TV, and for many years radio and TV existed only on Terrestrial Broadcast infrastructure.

With its evolution to digital, Terrestrial Broadcast is still an essential delivery method for media and entertainment, although alternatives to Terrestrial Broadcast have developed and play a role, sometimes alongside or complementing Terrestrial Broadcast.

The terrestrial standards developed by the DVB Project (i.e., DVB-T and then DVB-T2) have played an extremely important role in driving the development of the Terrestrial Broadcast platform across 150 countries, serving a population of 250m already across Europe and many more across the rest of the World; 82% of the worlds Terrestrial Broadcast transmitters operate with these specifications. DVB specifications at large are now used by over 1.1 Billion receivers in the world, which makes it a clear leader in digital television.

As the general digital technology and media landscape which Terrestrial Broadcast serves is evolving quickly, sometimes with far reaching consequences, the role and requirements for Terrestrial Broadcast may have to change significantly to adapt and develop in this new environment.

As the role of Terrestrial Broadcast changes, the DVB's specifications for Terrestrial Broadcast are likely to have to evolve accordingly, anticipating future requirements.

The DVB's Steering Board and Commercial Module felt it was necessary to **envisage and as needed plan these changes against a certain holistic vision of what Terrestrial Broadcast would likely be in the future**, so that the DVB's specifications would be consistent with this vision.

The Commercial Module and Steering Board therefore tasked the CM-T (Commercial Module - Terrestrial) to establish a dedicated Study Mission to generate a Long Term Vision for Terrestrial Broadcast.

This document is the report of the Study Mission, developed from September 2014 to October 2015.

The report aims to offer **a vision of what terrestrial broadcast will (have to) do in the mid/long term, identifying the most likely / important use cases to which terrestrial broadcast technology could / should be applied**[3].

This vision is aimed at covering a **period starting around 2020 and ideally lasting until around 2030 at least**. It is assumed that the period before 2020 will be principally addressed with existing standards and specifications except for some minor adaptations, although in many cases these existing standards (e.g. DVB-T2) are only starting to be deployed in some countries and transition is on-going, potentially lasting until or even beyond 2020.

"Terrestrial Broadcast" for the purpose of this report is defined as **the set of technologies and use cases which can be deployed on terrestrial broadcast networks** with significant proximity, though not necessarily a complete replication, of the three core components of Terrestrial Broadcast as we know it now, being: (1) High Tower High Power Broadcasting Infrastructure, (2) delivery of linear television and radio programs and (3) UHF frequencies designated for broadcasting TV; although the traditional broadcast delivery of live TV will remain a central use case of Terrestrial Broadcast, the Study Mission

[3] *Also refer to document CM-T 0031 "Framework for Long Term Vision Study Mission"*

scope intends to cover all new relevant use cases (e.g. mobile, on demand, etc.) that could benefit from terrestrial broadcast technologies and infrastructure.

Given the European roots of DVB, this report is written with a certain implicit focus towards Europe. However, given the recognized added value of global standards and technology, and the fact that Terrestrial Broadcast, whether based on DVB standards or not, exists in many non- European countries, the statements and proposals made in this report are meant to be sensitive to the broader global market.

Conversely, as no single European situation exists, the statements and proposals made in this report, although broadly representative, cannot be considered as being fully applicable to each country across Europe.

How this Report is Constructed and Organized

In Chapter 1, we focus on the Context in which Terrestrial Broadcast will evolve and identify a number of factors that are considered to be really shaping the future market context. These context factors are grouped into four main categories: end user needs, technology, business model and market structures, regulation and social factors.

Each of the 20 context factors identified is briefly discussed, and a first level of **impact assessment** is provided, i.e. answering the question; "**What is this likely to mean for Terrestrial Broadcast?"**

All factors are mostly analysed and discussed from a non-DVB perspective, except for one (N° 13: Significant potential for improvement in Terrestrial Broadcast) where we summarize the possible improvements that could be achieved in Terrestrial Broadcast technology, based on the findings of the DVB's Next Generation Terrestrial (NGT) Study Mission.

In Chapter 2, we have modelled a quantitative translation of the trends and impacts detected in Chapter 1, which takes the form of a so-called **"Supply & Demand Model".**

In Chapter 3, we have summarized the results of an External Survey, conducted in June 2015, where the Study Mission collected the thoughts of 62 media and digital professionals (which included both DVB members and non-DVB members) on the findings and possible proposals of the Study Mission.

Chapter 4 is what delivers the Long Term Vision for Terrestrial Broadcast, trying to answer the central question; "**What will or should Terrestrial Broadcast look like in 2030, and what will it be used for?" This builds on the** analysis and facts gathered in Chapter 1 to 3.

Firstly **14 "Predictions"** are presented which express the overall vision, according to the Study Mission, of what Terrestrial Broadcast is likely to be in 2020-203, or2030. These predictions include, directions in which Terrestrial Broadcast could try to move to maintain and enhance its attractiveness and business value within the broadcast and media ecosystem and for its stakeholders.

This vision is then translated into a set of **14 action oriented Recommendations**, whereby the Study Mission expresses 14 concrete proposals for evolving and adapting the Terrestrial Broadcast technology, functionalities and use cases, so that the vision expressed earlier can be fulfilled.

Where applicable, the specific actions, which fall within the remit of the DVB, are stated in each Recommendation. However, it is important to note that **not all of these recommendations are necessarily directly aimed at the DVB**, nor suggesting that DVB should initiate the work to develop new specifications for each of them; some of the recommendations are **more generally aimed at the broader Terrestrial Broadcast Community**, in which DVB and DVB members are important members.

The **report advises the Terrestrial Broadcast stakeholders to collectively act to secure the recommended evolutions**. It should be noted that the exact ways and means for this action are not fully known or detailed in the report and will remain an important topic for further action after the publication of this report.

Acknowledgments & Thanks

The work on this report, which took place for roughly a year from September 2014 to September 2015, has been intense, challenging, sometimes with heated debate but extraordinarily exciting.

The Study Mission group was comprised of 15 media and technology professionals[4] from 7 European countries, representing major national or global enterprises, who passionately worked together, with their respective and diverse point of views, to generate the report.

They, found it to be an excellent forum to discuss and draw together, as accurately as they could, a picture of what their industry was likely to be, or could try to become, in 15 years time, with so many changes around us.

For this, they would like to extend a **warm thank-you to the DVB, which triggered and hosted this work**, and to their respective employers who allowed the time and resources necessary to complete this significant piece of work.

They would also like to express **special thanks to the representatives from the sixty two organizations who contributed to the External Survey** (Chapter 3) which has been an extremely useful tool to inform and check the group's findings and proposals with the views from a broader group of professionals.

Finally, the Chair of the CM-T group would like to express his **deep gratitude for the professionalism, the engagement and the patience of the Study Mission participants** who have so efficiently contributed and supported the Study Mission working process.

DVB Approval

The document as it is stands here is the final edited version issued by the CM-T Study Mission and has been approved by the DVB's Steering Board (SB) in its meeting on the 18th of November of 2015. The Report is authorized to be made publicly available outside of the DVB.

[4] *It is important to note that the companies who participated in the study mission represented the complete range of the industry chain and DVB constituencies; broadcasters (4) – broadcast network operators (4) – technology suppliers (2) – consumer equipment and silicon (4) – non government organization (1)*

TABLE OF CONTENTS

CHAPTER 1: KEY CONTEXT FACTORS FOR TERRESTRIAL BROADCAST'S EVOLUTION

The purpose of this Chapter is to capture, from the discussions, which took place in the Study Mission, the most relevant factors that will shape the context in which Terrestrial Broadcast will evolve, and which therefore should have significant influence on its development.

The factors identified in this chapter are grouped into four main areas:

- End User Needs and Preferences
- Commercial Models and B2B Needs and Preferences
- Non Broadcast technology (Technology considerations that are likely candidates to be integrated into Terrestrial Broadcast are discussed in Chapter 4)
- Regulation & Spectrum

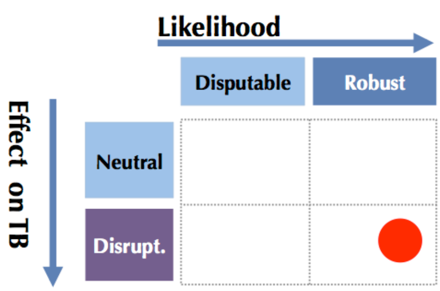
Each identified factor will be briefly described, and a first level of the impact on Terrestrial Broadcast will be provided, attempting to predict what consequences it will have on Terrestrial Broadcast and what kind of action/reaction should be taken to help Terrestrial Broadcast face this change.

These factors are predicted to have market relevance from or before 2020 and for at least the next decade so that they will have a real impact on the 2020-2030 context of Terrestrial Broadcast with the potential to significantly shape its evolution.

The factors listed in this Chapter 1 can be considered as being the core assumptions which the CM-T group took as being applicable to the future, and on the basis of which the group developed its assessment and proposals for the evolution of Terrestrial Broadcast.

There is an inherent and accepted level of subjectivity; the report does not aim to provide proof that all these predictions are correct, but the CM-T group consider them to be realistic, forming the basis for which the DVB should plan for the evolution of Terrestrial Broadcast.

Rating the Likelihood and the Impact of Context Factors



Each factor has been rated by a small two-dimensional matrix, the form and scale of which is explained below.

Likelihood rates the level of certainty that the said factor will play in the market.

Disputable would mean that there is no clear consensus within industry professionals that the factor will materialize in a significant manner over 2020-2030, although a significant proportion (at least half) believe it will (example; all TVs are connected). Factors that are only supported by a small fraction have been omitted.

Robust would mean that most or all industry professionals agree that the factor will materialize in a significant manner over 2020-2030 (example: massive mobile video - TV usage).

Effect on Terrestrial Broadcast rates the effect, from neutral to disruptive, that the materialization of the said factor is predicted to have on Terrestrial Broadcast.

Neutral would apply to a factor for which there is a consensus that it will have no significant positive or negative impact on Terrestrial Broadcast, and Terrestrial Broadcast can largely ignore it.

Disruptive would apply to a factor for which there is a consensus that it is likely to have a significant impact on Terrestrial Broadcast. It may be positive (signified by a green dot: creates an opportunity which the Terrestrial Broadcast community will be trying to embrace and work towards), negative (signified by a red dot: creates a threat that has the potential to significantly reduce the attractiveness of Terrestrial Broadcast, and which will lead the Terrestrial Broadcast community to try to respond to the threat), unclear (signified by a grey dot: no clear view on the likely effects of the disruption) or a blend of positive, negative and unclear (signified by a multi-coloured dot: may create opportunities and/or threats).

Overview of Key Context Factors affecting Terrestrial Broadcast

1. End User Related Factors

1. Ever Increasing video consumption, with more and more on-demand
2. HD as the basis - and going beyond HD
3. Connected Home is the norm, with multi-screen consumption of media
4. Growing Out of Home and On-the-Move Media consumption
5. Personalized & Social Media experiences with augmented and programmatic content
6. The need for trusted solutions and privacy

2. Technology Factors

7. Universal basic broadband connectivity, but lack of universal true ultra-high speed
8. "Connected Terrestrial Broadcast" becomes the norm
9. Sub-optimal and variable receiving conditions
10. IP broadcasting
11. Fast developing cellular networks, moving to 4G and then 5G
12. Continuous improvements in encoding
13. Significant potential for improvement in terrestrial broadcast proposition

3. Business Models & B2B Considerations

14. Industry structure changes: a decoupling of services and network; dilution of traditional business models; new players
15. A "Big Data" world
16. "Internet of Things"
17. Global standards

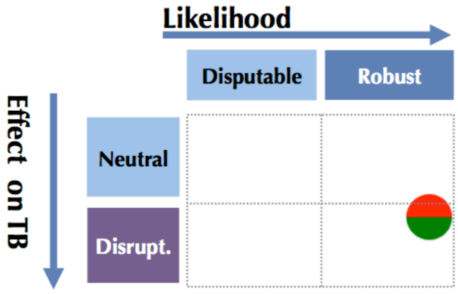
4. Regulatory, Spectrum & Other Social factors

18. Spectrum reduction
19. General interest objectives
20. Energy efficiency and environmental issues

1 End User Related Factors

1. Ever increasing video consumption, with more and more on-demand

Video remains the principal category of entertainment and average minutes of video & TV per day per person[5] will continue to increase although at a limited pace.



Classical viewing of Linear TV is and will remain a very important use case, but the video & TV programs consumed by people will integrate **more and more on-demand viewing,** also called “non-linear”; a 75% (linear) / 25% non-linear balance could be considered to be a realistic average in the mid-term, while it may vary significantly across countries and population segments.

A large part of on-demand viewing will be derived from linear TV through various time shifting mechanisms (PVR, replay, restart, OTT version of linear) reflecting the popularity of traditional linear broadcasted content.

The remaining part of non-linear viewing will be originated from newer sources / players (e.g. VOD, other OTT), independently of a linear existence of these TV programs; such alternative sources will be predominantly professional content producers, with quality targets and levels (editorial quality, technical quality) that are comparable to classical TV content.

Consumer preferences may also become more volatile and change more rapidly amongst different types of programs and sources of content.

➢ **Impacts on Terrestrial Broadcast**

- *The continuous appetite of end-users for video/TV with increasing quality levels will result in massive amounts of digital payload to be distributed*
- *Linear TV will remain a significant use case, and Terrestrial Broadcast will remain a valued delivery method in many instances given its high quality/low cost promise for programs intended for large audiences*
- *Adapting to on-demand is an important goal for Terrestrial Broadcast, both in the sense of (i) delivering on demand content and (ii) interoperating with BB delivered on-demand*
- *Increased variety of use cases needing more flexibility in pay-load on Terrestrial Broadcast (e.g. instant change of program in one terrestrial broadcast frequency, scheduled or not) is also a key goal to make sure scarce capacity is always used in the best manner*

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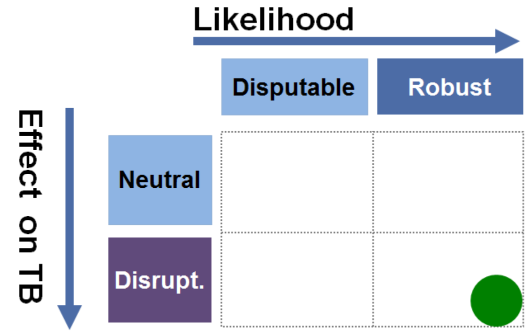
5 *Include all screens - See for instance Nielsen Total Audience Report Q3 2014*

2. HD as the basis – going beyond HD



Users develop technologies based upon predictions of the demand. In terms of television there is a long history of this where part of the television usage is focused on delivering the 'Cinema Experience' to the home. The cinema experience has been focused on delivering an immersive high quality audio and video experience to the viewer and this is a factor driving television broadcasters around the world in film, studio and live event content. Delivering this immersive viewing experience has driven the demand for high quality audio and video quality and the underlying technologies behind the delivery of audio and video in the end-to-end system from the camera to the home.

The switch from Analogue to Digital technologies in the Audio/Video industry has had a significant impact on television during the past 15 years. In the early phase (and partly still today) the image quality was Standard Definition (SD), the applied video coding standard was MPEG-2 and the range of related bitrates was between 3 and 6 Mbit/s (see e.g. Germany today with DVB-T and about 3.25 Mbit/s/service). The emergence of HD video has had a positive impact on television viewing and more recently there is a strong desire to follow the cinema industry to go beyond HD video quality in broadcast. The provision of High Definition (HD) services started in 2008 with DVB-T in France with H.264 coding and data rates of about 8 to 10 Mbit/s; more efficient services were started (e.g. in the UK) with DVB-T2 and H.264 coding.

The quality advantage to the viewer of an HD service is indisputable and there is no doubt of the strong preference of end customers for HD viewing. Most TV channel broadcasters, especially those with leading or premium pay TV channels, are aiming at being broadcast in HD at a certain point[6]. This is creating significant demand on the networks, and in the case of Terrestrial Broadcast it requires systematic usage of the most efficient technologies (i.e. T2 or NGT for the physical layer and HEVC for video coding). On the other hand, an overwhelming majority of receiving devices (TV sets, and also PCs, smartphones and tablets) now have the technical capabilities to display an HD quality image. UHDTV sets entered the market in 2014. Tablets and also some smartphones are starting to provide a display resolution beyond Full HD and will soon reach UHDTV resolution. A high image quality, beyond Full HD, is relevant for those devices due to the short viewing distance.

Clearly for Audio and Video services to continue to develop beyond HD, development of technologies has to continue. The explanation below shows how encoding technology is progressing to enable future developments, but multiple areas of technology development are needed to enable audio and video services to continue to evolve in a broadcast environment.

As part of an on-going evolution to deliver future demands, HEVC has been developed with the goal to reach 50% bitrate gain on average compared to H.264/AVC at the same video quality. Figure 1 below shows Formal subjective verification tests have been performed by MPEG to evaluate the quality of the HEVC Main Profile compared to the H.264/AVC High Profile.

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[6] *see for instance recent (Oct 2015) channel reallocation in France , where all but 2 DTT channels have asked to switch to HD*

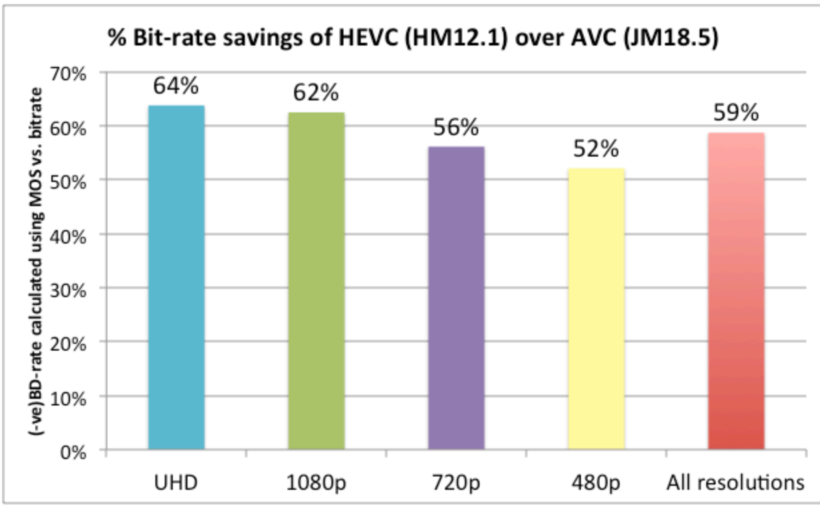


Figure 1: MPEG results for the average bit-rate savings of HEVC compared to AVC

(Source: JCTVC-Q0204)

These test results show that HEVC achieves on average 62% gain over H.264/AVC for 1080p content and 56% for 720p content, with minimum gains of approximately 35% and maximum gains of over 70% for some sequences. The increase in coding efficiency offered by HEVC compared to H.264/AVC might therefore lead to an increase of the number of HDTV programmes within the same available spectrum.

DVB is currently in discussion about the standardization of UHDTV with HEVC video coding. UHDTV phase 1 is already standardized in ETSI TS 101 154 to support 3840x2160p formats at up to 60fps with 8 or 10 bits/samples and either standard or wide colour gamut. Various equipment that support this first version of UHDTV are currently appearing on the market, and it is to be expected that services might follow soon (probably in France as early as in 2016, although these will represent an early start with limited content and receiver availability)

In the meantime, DVB is still discussing about the exact technical parameters in order to maximise the video quality for UHDTV phase 2. While support for 3840x2160p formats at up to 120fps with 10 bits/samples, wider colour gamut and higher dynamic range seems desirable, there are still discussions about the technical feasibility of these formats in the considered timeframe. For terrestrial broadcast, "improved HD" formats (1920x1080p at up to 120 fps with 10 bits/samples, wider colour gamut and higher dynamic range) are likely to be adopted rather than formats based on actual UHDTV resolutions due to bitrate constraints. The current schedule is to complete the specification for UHDTV phase 2 (alongside "improved HD" formats) in 2016, so that equipment and services could be available in 2017/2018.

Also under discussion within ITU-R is a new video format with extended dynamic range for future HDTV and UHDTV services.

UHDTV is one example of the current thoughts about future technologies for a ‘beyond HD’ service but these thoughts should not be constrained to just this. The development of encoding technologies alone is not sufficient to continue to satisfy increasing demand for audio-video services. Supporting technologies in the end-to-end system need to evolve to enable the continuation of services beyond HD and beyond Ultra HD in the long-term vision for terrestrial broadcasting.

Generally, other means of distributing TV services, e.g. satellite and cable, are currently at the forefront of the UHDTV distribution. A special case is OTT: It should be noted that the OTT industry is very quickly embarking the UHDTV standards, at least at the level of the source files and originating platforms although again, it remains highly disputable that all or at least most end-users will all have access to the high broadband connectivity (15-20 Mbps) required to enjoy live UHDTV. Furthermore, OTT content is often received with variable bitrate (adaptive streaming) so that the actual bitrate is adapted to the throughput of each individual connection and device. While this is a very smart manner of managing heterogeneous quality, it leaves uncertainty as to the proportion of time UHDTV resolution can be maintained for the received content.

As for terrestrial broadcast delivery of UHDTV, given also the very significant bandwidths required to deliver UHDTV services, it seems quite unlikely that a massive migration to UHDTV will happen, and it can be anticipated that the future landscape will be a mix of HD and UHDTV resolutions, the latter being an exception for quite a period of time.

However, this does not imply that broadband networks will become the natural hosts of OTT delivered UHDTV while terrestrial broadcasting would be an UHDTV-poor platform. On the contrary, both approaches will have to cope with the very heavy bandwidth requirements of UHDTV content, and their cooperation may be the only workable way to make UHDTV available to consumers, as explained below.

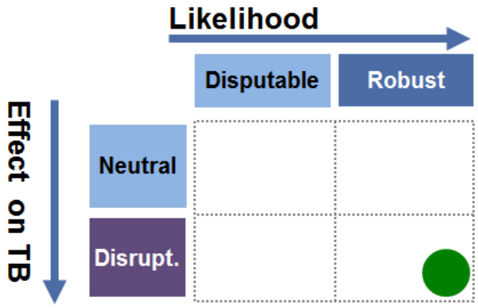
More specifically, the following can be anticipated:

- A few leading TV channels will have a UHDTV version on air on a permanent basis, as soon as this becomes technically feasible
- It is likely to be on a simulcast mode, i.e. the HD version being also broadcast as not all receivers will be compatible for many years
- A broadcast of a "UHDTV compilation service" is a likely model, where one or two (technical) UHDTV channels will be on air, not being assigned to a particular TV program. On the contrary, there will be some kind of rotation, where at different times/days, the UHDTV channel will be occupied by different TV programs. An automatic notification or switching of the TV set between HD and UHDTV resolution, when available, will be provided, for example on the basis of HbbTV-like mechanisms.
- Another possible model is the one of "Pushed UHDTV", where certain programs that cannot be broadcast in real time in UHDTV (e.g. due to lack of sufficient network capacity) could be broadcast as files in advance over the DTT network and stored in TV sets/devices (with the appropriate content protection etc.) and played (as UHDTV) at the same moment that the HDTV version of the program is on air. A TV set that has received the UHDTV version would automatically switch to and play that UHDTV version. Technical (e.g. network load) and cost issues need to be considered here.

