DIGITALEUROPE

DIGITALEUROPE WHITE PAPER ON SUPPLEMENTAL DOWNLINK IN THE UHF BAND

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Table of Content

1. Executive Summary

In 2013, DIGITALEUROPE published a position paper[1] recommending repurposing the 694-790 MHz band for Mobile Broadband (MBB) whilst carefully managing the impact on consumers and their legacy equipment.

Regarding the band 470 – 694 MHz, discussions have taken and still are taking place in the European Conference of Postal and Telecommunications Administrations (CEPT), on the Ultra High Frequency (UHF) band in the High Level Group (HLG) and the Radio Spectrum Policy Group (RSPG) and a report was prepared following the HLG meetings on the longer term options beyond 2020.

Some options could potentially allow for complementing or converging services of Digital Terrestrial Television (DTT) and Mobile Broadband (MBB) which would lead to innovation of enhanced technologies and services, but which would also likely require new operational, business and regulatory models. In this context, DIGITALEUROPE sees Supplemental Downlink (SDL) as a promising field to explore and recommends further research to develop concepts and proposals for the next decade whilst carefully considering compatibility with replacement cycles of devices necessary in the migration to protect consumer interests.

Mobile industry and consumers can benefit from additional capacities where spectrum frequencies are not needed by broadcast services and where there is no interference with legacy broadcast receivers and installations.

Mobile Broadband (MBB) based on SDL in the 470 – 694 MHz band can trigger innovative use of the band while allowing flexibly for co-existence with conventional DTT within a region or at a region's borders. SDL allows for additional mobile capacity to be introduced at a different pace across European Member States based on a common mobile terminal ecosystem.

Since DTT and SDL are of a similar unidirectional nature (transmitter towards receiver-only in this band), this will minimize the interference potential and assist cross border co-ordination. This will then help to protect existing DTT services and their evolution while allowing Member States to decide to introduce SDL for MBB at their own pace. In large terrestrial TV markets, DTT deployment was mainly based on reusing existing installations. Any SDL scenario should not constrain current and future DTT networks.

SDL capacity can also be used to provide broadcast content in a point to multipoint mode (e.g. eMBMS) as an extension of existing mobile standards which are easier to integrate into mobile devices than DTT technologies.

DIGITALEUROPE invites the European Commission, the CEPT and the RSPG to thoroughly explore the scenario of SDL for mobile services in the 470 – 694 MHz band as this would provide a step towards and a catalyst for the development of further convergence between mobile services and the delivery of broadcast content. In order to realise this opportunity, DIGITALEUROPE advocates:

- The investigation and development of an appropriate regulatory and spectrum licensing regime for the range 470 - 694 MHz taking careful account of all the numerous stakeholder interests. Given the importance of DTT, this framework should preserve current and future deployments of DTT, and avoid any disruption to current and future DTT installations. This implies for instance that potential licensees must not interfere with legacy DTT receiver installation and that re-planning additional DTT deployments or redeployment of the latter must be possible without additional constraints for DTT on a national or international level.
- Equally, it appears that DTT will continue to evolve and will remain an important delivery system in many Member States. An evolution of DTT delivery towards higher technical efficiency is beneficial for the

1 http://www.digitaleurope.org/DocumentDownload.aspx?Command=Core_Download&EntryId=522

availability of spectrum. As a consequence, introducing policies for DTT evolution in countries is recommended. For example, a voluntary policy towards DTT next generation systems (driven by better DTT service and or subsidies for users) together with concerned stakeholders in the member states may help to release spectrum whilst helping the DTT ecosystem to evolve.

In the following pages, DIGITALEUROPE will describe the state of the art of DTT and MBB (section 3) as well as their evolution in terms of technology and services (Section 4) before discussing the opportunities offered by the SDL scenario, its feasibility as well as the careful coordination it would require in order to preserve current and future deployments of DTT and avoid any disruption to current and future DTT installations (Section 5). Section 6 provides DIGITALEUROPE's conclusions and emphasizes its willingness to work together with respective stakeholders to further study acceptable and mutually beneficent frequency usage, licence and coexistence conditions in the 470 - 694 MHz band which would enable SDL while not interfering with the on-going 700 MHz release and LTE700 deployments.