In terms of a long term vision for terrestrial broadcasting the evolution needs to continue and not stand still; i.e. not only beyond HD but beyond Ultra HD (see e.g. 8K in Japan). Within the next 15 years (the scope in time of this report) developments in the area of video coding going beyond HEVC are also envisaged as enablers.

> **<u>Impacts on Terrestrial Broadcast</u>**
>
> - *Terrestrial broadcast network and technology planning should be based on the goal of achieving as fast as possible (before 2020) 100% HD.*
> - *The provision of terrestrial UHDTV services is technically feasible today on the basis of DVB-T2 and HEVC, but significant terrestrial broadcast capacities need to be available to enable terrestrial broadcasting to progressively deliver UHDTV formats, although this may not be universal. This will include the necessity for significant spectral efficiency improvements.*
> - *As a starting or complementary solution, alternative models (hybrid, compilation, pre-load) for delivery of UHD will emerge as well. UHDTV may be marketed as a premium service (like HD in some countries)*

3. Connected Home is the norm, with multi-screen consumption of media



In the future, it is envisaged that almost all homes will have an in-home network, typically Wi-Fi. Most, if not all in-home appliances and especially audio-visual devices will be connected. The in-home distribution and sharing of video will be a key feature of such networks. Their ability to transport high quality video reliably around a home is likely to improve with time.

Depending on the number of people in a household it is likely that several devices will be used simultaneously to access the full range of content. For example primary and secondary TV sets, tablets, mobile phones, laptops, game consoles may all be used simultaneously to view different content. At one extreme, this content could all be linear TV and at the other this could all be on-demand content. The user is unlikely to care how the content is delivered providing it is of acceptable quality and cost for the context.

Hybrid Terrestrial Broadcast (a combination of Terrestrial Broadcast and broadband delivery) has already been very successful in some markets, placing Terrestrial Broadcast at the heart of the connected home. Hybrid Terrestrial Broadcast's ability to deliver a quality of service that consumers have come to expect from Terrestrial Broadcast, together with the increased choice offered by on-demand services, has helped the platform maintain a strong position in many markets.

Terrestrial Broadcast consumer products have already built upon this success to progressively integrate with in-home networks and the devices (screens) connected to them in a more seamless manner. Developments in this area, which extend the reach of DVB services to home network devices, can be demonstrated by a multitude of solutions and products that are available today such as:

- Network attached tuners with simple IP streaming (e.g. Tablet TV).
- SAT>IP[7] solutions allowing IP streaming home gateways.
- DVB link solutions for home NAS.
- DLNA[8] enabled products (e.g. PVRs).
- TV Manufacturers streaming to second screens.
- PVR to Internet streaming interface products (e.g. Slingbox).

Note that once Terrestrial Broadcast delivered content is redistributed across an in-home network, mechanisms need to be in place to enable digital rights management / conditional access to work seamlessly across Terrestrial Broadcast receivers and devices connected to the home network. This issue is relevant to both pay and FTA broadcasters.

Although such technology is not new, the key to future success would seem to be enabling products that can **seamlessly** integrate into such networks. This means end user devices such as mobiles, tablets or secondary TVs need to be able to effortlessly **find** and **access** content from any networked Terrestrial Broadcast receiving devices. This functionality requires devices to use industry accepted interface standards to enable a "plug and play" approach for the consumer.

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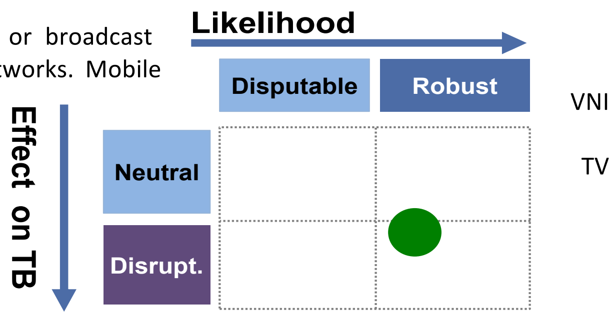
[7] *http://www.satip.info/sites/satip/files/resource/satip_specification_version_1_2_2.pdf*

[8] *Digital Living Network Alliance*

Impacts on Terrestrial Broadcast

- *Terrestrial Broadcast needs to be **seamlessly** integrated into home networks, not an isolated delivery pipe to the home, that feeds only one screen (for example, the main TV set).*
- *Terrestrial Broadcast receivers must be fully connected to the home network, content delivered by Terrestrial Broadcast must be able to be **found** and **accessed** effortlessly by any in-home device / screen.*
- *New ways of distributing content within the home are likely to emerge as network connected broadcast receiving devices become more main-stream, and home networks evolve.*
- *With multiple devices being used to view different content simultaneously, this implies the need for the content delivered by Terrestrial Broadcast to be more easily distributed (e.g. multiple Terrestrial Broadcast tuners and the capability to serve multiple streams from cache devices).*
- *Mechanisms to enable seamless DRM/CA across such networks are important.*

4. Growing Out of Home / On the Move Media consumption



Video services can be delivered point-to-point or broadcast over mobile broadband or via broadcast TV networks. Mobile video consumption is growing rapidly (Cisco 2015), so it is likely mobile broadband networks will need assistance from broadcast networks.

Ownership of smart phones and tablets with high quality displays and powerful processors is growing fast while mobile networks, although not always delivering perfect service, are increasingly available to anybody almost anywhere; this is encouraging users to consume the online, on-demand services they use indoors, when they are outdoors and when they are travelling.

The demand for live TV content on handheld, mobile terminals, outside of the home is a key but only one 'mobile' use-case which may not be the most significant and will probably be limited to a few landmark events / programs (e.g. key sport events, breaking news). When travelling or when they have time to spare, users want on-demand, and may prefer short-form (although pre-load of long form content like movies, series episodes, may be quite relevant for commuting, etc.)

In car entertainment will become more and more important; preferred content (type and form) may also vary for in-car viewing against handheld and on the move.

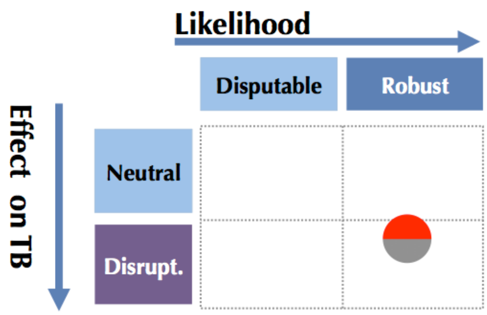
Currently, when outdoors, users must rely on unicast delivery mechanisms over mobile broadband and Wi-Fi networks for their online video services. While the capacity and ubiquity of these unicast networks and technologies are improving, the limits of pure unicast access to content become very visible, in terms of massive growth of traffic, on mobile quality, lack of sufficient data quotas for end-users as well as unsatisfactory quality of experience (delay in access to content, freeze, errors, etc.); the use of broadcast technologies (potentially within the mobile networks) is increasingly seen as a way to yield greater efficiencies in order to support the expected growth in demand, with the expected quality, at a sustainable cost.

As the storage capacity of the handheld devices is increasing year-on-year, approaches that rely on the caching of content directly on the device become more affordable and compelling for the user, as they would greatly increase the quality of viewing experience, while the overall network load can be better absorbed.

➢ **Impacts on Terrestrial Broadcast**

- *Addressing mobile devices on the move is still a major goal for Terrestrial Broadcast in some regions, as it cannot be taken for granted that mobile networks can alone meet the massive demand for out of home media consumption*
- *Serving mobile devices cannot be limited to delivering existing linear TV services to mobile platforms; Terrestrial Broadcast must become capable of delivering the complete digital content catalogue, principally on-demand media, although live TV must also be supported; this will be achieved by push and cache mechanisms for popular content (known as the fat tail).*
- *Terrestrial Broadcast networks must become part of a heterogeneous data/mobile network that facilitates the consumption of on-demand video services, in any location and when moving at a variety of speeds, at a low cost and with a high quality level. Such a network would make best use of finite RF spectrum resources.*
- *Terrestrial Broadcast must work closely with the CE industry and mobile ecosystem to ensure the features and specifications of the distribution networks and the handheld terminals are aligned. It is likely that existing standards are sufficient, but this close working may lead to some kind of a convergence between telecom and Terrestrial Broadcast stakeholders for a mobile broadcast standard*

5. Personalized & Social Medias experiences with programmatic and augmented content



Tomorrow's consumers are likely to demand more personalization. Individually tailored music/video services, personalized apps with augmented content delivered via the web or HbbTV are already proliferating. People want to be in control of their digital content, and increasingly want to choose where, when, and how they experience it.

If the user permits it, tomorrow's receivers will know who is watching, what they like to watch, and their desires and preferences for how to engage with content.

Television has to evolve to compete for the consumer's time. TV related social media, alternative media associated with TV shows, blogging about TV, and targeted and customized advertising on all screens are becoming the norm. TV programmes are now being judged on the level of social media activity they generate not only on their viewing figures. This will further accelerate as hybrid television, improved content recognition, synchronization, knowledge of the consumer, and context/content awareness between devices all improve.

The generic experience of watching TV will in the future become personalized in many ways;

- A wealth of audio, video and rich data content available for the same underlying program
- Smart recommendation engines and augmentation apps will offer additional streams, via IP and broadcast.
- Companion screens which are content aware giving social hive access to the content that is watched.
- Additional audio and video elements synchronized together on the primary and companion-screen.
- Programmes that grow after their release, for example with the addition of supplementary audio, video and data.
- Flexible advertisement insertion systems that personalize TV commercials.

The Key aspects of Personalized TV (further details in Appendix 1) subject to data privacy consent, section 6.

- **Personalized Experiences** - Personalization lets viewers and listeners choose and tailor the TV experience to their unique needs or preferences, using object based codecs and data.
- **Personalized Commercials, Content Packages, and Offers** - Terrestrial Broadcast will evolve to allow a TV to swap generic advertisements that are irrelevant to many viewers and instead, play commercials that are tailored to their interests.
- **Personalized Content selection** - In future, consumers may choose to permit the set up their own TV viewer profiles based on aspects they care about, and to blend this with data from social media to provide enhanced recommendations

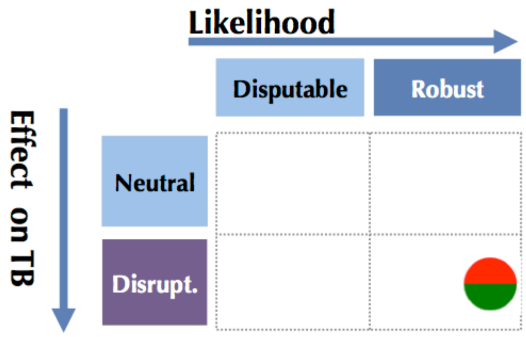
➢ **Impacts on Terrestrial Broadcast**

- *TV becoming personalized means that it is less generic. This presents a challenge for Terrestrial Broadcast as many more personal/ 'unicast' objects will be available. Hybrid delivery is key, and Terrestrial Broadcast should allow the most common set of popular objects to be broadcast whilst more niche personalization aspects could use an IP unicast pipe.*
- *There is however no inherent contradiction between 'personalized' and 'broadcast'. A variety of mechanisms may be used to create a personalized experience from broadcast delivered content such as (1) the broadcasting of multiple program elements that can be selected on personal basis at each receiver and (2) personalized re-linearization for time shift viewing, where the end user device can store many or all the program elements objects or ads which are received over time, in any order, through linear broadcast, and then re-linearize them later according to the user's preference or profile or in a user-specific schedule or order*
- *Although more elements/objects will be carried in a program elements bundle, it is unclear if these will significantly increase overall bitrate, as object based audio codecs for example are designed to highly optimize the carriage of multiple audio elements.*
- *Terrestrial Broadcast will need to become adaptable and seamlessly integrated into a hybrid delivery system. Ideally it will adapt dynamically to carry the content elements and objects that prove popular at that moment for a given program, and equally dropping elements (e.g. alternative commentary) from the main broadcast if the usage is low.*
- *Social media and recommendation engines can create popular content "phenomena" (e.g. Red Bull balloon jump.) Terrestrial Broadcast is a great way to carousel or augment a CDN for the delivery of such content cost effectively and efficiently, but needs to integrate seamlessly to momentary social trends and be capable of linking from social media.*
- *Terrestrial Broadcast standards need to evolve to enable object based audio, video and data, and to simplify the carriage and integration of enhancement layers for quality of video and audio, experiences (elements that can be added by the user at playback), and personalized content (relevant clips, photos, text derived from the social hive)*

6. The need for trusted solutions and privacy

Introduction

In the past, security in the field of television was mainly concerned with conditional access used by pay TV broadcasters for premium content, sometimes augmented by secure transactional interactive services. Early deployments of interactive applications on free to air broadcast networks were not transactional and needed no personal data to be held. The result was that free to air networks were not perceived to be a target for hackers, and in general, relatively little consideration was given to securing the delivery of broadcast streams and signaling.



In recent years, networks and devices capable of the delivery and rendering of premium content and interactive services have increased both in type and number. As a consequence, security requirements have become more complex, and DVB work on formulating commercial requirements for new specifications or for maintaining existing specifications frequently has to address security issues (e.g. content protection, data security, consumer privacy and protection etc.). In addition, other aspects of security such as user access and network security, while possibly out of scope for DVB, nevertheless may impact or influence DVB commercial requirements and specifications. In this changing environment the number, nature and complexity of security requirements across the full spectrum of DVB-based applications has increased dramatically.

In the light of the increasing technical complexity, regulations such as the EU's Data Protection Directive are being updated to set out the protection that consumers should expect from service providers.

DVB security and interactive standards

DVB developed specifications to address interoperability in content security, for example: CSA 1-3, Simulcrypt, CI Plus (> v1.3). These specifications have all been deployed on terrestrial networks, however Long Term Terrestrial Broadcast market requirements may require additional solutions. DVB published its specification for middleware (MHP/GEM) in 2000 and other DVB specifications are widely used in conjunction with other applications for interactive middleware specifications. One example is the Application Identification Table (AIT) within the DVB signaling specification ETSI TS 102 809, which is used to carry application signaling for MHP and other interactive systems such as HbbTV.

Emerging threats

Recently, some theoretical analysis conducted by academic institutions has highlighted the potential for security gaps or omissions in the RF segment of television networks to be exploited. Demonstrations of intercepted and altered applications have been given using terrestrial receivers. If a broadcast application can be replaced by an attacker within the RF signal and run unchallenged in the television receiver, control of the receiver can be taken over and user privacy compromised. This opens possibilities which include: gaining anonymous access to the internet, seeing and hearing users in their homes (where TV devices have cameras and microphones), acquiring personal data and offering fraudulent services. Further analysis within DVB has also highlighted the possibility of broadcast streams being usurped.

Early analysis of this threat within DVB has shown that for many scenarios, an attack on a television network will not go undetected for long because a successful attack on some viewers will have the side-effect of causing interference to other viewers. However, some possible compromises do not need more than a period of seconds to have an impact. At the time of writing this LTV for terrestrial broadcasting, the DVB security experts group is compiling a report that will provide an analysis for DVB of the security risks and threats to broadcast networks of different types and recommendations to DVB for action. It is important that significant risks and threats are addressed in order to maintain user trust in products and services.

Recommendations for DVB members drawing up future requirements

A guiding principle for DVB specifications is to achieve maximum interoperability, allowing different products, different business models and different infrastructures to coexist while supporting the security requirements of applications. While following this principle, it is also necessary to take account of the increasing complexity and new regulations when drawing up future requirements to ensure that all aspects of security are taken into consideration. The DVB Security Experts Group has developed a Harmonised Security Framework for DVB to assist members considering new requirements. The document is intended to help individuals and groups developing new specifications to carefully analyse all the threats to security and data to which their specification may be subjected and to ensure that, where considered necessary, appropriate protection is in place from those threats.

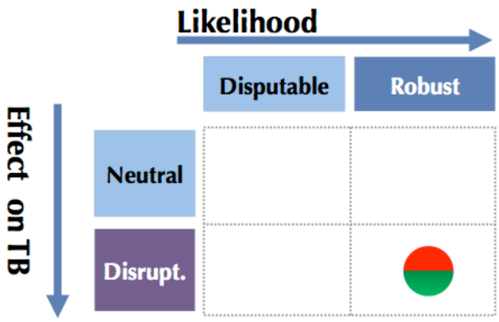
For further information, the reader is advised to review the DVB HSF or consult the DVB security experts group.

➢ **Impacts on Terrestrial Broadcast**

- *Terrestrial Broadcasting must respond to the increasing technological complexity of television services and devices which is allowing new methods of hacking to be envisaged; where risk analysis deems it necessary, the necessary adaptations and enhancements should be made to Terrestrial Broadcast standards so that it is possible for consumers to have their services, privacy and personal interests protected in order that the trust of all relevant stakeholders can be maintained.*
- *Terrestrial Broadcasting must ensure that content and service providers can comply with regulatory requirements for user privacy and data protection; the necessary adaptations and enhancements should be made, where necessary, to Terrestrial Broadcast standards to ensure that compliance with the regulatory requirements in relevant markets can be provided for.*

2 Technology Context Factors (Non Terrestrial Broadcast)

7. Basic broadband availability (in the home) will be universal but ultra-high speed will not, and in certain countries will remain an exception even in urban areas



Most individuals, at least in developed countries, will be able to access a broadband connection, both fixed and mobile, with a minimum of a “low/medium” speed[9] (i.e. 2 Mbps at least); such a connection is quite sufficient for most web/business type of communications (e.g. mail, transactional, information) but less adequate for TV / entertainment consumption especially as HDTV progressively becomes the norm, and limited UHDTV content will be available.

On the other hand, access to a home or stationary very / ultra-high speed broadband connection (i.e. 30 Mbps and above, up to 100 Mbps) which would be required to consume, in good conditions, one or more live HDTV programme(s) not to mention UHDTV programme(s), is announced in some countries and discussed at European Commission level but is far from being here; even if the plans for infrastructure are fulfilled, they will leave significant areas of the world (mainly developing countries) without such ultra-high speed connections, and the level of subscription to them by consumers[10] is currently not very high.

The lack of sufficient throughput for some locations will also significantly constrain access to on-demand services (HDTV and the more challenging UHDTV format), as the uploading time will be too long or streaming conditions will be unstable.

Whilst mobile and other wireless networks are making important progress in throughput and capacity, constraints for receiving massively live or non-live content through cellular networks will remain quite significant (cost of usage, bit rate, volume caps, and stability).

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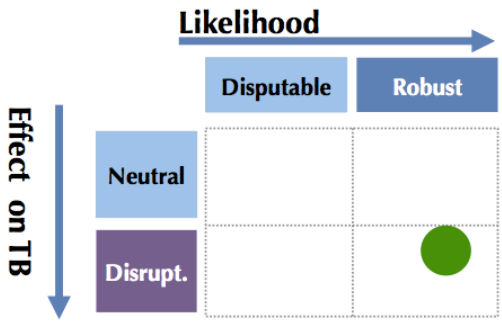
9 Broadband market, European Commission 2014

10 30% of FR and 26% of US homes have a speed lower than 4 Mbps (Akamai, State of the Internet report, Q4 2014 ; less than 6% have more than 15 Mbps in France, and less than 20% have at least 10 Mbps in France

➢ **Impacts on Terrestrial Broadcast**

- *Although not all homes will need it, Terrestrial Broadcast will remain a valuable and significantly present delivery method for TV, especially HDTV, and for a large number of homes, it will remain the only ultra-high speed (100 Mbps and above)access available.*
- *There will be increasing cases where Terrestrial Broadcast will be used for the delivery of on-demand content (e.g.; a terrestrial broadcast capacity is used at certain times of day/night to deliver programs intended for on-demand viewing, which are locally stored until watched, or not) to cope with the lack of a sufficient broadband connection at all homes; some adaptations will be needed to make this happen in a simple manner.*
- *Both of these use cases (linear and on demand) will be even more compelling in developing countries, where broadband connectivity will take time to grow.*
- *As UHDTV content starts to become available (probably more on specific events or items rather than continuous live streams) , it will be relevant to deliver it through a combination of Terrestrial Broadcast and Broadband, as neither of these networks can do the job alone in all circumstances.*

8. “Connected Terrestrial Broadcast” becomes the norm



Most receivers initially geared towards Broadcast reception (e.g. a classical TV set, a satellite set top box) will integrate a broadband connection as well, and such connection will be generally connected to the Internet, enabling a wide range of so called “ connected TV” use cases like catch-up, specialist and VoD services delivered by broadband. Terrestrial Broadcast will need to play to its strengths in such a future.

Note: Such a service combination may not be feasible in some countries.

Proprietary or standardized (e.g. HbbTV 2.0) technology frameworks will progressively enable a smooth interaction of the broadcast delivered services and the broadband ones, towards a seamless end-user experience.

This will be especially relevant when there is insufficient broadband capacity to deliver linear TV services, especially as these move to HD or UHDTV resolution. Conversely, having access to online content has extended the viewing window for scheduled content (e.g. catch-up and replay services) and has also resulted in cases of new channels launching first on broadband and “upgrading” to terrestrial as the business case becomes proven.

As connected TVs become the norm, use can also be made of the broadband link to deliver error correction data related to the broadcast signal. A typical solution is called “Redundancy on Demand”. This could give the broadcaster the ability to increase the coverage area, while limiting the cost of the broadcast network. However, due consideration must be given to the broadband network capacity and synchronization between broadcast and broadband content delivery.

There is currently rapid growth in the consumption of online video content (catch-up TV and VoD) in the home using connected TVs, smart phones and tablets, facilitated primarily by the deployment of fixed-line broadband, in-home Wi-Fi networks, and possibly in the future, data passed through mobile networks. This success has led a few traditional broadcasters to begin moving some services over to online distribution alone. It has also enabled some totally new entrants to launch services in the on-demand and streaming media marketplace.

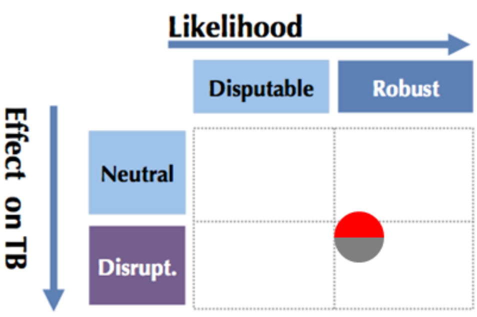
The connection of the TV set or other broadcast receiver to the broadband network creates a return channel from the TV receiver to the broadcaster/operator which provided the opportunity for feedback of information related to TV signal reception conditions and content consumption.

> **Impacts on Terrestrial Broadcast**

- *It becomes safe to assume that any device connected to Terrestrial Broadcast or using a Terrestrial Broadcast delivered feed will have in parallel broadband access to complement the high throughput, cost effective, high quality, one-way delivery of Terrestrial Broadcast by the medium throughput, bi-directional, one to one communication broadband network; this opens a whole world of new technical (e.g. local content restoration) or service and business possibilities (e.g. access to on demand content, usage feedback)*
- *On the basis of the existing standardized frameworks (e.g. HbbTV) and their continued market penetration, special emphasis should be given to the smooth integration of broadcast and broadband to leverage the 'best of both worlds' combination.*
- *Terrestrial Broadcast could be used to transmit an EPG for the broadband services. This is more convenient for users as it simplifies service discovery. As the Terrestrial Broadcast service provider will require a broadcast license from a regulator to deliver an EPG in this way which will likely involve some quality assurance, this may indirectly improve a user's trust in the broadband service being offered.*
- *Expect broadcasters to start moving niche content and channels off traditional broadcast platforms and onto VoD and streaming. The capacity recovered can then be used for conventional or new use cases of the platform.*
- *The connected home opens exciting new opportunities for Terrestrial Broadcast, such as:*
    - *Offloading broadcast content from broadband networks*
    - *New ways of distributing Terrestrial Broadcast content within the home*
    - *Possible technical innovations such as the ability to repair damaged Terrestrial Broadcast content using a broadband connection*

9. Sub-optimal and variable receiving conditions

The dense occupation of the spectrum and proximity between terrestrial broadcast and mobile networks may cause harmful interferences to the terrestrial broadcast service in specific locations, which will occasionally and locally degrade reception. This would be detrimental and needs to be addressed to minimize the likelihood of degradation.

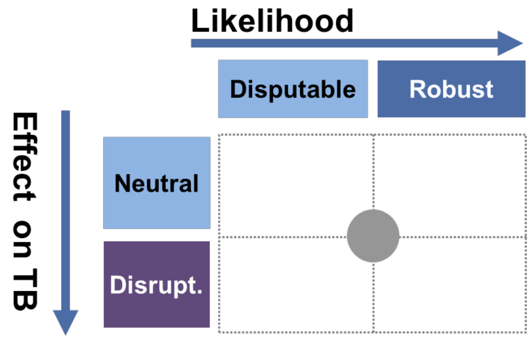


These issues might be transient and hard to predict as they will be linked to many factors.

➢ <u>**Impacts on Terrestrial Broadcast**</u>

- *Terrestrial Broadcast should seek to integrate mechanisms enabling local / opportunistic error correction to upgrade receiving conditions in order to maintain high quality, reliable reception in spite of imperfect and variable conditions.*
- *Signal and quality feedback from the receivers to the network would be desirable, to enable the network to become aware of actual reception and possibly adapt to it.*
- *Other mechanisms can be considered, such as signal reconstruction with a contribution received through broadband.*
- *Although it cannot be expected that these would be systematically deployed, mechanisms that require modifications or special antennas or receivers could be relevant and be promoted.*

10. IP Broadcasting



Internet-centric devices connected via air or cable interfaces are increasingly used to access entertainment and information, in an environment with Wi-Fi WLAN in most buildings and often outdoor, with four generations of mobile network communication in the field. In this context, the television set is no longer a single source of daily entertainment and information. An increasing part of video consumption is also demand-based and not linear TV, though the latter remains quite prevalent.

From a technical point of view, the world speaks IP. But can't these two worlds – IP and Transport Stream – coexist? Yes, they can – as we see it today in the field. In fact both protocols can even be used within the area of the other protocol; as examples see the HTTP Live Streaming (HLS) protocol (by Apple Inc.) encapsulating TS packets in a particular way on the one hand and IP packet encapsulation in the Transport Stream (Multi-Protocol Encapsulation MPE, ETSI EN 301 192) on the other. It is also open to question whether the whole addressing scheme of IP is required for broadcasting. Usually it's not, but there can be exceptions for addressing only groups of receivers or peripheral devices. Also relevant is that within a local network at the receiving end an addressing scheme is required, for which the target should be to have the same IP streams available at the receiving end as they were provided by the service/application provider.

As far as packaged media is concerned, DVDs use a particular form of the MPEG Program Stream format (which has a close relationship to the TS) and BluRay Discs make use of a specific format similar to the TS (with an extended header). The TS can also remain in place when it comes to private recordings of TV content on e.g. a hard-disk associated with a TV set or a STB. Managed IPTV services in several cases also use a TS encapsulated in IP packets (see e.g. "Telekom Entertain" in Germany). The new media, mainly delivered via the Internet, is naturally IP-based. But does this mean anything to Transport-Stream-based television?

Since the broadcast receiver is often only one element of an infotainment device, other aspects come into play: Hybrid applications use both paths – the broadcast path for downloading data and the broadband path for the upload (and also for download purposes). With the bidirectional modems ((V)DSL, Wi-Fi, UMTS/LTE etc.) the protocol stack is an IP-based one. Hence it would ease implementations if the broadcast downlink path would use the same or at least a similar stack. Nevertheless it is still possible to combine IP and TS for such hybrid applications – as shown by HbbTV available in version 2.0 today.

As far as the protocol overhead (packet headers) is concerned, there is usually not much difference between TS- and IP-based transport – unless IP packets in use would be very small. In addition, IP/UDP packet header compression can widely eliminate the permanent presence of huge packet headers. The disadvantage is the extended time period for gaining access to the content – after switching receivers on and after zapping to another services/application feed.

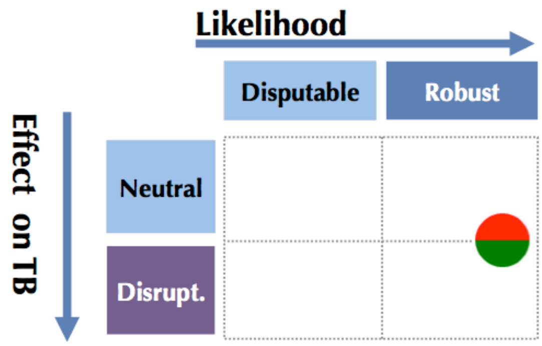
In summary, both approaches – TS and IP – will continue to coexist for a longer period. But it can already be seen today that IP-based solutions will become more widespread in the future. This is because delivery of content to consumer devices will happen more and more via the Internet, wired and wireless, and increasingly via IP-centric devices like tablets and smartphones. Also the applications and tools permanently under development for IP-based data feeds make this alternative to the TS very attractive. ATSC 3.0 demonstrates that IP-based broadcasting can be an option for the terrestrial broadcast future.

Impacts on Terrestrial Broadcasting

- *With a long term perspective in mind it is hard to imagine that real time television remains one of the few exceptions in terms of applications that use the TS. Broadcasting needs to be integrated more seamlessly into the world of entertainment and information that people are making use of today and in the future. Also the development speed and the new tools designed for the broadband market should be available for broadcasting too.*
- *Especially when considering the desire of the TV service providers to be present on mobile devices like smartphones, phablets and tablets, an LTE-eMBMS-like physical layer might be the most decisive step for reaching the smart devices of the 21st century (see also the more LTE-friendly broadcast standard ATSC 3.0). An alignment of the remaining protocol stack can and will be realized to a certain extent (100% alignment is difficult to achieve because of the different nature of the devices, i.e. bidirectional and unidirectional in the first place). Hybrid provision of content via broadcast and broadband could lead to IP-based solutions for the broadcast part.*
- *Since IP stacks are implemented in almost all stationary TV devices nowadays, no major technical challenge is foreseen for those devices when broadcasting is done in an IP-based way.*
- *Many other parts of the broadcast chain use TS for distribution, content replacement and for testing. When considering a move to IP, DVB should be mindful of the impact on the whole end to end chain and not just the transmission layer.*
- *DVB currently plans for a Study Mission on "IP Broadcasting" which can be expected to lead to a better understanding of the commercial and technical impacts of a migration towards IP Broadcasting in general.*

11. Fast Developing Cellular Networks - moving to 4G and then 5G

Fast growth in traffic requires new technologies.



Cellular networks are rapidly developing to address new use cases and applications beyond the initial carrier-centric voice services. Between 2014 and 2018, it is expected that 8 billion smart phones will be shipped, i.e. 2 billion every year. By 2020, around 25 billion devices will be connected through cellular technologies. However, whereas more and more applications are added to mobile devices and cellular platforms, the popularity of video content will increase and is expected to be 2/3 of the mobile traffic by 2017; the overall mobile data traffic itself is expected to roughly be doubled every year, leading to a total mobile data load that could be 100 to 1000 times its current level in the 2020-2030 horizon. A significant proportion (more than half) of this traffic is expected to be satisfied by Wi-Fi offload in fixed locations and so the forecasted increase in traffic needed to be delivered directly over mobile networks will be much less.

Recognising that Wi-Fi is part of the solution, these trends obviously provide tremendous pressure that should be dealt with by new technologies in the area of mobile video distribution, including more efficient codecs, intelligent radio technologies, smart content delivery networks and media protocols and other architectural enhancements.

Cellular network technologies are expected to evolve rapidly in different directions. A mix of technologies are expected to be introduced to deal with the tremendous growth of video, including carrier aggregation in LTE-Advanced, higher cell densities, offload to white spaces and unlicensed spectrum using Wi-Fi, LAA and LTE-U, device-to-device communication and other spectrum efficiency enhancements.

LTE enables carrier aggregation and bitrates up to several hundred Megabit/s, although what is important to any given user is that they can receive services at an appropriate bit rate for the desired service - which may only need to be 500kbps-1Mbps for a single stream of video. On offloading, estimates vary, but most accept that at least half and in some markets up to 80% of the mobile data traffic is off-loaded to Wi-Fi networks and there are indications from Cisco, Ofcom et al that this will continue to be the case for some time to come (in part at least for affordability factors). Such technologies may advantageously be used for the purpose of distributing TV content, be it linear or On-demand streaming, in an OTT fashion and unicast, typically using HTTP-based Adaptive Bitrate technologies such as Dynamic Adaptive Streaming over HTTP (DASH). This model is already established quite successfully today to deliver content from broadcasters to different types of mobile devices and will continue to be exploited further, though it may have its own limitations and quality of service issues (associated with both possible in-home Wi-Fi issues and/or limitations of the home broadband access)

LTE Broadcast (eMBMS)

Within this mix of technologies, yet another key component for improved video delivery in cellular networks is expected to be the use of LTE broadcast in order to enable scalable and efficient distribution of popular video content including live TV services as well as on-demand content. Emerging pre-loading approaches are indeed already enabling the broadcast based delivery of on-demand content.

LTE Broadcast - while still in its infancy as currently deployed - creates a starting point for new enhancements to address these challenges and to enable new services. The ability to dynamically and flexibly make use of the available resources is especially important, i.e. a flexible spectrum and delivery architecture that enables efficient and high-quality distribution of video services.

LTE Broadcast, being a Single Frequency Network (SFN) technology, can provide efficiency even with a small number of users per cell. This provides incentives for the deployment of LTE Broadcast in networks and devices thus increasing penetration of LTE Broadcast enabled devices. In addition, LTE Broadcast when deployed in small cells can provide indoor coverage. This can enable LTE Broadcast to use higher modulation and coding schemes and thus improve overall spectral efficiency. In addition, LTE Broadcast provides a service layer that enables full integration and seamless transition between broadcast and unicast mode, addressing use cases such as coverage extensions, MBMS operation on Demand (MooD) and other hybrid use cases.

LTE Broadcast as it exists today, would need several enhancements to overcome deficiencies identified for free-to-air broadcasting including: i) free-to-air capability (e.g. **sim-less operation**, **network sharing, network neutral** discovery for PSB content) ii) support for **broadcast style multiplexing** in LTE (e.g. statistical multiplexing, dedicated capacity for broadcast content) iii) seamless switching between the LTE broadcast and mobile/internet unicast delivered content iv) **larger cell sizes** and more fully integrated capability across mobile networks (not just selected cells) to support users wherever they happen to want to view TV content.

There is work initiated at 3GPP to address the identified weakness of the existing LTE Broadcast (as noted above), especially extending the cyclic prefix in order to increase the maximum supported cell size (which would enable **High Tower LTE Broadcast**), plus additional capacity enhancements including new modulation and MIMO schemes, 100% usage of the available spectrum for LTE Broadcast services as well radio network sharing across operators, downlink only and un-connected mode (SIM-less). In addition, the service layer is enhanced in order to enable new services, including interactivity, combined unicast/broadcast, consistent and new audio visual experiences, targeted ad insertion, etc.; should these enhancements actually be implemented in the LTE specification, LTE Broadcast would become a powerful terrestrial broadcasting technology with the added benefit of being "natively" present in mobile devices, a critical step that has never been achieved in the past by other mobile broadcast technologies (DVB-H, Flo).

5G

Beyond the advances in LTE/4G, the 5G project is on the horizon. Whereas pre-standardization work is at its peak, the standardization in 3GPP has only just been initiated in order to meet the timelines set by the ITU-R in 2019. 5G is expected to address new use cases with a new physical layer, including but not limited to:

- Data rates of several tens of Mb/s should be supported for tens of thousands of users.
- 1 Gbit/s to be offered, simultaneously to tens of workers on the same office floor.
- Several hundreds of thousands of simultaneous connections to be supported for massive sensor deployments.
- Spectral efficiency should be significantly enhanced compared to 4G.
- Coverage should be improved
- Signalling efficiency enhanced.
- Broadcast-like services

Converging Broadcast and LTE

Suitable combinations between existing DTT-based (high power high tower) and cellular technologies (low power low tower), as well as the combination of mobile and stationary TV services are currently being studied in different contexts.

It is not expected that a one-model fits all approach will be the outcome, as technically and economically viable solutions strongly depend on legacy scenarios in different regions. Another relevant aspect to be considered is that the overlap of the types of programmes and content to be delivered to mobile and stationary receivers is uncertain, hence any combination of technologies needs to take into account the different usage patterns.

Based on this, several studies are on the way to evaluate the commercial and technical benefits of such technologies. Examples include, but are not limited to:

- Combinations of Low tower /small cell architectures with HPHT networks, for which the HPHT network serves as an overlay either for direct eMBMS from HT to mobile device where reception permits, or to distribute content to eNodeBs (LTE Base stations) which further distribute the content to cellular receivers to address the indoor coverage.

- The exclusive use of low tower and cellular architectures for the distribution of mobile and stationary TV services in common spectrum resources.

  It should be noted that in countries where classical broadcast (satellite, High Tower terrestrial, cable) are present, there are no clear benefits associated with the low tower approach, as it seems to result in a significantly higher cost, uses scarce mobile broadband infrastructure and spectrum needed for other purposes, and there are no indications that mobile operators or broadcasters have plans to move into this direction.

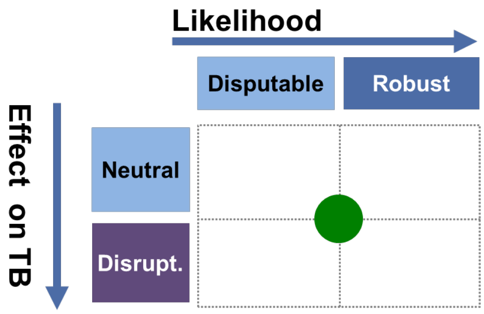
  Such an approach would also raise a major hurdle at the level of receiving equipment (TV sets), as huge legacy bases of equipment without LTE capability exist and will remain in service for many years, against mobile devices which have a much faster renewal cycle.

Impacts on Terrestrial Broadcast

- *Existing models for providing TV content to mobile devices, using OTT and unicast distribution (both cellular and Wi-Fi) will continue to be relevant and are expected to be improved further by dynamic advances in radio, delivery architecture and compression technology.*
- *Broadcast Technologies are also expected to play an important role for video distribution to mobile devices, as they will enable better efficiencies and thus limit the need for growth in network infrastructure and spectrum allocations; this may be a traditional broadcast approach in some markets (e.g. : T2 Lite) , while in other markets, this will be achieved principally by broadcast modes embedded in mobile networks (LTE Broadcast with on-going enhancements and later 5G)*

- *To cover a wider range of applications including mobile receivers, indoor reception, and higher reception speeds, distribution architectures combining HPHT with low power low tower (LPLT) are of significant relevance and need to be further studied ; this combination will also require some coordination / convergence between traditional broadcast (HTHP) standards and LTE/5G standard.*

12. Continuous improvements in encoding



General Trend

Based on past experience with three generation of video codecs used in DVB, it can be anticipated that future codecs will follow a similar trend in terms of efficiency:

- Each codec is introduced with a particular target in efficiency improvement as objective compared to the last generation
- During the years of lifecycle of a codec, progress is made based on more efficient implementations of encoders.

A typical curve for a constant subjective quality of picture is depicted in figure 1.

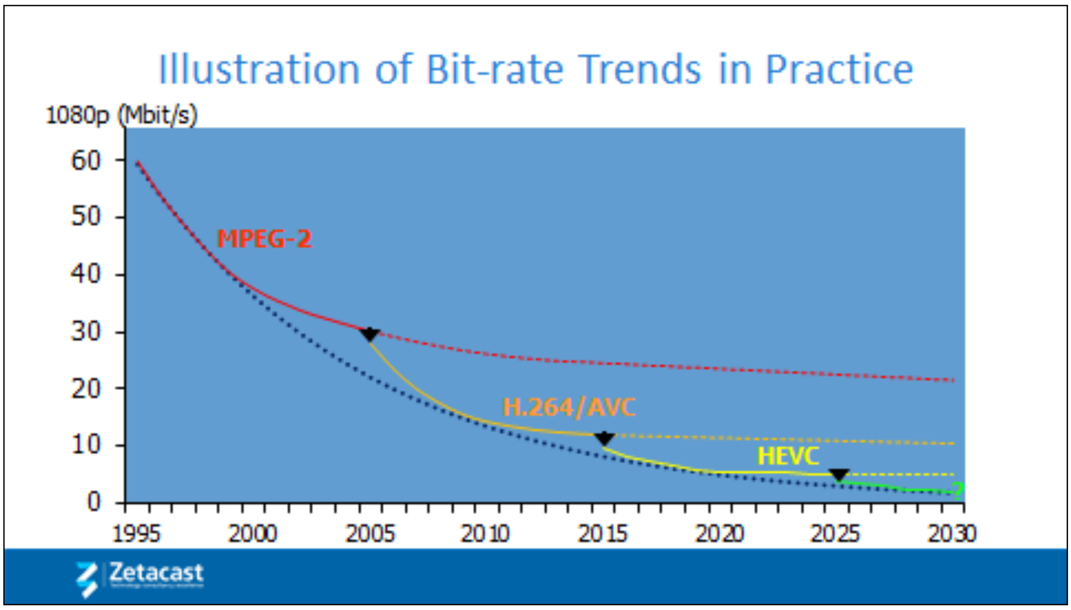


Figure 1: Evolution of Efficiency of Codec "Ken McCann's law" [1]

Accordingly, whilst there is no certainty that CODEC improvements will continue at the same rate one could, based on past experience, extrapolate that every 7 years, for a given subjective quality, the bitrate needed is reduced by 50 %.

This is applicable independently from the resolution, so that where 20-30 Mbit/s is considered to be a requirement for UHDTV in 2014, in 2021 data rates in the order of only 10-15 Mbit/s may be sufficient. Whether such an improvement is achievable with today's real-time HEVC encoders remains unproven, but there is some evidence of scope for improvement from the superior compression efficiency that can be

[1] *Source HEVC in DVB" ; Ken McCann ; DVB World 2014 , Prague , March 2014*

obtained by non-real-time HEVC encoding software (which makes greater use of techniques such as multi-pass encoding).

The same principle of extrapolation leads to 25 % and 12.5 % of today's bitrate for 2028 and 2035 respectively. We can reasonably assume that this would require a fourth generation of codec. This new codec would probably include some tools that were investigated for HEVC but excluded due to complexity concerns (such as adaptive loop filtering) as well as tools whose potential has not yet been well explored (such as using a content-adaptive 4:4:4 format rather than 4:2:0). However, the further that we look into the future the less certain it is that current bit-rate trends will continue. As with Moore's Law (which is the underlying driver), there will eventually be a reduction in the rate of improvement in coding efficiency.

Table 2 illustrates the evolution of efficiency for some example of bitrates for the years 2021, 2028 and 2035.

Bitrate	**2014**	**2021**	**2028**	**2035**
Ex. 1	30	15	7,5	3,75
Ex. 2	20	10	5	2,5
Ex. 3	10	5	2,5	1,25
Ex. 4	5	2,5	1,25	0,625

Table 2: Examples of bit rate evolution for comparable quality in Mbit/s [3]

HEVC Codec Efficiency Improvement

In the past we have seen significant improvements in AVC encoder efficiency, and we expect similar improvements of efficiency for HEVC. This improvement typically comes in several steps.

When a new CODEC is defined the first generation of encoder (which is often based on software) is quickly improved on, leading to second and third generations of encoders, as already described by TDF[2]

As an alternative to deploying a new CODEC it may also be possible for operators to consider using more efficient profiles of currently used CODECs to improve the compression efficiency.

New codec generation

Discussions have started within the ISO/IEC JTC on the opportunity to start work on a fourth generation codec. The IEC / IEC JTC have requested contributions regarding a new codec generation and intend to hold a first workshop in October 2015[4].

Looking to the past three generations of video codecs, a new generation has been adopted every 10 years, if this trend were to continue a fourth generation of video codec would be expected around 2023.

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[2] *Are we ready for UHDTV? , TDF, Paris ; 2014 ; http://www.hdforum.fr/sites/default/files/arewereadyforultrahd_distributors.pdf*

[4] *Request for contributions on future video compression technology ; ISO/IEC JTC1/SC29/WG11 (MPEG) document N15273 ; MPEG , Geneva , February 2015*

Other codecs

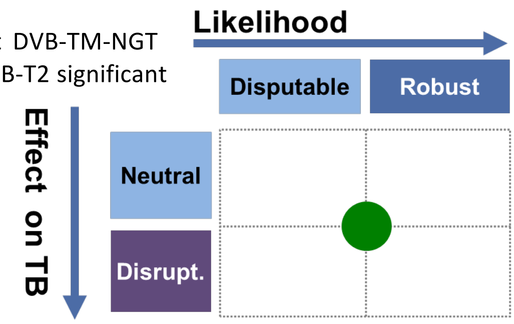
There may be other codecs other than those defined by MPEG appearing to the market which may be directly relevant to the DTT market or indirectly stimulate the improvements of future MPEG codecs.