2. Introduction

DIGITALEUROPE welcomes the intense discussion in the EU Commission, in RSPG and CEPT on the best possible future use of the valuable UHF spectrum resources in Europe for the emerging of a win-win situation for broadcast, mobile operators, consumers and industry.

For this discussion on the future of the UHF band (470-790 MHz), DIGITALEUROPE would like to suggest distinguishing between two distinct areas, differentiated by the affected part of the band, the applicable timing, and the maturity of the proposed options.

1) 700 MHz band (694-790 MHz) 2017-2020:

   With the WRC-12 decision on a co-primary allocation to the mobile service effective immediately after WRC-15, Europe has to decide on how to use the 700 MHz band over the rest of this decade. Europe can choose between a continued use for digital terrestrial television (DTT) via DVB-T or DVB-T2 or alternatively use for Mobile Broadband (MBB) via LTE-Advanced towards meeting the Digital Agenda for Europe targets of 30 Mbps to all by latest 2020. In 2013, DIGITALEUROPE has published a position2 which can be summarized as follows:

   DIGITALEUROPE recommends repurposing the band for MBB but considers essential that a re-farming of the band is performed with no disruption of the DTT service and with minimum impact on the DTT consumers. The process should be prepared in close cooperation between Consumer Electronics (CE) and mobile industries, taking into account their respective roadmaps.

2) 470-694 MHz beyond 2020:

   Related to above choice on the 700 MHz band, there is today a discussion on the longer term options beyond 2020 for band 470 - 694 MHz. Here, a discussion on technical possibilities of complementing usage or even converging usage of DTT and MBB has commenced:

   - Converged service: Such an option can lead to innovation in terms of enhanced technologies and improved services, but is also likely to require new business and regulatory models, which renders it unpractical in foreseeable time.
   - A separation into an even smaller band for DTT and a dedicated part for MBB such as currently discussed in the US regarding the 600 MHz band. This option reduces spectrum for DTT and causes a new disruption.
   - The use of spectrum in a flexible way, allowing to introduce Supplemental Downlink where capacities are available.

DIGITALEUROPE sees this third option as a promising field to explore and recommends researching further in this area and developing concepts for the next decade. In the present document, DIGITALEUROPE would like to describe the state of the art of DTT and MBB, their evolution and discuss a flexible approach which could overcome the challenges whilst allowing for new possibilities: Supplemental Downlink in the band 470 – 694 MHz.

2 DIGITALEUROPE Position on the 700 MHz Band, http://www.digitaleurope.org/DocumentDownload.aspx?Command=Core_Download&EntryId=522

3. State of the Art

3.1. Broadcast

Terrestrial TV was historically the main delivery path for linear television in all countries. With the introduction of Digital Terrestrial Television (DTT), it still remains the dominant delivery path in several European countries, although alternative delivery paths have emerged. DTT is mostly associated with the offering of Free to air (FTA) and anonymous services with an easy set up. In most cases, a modern TV-set has already an integrated tuner for DTT and the existing aerial for analogue reception can be often simply reused, sometimes without any upgrade. In some countries, portable reception is possible, so that no rooftop aerial installation or upgrade is needed. In countries where a Free To Air is present on satellite as well, DTT positions itself as the reception mean without any need for new installations of cabling, satellite dish, etc.

Legacy installations and MFNs

In countries where terrestrial delivery is dominant, DTT was introduced to reuse as much as possible the existing infrastructure on the consumer side (aerials, filters and amplifier) and the broadcast network side (transmitter sites). This was necessary:

- to avoid costly realignment upgrade of aerials which would have reduced the acceptance of the analogue to digital switch over
- to keep the costs of infrastructure investments manageable.
- to simplify international coordination by reusing existing coordinated resources
- to allow to keep the infrastructure and provides flexibility for localized and regional content

As a consequence, in these countries, DVB-T is planned in Multiple Frequency Networks (MFN) across the entire band (currently 320 MHz in 470 - 790 MHz) with High Power High Tower to medium power transmitters. Single Frequency Network (SFN) mode operation is limited to small groups of TV transmit stations. Where the reuse of a channel is not possible by high power transmitters, the frequency channel can be reused for low power broadcast transmitters (e. g. gap fillers to improve coverage) or Programme Making and Special Events (PMSE).