Other codecs that appeared in the past in the market, such as VP9 and VC1, serve the IT sector.

Impacts on Terrestrial Broadcast

- *Whether from MPEG or from others sources, it seems likely that a next generation, standardized CODEC would reach the market to replace / extend HEVC around between 2023 (anticipated for standard publication) and 2025 (initial mass market products).*
- *DVB should plan and prepare to adopt such new standard codec (estimated DVB standard adoption date of 2024).*
- *Such new codec would need to provide a 30-50% gain against HEVC, which would in itself directly, and may easily, provide a large part of the required performance improvement as evaluated in the supply & demand model (desired improvement of 1x to 2,3x with median value of 1,8x).*

13. Significant potential for improvement in terrestrial broadcast



With respect to the physical layer, DVB-NGH, a recent DVB-TM-NGT Study Mission and ATSC 3.0 have all shown that after DVB-T2 significant steps can still be made in terms of spectral efficiency. In the NGT Study Mission Report the related technologies were separated into two complexity profiles, a Low and a Higher Complexity Profile (LCP/HCP) – as follows:

- Low Complexity Profile:
  - Time Frequency Slicing (TFS) together with Multiple Frequency Re-use Patterns (MFRP)
  - Improved error control coding (iFEC)
  - Improved time interleaving (iTI)
  - Non-uniform constellations (NUCs)
  - Layer Division Multiplex (LDM)
- Higher Complexity Profile:
  - All technologies being part of the Low Complexity Profile above
  - MIMO
  - Interference cancellation with separate aerials and tuners (IC)

For ATSC 3.0 all technologies listed above – apart from Time Frequency Slicing/Advanced Network Planning (TFS/ANP) to its full extent – have been adopted and they appear in *Italic characters*. ATSC adopted channel bundling, which represents a subset of TFS. Note that interference cancellation is a technology that doesn't require any amendment to the signal on air and would so exist on the receiver side only.

Advanced Network Planning (ANP) summarises two improvement of network structures, namely Multiple Polarization Networks (MPN) and Multiple Frequency Re-use Patterns (MFRP), the first reducing interference by making use of different polarizations in the same network and the second preventing interference from particular direction(s) from affecting all RF channels within the TFS arrangement.

ATSC 3.0 demonstrates part of the performance improvements feasible in 2015 – with the exception of the additional, significant gains that TFS/ANP enables.

For the LCP there are no changes to the aerial set-up required, whereas for the HCP such changes are necessary. Under these conditions Multiple Polarization Networks (MPN) were not listed, because they require a change to the aerial set-up for a part of the area, which means an incompatibility with the LCP. For the HCP MIMO occupies the two polarization plains already. The gains achievable depend on network structures (MFN, SFN clusters or large SFN), number of multiplexes/RF channels per location that can be TFS/ANP-combined and the nature of the interference, i.e. the related differences make up the spans given here:

- Low Complexity Profile: 14% to 96% (TFS, MFRP, NUCs, iFEC covered)
- Higher Complexity Profile: 94% to 261 % (LCP technologies plus MIMO covered)

Details regarding the aforementioned technologies and their impact can be found in annex 2 of this document. Commercial and practical aspects of the deployment of the aforementioned technologies will be considered further.

Whereas almost all LCP technologies previously outlined require an upgrade or an exchange of modulators (provider side) and an exchange of demodulators (receiver side, limited impact), TFS/ANP in most cases requires higher investments because of the connected network re-planning with fewer RF channels required for an MFN.

It must be taken into account that in some cases such a network re-planning may take place in conjunction with the loss of the 700 and 800 MHz bands. In those cases the impact of introducing NGT on the basis of the LCP will also be limited for the provider side.

Typically TFS/ANP-related investments – in conjunction with the corresponding network re-planning in many cases – will be required for:

- Partly new power filters for transmitter sites after changing to other RF channels (it may be possible to re-use some for the same RF channel employed at a different location)
- Partly new aerials or newly adjusted existing ones (besides the emitted frequencies, coverage patterns could also be required to change, once again aerials might be reused at another location – similar story as with the power filters above)

TFS might also impose regulatory adjustments in several countries in order to enable sharing more than a single multiplex between different service providers.

Impacts on Terrestrial Broadcast

- *The achievable gains between 14% and 96% with the Low Complexity Profile (LCP) and between 94% and 261% for the Higher Complexity Profile (HCP) reflect a major step in spectral efficiency which can be used to help address the challenges and need for more capacity for the Terrestrial Broadcast platform as new use cases progressively materialize.*
- *The ATSC 3.0 physical layer standard is significantly more efficient than DVB-T2 and therefore builds a sound alternative to the latter.*
- *The major enhancement in spectral efficiency achievable with NGT can be exploited in several non-exclusive ways (alongside the deployment of HEVC expected within the next few years):*
    - *Reduction of costs per transmitted service*
    - *Improved quality of services*
    - *Higher number of services*
- *With the LCP providing the easiest step towards the next generation of terrestrial broadcasting, network re-planning issues need particular consideration in conjunction with the adoption of TFS/ANP. Gains achievable with TFS/ANP – and herewith with the LCP – depend mainly on three factors. With the knowledge of these influential factors, gains can be determined before adopting the technology in the field.*
- *Ideally, the introduction of NGT might be combined with another milestone on a higher layer, e.g. the introduction of UHDTV-1 phase 2 or HD profiles of it (incl. HFR, HDR, WCG) on the basis of HEVC. The rationale behind is that both steps require a new receiver. For the mentioned example –*

> *as for other similar example combinations – windows of opportunities exist that shouldn't be missed.*
>
> - *When the development of an NGT standard will be considered, the benefits of converging towards a global standard together with other broadcast SDOs (ATSC, ARIB) and with 3GPP if possible shall be taken into account. Factor 18 explains the related issues in more detail.*

The example of ATSC 3.0

The entire set of ATSC 3.0 specifications consists of about 20 standards covering all layers of the protocol stack. The major elements are:

a) Bootstrap, down- and optional uplink, scheduler (physical layer)
b) ATSC Link Layer Protocol ALP and Service Information
c) UDP/IP (incl. header compression)
d) MMT and ROUTE
e) HTTP and DASH (ISO BMFF)
f) Media Codecs and watermarking
g) HTML 5
h) Applications and application signalling
i) Companion devices
j) Security

Both DVB-T2 and ATSC 3.0 support the carriage of MPEG-2 TS as well as IP (via a link layer). However, whereas DVB is fully TS-centric from both the specification and implementation perspective, ATSC 3.0 is IP centric and specifies a full IP-based stack, but nothing related to MPEG-2 TS except how it can be encapsulated into link and physical layers. Using a DVB-based MPEG-2 TS on top of ATSC 3.0 physical and link layers should however be possible. Likewise, using IP-based layers of ATSC 3.0 on top of GSE/DVB-T2 is also possible.

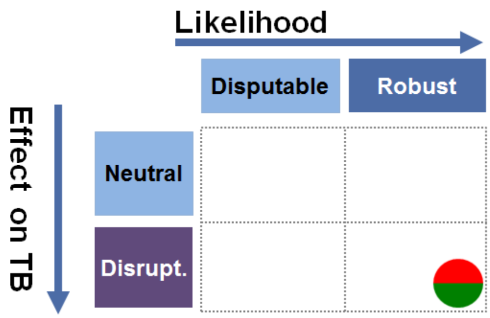
As far as the physical layer is concerned, ATSC 3.0 has, to a large extent, built on and further refined and optimized system concepts from DVB-T2 and NGH but also added some new elements, some of which were studied in the NGT Study Mission. The basic functional blocks are:

A) Baseband packets with reduced overhead
B) LDPC FEC codes of higher performance
C) 1D and 2D non-uniform constellations
D) Layer Division Multiplexing (LDM)
E) Advanced time interleaving
F) An LTE-friendly frame structure
G) Channel bonding – achieves a subset of the gains of TFS
H) MISO and MIMO

Achieving the same spectral efficiency (bits/s/Hz) as DVB-T2 ATSC 3.0 requires, on average, a signal-to-noise ratio some 0.5 dB below the corresponding T2 figure.

14. A decoupling of services and networks - dilution of traditional business models – new players

Decoupling



Broadcasters, which were originally bound to traditional broadcast networks, and principally Terrestrial Broadcast, are now delivering their content and services through a variety of platforms (satellite, cable, and IP over DSL, fiber, mobile, web) and the Terrestrial Broadcast platform is only one option amongst several, often considered to be the most important for free to air content, but certainly not the only one.

Broadcasters are also operating a range of new services (e.g. Catch Up, VOD etc) in addition to linear TV, which are not naturally hosted on the Terrestrial Broadcast delivery platform, though some quite successful examples of a seamless integration exist (e.g. YouView in the UK).

As a result, there is a certain decoupling between “Broadcasters” and Terrestrial Broadcast, although some broadcasters (but not all) still see Terrestrial Broadcast as their central delivery solution; this can be the case of of Public Services obligations, or given the wish/need to reach to certain population segments, or simply the will to avoid any gatekeeper in the middle.

The decoupling could be mitigated going forward as the Broadcasters increasingly realize the level of technical and commercial intermediation that it imposed on them when they use other networks (e.g. ; broadband networks).

Such intermediation may conflict with their business interests, especially when these networks host OTT services which are directly competing with them, and as a result, broadcasters may re-prioritize Terrestrial Broadcast in their strategies. Broadcasters also have ongoing concerns about the technical limitations of broadband networks becoming bottle necks affecting, for example, HD delivery.

Blurring of Business Models and new players

Traditionally, TV players were strictly segmented between “Free to Air “and “Pay TV”, the latter using mostly cable and satellite as technical platforms.

More recently, two new categories of players emerged;

- telecom operators/internet service providers, which started through DSL or fiber, leveraging the DTT in a hybrid manner (e.g. FR[11], UK) to create and distribute managed TV offers combining the mainstream channels with premium channels and content (e.g. ; sports, movies).
- So called “OTT” providers, which would provide specific TV services (e.g. Netflix), delivered to the end user though the (open) Internet or in some cases as part of the managed service of a cable or telecom operator.

As these new players developed their presence in the market, broadcasters have started to develop non-linear services for themselves (e.g. catch up TV), which they deliver either through managed networks (IP, cable, sat) or through the open internet as OTT; in some cases (e.g.; Smart TV, HbbTV) the OTT part of

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[11] *Estimation in France is that at least half of the IPTV set top box population are actually also connected to the DTT aerial and use in a certain proportion the DTT signal to feed the TV set, though the IPTV box ; such a configuration allows either for access network offload or for higher video quality delivery (e.g. DTT HDTV where IPTV is limited to SDTV).*

their service is integrated with the linear part. Some pay TV providers have also developed OTT offers of their own (e.g. Sky's NowTV, Canal Play) to compete head to head with the new pure OTT providers and avoid a harsh loss of traditional paying subscribers or simply get their fair share of this new market, or increase their commercial franchise.

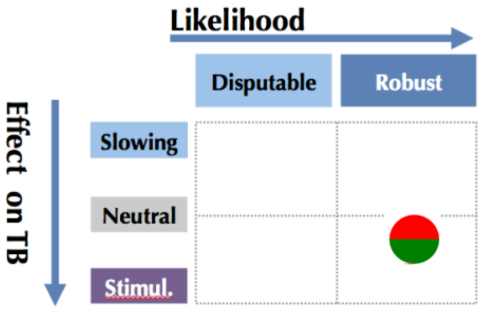
Although the original business models of each company are likely to continue to play a role in the future, one can see that "everybody does a little bit of everything" and that all main players will offer a wide continuum of services.

As they do so, they will consider and combine a range of network options to deliver these broad offers, including Terrestrial Broadcast.

➢ **Impacts on Terrestrial Broadcast**

- *Terrestrial Broadcast must remain fully capable and ready to serve the core needs of Broadcasters (delivering linear TV content) as they are not likely in most cases to decide to do without it; its unique advantages (low cost, high quality, high reach delivery platform) should be protected, developed and promoted on this basis.*
- *Terrestrial Broadcast also needs to become more versatile and flexible, being able to serve, in addition to the central linear TV use case, all new use cases of broadcasters and other entertainment operators (e.g. ; mobile, on demand, etc..), and also to adapt quickly to changing consumer preferences (e.g. ; re-arranging programs on network capacities, customizing programs on some instances, .. ; it should be accessible and friendly for innovating business models , not only to the traditional core of FTA TV.*
- *Terrestrial Broadcast should be easy to "connect" and integrate with non-broadcast service models (e.g. broadband on-demand) so that broadcasters can continue to fully leverage Terrestrial Broadcast in their approach to the market (e.g. HbbTV / Connected TV) and that end-users can easily use Terrestrial Broadcast in a rich seamless environment.*

15. A big data world



The Big Data world plays an important role in the new economy as it is a new way to try to ensure business success. The Big Data concept refers to the collection and the analysis of massive amounts of data to inform decisions and find final key clues that could be essential for companies to hit their targets.

The television industry evolves to new viewing dynamics, formats and content type consumptions which are boosted by multiple facts: the proliferation of devices, the new digital age capacities and the social media networks. This new environment generates a huge amount of real time data that, when well processed, provides an enormous opportunity for the sector to optimize networks, find out markets to target, audiences, content recommendation drivers and even create tailored programming based on those inputs.

Users interact every day with brands, providing different kinds of digital data flows from every channel and brand. Big Data enables the possibility to have an Omni channel approach in order to more closely fit the customer's needs. Television could be a key input to that approach.

Television viewing is multidimensional and requires big data systems to cope with this new reality. Linking Big Data with Broadcast Television open up new business models that are closer to internet environments, bringing the chance to the Terrestrial Broadcasting to find future possible evolutions.

The better use of viewer data can transform how broadcasters and advertisers reach consumers. This approach can provide a deeper understanding about consumer habits and interests, by being able to cross-reference data consumption in real time. It brings more value to advertising on Terrestrial Broadcasting because it can provide higher income to the model. It makes terrestrial broadcasting of linear television content more valuable and attractive to consumers and agencies.

A rich set of descriptors (location, usage, time, content, etc.) could be collected by Big Data systems and merged with other sources of data from broadcasters to define households that meet marketers predetermined target attributes.

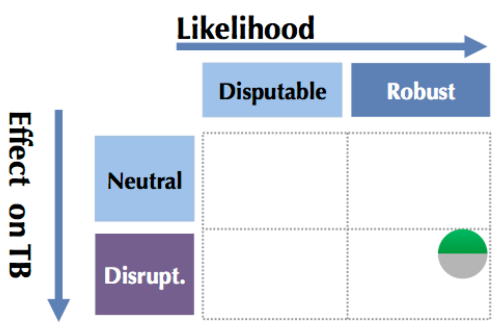
Big data technologies can enable advertisers and broadcasters to selectively segment TV audiences and serve different advertisements, sent though broadband and mixed seamlessly within a common broadcasted programme. Segmentation can be done using different types of data depending on the source, such as; geographic, demographic, behavioural and even self-provided by individuals.

This environment requires protection for the privacy of individuals in terms of regulating the collection, storage, management and trading of data to enhance the Terrestrial Broadcast ecosystem.

➢ **Impacts on Terrestrial Broadcast**

- *Terrestrial Broadcast must seek to become big data friendly and ensure (at least as well as other platforms), by cooperation with unicast networks, a "big data enabling return channel" in order to meet global market trends and needs and to be ready to provide real time information to big data processing systems.*
- *Terrestrial Broadcast provides the mechanisms and the opportunities to leverage the information derived from big data to adapt programmes, advertising and data services and make use of other analytics.*
- *The collection of end user usage data could bring to Terrestrial Broadcast and its main players, new ways to improve their understanding of their customers and analyze their needs in order to provide real time metrics and analytics to the ecosystems.*
- *Big Data is a key factor for the future of new business models on Terrestrial Broadcast, because it brings to one of the main source of revenues of TV, advertising, new ways to target the audience effectively bringing more value to all the players. If the TV does not become smart / connected the possibilities will vanish.*
- *Terrestrial Broadcast should establish the right framework to guarantee personal data and privacy is protected. The data should be anonymous aggregated data only so that it is not sensitive and managed as broad marketing segments rather than profiles, save for agreed exceptions.*

16. Internet of Things (IoT)



Internet of Things (or M2M communications) becomes a reality; home appliances, cars, public services, utility and municipal infrastructure, etc. become connected and are looking for network solutions to exchange data.

The current focus is on use cases and technologies providing one on one communications, upwards or downwards, with very low data weight (i.e. small messages).

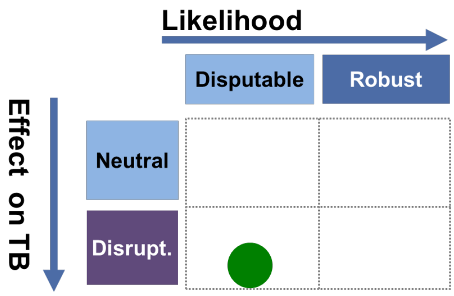
New networks and technologies using un-occupied and/or un-licensed frequencies (e.g.; SigFox, LORA, …) have emerged, and mainstream technologies (e.g.; LTE) are adapting to meet these needs; this is resulting in the growing availability on the market of low cost solutions for small payload data uploads and downloads, with a focus on unicast.

Although there is no strong evidence for this, it is possible to foresee that on some occasions, these connected objects may also need broader payloads (e.g.; a large middleware update for a TV set or another home appliance) and deliver to a much broader audience (i.e., same data need to be received on millions of devices) while open un-licensed frequencies may eventually prove too scarce to meet the vast demand or the ad-hoc technologies have not been specified to do this.

➢ **Impacts on Terrestrial Broadcast**

- *The existence of low cost/low payload solutions becomes an opportunity to provide an upwards return channel (outside of Terrestrial Broadcast networks and technologies, using dedicated IoT networks) for broadcast minded devices which use DTT only as a main downwards connection, even without being connected to a broadband network*[12] *; this opens the way to a range of hybrid services, for example, VOD where receiver "asks" for a certain piece of content which can be later broadcasted, quality monitoring and audience measurement.*
- *Subject to the proper protection from disruption of the higher priority TV services through a close coordination with the terrestrial broadcast planning system, an opportunistic /secondary usage of Terrestrial Broadcast networks and spectrum (e.g. white spaces) could be considered, opening more IOT throughput capabilities to meet vast needs.*
- *Eventually, a direct (occasional, minority, downwards) integration of IOT data flows into Terrestrial Broadcast networks could leverage the Terrestrial Broadcast infrastructure in a win-win manner at times when it is less used for the core TV service, or when there is spare capacity; this would enable the delivery of heavy payloads to IOT devices, outside of the reach of IOT networks (e.g.; a software upgrade of a few MBs for a vending machine).*

17. Global Standards



The trend towards globalization remains strong. This is especially true for communication technologies. De-facto proprietary vertical standards (e.g. operating systems of mobile devices) in one area co-exist with more open/co-operative horizontal standards (e.g. LTE) in other areas, but all these standards are applied globally, while regional standards (such a region could be Europe) naturally disappear more and more – at least in the field of mobile devices.

In 2011 FoBTV was kicked off as a global framework for enabling the development of worldwide terrestrial standards in cooperation. It is probably fair to state that the enthusiasm evident in the early phase of FoBTV has disappeared and the interest in FoBTV in summer 2015 is pretty low. One possible reason is that the framework approach – rather than a real standardization approach – was not attractive enough for most key players in this arena.

Nevertheless, there is a natural movement towards aligned broadcasting standards for terrestrial use, i.e. the differences between DVB-T2 and ATSC 3.0 won't be too dramatic and both could be implemented in the same piece of silicon. It might also be anticipated that Japan and China would also proceed along such a global alignment route.

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12 *See for example the return channel for STB developed by SIGFOX and WYPLAY (http://www.infohightech.com/wyplay-connecte-les-decodeurs-tv-frog-au-reseau-internet-des-objets-de-sigfox/)*

A major strategic target regarding the development of global broadcast specifications would be to produce a common standard (aka. Common Broadcast System, CBS) by cooperation between 3GPP (their current system for broadcast/multicast purposes is LTE-eMBMS or LTE Broadcast) and the broadcast standards stakeholders, namely DVB/ATSC/ARIB/…. Unfortunately all related effort so far was invested in vain and 3GPP did not develop enough interest in such a joint project. A clear disadvantage for the broadcast stakeholders is that all the constituent are of a regional nature and FoBTV did not turn out to be able to create a global alignment. The most promising approach is likely to be a related eMBMS improvement activity within 3GPP and/or a joint effort of ATSC and DVB towards 3GPP.

If cooperation between 3GPP and the broadcast SDOs can't be realized within the foreseeable future, closer cooperation between the SDOs working on broadcast specifications in different parts of the world should be considered, ultimately heading for a global forum similar to 3GPP.

Note that a distinction between broadcast specifications suitable for a) stationary reception and b) portable and mobile reception is not required (though network deployments are likely to remain distinct given distinct reception targets and constraints) because the same specifications cover a sufficiently wide range of signal-to-noise ratios and can be applied to all reception scenarios. Examples for such universal broadcasting standards are DVB-T2 and ATSC 3.0.

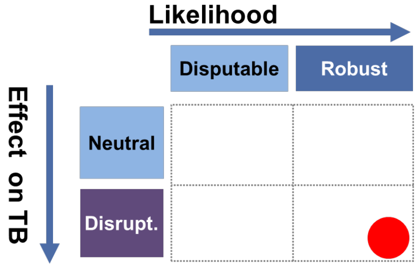
➢ **Impacts on Terrestrial Broadcast**

- *Given the industrial benefits (economies of scale, attractiveness to CE OEMs, ..) and the trend to global standards, Terrestrial Broadcast may find it very useful to evolve towards a global Terrestrial Broadcast standard ("GTB 1.0", Global Terrestrial Broadcast 1.0)*
- *Such a move would greatly facilitate, and potentially be justified only by the possibility to also evolve towards "Common Broadcast System" (CBS) which would be applicable to cellular mobile networks (Low Tower Low Power, LTLP) as well as to classical High Tower High Power (HTHP) broadcast networks*
- *Should cooperation between 3GPP and broadcast SDOs not be realized within the foreseeable future, the latter organisations should build a global forum in order to design global standards in the future*[13]

[13] *3GPP was created in 1998 as the global forum for the development of mobile communication standards.*

4 Regulatory and Spectrum Factors

18. Spectrum Reduction



Two frequency bands are generally available for terrestrial TV services: the VHF band and the UHF band[14]. There are significant differences across the world in terms of spectrum availability and deployment of terrestrial broadcast networks.

The upper parts of the UHF band have recently been cleared from broadcasting and assigned to mobile communication service providers. In particular, in the ITU Region 1 (an area broadly covering Europe, Africa, Middle East, and Russian Federation) the 790-862 MHz band (the 800 MHz band) has been allocated to the mobile services in 2007 whilst in 2012 a mobile allocation was included in the band 694-790 MHz band (the 700 MHz band), effective as of November 2015.

The rest of the UHF band (470-694 MHz) is currently under consideration for a further mobile service allocation. A decision will be taken at the ITU conference in 2015 (WRC-15).

Several studies[15] have been recently carried out in Europe as a basis for a political decision on the future use of the UHF band. In particular, Pascal Lamy, the chairman of the EU High Level Group on the UHF band, recommended that the 700 MHz band be transferred wireless broadband across Europe by 2020 (+/- 2 years). Furthermore, regulatory certainty and stability for terrestrial broadcasters in the remaining UHF spectrum below 700 MHz should be retained until 2030. The Lamy report also recommends a review of the technology and market developments by 2025 and to facilitate the flexibility of use of the sub-700 MHz band in the countries with a low demand for DTT. The Lamy recommendations are essentially followed by the European Commission[16] and the EU Member States.

The following assumptions can be made for the future:

- After 2020 the 700 MHz band will be progressively used for the mobile service in most countries, perhaps with some exceptions (e.g. Russian Federation). This will reduce the UHF spectrum available to DTT to a maximum of 224 MHz (as opposed to 392 MHz prior to the release of the 800 MHz band, i.e. a 42% reduction).

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[14] *The boundaries of the frequency bands allocated to terrestrial broadcasting in the ITU Radio Regulations are not identical in all World regions. Generally, TV services are implemented in the following frequency bands:*

- *The VHF band (174 - 230 MHz). Although there is broadcasting allocation in the VHF band, the band is not available (in part or entirely) for TV services in all countries because of other existing services. Furthermore, in some countries the households are not equipped with suitable receiving installation for TV services in the VHF band.*
- *The UHF band (470 - 790 MHz)*

[15] *The results of these studies are available in the following documents:*

- *Pascal Lamy's report to the European Commission on the results of the High Level Group on the UHF band (http://europa.eu/rapid/press-release_IP-14-957_en.htm)*
- *RSPG Opinion on a long-term strategy on the future use of the UHF band (470-790 MHz) in the European Union (http://rspg-spectrum.eu/wp-content/uploads/2013/05/RSPG15-595_final-RSPG_opinion_UHF.pdf)*
- *CEPT / ECC Report 224: Long Term Vision for the UHF broadcasting band (http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP224.PDF)*
- *Challenges and opportunities of broadcast-broadband convergence and its impact on spectrum and network use - A study by Plum and Farncombe for the European Commission (https://ec.europa.eu/digital-agenda/en/news/challenges-and-opportunities-broadcast-broadband-convergence-and-its-impact-spectrum-and-0)*

[16] *European Union strategy for the future use of the UHF broadcasting band (470-790 MHz), including the 700 MHz band (694-790 MHz) (http://ec.europa.eu/smart-regulation/roadmaps/docs/2015_cnect_017_uhf_en.pdf)*

- The band 470 - 694 MHz band may remain available for terrestrial TV until at least 2030. However, some regulators may permit access to this band for mobile broadband (i.e. supplemental downlink or white space devices, or both) on a shared basis with DTT.
- The VHF band will remain only partially available for TV services.
- A significant risk of further reductions of spectrum availability remains, in particular because of the pressure from the mobile industry.

Whilst the above described situation applies mainly in the European context, similar trends are observed in other parts of the world. Therefore, it can be reasonably assumed that the implications for Terrestrial Broadcast , from this discussion should essentially be applicable to a broader geographical area.

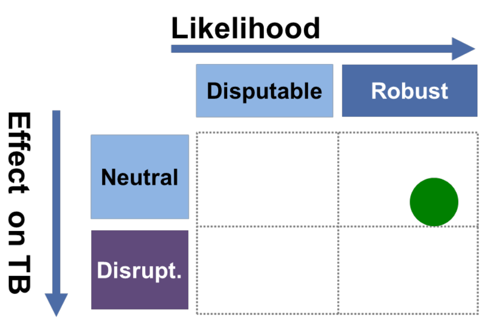
➢ **Impacts on Terrestrial Broadcast**

To provide future services within less spectrum the Terrestrial Broadcast networks should evolve towards:

- *higher spectral efficiency (further details can be found in Chapter 2 Supply & Demand)*
- *increased resilience to interference from the adjacent bands (e.g. LTE) and within the band (e.g. white space devices)*
- *increased agility and flexibility in allocating the available transmission capacity in order to address the most relevant use cases in a social and economic sense and avoid "wasting" scarce spectrum on services with a lower impact at certain times.*
- *assessing if there is a role for Terrestrial Broadcast to play to serve or assist consumption on mobile devices, which is largely stationary and would be complementary to existing support through Wi-Fi offload.*

19. General Interest Objectives

Terrestrial TV services are normally subject to audio-visual media regulation which require individual authorisation. This gives the national media authorities an important tool for the implementation of general interest, social and cultural policy objectives thereby providing an essential outlet for national creative content and the means to promote social inclusion.



The terrestrial broadcasting platform is a principal delivery means for Public Service Broadcasting (PSB) services as it generally provides free-to-air access. In many countries there is a regulatory requirement that the terrestrial broadcast networks for PSB must achieve a near-universal coverage i.e. exceeding 98% of the population. In some countries PSB providers are legally obliged to transmit terrestrially. Other regulations designating particular technologies are sometimes applied to Terrestrial Broadcast platforms to ensure that viewers are not disenfranchised by hasty technology changes. These regulations can act as a constraint on innovation and transition.

Beyond PSB, the terrestrial platform is also capable of supporting commercial free-to-air and subscription-based TV services. These services could be national, regional or local as the terrestrial networks can be designed in such a way as to provide coverage tailored to administrative boundaries or to commercially defined target areas. This offers diversity and choice to the viewers and sustains platform innovation and competition, which is another general interest policy objective.

However, allocation of Terrestrial Broadcast multiplex capacity to different content and services is usually regulated and rather static. This may put Terrestrial Broadcast at a disadvantage compared to other distribution platforms that have more flexibility to adjust to audience demands.

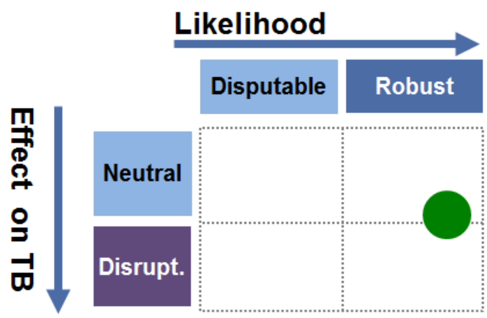
Terrestrial Broadcast networks are often designed for high reliability and where they are they provide critically important infrastructure which can be used for information dissemination to the public in times of emergencies, including natural and man-made disasters.

➢ **Impacts on Terrestrial Broadcast**

- *Because it is specially adapted to supporting public service objectives (e.g. national social and cultural objectives, maintaining continuity of information to the public even in emergency situations) Terrestrial Broadcast is very likely to remain in the very long term in many countries an important and highly desirable platform from the point of view of national authorities, in addition to its intrinsic reasons for resilience.*
- *In order to achieve this at minimum costs and with satisfactory quality it is very important for Terrestrial Broadcast to retain its ability to deliver a high volume of linear TV services but also to serve new applications. This would enable Terrestrial Broadcast to adapt to the evolving consumer demand and the needs of the service providers and retain a high reach in the public. Otherwise, Terrestrial Broadcast would be at risk of becoming an aging and non-competitive platform, unable to fulfil the important public objectives.*
- *As an additional benefit, the Terrestrial Broadcast platform would enable open and affordable access to the new services, in particular for the households without access to the next generation broadband services.*
- *National authorities should facilitate and encourage the technical evolution of the Terrestrial Broadcast and the integration of new services and applications, in particular through appropriate amendments to the regulatory framework.*

20. Energy efficiency and environmental issues

The general awareness of society to the problem of carbon emissions and the need to use energy more efficiently has increased substantially in recent years. At the same time electronic devices and communications networks have become ever more substantial consumers of energy worldwide.



Conversely, the cost of energy has become an important parameter in the economics of electronic devices and communications networks, and hence of the digital ecosystem.

Modern developments in technology have significantly increased available Terrestrial Broadcast transmitter energy efficiency ratings over the past few years, driven by the ever increasing cost of energy. Some manufacturers claim energy savings of as much as 50% over previous generations of digital Terrestrial Broadcast transmitters [ref 3].

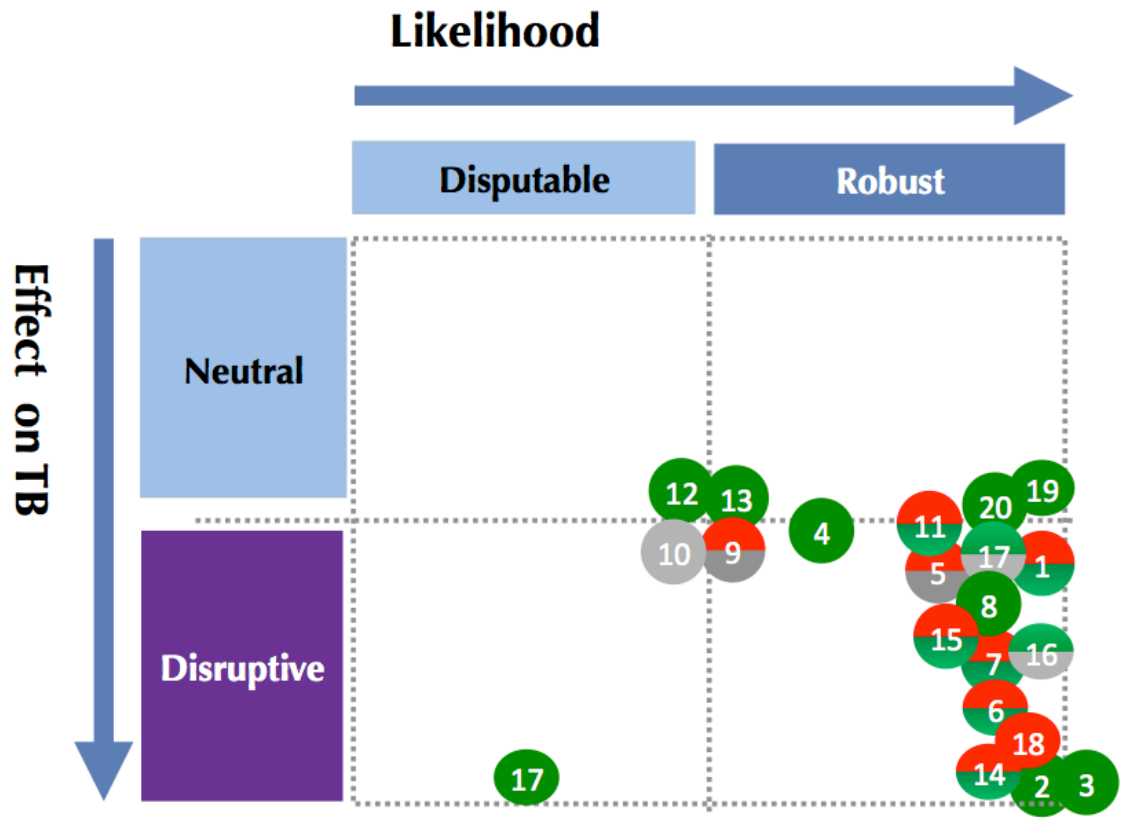
Terrestrial Broadcast is recognised as being a reasonably energy efficient broadcast technology (assuming audiences are large). Domestic receiver and screen power consumption tend to dominate a Terrestrial Broadcast network's total energy consumption [ref 1, ref 2].

It should be noted that broadcasts to a small audience are most energy efficiently conveyed using video-on-demand. However, Terrestrial Broadcast is regarded as significantly more energy efficient than video-on-demand for larger audiences [ref 2], although this gap may be reduced in the future if Content Delivery Networks, Multicast and similar technologies become used more extensively for broadcast traffic over IP networks. The trend towards ICT energy reduction in general is also likely to see improvements in the future power consumption of IP based networks.

When looking at the bigger picture of environmental concerns, technologies that discourage excessively frequent replacement of consumer equipment are also beneficial [ref 1]. Modular hardware design to aid repair and remanufacturing together with upgradeable software can extend a product's lifetime and make recycling easier.

<u>Impacts on Terrestrial Broadcast</u>

- *Terrestrial Broadcast is an energy efficient mechanism for delivering broadcast content to a large audience.*
- *Future Terrestrial Broadcast technologies should provide a favourable energy link budget.*
- *Future Terrestrial Broadcast technologies should encourage the use of low power receiving equipment.*
- *Low power receiver standby modes should be encouraged (the EU already has an Energy using Products (EuP) directive mandating such strategies for new equipment).*
- *In order to discourage replacement cycles of Terrestrial Broadcast consumer equipment which could be considered to be excessively frequent, technology migration will need to take account of factors including ecological improvements, disposal costs and consumer benefits.*



Most of the 20 major context factors identified and discussed are evaluated with a high probability of actually coming to play, and also as likely to have a significant impact on Terrestrial Broadcast ; they can thus not be ignored when thinking of the future of Terrestrial Broadcast.

As for the nature of such impact, there is a mixed situation, where both (anticipated) positive and negative impacts are forecasted, with still a (clear) majority of positive anticipated impacts.

It should be kept in mind that impacts are estimated, and as for positive impacts they should be really understood as " having the potential to have a positive impact if Terrestrial Broadcast adapt to take advantage of the situation"; very few factors are likely to have a direct and automatic positive impact, where positive consequences will materialize without action or adaptation of the Terrestrial Broadcast platform.

For Reference : the 20 Major Context Factors

1 *Ever Increasing video consumption, with more and more on-demand* **2** *HD as the basis - and going beyond HD* **3** *Connected Home is the norm, with multi-screen consumption of media* **4** *Growing Out of Home and On-the-Move Media consumption* **5** *Personalized & Social Media experiences with augmented and programmatic content /* **6** *The need for trusted solutions and privacy* **7** *Universal basic broadband connectivity, but lack of universal true ultra-high speed* **8** *"Connected Terrestrial Broadcast" becomes the norm* **9** *Sub-optimal and variable receiving conditions* **10** *IP broadcasting* **11** *Fast developing cellular networks, moving to 4G and then 5G* **12** *Continuous improvements in encoding* **13** *Significant potential for improvement in terrestrial broadcast* **14** *a decoupling of services and network; dilution of traditional business models; new players* **15** *A "Big Data" world* **16** *"Internet of Things"* **17** *Global standards* **18** *Spectrum reduction* **19** *General interest objectives* **20** *Energy efficiency and environmental issues*

CHAPTER 2 : SUPPLY AND DEMAND FOR TERRESTRIAL BROADCAST

Introduction

Based on the contexts described in Chapter 1 for the environment of Terrestrial Broadcasting, the CM-T Group felt it would be useful to develop a "Supply and Demand" model which gives an estimate of the spectrum available – the "Supply" and the forecasted demand for services (taking into account service demand and technology factors) – the "Demand" in the 2020-2030 time frame. This Supply and Demand model for Terrestrial Broadcast, aims to provide an indication to help assess the desirable level of progress which may need to be achieved in spectral efficiency.

DEMAND = the need for Terrestrial Broadcast capacities, looking both at existing applications (linear TV for fixed reception) and possible new applications.

This demand is estimated in Mbps, reflecting successively a number of factors, including:

- Changes (as the case may be) in the number of linear TV channels
- the MPEG-2 switch off and the complete migration to MPEG-4
- the continued transition of SD to HD (including the need for simulcasting SD and HD)
- the forecasted further improvements in MPEG-4 codecs
- the progressive introduction of UHDTV channels
- the introduction of HEVC codecs (not just for UHDTV services)
- the switch to DVB-T2

SUPPLY = the spectrum that will be available for Terrestrial Broadcast.

When supply and demand (changes) have been estimated, it is then a simple matter to assess the change in spectral efficiency that is needed to match supply with demand.

The model was developed for four European countries, where there is a very important presence of Terrestrial Broadcast services; namely France, Italy, Spain and the United Kingdom. It is based on the factors discussed in Chapter 1 and the professional knowledge and judgment of CM-T members, principally operating in each of these 4 countries.

The results have then been aggregated to come to "forks".

Important Note

The model developed for each of the four countries **should in no case be interpreted as reflecting decided or agreed plans for those countries as such plans** generally do not yet exist, nor as prosing such plans.

On the contrary, the models are to be taken as **a realistic projection of what the situation could be in 2025-2030** in each country, given the market and technology context depicted in the LTV report.

It should be noted that the order in which the different change factors are presented here does not reflect a timed or logical or intended/planned sequence; it is simply a practical way of presenting the different steps to go from Starting Point (1) to Net Final Demand (15).

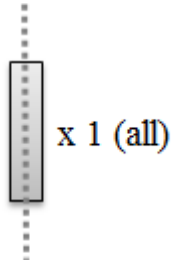
DEMAND – Traditional Linear TV

(1) Starting point – Demand for Traditional Linear TV

The starting demand point varies between 160 Mbps and 210 Mbps for three of the four countries, with the exception of one country where the starting capacity reaches 405 Mbps. The number of DTT programs varies between 25 and 100, with a mix of HD and SD with SD being dominant.

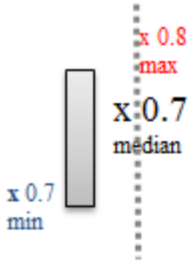
(2) Number of Linear Channels

All countries initially plan for a stable number of linear channels on Terrestrial Broadcast (though the mix of HD and SD is rebalanced; see below). In one country, where the initial number of channels is very high, there is an anticipated reduction in the number of channels (-25%) in conjunction with the full HD migration.



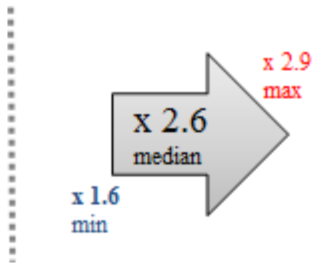
(3) Transition MPEG-2 to MPEG-4

The transition to a full MPEG-4 environment will result in a decrease of required capacity of between x0.7 and x0.8; this results from an expected gain of 40% when a given channel is transitioned from MPEG-2 to MPEG-4, while the number of channels to be transitioned varies between countries (some channels are already MPEG-4).



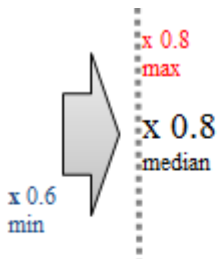
(4) All HD

The forecasts illustrate all countries with all of their linear TV channels in HD, though the bit rate per HD channel varies between 8 Mbps and 10 Mbps. When this is done, SD simulcasting is stopped, which releases some bandwidth. The resulting change factor varies between x 1.6 and x 2.9, because of the current profile of HD used and the total number of channels.



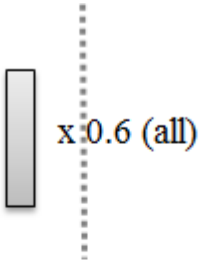
(5) HD MPEG-4 CODEC Improvement

The expected gain on MPEG-4 codec improvement is generally about 20% on a given channel (one HD channel goes from 10 to 8 Mbps, or 8 to 6.4 or 7.25 to 6), while one country plans for a higher gain of 40% (from 8 to 4.8 Mbps HD channel).



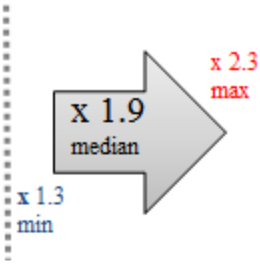
(6) Full HEVC

All countries expect a 40% further gain if /when HEVC is deployed on all (HD and then UHDTV) channels.



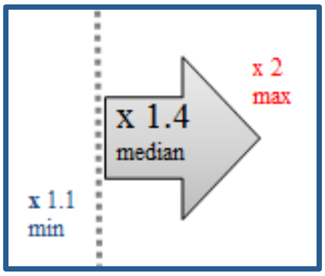
(7) UHDTV introduction

All countries expect the existence of about 10-11 UHDTV channels (without simulcasting) within the timeframe of this vision ; given the significant discrepancies between required capacity before UHDTV (which stems principally from the difference in total number of channels) this results in a change factor that varies significantly between x 1.3 and x 2.3



(8) Summary: Change in Demand for Traditional Linear TV

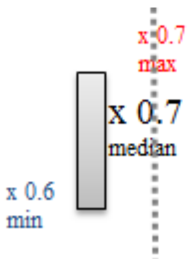
The combination of change factors (2) to (7) above results in an overall change in the demand for capacity to broadcast traditional linear TV that varies between x 1.1 and x 2 depending on the varying forecasts for each country.



Known Spectral Efficiencies & Step Results

(9) Full DVB-T2 migration

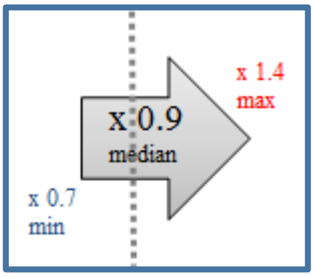
The full migration to DVB-T2 across all countries will yield a x0.7 to x0.6 reduction in the need for spectrum (in MHz, with planned capacities for a DVB-T2 Multiplex of 31, 34 or 40 Mbps (versus currently 20, 22.5, 24 or 27 Mbps in DVB-T).



Again, as explained in the introductory note, it should be noted that the calculated effect of DVB-T2 is intended to be a measure of the DVB-T2 effect if it is fully deployed, not a prediction of an actual full DVB-T2 migration, nor of its date, both of which are likely to differ between different countries.

(10) **Summary: Change in Demand for Traditional Linear TV after T2 effect**

The net change in demand for terrestrial broadcast capacity for traditional linear TV, after the effect of DVB-T2 introduction, is calculated by multiplying (8) and (9) and results in a change factor that varies between x 0.7 and x1.4.



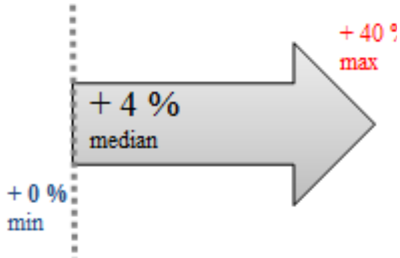
New Applications

As introduced in Chapter 1, a number of new applications are likely to be introduced on Terrestrial Broadcast, in addition to the current core application of broadcasting linear TV.
The quantitative estimate of the impact of these new applications is of course very difficult to forecast, as they are yet to be widely created or implemented in the market, nevertheless this forecast has been attempted and is summarized below.