Some countries had to depart - at least partly - from the principle of reusing the same frequencies and network sites. This was necessary to accommodate more services than originally planned, permit the release of the 800 MHz band or to optimize the network and reduce the total number of transmitter sites.

Such measures are associated with, on the one hand, the need for users to upgrade their reception accordingly in a limited to wider extent and, on the other hand, communication measures to announce the changes.

In countries where terrestrial reception is less dominant, regional SFNs with more robust variants delivering less capacity have been adopted. Sometimes more robust variants allow for portable reception which simplifies any changes in transmitter sites.

Today, there are strong differences in terms of share of terrestrial broadcast between European countries (10 % to 70 % of households) and sometimes also within a country (e.g. in Germany 0.2 % from some regions up to to ~25 % of households in others). Following main reasons can be identified:

- the lack of commercial offer over DTT in these regions (or their late introduction)
- the political wish to deploy cable and the systematic replacement of aerials by cable
- attractive pricing for satellite bouquets
- the presence of an alternative Free to Air offer before terrestrial availability

DTT is deployed in most of European countries with high reliability (which includes redundancy and backup solutions for high power transmitters) and the reception quality criterion is assumed to be less than one error per hour with high geographical availability (90 – 95 % locations) for at least 90 % of population.

Terrestrial broadcast typically provides public and/or commercial free-to-air and anonymous television services whereas other distribution paths may require paid subscriptions and/or additional reception equipment (e.g. set-top boxes).

The role of DTT for economical, cultural and media policy objectives

In several countries, given the historical predominance of DTT, DTT services were considered to play an essential role in fulfilling policy objectives like accessibility, cultural production, media pluralism and diversity. This is in generally associated with the grant of a DTT license to use spectrum. In countries with such a regulatory regime associated with DTT, services present only on other platforms do not have such high duties.

3.2. Mobile Broadband

Mobile networks have grown from providing basic voice and text message services to providing full blown mobile internet access with ever increasing data rate capabilities. The mobile device penetration levels have well exceeded 100% in the EU markets and voice and text message use have reached high, stable levels. The data consumption has hugely increased in recent years with further increase being expected, fuelled by the introduction of the new technologies LTE and LTE-Advanced and new device capabilities, in particular with respect to high quality audio-visual content. This growth is fuelled by the strong increase in use of smart phones and tablet computers with ever enhanced display quality and resolutions, faster processors and ever improving multi-media capabilities. Operating systems based on touch screens and apps optimized for the smaller screen size provide easy access to information and audio visual content on the internet even to less technically skilled parts of the population including elder people. Social networks particularly benefit from access not only at home and in the offices, but also on the move. Increasingly, social networking includes exchange of high quality multimedia content with audio, still and moving pictures. So Mobile Broadband has become an essential element in everyday life and an important factor to the economy.

Large scale rollout of LTE networks is under way across Europe. Wide-area coverage layers are provided at 800 MHz and can be enhanced in the future with the much discussed re-purposing of the 700 MHz band. Capacity layers in more densely populated areas currently rely on 1800 MHz and 2600 MHz. 800 MHz and future 700 MHz LTE networks typically use existing base station sites of the 900 MHz site grid providing very high population and area coverage via GSM today. Any LTE capacity layer primarily relies on existing GSM 1800 MHz and UMTS 2100 MHz base station sites. In areas with very high data demand, first deployments of additional small cells provide extra capacity. In homes, in offices and increasingly in public locations with high traffic demand, also Wi-Fi can complement mobile broadband network capacity on a best effort base.

By nature, data rates actually delivered by mobile networks vary over time and locations as they depend on the distance to the next base station and the degree of use of that base station - multiple users share its capacity. Additional coverage and capacity can be provided via additional base station sites, via improving system efficiency, e.g. with additional antennas, or by making additional spectrum available for Mobile Broadband. LTE provides for efficient frequency use by re-use 1, i.e. the same spectrum is used by each base station, or even multiple times per base station (in each sector of a base station).

4. Technology & Service Evolution

4.1. Broadcast

Upgrade of Picture Quality

DTT offers today a limited offer in High Definition (HD) and has not started to deliver any Ultra High Definition (UHD) service. A partial migration to HD and / or UHD, which may be necessary to compete with other delivery platforms, would require an increase in capacity and thus spectrum requirements.