(11) Non Linear TV stationary services (e.g. Push VoD)

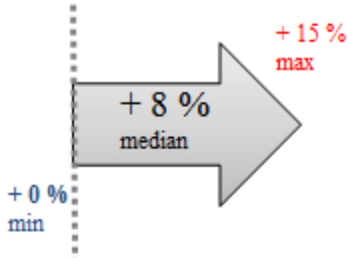
The estimated impact of the carriage of non-linear TV content varies greatly between the countries; the increment in required capacity (beyond the result of (10) above) varies between 0% and 40%.

It is worth stressing that when a level of 0% was advised, it was not necessarily meant to indicate a lack of interest for such new application, but was more likely a perceived lack of capacity available for allocation to this usage and/or uncertainty as to how such a use case could be implemented. Further work has been recommended to explore the concept of Push VOD further (see Chapter 4



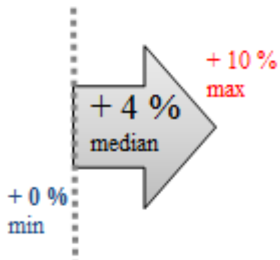
(12) Mobile Linear TV services

The increment in required capacity for delivery of mobile linear TV to mobile devices (beyond the result of (10) above) varies between 0% and 15%; again, this is a quantified resulting impact, while at certain moments the actual allocation to mobile might be greater than the available capacity, with a temporary re-allocation of fixed linear TV capacity to mobile . It is worth stressing that when a level of 0% was advised (one country) , it was not meant to indicate a lack of interest for such new application, but was more determined by the perceived lack of capacity available for allocation to this usage. As interest for the usage would still exist it has been anticipated (but cannot be reflected quantitatively in the model), that such new applications could be introduced by occupying alternative bands, not necessarily use frequency bands below 700 MHz (they could use instead 700 MHz band).



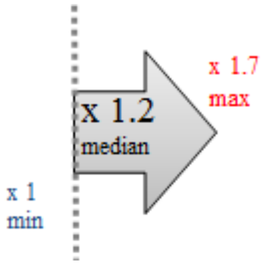
(13) Non Linear Mobile TV services

The increment in required capacity for delivery of non-linear content to mobile (that applies to the result of (10) above) varies between 0% and 10%; same comments as in (11) and (12) above apply.



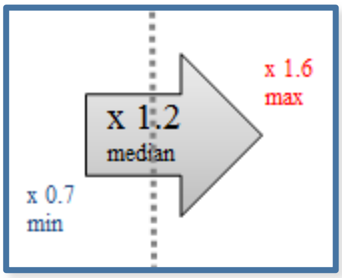
(14) Summary: Combined effect from new applications

The combination of (11) (12) and (13) suggest that the required terrestrial broadcast capacity would be multiplied by a factor between x 1 and x 1.7 to accommodate new applications.



Again, in the low case (x 1), the lack of impact should not be interpreted to indicate a lack of interest or relevance for such new application, but as the perceived lack of capacity available for allocation to these new applications, which would be introduced by occupying opportunistically capacities assigned to linear TV at certain moments, or by occupying alternative bands (they could use 700 MHz band).

(15) Net Change in Demand Effect

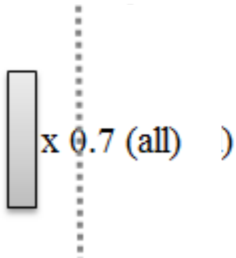


The combination of;

- *(8) change in demand for traditional linear TV, plus*
- *(9) full DVB-T2 migration, plus*
- *(14) new applications*

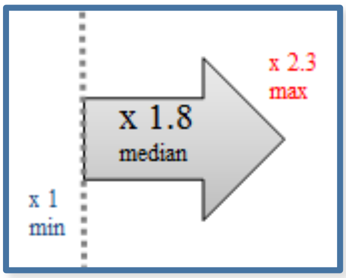
will result in a total change in demand for terrestrial broadcast capacity that varies between x 0.7 and x 1.6.

(16) Supply Evolution



Given the planned re-allocation of the 700 MHz band, the supply (in MHz) of spectrum assigned to terrestrial broadcast will decrease by 30% (factor of x 0.66).

(17) Required gain in Spectral Efficiencies



If the demand, as projected in (15) is to be matched by the supply as projected in (16), the division of (15) by (16) indicates the change in spectral efficiency that is needed to ensure that supply can be matched by demand.

Therefore, the required progress in spectral efficiency projected by the supply and demand model would be a minimum of none (factor of x1) and a maximum of x 2.3.

Conclusions from the Supply and Demand Model

- **The forecasted capacity required by traditional linear TV will evolve between x 1.1 and x 2,** depending on the number of services already deployed with the current available spectrum resources, across the different countries , **with a median value of x 1.4**, after reflecting the following change factors:
  - Number of linear TV channels
  - Switch from MPEG-2 to MPEG-4 , and further MPEG improvements
  - Migration to all HD
  - Full introduction of HEVC
  - Limited introduction of UHDTV

- When a complete migration to DVB-T2 is factored in, the required spectral capacity **will evolve by a factor between x 0.7 and x 1.4,** depending on the countries , **with a median value of x 0.9**

- The planned reallocation of the 700 MHz band to mobile communications in itself is creating a capacity reduction of x 0.7, which means that only the least demanding scenario in the paragraph above can be satisfied, while the median scenario (demand : x 0.9) CANNOT be satisfied under such circumstances

- When new terrestrial broadcast applications (mobile & filecasting/on demand) are factored in, the requested spectral capacity **will evolve between x 0.7 and x 1.6,** depending on the countries , **with a median value of x 1.2**

- Therefore, matching Supply and Demand under those assumptions requires improvements in **spectral efficiency of Terrestrial Broadcast of between x 1 and x 2.3, with a median value of x1.8 ;**

- The proposals outlined in the Next Generation Terrestrial (NGT) report could produce such improvements, although it remains to be fully evaluated as to whether they can be practically deployed in economically viable ways

- Should one consider a further reduction of the spectrum allocated to terrestrial Broadcast (e.g. : 600 MHz), the **required improvement in Terrestrial Broadcast spectral efficiency would be between x 1.8 and x 4.1, with a median value of x 3.2**, which is way above the currently identified possible improvements, even ignoring practical implementation uncertainties ; such further spectrum reduction would therefore not allow the anticipated development of Terrestrial Broadcast usage, even when all technical improvements are leveraged.

CHAPTER 3: EXTERNAL SURVEY RESULTS

1. Introduction

As part of the Long Term Vision process we considered it essential to take into account inputs from the stakeholders of the Broadcast ecosystem in the main countries where DVB is used. To this end we conducted an online survey during June 2015.

The survey was completed by 62 respondents consisting of:

- 28 broadcasters (45.2%)
- 16 network operators (25.8%)
- 11 manufacturers (17.7%)
- 7 Other (11.3%)

Respondents came from 25 different countries. Almost all respondents use or are associated with the Terrestrial Broadcast platforms (95%).

The survey was split into three main sections reflecting the structure of the Long Term Vision report: 1) The Evolution of the TV Landscape in General, 2) Views on the possible evolution of Terrestrial Broadcast, and 3) Future Supply & Demand of Terrestrial Broadcast. There were 41 questions in total with the opportunity to leave additional comments.

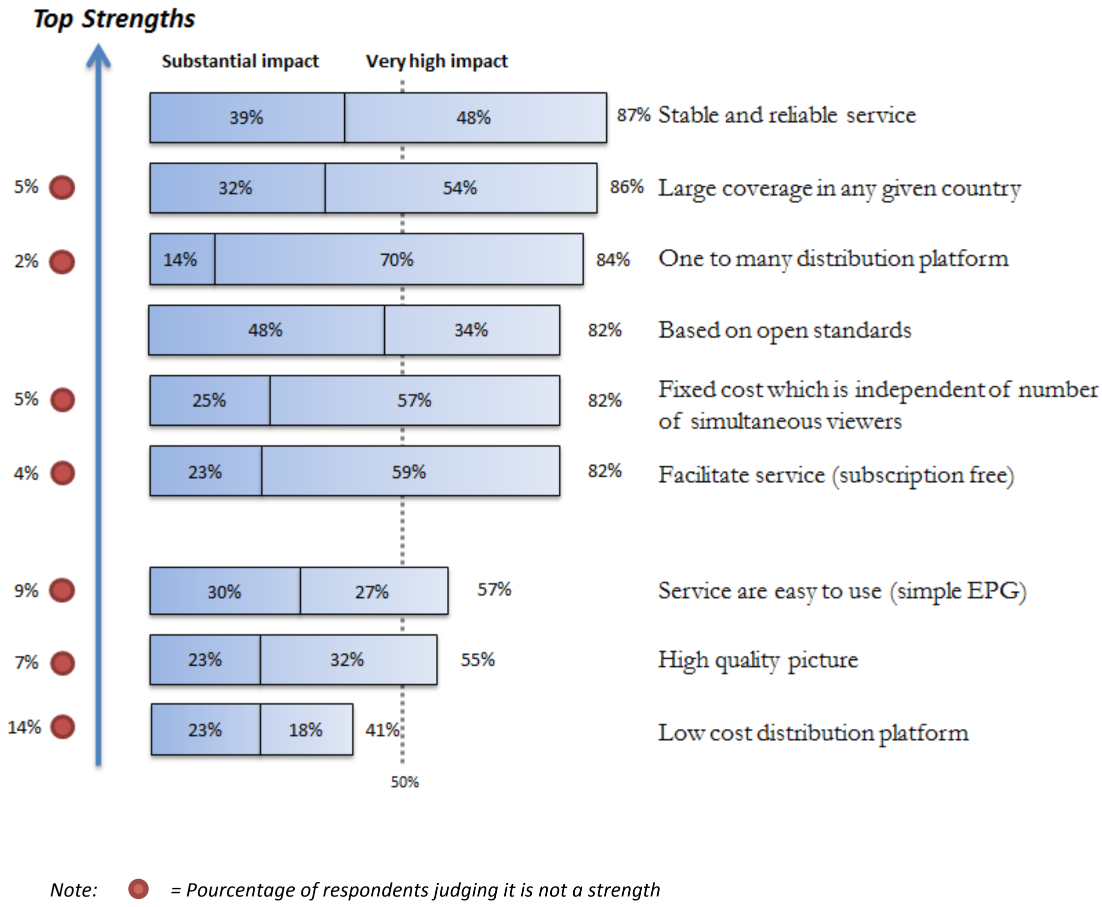
Throughout the survey we used a common scale to rate responses, unless indicated otherwise:

- 0: Does not apply or Don't know
- 1: Not at all Likely or Strongly disagree
- 2: Unlikely or Disagree
- 3: Neither likely or unlikely or Neither agree or disagree
- 4: Likely or Agree
- 5: Extremely Likely or Strongly Agree

In this summary we have focused on the top (4-5) boxes and bottom (1-2) boxes.

2. Strengths and Weaknesses

The top strengths and weaknesses are shown in Figure 2.1.



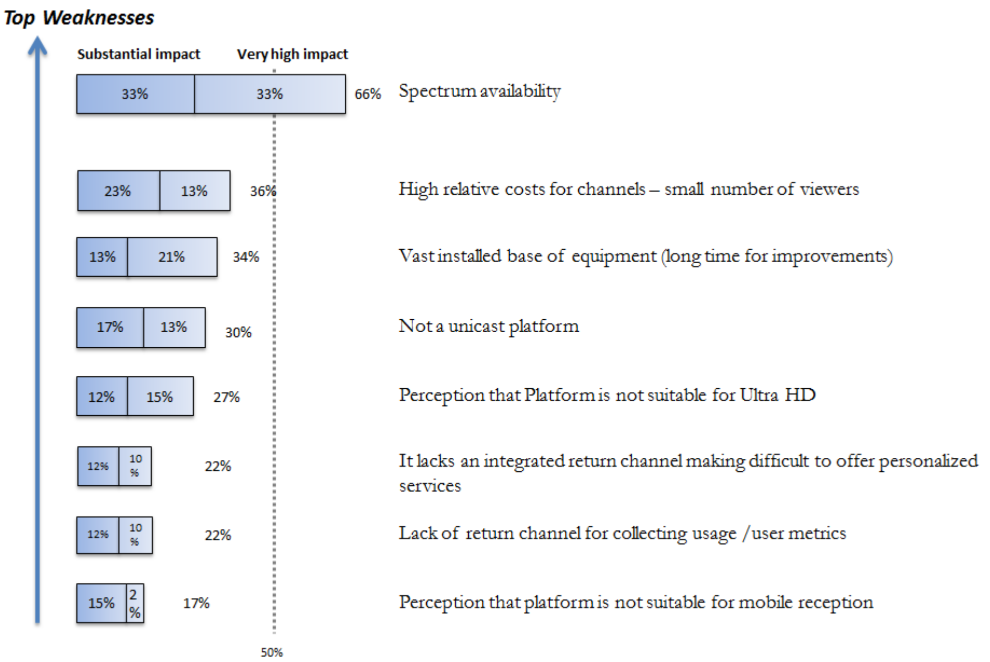


Figure 2.1: Summary of responses to Terrestrial Broadcast Strengths and Weaknesses

Strengths

The top three strengths are:

- "Stable and reliable service"; with 87% of responses saying substantial or very high impact.
- Large coverage area (86%)
- One-to-many distribution (broadcast) platform (84%)

Weaknesses

The top 3 weaknesses were stated to be:

- Spectrum availability; with 66% stating this had a substantial or very high impact.
- High relative costs for channels with small number of viewers (36%)
- Vast installed base leading to long upgrade cycles (34%)

3. Opinion on the Evolution of the TV Landscape in General

In this section we asked for opinions on the evolution of the TV landscape over the next 10-15 years (2025-2030).

The results are shown in Figure 3.1.

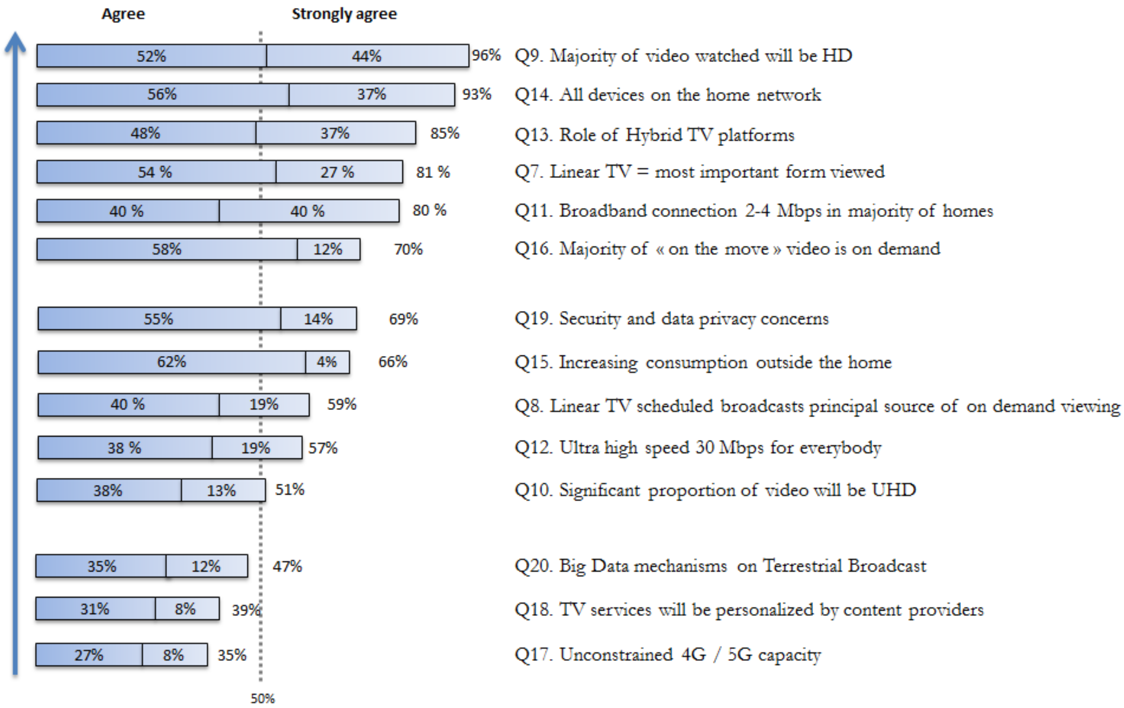


Figure 3.1: Summary of responses on the Evolution of the TV landscape in general

Strong/Full Agreement

The top 3 topics with strong agreement are:

- The majority of video watched will be HD (96%)
- Most devices in the home will be networked and used to view video/TV (93%)

- Hybrid TV platforms will be playing a major role in satisfying consumer demand for all types of content (85%)

Neutral/Uncertain Agreement

The three topics with least agreement are:

- Terrestrial Broadcast will support "big data" (47%)
- Most TV services will be personalised (39%)
- Mobile cellular networks (4G and then 5G) will have high enough capacity and be affordable for the viewers to meet the demand for ... mobile video content without quality or cost constraints (35%)

4. The Possible Future Evolution of Terrestrial Broadcasting

In this section we asked for opinions on the possible future evolution of Terrestrial Broadcast.

The results are shown in Figure 4.1.

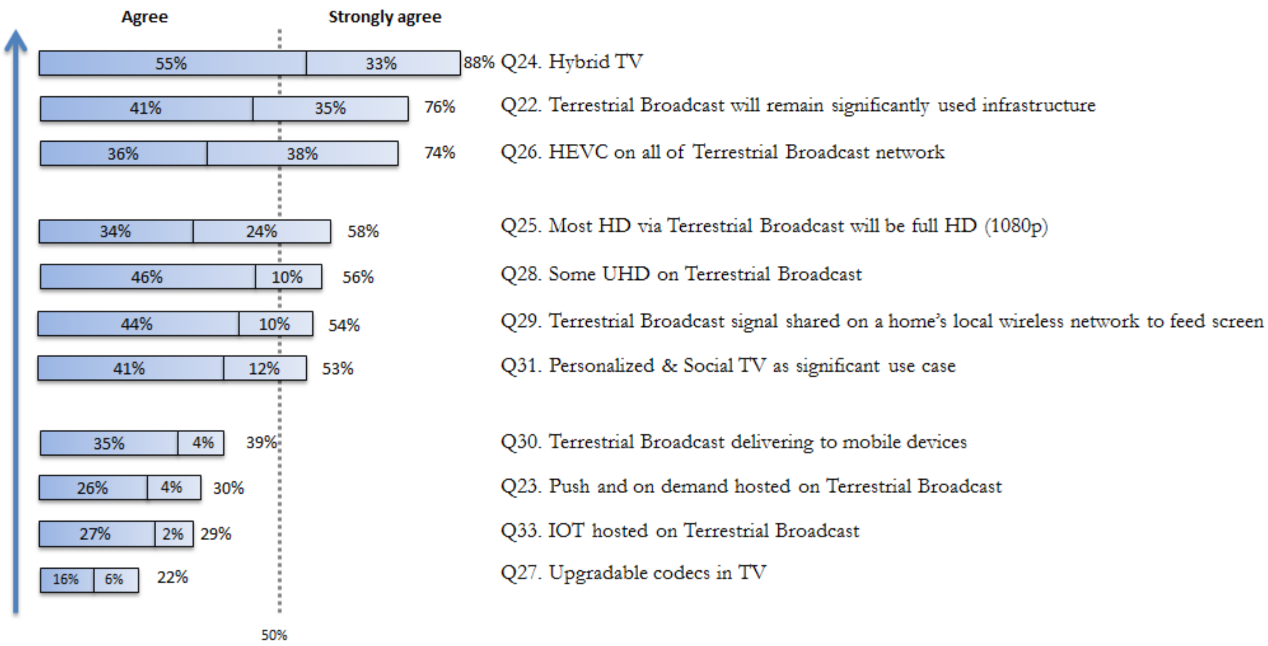


Figure 4.1: Summary of responses on the Possible Future Evolution of Terrestrial Broadcasting

Strong/Full Agreement

The top 3 topics with strong agreement are:

- Hybrid TV – content delivered by broadcast and by internet will be integrated in a seamless manner (88%)
- Terrestrial Broadcast will remain a significantly used infrastructure (76%)
- In the long term (2025-2030) HEVC will be used on all of the Terrestrial Broadcast networks in your country (74%)

Neutral/Uncertain

The 3 topics with least agreement:

- Push and on demand content will be provided by Terrestrial Broadcast (30%)
- IoT will be partially delivered over Terrestrial Broadcast (29%)
- The codecs in TV devices will be upgradeable to support the next generation of video coding beyond HEVC (22%)

5. The Future Supply & Demand for Terrestrial Broadcasting

A number of questions were asked to ascertain the level of demand for various services on the Terrestrial Broadcast platforms. The summary of these responses are shown in Figures 5.1 through 5.4.

Q: "The model suggests that the total number of linear channels on the Terrestrial Broadcast platform will remain stable. Please state your opinion on a 5 point scale with 1 being much less than today and 5 being much more than today."

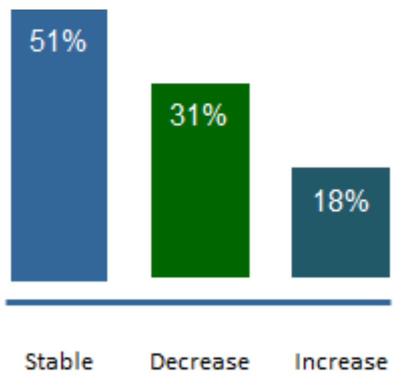


Fig 5.1: Number of Linear Channels

Q: "The model suggests a complete transition from SD to HD i.e. ultimately no more SD linear channels but only HD linear broadcasting. Do you think this is likely to happen in the considered time frame (10 years and more)?"

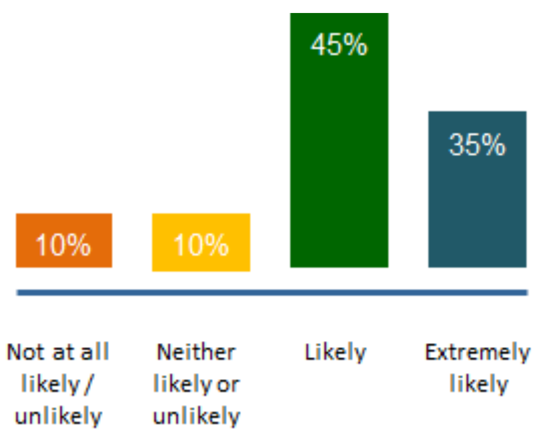


Fig 5.2: An all HD future

Q: “On the demand side, the model suggests an average of 10 UHDTV channels per country over Terrestrial Broadcast. Would you agree ?”

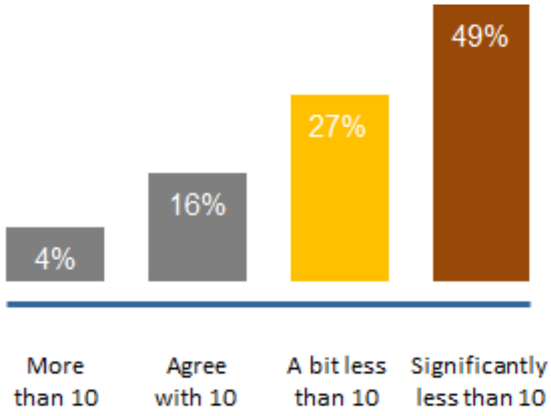


Fig 5.3: 10 UHDTV Channels per Country?

Q: “Without taking into account likely performance or efficiency improvements, which are covered in a later question, would you say the demand for Terrestrial Broadcast services will increase…?”

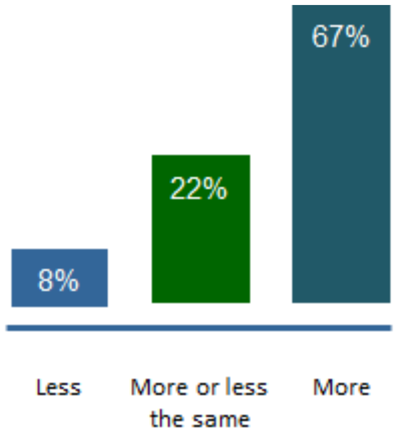


Fig 5.4: Demand for Bandwidth for Terrestrial Broadcast Services

Q: “Do you agree that in the timeframe of 2020-2030 DVB should be considering adoption of a next generation of as yet undefined AV CODECs to enable a more efficient compression of these new services?”

Figure 5.5 Adoption of Codecs Beyond HEVC

In summary:

- 51% of respondents believe that the number of linear channels will remain stable with 31% believing that there will be a decrease and only 18% thinking there will be an increase (Fig 5.1)
- 80% agree that the Terrestrial Broadcast platforms will go all HD (Fig 5.2)
- Only 16% agree that there will be 10 UHDTV channels per country; 49% think there will be significantly less and only 4% think there will be more (Fig 5.3)
- There is limited demand for new push and on demand services and services aimed at mobile devices, with nearly a third of respondents believing that no capacity should be allocated to these services:

Capacity Allocated	**Push On Demand**	**Mobile specific**
None	33%	33%
0-5%	31%	25%
5-10%	18%	25%
10-25%	8%	14%
More than 25%	10%	4%

- 67% of respondents believe there will be a little or much more demand for bandwidth in the future (Fig 5.4)
- There is very strong support (90%) for supporting a new generation of codec beyond HEVC (Fig 5.5)

6. Options for DVB

The final question asked respondents whether the DVB should develop a new physical standard and, if so, whether that development should focus on either the Low Complexity Profile or High Complexity Profile. 78% of respondents believe that the DVB should develop a new physical standard. Views were mixed on which complexity to focus on but with a consensus emerging that it would be too early to rule out the high complexity profiles at this stage.

Some comments received on this matter support this view:

- “Probably too early to just work on just the LCP as need to know more about the impacts on, and cost to, the end user of HCP.”
- “The HCP may become important for countries where terrestrial broadcasting is the most important distribution platform for fixed reception.”

7. Conclusions

The key conclusions that can be drawn from the survey results are:

1. Terrestrial Broadcast's top strengths are its stability and reliability, the broadcast nature of the platform and large coverage area.
2. There is a strong view that all services will be provided in at least HD format in the future with some Ultra HD, although the exact timing is uncertain
3. There is also a strong view that devices in the home will be networked together and nearly all used to watch live and on-demand video. There is support for Terrestrial Broadcast to be networked across the home.
4. There is a very strong view that hybrid TV can provide an integrated broadcast/broadband experience
5. Truly new use cases like pushed on demand and mobile content being delivered over Terrestrial Broadcast do not yet have strong support.
6. Personalised TV will become a growing use case
7. Terrestrial Broadcast will continue to experience demand for more capacity due mainly to the transition to HD and introduction of some UHDTV services.
8. There is a strong view that Terrestrial Broadcast needs to continue to evolve its physical layer standard beyond DVB-T2.

8. General Conclusions by the Study Mission Working Group

The survey has widely confirmed and reinforced the findings of the Study Mission.

However, the level of support is more moderate, but at the same time not insignificant or marginal, than the working group had expected for some items, including:

- Systematic personalization of TV content
- Systematic big data mechanisms on Terrestrial Broadcast
- Delivery of pushed on-demand content through Terrestrial Broadcast
- The need for content to be delivered to mobile devices through Terrestrial Broadcast
- Using Terrestrial Broadcast networks to transport certain types of IoT data

As can be seen in the subsequent Chapter 4, the Study Mission has duly integrated this moderation into its own weighting and prioritization of some items, though it remains important to mention that the Study Mission felt that limited support in the survey should not necessarily trigger the exclusion of some items from the Study Mission report and proposals; this is especially true of items of a more innovative nature where the lack of current examples may make it difficult for survey respondents to state their agreement with something that is not accessible to them and which the survey cannot explain in perfect detail. However, the Study Mission draws comfort from a statement which, it is alleged, was once made by Henry Ford: "*If I had asked my customers what they wanted they would have said a faster horse and I would not have created an automobile*".

Finally, the prediction of the Study Mission group that there could be 10 UHDTV channels per platform in the future was not supported by the survey findings – perhaps underlining the current uncertainty over how widely UHDTV will be adopted.

Overall, the Study Mission finds that the survey has been a robust, although not total, confirmation and reinforcement of the majority of its findings and proposed way forward.

Disclaimer

The results, analysis and conclusions compiled in this report are based on and drawn from the results of a survey of the DTT stakeholder community conducted by the DVB CM-T group. As many of the questions relate to predictions about the future, there is, of course, no guarantee that any predicted outcome will or will not materialize.

CHAPTER 4 : A FORWARD LOOKING VISION AND PRACTICAL RECOMMENDATIONS FOR TERRESTRIAL BROADCAST

Introduction

These are two questions that Chapter 4 aims at answering.

What will, or what should, Terrestrial Broadcast look like in 2030, and what will it be used for?

The Study Mission's answer to this first question is through the formulation of **fourteen Predictions** which together define the long term vision.

Of course, making such predictions is a complex exercise, in which some elements can be quite safely predicted, and some others remain debatable based on opinion or a desire that a certain evolution will occur.

Similarly, as a number of paradigm shifts in the market may result in forms of substitutability and even competition between different platforms (Terrestrial Broadcast, cable, IP, satellite, LTE ...), different stakeholder groups within DVB may have different opinions or preferences, because of their legitimate business interests, on the outcome of these shifts.

This Study Mission has intentionally focused **on a positive but realistic scenario for Terrestrial Broadcast**; where an uncertain element has a realistic positive (as well as a negative) potential outcome for Terrestrial Broadcast, we decided to integrate the positive outcome as a true possibility (although not the only one), so that the recommendations made to DVB in terms of evolving the DVB Terrestrial specification "prepare for the good".

It is perfectly understood that other points of view may exist in DVB (and even more outside of DVB) as they have existed in the Study Mission from companies who are exposed to, and arbitrating between, different network platforms. There is no pretention from the Study Mission that this positive vision is the one that will prevail but it is a positive vision that those companies engaged in Terrestrial Broadcast will probably be willing to achieve and leverage for their own good, and in the process of doing so, they are likely to turn to DVB for a matching evolution of technical specifications.

How will it achieve the vision?

The Study Mission tried to translate this vision into a number of concrete Recommendations, which are prioritized and categorized. These Recommendations point to a **number of important evolutions that Terrestrial Broadcast should complete**, in order to enable the vision presented above to become the reality.

It should be noted that these Recommendations are formulated with the view of maintaining the relevance, efficiency and usefulness of Terrestrial Broadcast, independently of the specific DVB stakes. They are more **addressed to the broader "Terrestrial Broadcast Community" without necessarily having direct implications to DVB** (e.g.: generation of a new specification).

Four different priority levels for the Recommendations

Based on the rating done internally in the Study Mission, the Recommendations have been categorized according to four levels of priority, which are;

1. **ACT** — a high relevance, a high consensus in the Study Mission and the perception that a fast timing is appropriate and possible, justifying immediate and priority actions

2. **PREPARE** — these are matters were there is a strong consensus that the relevance is high, but an agreement there is no need to act quickly and there is time to prepare

3. **ANTICIPATE** — the perceived relevance is not as high, or the consensus about the relevance is not as strong, however the possible impact could be significant and therefore the recommendation is to understand the matter and develop a viewpoint

4. **OBSERVE** — these are topics for which a consensus of the low impact/relevance has been agreed, at least for the moment and so it is suggested that no action is required now; but it is nevertheless recommended to observe market developments, so that the level of action can be increased should a higher relevance prevail in the future

Proposed Long Term Vision for Terrestrial Broadcast

[P1] **Significant consumption on Linear TV** (in absolute and relative terms) will remain and it will shift substantially to higher quality requirements (HD at least).

[P2] Terrestrial Broadcast will continue to play a substantial role to **convey Linear TV** and to be used by a significant % of homes in many countries (and a majority in some countries) as their main (although not only) source of TV content.

[P3] Because of reduced spectrum, higher picture quality requirements and potential new applications, **further performance improvements (beyond HEVC and T2)** of Terrestrial Broadcast could become desirable in some countries, aiming at a capacity increase in the area of x1.7 to x2.5; deployment of such **improved technologies**, potentially in conjunction with a next generation CODEC, can be anticipated to happen between 2020 and 2030.

[P4] On Demand viewing will become increasingly important, whilst not all homes will be able to receive On Demand services satisfactorily given broadband limitations; starting from experimental/marginal use cases, Terrestrial Broadcast could become a **significant delivery option for On Demand content** through the pre-loading on consumer devices of On Demand content which is expected to have a high audience.

This will be achieved through either the assignment of specific “channels” to on demand, and/or the opportunistic and dynamic use of spare capacities in channels or multiplexes at certain times. Terrestrial Broadcast technology (e.g. signalling, etc.) will adapt to facilitate seamless reception and consumption of On Demand on a Terrestrial Broadcast receiving device (e.g. STB , TV set) and beyond into the Connected Home.

[P5] More generally, Terrestrial Broadcasting will need to be operated in a **more flexible and versatile mode than is currently the case**, because of the continued changes in consumer preferences; a more flexible allocation of delivery capacity to “programs” with smart mapping and meta-data mechanisms helping to facilitate the implementation and operation.

[P6] Mobile / out-of-home consumption will continue to increase for both linear and non-linear TV content, although not substituting and quite different from traditional TV watching (snacking, etc.). While a large part of this traffic is diverted to Wi-Fi networks, it could still represent a challenge to cellular infrastructure and so **mobile broadcasting** (combined with caching of content on the device) will be increasingly used. This will involve “in-band” LTE broadcasting (e.g. eMBMS) and some more traditional Terrestrial Broadcasting (High Towers, High Powers, etc. for example T2 Mobile). Some **convergence or hybridisation** of the two could be initiated, and this will be further developed in the future.

[P7] The Terrestrial Broadcast service that reaches a home will be distributed around the **home network** to a variety of in-home devices

[P8] Most devices that have a Terrestrial Broadcast intake (e.g. a TV set) will be also connected to a Broadband network. These devices will make use of this **hybrid connectivity** for a range of different use cases and offer a seamless experience

[P9] Following its introduction in OTT and other platforms**, UHDTV** may start to emerge as early as 2016-2018 on Terrestrial Broadcast networks, although it will be initially more of an attribute of (individual) shows and program items than 24hr operation of a TV channel. This is likely to take the form of a soft/ opportunistic start e.g. some UHDTV programs on a shared UHDTV channel, hybrid UHDTV re-built locally by combining HD received over Terrestrial Broadcast and UHDTV complements received through Broadband, pre-loading of UHDTV content via Terrestrial Broadcast. Progressively, a number of popular TV channels will have a fully-fledged UHDTV broadcast, as for their current HD broadcasts.

[P10] As **IoT / M2M usage** intensify and potentially require downstream communications, higher payloads, or one-to-many capabilities, Terrestrial Broadcast could be used occasionally, locally, opportunistically for M2M / IoT deliveries as a complement to native IoT networks. Conversely, typical Terrestrial

Broadcast devices (e.g. TV sets, STBs) may use IoT networks and applications to feedback usage, or technical conditions to certain systems.

[P11] Given the general trend to global standards, there will be discussions and practical measures aimed at the next generation of **broadcast standards being globally aligned** or more highly coordinated compared with today's regional standards.

[P12] As most TV sets (and other Terrestrial Broadcast enabled devices) will have a **return channel** over the internet (wired or wireless, or even IoT), Terrestrial Broadcast networks will become aware of the individual usage history as well as of technical receiving conditions; this will enable smart advertising use cases, just like it may be done on IPTV, as well as other growing "Big Data" minded processes.

[P13] Terrestrial Broadcast programs and services will become fully integrated within an "**all-IP" world**, but this could happen without requiring the replacement of Terrestrial Broadcast's Transport Stream by an IP mechanism.

[P14] As energy concerns are mounting, Terrestrial Broadcasting will need to increase its **energy efficiency** to continue to fit well within the environmental agendas.

Recommendations for Terrestrial Broadcast

Pack 1 : ACT

[R1] Terrestrial Broadcast should ensure a high level of **Security**, so that end-users, content creators and editors are fully comfortable with valuable information and content travelling through Terrestrial Broadcast.

[R2] Terrestrial Broadcast should easily enable a "**Local Service Rebuild"** capability for Terrestrial Broadcast receivers, i.e. a set of mechanisms by which a Terrestrial Broadcast receiver will be capable of re-assembling, on the basis of end user choices/preferences or remotely transmitted instructions, the individual services and programs to be consumed by this individual receiver, combining digital flows and files received from different sources, Terrestrial Broadcast-borne or not.

[R3] Terrestrial Broadcast should enable and facilitate the organized and standardized collection and **integration of return channel data** into Terrestrial Broadcast systems and services and its smart utilization by Terrestrial Broadcast services and networks.

[R4] Mechanisms and actions should be undertaken to facilitate the seamless distribution of Terrestrial Broadcast signals (content, services) into **Home Networks.**

Pack 2 : Prepare

[R5] As soon as practicable, a tight liaison should be undertaken with the mobile world and specifically the 3GPP organization towards defining a **converged mobile broadcast standard** , which would be "natively" implemented in any LTE (and later 5G) devices, while it would also be suitable for an easy integration into the traditional/ existing Terrestrial Broadcast infrastructure.

[R6] Terrestrial Broadcast should be prepared to make full advantage of the **next generation video codec(s)** (after HEVC) and be fully prepared to **integrate it into its specifications.**

[R7] Terrestrial Broadcast should plan a **next generation physical layer (NGT)**, with a view of having such a NGT standard finalized by 2020-2022 and capable of reaching massive market deployment around 2025 -2027.

[R8] Terrestrial Broadcast standard should aim at the emergence of a **global terrestrial broadcast standard**, possibly as early as 2020-22 (i.e. the timescale of the NGT standard)

Pack 3 : Anticipate

[R9] Terrestrial Broadcast should enable an easy and fluid **filecasting method** (**i.e. delivery of non-real-time content)** (e.g. video on demand content, but all kind of digital files should be eligible) though a broadcast network.

[R10] Terrestrial Broadcast should become suitable for highly **dynamic service plans**, where the allocation of Terrestrial Broadcast capacities to services can be reconfigured very quickly **,** with the appropriate notice of Terrestrial Broadcast receivers

Pack 4 : Observe

[R11] DVB could consider adapting its Terrestrial Broadcast specification to make it more suitable for the **hosting of IoT traffic and related applications** making an opportunistic usage of unoccupied Terrestrial Broadcast capacities.

[R12] The introduction of **Redundancy-on-Demand** mechanisms could be relevant for receivers that are subjected to degraded receiving conditions, enabling the local restoration of the signal quality without changing the transmitting network

[R13] DVB could consider to adopt a **New Protocol Stack** which would replace (or be an alternative) to the current TS approach

[R14] DVB could consider adapting its Terrestrial Broadcast specification to make it suitable to **operate Terrestrial Broadcast services in non VHF/UHF bands**

[R1]	Security
Recommendation	Terrestrial Broadcasting must respond to the increasing technological complexity of television devices which is allowing new methods of hacking to be envisaged. Consumers will need to have their privacy and personal data protected to maintain their trust and to comply with regulatory requirements. It is therefore important that Terrestrial Broadcasting stakeholders conduct the necessary analysis, including risk analysis, and make the necessary adaptations and enhancements to standards used both for and alongside Terrestrial Broadcasting so that legitimate privacy and security concerns are to their satisfaction.
Commercial rationale	In an environment in which most devices will have a broadband connection including a return channel, and consequently will offer hybrid services and monitor individual usage, security and data privacy concerns are raised. Lack of consumer trust in services delivered terrestrially will undermine their popularity and uptake. Breach of data privacy laws could result in legal action. If the reputation of Terrestrial Broadcasting is deemed “unsafe”, whether or not this is true in practice, it would be very detrimental to Terrestrial Broadcast platforms and the interests of its stakeholders.
Illustrative Use Cases	▪ Services requiring some form of personal identity declaration delivered using hybrid functionality such as catch-up and other over-the-top download services. ▪ Interactive services such as those requiring authentication of identity, for example transactional shopping. ▪ Interactive services, which if intercepted and altered, could be used to mount a variety of attacks on the security and privacy of consumers.
Mapping – Chapter 1	Sections 6, 8 and 16.
Mapping – Chapter 2	P8 and P13
Relevance	High
Priority/Timing	Fast
Category	Technology Enhancements and Efficiency
Standardization & Technology Context	DVB has addressed issues of security and authentication in the past, and is currently embarked on adding authentication functionality to interactive signaling. DVB has also completed a set of commercial requirements for personal data privacy and security (work carried out within the IPTV AHG that could be applied to other platforms) but at that time the work did not proceed to a technical solution. DVB CM-SEG is DVB’s standing group of security experts which can be consulted in relation to emerging requirements.
Issues to be addressed	The full scope of issues to be addressed should be determined by Terrestrial Broadcasting stakeholders in conjunction with security experts.
Recommended DVB Action path and goals	TM-MIS is already addressing the most urgent concerns (along with HbbTV). CM-SEG can be requested to offer advice and assistance on longer term security and privacy matters.
Comments	

[R2] Local Service Rebuild

Recommendation		A technical mechanism signaled in the broadcast and functionality implemented on the decoder to create a more personalized TV experience. Seamlessly combining or substituting program elements and/or replacing sections of the program (e.g. targeted advert replacement or additional audio or video tracks) The supplementary Service streams could be delivered though broadcast, instantaneously streamed via IP or retrieved from previously received content cached on a local disk. These elements and program sections would be dynamically rebuilt and synchronized into a linear presentation at playback time.
Commercial rationale		There is strong consumer and industry demand, for a more tailored viewing experience. Some aspects of personalization of content such as targeted adverts are already the norm on other audio & video delivery platforms. Others such as personalized audio are already being discussed within the DVB. This new functionality will benefit the end user, and possibly create new business models for content creators, broadcasters and operators. As most of this functionality and commercial use-cases are already possible for content viewed online, it is important that the same flexibility be enabled on Terrestrial Broadcast.
Illustrative Use Cases		• Flexible and targeted advert insertion systems that personalize TV commercials, based on information the viewer agrees to share (e.g. location). • The creation of "Freemium" programming where the basic presentation is free but where the viewer has opportunities to purchase additional elements (audio/video/data) or alternative/additional scenes. • The viewing of a program in UHDTV, where the HD version of the program is broadcast and the UHDTV enhancement data is delivered separately (e.g. can be broadcasted live on another channel, can have been pushed on broadcast earlier or can be pulled from the Broadband connection) • Sponsored streams or scenes, where an advertiser can provide a branded, additional audio track or camera angle. This can either be an option that can be selected by any viewer or be provided only to viewers who answer a call-to-action or provide their details.
Mapping	Chapter 1	Factors 1, 2, 3, 5, 6, 7, 8, 10, 15, 16 and 19
	Chapter 2	
	Chapter 3	
	Chapter 4	P4, P5, P8, P9, P13, P14
Relevance		High
Priority/Timing		Fast
Category		Enhancement
Standardization & Technology Context		The following DVB groups; GBS, AVC(NGA/UHDTV/SSS), IPI, COS/CSS, have discussed some of the local service rebuild use cases and do have some of the mechanisms necessary. It is also likely that that some of the use cases can be addressed by the use of the

	latest HbbTV specifications, but some functionality may need solutions that can operate without an application e.g. those being discussed by DVB CM-AVC SSS
Issues to be addressed	1. Signaling - Content identification, announcement and discovery 2. Audio and Video codecs (supplementary elements and splicing) 3. Synchronization 4. Hybrid delivery 5. Local on-device storage ; management of storage space 6. Content protection 7. Security/Viewer profile management It is likely that that some of these issues can be addressed by the use of the latest HbbTV specifications, but some functionality may need solutions that can operate without an application (e.g. those being discussed by DVB CM-AVC SSS).
Recommended DVB Action path and goals	Approve CM-T to initiate the drafting of CRs and coordinate with the existing commercial work in this area e.g. SSS and NGA.
Comments	

[R3]	Return Channel Integration
Proposal - Statement	Create a standard framework for the communication (through a non-Terrestrial Broadcast mechanism) of data by the devices receiving the terrestrial broadcast signal. Data may be of a technical nature (e.g. signal quality feedback from connected TV receivers to optimize effective and efficient coverage of the desired area) or commercial (e.g. viewing statistics to provide feedback to broadcasters).
Commercial rationale	Use growing population of connected TVs to enhance network coverage through optimization of network plan and provide broadcasters with more accurate and representative viewing data. Failing such a return channel mechanism (which are native/easy in other platforms) there would be a risk that the viewing experience or the value to the broadcasters of a Terrestrial Broadcast home would become inferior (e.g. when compared to IPTV platforms) and this would be highly detrimental to the Terrestrial Broadcast platforms and its stakeholders.
Illustrative Use Cases	1. A Terrestrial Broadcast network operator would like to optimize the Tx network operation using the received signal strength reported back from the population of connected TVs 2. A TV service provider or broadcaster would like to gather viewing data for some or all of their content
Mapping – Chapter 1	Sections 5, 6, 7, 8, 9, 16 and 21
Mapping – Chapter 2	N/A
Mapping – Survey	N/A
Mapping – Vision	P5, P8, P11, P13, P15
Relevance	**High**
Priority/Timing	**Fast**
Category	Non Traditional Applications
Standardization & Technology Context	TM-GBS
Issues to be addressed	1. A standard method for measuring signal quality implemented in all TV receivers 2. Sufficient number of suitable, connected TV receivers connected to internet 3. Privacy concerns of users addressed by regulation or by education *4.* Methods for accurately determining receiver location (e.g. post code, Wi-Fi, GNSS)
Recommended DVB Action path and goals	Approve CM-T to create CRs
Comments	

[R4] Terrestrial Broadcast in Home Networks

Proposal - Statement		Terrestrial Broadcast needs to be seamlessly integrated into home networks. Network connected devices should be able to effortlessly ***find*** and ***access*** Terrestrial Broadcast delivered content from within the home. *Such content may be live. Alternatively it might have been cached on a Terrestrial Broadcast enabled server, PVR type of device, or possibly via Network Attached Storage (NAS). Such functionality may also include the ability to access the same content from anywhere via the internet.*
Commercial rationale		The full integration of Terrestrial Broadcast into home networks, making its content (both live and cached) available to all multimedia enabled in home devices, will sustain its long term position at the heart of the digital media ecosystem. Such integration should benefit all Terrestrial Broadcast stakeholders. Universal client device **interoperability** with Terrestrial Broadcast integrated networks and the **ease of their use** seems to be the key to making an attractive consumer proposition.
Illustrative Use Cases		Hybrid Terrestrial Broadcast has brought a broadband connection to enhance Terrestrial Broadcast. The core Terrestrial Broadcast services are likely to remain popular for their high QOS of delivery that consumers have come to expect. • In the future, many homes are still unlikely to enjoy a sufficiently fast broadband connection for the comfortable reception of HD streams (even less so for multiple simultaneous HD streams or UHD content). However such homes may still want to stream high quality live content to in-home connected devices. The sharing of the Terrestrial Broadcast signal on the home network enables this. • Another key use case is simply the ability to redistribute terrestrial content effortlessly around a home to multiple connected devices. Devices that would not otherwise be able to access the Terrestrial Broadcast platform.
Mapping	Chapter 1	*Sections 3, 8*
	Chapter 2	*P7, P8, P14, (P1, P2, P4)*
	S & D	
	Survey	*Q13, Q14, Q22, Q24, Q29 (Q11, Q12; Q31, Q32)*
Relevance		***High***
Priority/Timing		***Fast***
Category		*Adapting to new media consumption context*
Standardization & Technology Context		It would seem that now is a perfect time to act, as such technology appears a natural step on from the majority of connected Hybrid Terrestrial Broadcast products available in the market today. It is recognised that **many** consumer products are already available that provide much of the core functionality required for this item. Some areas where further standardisation effort (possibly only tweaks) might be beneficial are listed in 'issues to be addressed' below.