Migration towards Internet Protocol (IP)?

In countries which have multiplied services, the limited number of historical channels have lost significantly their audience and are now following a group strategy by reconstituting their audience with narrower targeted services. A limited number of the services have very small audiences and could potentially be delivered via IP depending on economical and regulatory situation. A smaller fragmentation in special interests is allowed for example by HbbTV (VOD, OTT).

A migration of DTT to IP has been sparsely observed so far and is announced for some services. However, several large networks have launched services directly via IP services, so that to mid-term, depending on lower IP delivery costs and increased IP penetration, some services could migrate.

As illustration, figure 1 shows a typical distribution of Market share amongst different services.

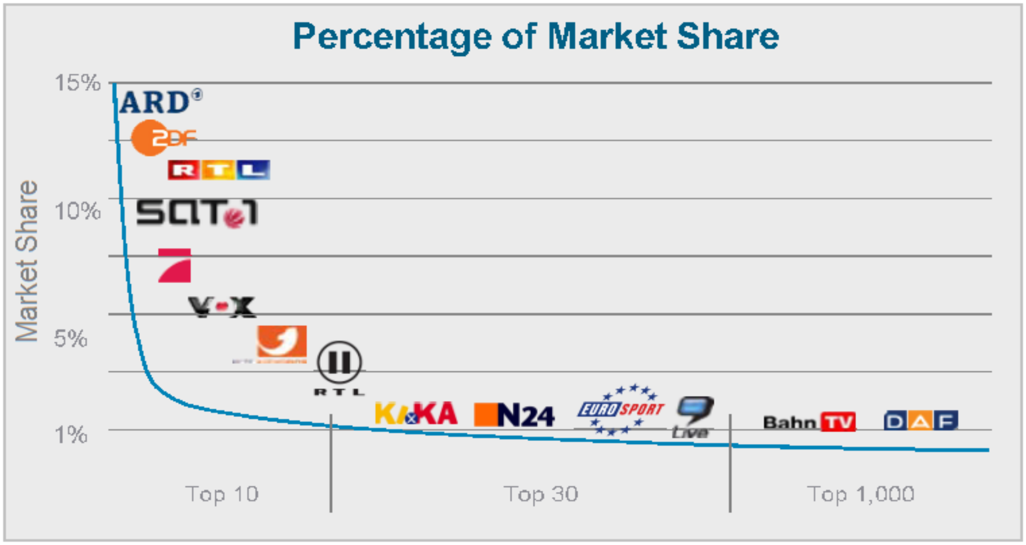

Figure 1: Example of the percentage of TV market share in Germany

With UHD a new push towards IP could take place. Increasingly broadcasters are eying UHDTV delivery via IP as this allows for a smooth introduction, without disruptive upgrades in transmission. Given the limited number of UHDTV content, ongoing transitions and spectrum pressure, such a trend is not likely to happen and could leave UHDTV mainly delivered over IP on short to mid-term. It remains an open question whether, by the time when UHD could be regularly broadcast, high speed broadband IP penetration will be sufficiently high and affordable, so that no terrestrial broadcast delivery is necessary. Consequently, at this stage, it is not possible to prejudge whether UHDTV will appear on DTT or not, so that a premature assumption would lead to constrain unduly the DTT platform.

Migration to more efficient technologies?

Compared to analogue TV, DTT with MPEG-2 allowed for an efficiency increase by 4 to 6 (average 5). MPEG-4 part 10 (H264 AVC) is twice efficient in data rate bandwidth compared to MPEG-2. DVB-T2 allows for 30 % more spectral efficiency compared to DVB-T. H265 (HEVC), the newest audio-video codec allows for double the efficiency compared to AVC. Hence, it can be concluded that T2 with HEVC will have an efficiency factor of 5*1/0.7*2*2 =28.6 compared to analogue TV. It can be said that a migration towards much more efficient use of spectrum is achieved or is about to be achieved.

These successive gains in efficiency were and will be distributed (as well as any future migration will be) in:

- spectrum re-farming for mobile applications
- An increased number of services (including radio services)
- Mobility /portable reception
- Reduction of transmission infrastructure
- An increased picture quality (HD services)

These latter three investments of efficiency gains were necessary to obtain the acceptance of the viewers, although it has to be recognized that each disruption causes migration to other platforms.