Issues to be addressed	1. Is anything missing from existing standards / implementation guidelines, that could help promote such functionality?
	2. Is the “glue” for such systems standardised sufficiently?
	    a. Content ‘find’ mechanisms.
	    b. Networked device ‘discovery’, wake up and control mechanisms.
	    c. Interfaces / APIs.
	    d. Reference architectures.
	    e. Mechanisms to enable seamless copy protection/DRM/CA across such networks allowing controlled redistribution of content.
	    f. Interoperation with pre-existing non-DVB standards typically used in such systems.
	3. Can anything be done to enhance the following?
	    a. Ease of use.
	    b. Universal device interoperability (avoid proprietary solutions).

DVB stakeholders	TM-CSS, TM-other?

Recommended DVB Action path and goals	• Request investigation by relevant TM ad-hoc groups to identify if any work in this area could encourage greater main stream adoption of such technology.
	• Note that totally new standardisation itself is probably not required. See ‘issues to be addressed’ above.
	    ➢ Approaches such as profiling of existing standards to improve the likelihood of successful cross-vendor product operation might be useful.
	    ➢ Improved / new system reference architectures might also promote the use of such technology, without the need to re-write the underlying standards.

Comments	

[R5] Converged Mobile Broadcast Standard

Recommendation		Terrestrial Broadcast should liaise as tightly as possible with the mobile world and specifically the 3GPP towards defining a **Converged Mobile Broadcast Standard**, which would ultimately be “natively” implemented in any LTE (and later 5G) mobile devices, while it would also be suitable for an easy integration on the traditional/ existing Terrestrial Broadcast infrastructure. *The LTE mobile device can receive a broadcast feed that is transmitted from a HT and/or a LT. The broadcast feed can be used either for live or filecasting traffic. The HT signal would be meant mainly for outdoor reception while indoor reception would be either LT either in-home Wi-Fi.*
Commercial rationale		Mobile traffic is growing very steeply with consequences of cost and of contention between broadcast and mobile ecosystems for spectrum plus issues related to the quality of service. Broadcasting to mobile would be a good way to reduce traffic (offload) and thus ease these adverse pressures, which would benefit the consumers and all market stakeholders There are great benefits to terrestrial broadcast stakeholders (native reach to mobile devices, opening new markets and improve asset utilization to reduce average cost of service) if existing HT broadcasting infrastructure could be used to broadcast to mobile, although it should be recognized that DVB already has technologies that allow broadcastings to mobile devices, so the overall business case for this application should be discovered before any further technical work (DVB or 3GPP) is recommended.
Illustrative Use Cases		• HT broadcast to LT BS, enodeBs, or caches • HT broadcast directly to device (outdoor) • Hybrid HT/LT broadcast to devices
Mapping	Chapter 1	Factor 4 ; Factor 11 ; Factor 18
	Chapter 2	(12) (13)
	Chapter 3	
	Chapter 4	P6
Relevance		Medium
Priority/Timing		Fast
Category		New Usage of Broadcast
Standardization & Technology Context		3GPP is considering technical adaptations to eMBMS which go in the same direction, although it may be done with a different intention. ATSC 3.0 has paid more attention to mobile / 3GPP compatibility 5G standardization process is starting and may be the right window to create this convergence It might be worthwhile (or even necessary) to sync a next gen DVB terrestrial standard with (i) alignment with 3GPP and (ii) a global standard; the right time window could be the issuance of 5G.
Issues to be addressed		1. Modifications to the LTE eMBMS standard to enable HT transmission (3GPP) 2. Signaling and PHY Layer mechanisms to enable HT / LT cooperation 3. Network infrastructure including modification to HPHT network equipment and possible co-operation between HPHT and LPLT networks 4. Sufficiently wide adoption for handset vendors to enable LTE eMBMS feature in handsets 5. Mechanisms to enable the selection of content to be broadcasted (e.g. ; counting the requests of a given content by devices and triggering a broadcasting on the basis of certain business rules) Mechanisms for the device’s rendering applications to check and use

	broadcasted content (pushed) and pull as needed required complements
Recommended DVB Action path and goals	**<u>Propose to 3GPP to initiate liaison on the matter</u>** • seek, especially within DVB, the right "mobile" players to help in the liaison • better articulate the rationale and proposal to make it meaningful to 3GPP • check if this requires a new DVB standard or adaptation of an existing standard (could be the registration, as a DVB standard, of a modified eMBMS profile) ; alternative is that the standardization is done only in 3GPP with advice from DVB • when a clear intention is secured, initiate the development of CR's in CM-T (ad hoc group) **<u>Monitor and liaise to 5G standard generation bodies (to be further identified) to assess if same goal can be secured in 5G</u>**
Comments	

[R6] Prepare for Next Gen Codec

Recommendation		A replacement for HEVC delivering a minimum level of efficiency improvement (level TBD)
Commercial rationale		Terrestrial Broadcasting will come under continued pressure to manage its assigned bandwidth carefully along with the expected demand for more HD services and potentially some UHDTV services (potentially part time)
Illustrative Use Cases		
Mapping	Chapter 1	Factors: 2, 3, 12, 15, 18, 19, 21
	Chapter 2	S&D model
	Chapter 3	External Survey
	Chapter 4	Predictions P4, P5, P6, P7, P9
Relevance		High
Priority/Timing		Low >5yrs
Category		Encoding
Standardization & Technology Context		CM-AVC
Issues to be addressed		1. Legacy receivers 2. Needs a new Commercial service? Ex. UHDTV/UHDTV-2 3. Need MPEG (& others) to define next gen CODEC 4. Need HEVC to become widely deployed first 5. Synchronise with Next gen physical layer 6. Global standardisation consideration for Terrestrial Broadcast or + mobile)
Recommended DVB Action path and goals		CM-AVC should consider next gen CODEC when they become standardised
Comments		

[R7]	**Next Gen Physical Layer**	
Recommendation		A replacement for DVB-T2 (improvement level to be defined)
Commercial rationale		Spectral efficiency needs to be improved
Illustrative Use Cases		Aimed at ultimately fully replacing current DVB-T or DVB-T2 networks.
Mapping	Chapter 1	Factors 2, 3, 12, 15, 18, 19, 21
	Chapter 2	
	Chapter 3	
	Chapter 4	Predictions: P4, P5, P6, P7, P9 Recommendations: R4, R5, R6, R7, R9
Relevance		High
Priority/Timing		Low, > 5 years
Category		Transmission Mechanism
Standardization & Technology Context		CM-T, TM-T
Issues to be addressed		1. Legacy receivers 2. Needs a new Commercial service? Ex. UHDTV/UHDTV-2 3. Consumer antenna requirements 4. Synchronise with Next gen Codec 5. After T2 is rolled out as the primary delivery mechanism (i.e. no mixed T/T2/T3 networks) 6. Global standardisation consideration for Terrestrial Broadcast or + mobile)
Recommended DVB Action path and goals		*DVB should conduct or maintain (roughly over 2016-2017) an informal process to refine thinking on the matter (a possible solution being a joint work group between CM-T and TM-T).* *This work group shall take into account the key factors of that situation including (1) the practical deployment implications of the NGT techniques (or any other relevant identified technologies) (2) the materialization of ATSC 3.0 and (3) the prospects for converging terrestrial broadcast at a global level, and especially DVB/ATSC as well as the convergence with mobile standards (3GPP 4G/5G), the latter question requiring to entertain – to the extent possible- contacts with said institutions.* *The goal would be to come to a point (estimation : 2018) when one or more clear scenarios could be formulated, and then serve as the basis for a more classical specification drafting work (CRs, etc.) ; such scenario shall also determine the timing (fast, normal, slow) to be adopted in this process.*
Comments		

[R8] Convergence to a Global Standard

Recommendation		Convergence of Terrestrial Broadcasting (Terrestrial Broadcast) towards a global standard for easing the implementation of a future Next Generation Terrestrial Broadcast standard (DVB-NGT) together with other relevant Terrestrial Broadcast standards
Commercial rationale		Organizing Terrestrial Broadcasting around regional SDOs (e.g., DVB, ATSC, ARIB), could become an issue in the mid/long term since OEMs that develop, produce and integrate equipment and systems favor global technologies. It is worth noting that the mobile ecosystem has now fully converged to a global standard (4G, 5G).
Illustrative Use Cases		N/A
Mapping	Chapter 1	Sections 7, …., 13, 18, 19, 20
	Chapter 2	P2, …, P8, P11, P12, P14
	Chapter 3	
	Chapter 4	
Relevance		High
Priority/Timing		Relaxed / Observe
Category		Technical Enhancements and Efficiency
Standardization & Technology Context		ATSC just developed its ATSC 3.0 standard ; 5G process is now progressing and could have some broadcast implications
Issues to be addressed		1. Aim at converging the next generation DVB terrestrial specification ("T3") with the subsequent release of ATSC after 3.0; this will form a "Global Terrestrial Broadcast 1.0" 2. Will ideally be combined with development of a "Common Broadcast System" (CBS) applicable to cellular mobile networks and to classical High Power High Tower broadcast networks 3. Low interest of 3GPP in the past
Recommended DVB Action path and goals		Maintain informal but close liaison with the relevant institutions (ATSC, 3GPP, ..) to detect the possibilities for global alignment, and as the case may be, initiate formal action to achieve it. In depth discussion at the DVB should also take place on the opportunity to do so. Take maximum advantage of the 5G window of opportunity.
Comments		

[R9] Filecasting on Broadcast

Proposal - Statement	Enable an easy and fluid delivery of files (e.g. video content, but all kind of digital files should be eligible) though a broadcast network, normally used for transmission of live services only. Enable simple access to these files for applications and end-users across all devices. This should be designed as a transport utility, available to all 3rd party end-user facing services, not as an end-user facing service itself.
Commercial rationale	Users demand more and more on-demand content, and this is currently achieved principally by using unicast broadband networks. In many instances, these networks have limited capacities and this is constraining demand. The usage of a broadcast delivery (one-to-many) would create a substantial economic benefit (reducing the load on unicast networks) and increased quality level (better viewing quality as file viewing is insensitive to network issues). Conversely, this would bring benefits to the broadcast ecosystem as it will serve a major new use case and help keep homes and volumes on the platform. Such approach would also potentially make a better use of spectrum, by realigning end-user needs and spectrum allocation.
Illustrative Use Cases	Example 1: a pay TV operator, offering live and non-live content, will select every day its most popular on demand content and broadcast them during the night. They will be stored on the STB managed by this operator. When the end user wants to access on demand content (through the STB), they will, without knowing, access the pre-loaded stored content. Example 2: an ISP derives from the home gateways (Wi-Fi routers / modems) of its end users which digital files (video or not) are the most popular and delivers them to a broadcast network operator so they can be broadcasted. When they are broadcasted, the ISP gateway (which will have a DTT tuner) stores them. When an in-home device wants to access this content and initiate a "pull" request on the internet, the home gateway will recognize it already has the desired file and will deliver it from the locally cached version instead of downloading it from the internet.
Mapping – Chapter 1	Factors 1, 3 and 7
Mapping – Chapter 2	(11) (13)
Mapping – Survey	Q23
Mapping – Vision	P4
Relevance	**Medium**
Priority/Timing	**Anticipate**
Category	Adapting to new media consumption context New Broadcast Applications
Standardization & Technology Context	Significant relevant specs exist in HbbTV 2.0; ATSC 3.0 seems to have largely integrated this requirement
Issues to be addressed	1. Local on device storage ; management of storage space 2. Signaling - Content identification, announcement and discovery 3. Error recovery through broadband 4. Content protection 5. Remote activation / control of the receiving device (needed to force the device to ON mode when relevant content is filed) 6. Link to relevant CDN / caching protocols (to enable that the Terrestrial Broadcast device can be logically integrated in the CDN protocols) 7. Preference to Cache; a mechanism by which the Terrestrial Broadcast fed

	cache is made aware of all the unicast content requests or inflows originated in the home, so that, if it already has the content available, it can "substitute" the pull unicast delivery. 8. DRM & Encryption
Recommended DVB Action path and goals	(a) Establish a better understanding of ATSC 3.0 and HbbTV available pieces in this direction (b) Initiate " Draft CRs" ; i.e. not formal CRs but a draft of what the CRs could be (c) Conduct gap analysis Draft CRs / existing standards (ATSC, HbbTV) (d) Confirm to CM the relevance of CRs and a specification
Comments	

[R10] Dynamic Service Plans

Proposal - Statement		An adaptation of the service identification mechanisms (and potentially of other physical layer mechanisms) enabling a very fast and dynamic reconfiguration of the mapping of services in a DTT multiplex. All network elements as well as receivers need to be made aware of the change with very short notice.
Commercial rationale		End user preferences are changing, and DTT will progressively integrate new media consumption use cases such as on-demand and UHDTV. As spectrum is constrained, it cannot be taken for granted that permanent capacity will exist for these new services, and it may be necessary to make temporary occupation of existing capacities with such new services.
Illustrative Use Cases		Example 1: Program 55 is a live channel which has low audience at night (e.g. kids program). At certain moments at night, scheduled or not (e.g. audience driven), the bandwidth allocated to this program can be drastically reduced (e.g. switching HD to SD, or even switching to a frozen screen) and bandwidth made available will be re-allocated to filecasting. The home devices interested in file casting as well as the TV sets (and EPG as well) need to be made aware of that transition so that they can listen and record to the filecasted content. Example 2: Two TV programs A and B are sharing a single DTT channel (say channel 44) and they have agreed that it will be the one with the highest audience at any moment which will use the DTT capacity, while the other one will be available through streaming. This should be done without any impact on the end-user, who should still use position 44 for Program A and position 59 for program B. The TV receiver needs to be informed in real time how it should map the programs and the positions, depending on which program occupies channel 44 in reality.
Mapping	Chapter 1	Factors 1, 7 and 15
	Chapter 2	(11)
	Survey	na
	Vision	P4 P5
Relevance		**Medium**
Priority/Timing		**Anticipate**
Category		Adapting to new media consumption context
Standardization & Technology Context		*Not identified yet*
Issues to be addressed		*Not identified yet*
Recommended DVB Action path and goals		Assessment of what needs to be done (2016); new specification if any in 2017 for commercial deployment 2018)
Comments		*There might be regulatory and commercial questions which are not being discussed here*

[R11]	IoT Traffic on Broadcast
Proposal - Statement	Use TV broadcasting network to provide a downlink to a population of IoT devices. It is possible that a signal suitable for IoT devices would be embedded in the broadcast stream, possibly with a modulation adapted to the low cost / low energy profile of IoT.
Commercial rationale	IoT devices and applications will proliferate, with a growing need for connectivity of these devices ; innovative technologies exist for both UL and DL, focusing on very small payloads; Terrestrial Broadcast could have specific advantage to provide low cost, high efficiency DL connectivity (e.g. a water meter need to receive a significant software upgrade of a few MB); conversely, adding this application to a Terrestrial Broadcast network (with a quite low occupation and disruption) could help to further anchor the Terrestrial Broadcast network in the evolving digital ecosystem and decrease its average cost of utilization.
Illustrative Use Cases	1. An IoT service provider wishes to deploy a large population of devices that are likely to require an enhancement or modification of function during their lifetime. A low-cost update method for the whole population is required. The IoT service provider and Terrestrial Broadcast operator enter an agreement to provide the relevant signal as part of TV broadcast network.
Mapping – Chapter 1	17
Mapping – Chapter 2	N/A
Mapping – Survey	N/A
Mapping – Vision	N/A
Relevance	**Low**
Priority/Timing	**Observe**
Category	Non Traditional Applications
Standardization & Technology Context	Not identified yet
Issues to be addressed	Most IoT devices will have a bi-directional connection to the internet in any case. IoT devices are low-power devices and most are low-cost, so Rx complexity must be kept low.
Recommended DVB Action path and goals	Observe and continue to assess commercial demand and possible technology combination opportunities.
Comments	

[R12]	Joint use of broadband and broadcast for effective/robust service delivery
Proposal - Statement	Use of internet to provide additional forward error correction data to broadcast signal for the TV receivers that require it (e.g. dependent on location or channel conditions at a particular time)
Commercial rationale	Expand coverage area without increasing Tx power or # of Tx. Fix 'not-spots'.
Illustrative Use Cases	A broadcaster/network operator wishes to facilitate indoor reception of a Terrestrial Broadcast service that is planned for reception from a rooftop antenna by utilizing the broadband connection of the TV receiver.
Mapping – Chapter 1	Sections 7, 8, 9 and 16
Mapping – Chapter 2	N/A
Mapping – Survey	N/A
Mapping – Vision	P8, P11, P15
Relevance	**Medium**
Priority/Timing	**Observe**
Category	Technical Enhancements and Efficiency
Standardization & Technology Context	Not identified yet
Issues to be addressed	1. Sufficient, low-latency internet capacity covering TV receivers in target area 2. A standard method for the creation, distribution and use of FEC data via internet *3.* Acceptance from broadcasters than service is dependent on internet connection
Recommended DVB Action path and goals	None at this time
Comments	

[R13]		Next Generation Protocol Stack
Proposal - Statement		Instead of services being directly encapsulated into MPEG-2 TS they are carried over IP using a new protocol stack, typically without involving the MPEG-2 TS. Video services over IP could be introduced in connection with new video coding and/or physical layer standards, since legacy receivers are not able to receive IP services over broadcast. Services using MPEG-2 TS would, for legacy reasons, typically have to co-exist in parallel with IP services for many years in a particular country. There may also be country-based different decisions regarding the adoption of IP. For countries adopting IP the MPEG-2 TS services may over time be phased out and replaced with IP services. This may imply a total replacement of the entire signaling scheme (currently PSI/SI) for service announcement, service discovery etc. Support for mixed TS & IP services (both regarding service data and signaling)
Commercial rationale		To increase interoperability and simplify operation with services, networks and equipment using IP, especially when a service provider uses both broadcast and broadband. The same applications based on very similar protocol stacks can then be fed by broadband and broadcast, i.e. new applications entering the market can make use also of the broadcast branch immediately. Also ATSC 3.0 uses IP, which implies an implementation advantage if also DVB uses the same (or similar) IP-based stack.
Illustrative Use Cases		Possibility to have the same or similar protocol stack for different contributing parts of hybrid systems.
Mapping	Chapter 1	Sections 3, 8, 10, 18
	Chapter 2	P7, P8, P14
	Survey	NA
	Vision	Q13, Q14, Q22, Q24, Q29
Relevance		**Medium**
Priority/Timing		**Medium/Low** (synchronised with introduction of HEVC or next gen PHY?)
Category		Interoperability with the IP world (e.g. Home Networking)
Standardization & Technology Context		Commonality with e.g. ATSC 3.0 could be sought
Issues to be addressed		The issues are complex and a summary is given in TM5225: *Report from Workshop on Technologies beyond the TS* Commercial benefits to be assessed against drawbacks of not doing it and of doing it.
Recommended DVB Action path and goals		Carry On with joint CM/TM study mission to further assess the necessity and potential profile of a new protocol stack Wait for results of such a joint CM/TM study mission
Comments		

[R14] DVB outside of UHF band IV/V and & VHF band III

Proposal - Statement	There are frequency bands, currently allocated to broadcast, which are unused or where the current services are likely to be switched-off in the future, often without any clear new use cases. To be able to exploit such bands existing DVB systems may have to be adapted (e.g. new RF BWs) and/or new DVB systems be developed, appropriately designed for these frequency bands.
Commercial rationale	To efficiently exploit available terrestrial spectrum
Illustrative Use Cases	Introduce new broadcast services in a (partly) empty band
Mapping – Chapter 1	Section 19
Mapping – Chapter 2	NA
Mapping – Survey	NA
Mapping – Vision	NA
Relevance	Low
Priority/Timing	Low
Category	PHY layer characteristics adapted to existing spectrum
Standardization & Technology Context	May require the adaptation of an existing standard or a completely new standard
Issues to be addressed	Actual and expected future use of relevant bands. Suitability and required modification of existing or new DVB terrestrial standards to be used in new frequency bands
Recommended DVB Action path and goals	Put into sleep mode until relevant use case and commercial needs are identified
Comments	