Compared to the other platforms, terrestrial television migrations and enhancement are associated with complex migration processes subject to consensus between politics and broadcasters. This is due to:

- lack of sufficient capacity or spectrum for longer simulcast
- a mostly horizontal market (where equipment is not subsidized and/or provided by the operators in conjunction with a service) with average replacement cycles of 7 years for TVs and with an end consumer expectation to be supported for a very long time
- Political obligations of continuity of services and commitments towards vulnerable persons.

Broadcast technology evolution is mainly driven around a consensus between industry and broadcast services to develop a next generation of delivery systems, notably within the DVB project. This consensus is built on a confidence of consumers' commercial acceptance. Any evolution has to be done generally by reusing existing spectrum, whereas mobile systems often can be deployed in additional spectrum. Therefore, a technology evolution of DTT is only feasible if acceptable by the user and by authorities (politics and regulators). This is in particular crucial, as the concept of DTT has been historically to minimize disruptions to the user and reuse widely the outdoor antenna and in-house distribution installations (see section 3).

The acceptance of such evolution has to be obtained through a better service, new offers, increasing number of services, which is subject to the return on investment to integrate these new technologies for the industry on one end and to launch these new services on the other end. Such an investment by broadcasters becomes more challenging, because over the years, broadcasters have been under pressure to reduce their transmission costs whilst the cost of spectrum usage has increased.

The current discussion on DVB-T2 introduction with HEVC or AVC is a typical example: Several broadcasters and industries are preparing for the next evolution with HEVC including UHDTV. The emergence of UHDTV or HD HEVC is linked with the availability of spectrum on temporary time for simulcast and in any case, long term perspective on their investment.

It is worth mentioning that some other more disruptive technologies are also in discussion in standardization groups but the feasibility of their introduction largely depends on:

- the offer of additional attractive services by broadcast service providers (the higher the disruption the higher the required incentive),
- the availability of spectrum for a simulcast,
- and the motivation of consumers to upgrade.

Currently and on mid-term, the above conditions for these more disruptive technologies are not met.

Conclusion on potential technological and service evolution

DTT has a longer cycle of evolution because the same spectrum has to be reused with a minimum disruption to users, a horizontal market, and longer replacement cycles.

The future evolution of DTT and the impact of a potential migration do not permit to conclude to a reduction of spectrum needs or an increase of spectrum needs.

In order not to constrain a priori any evolution of DTT, any usage of spectrum below 694 MHz should not constrain any existing or future installation or DTT deployments.

4.2. Mobile Broadband

To cope with the strong increase in demand for higher data rates and more capacity, LTE-Advanced provides Carrier Aggregation which allows for using more RF bandwidth per radio link. Currently, commercial deployments outside Europe support up to 40 MHz bandwidth, 60 MHz can be demonstrated in today's network infrastructure with terminal chipset support expected soon, and 3GPP specifications currently foresee aggregation of up to 100 MHz, which can be expanded to even more in the future.

LTE-Advanced Carrier Aggregation in the 800 MHz and 700 MHz bands has been proposed[3] to provide rural broadband timely and cost efficiently where fixed solutions are too costly. Countrywide blanket coverage from LTE-A base stations with fibre backhaul can provide a site grid for further possible upgrades with additional UHF spectrum in the 470 - 694 MHz range in the future.

Capacity issues of mobile broadband will be increasingly solved by small cells in bands up to few GHz complemented by Wi-Fi capacity in unlicensed bands at best effort. For cost efficient coverage over large areas, however, sufficient spectrum sub 1 GHz will remain crucial. Consumption of audio-visual content results primarily in traffic on the downlink (DL), i.e. towards the end user. Hence, an increasing asymmetry of up to 1:10 can be observed in data demand between uplink (UL) and DL, as recently described in an input paper4 to ITU-R WP 5D. Symmetric frequency division duplex (FDD) assignments typically yield UL:DL ratios of 1:2 due to higher transmit power and more transmit antennas in DL direction. Supplemental Downlink (SDL) provides additional RF bandwidth exclusively in DL direction to better balance the capacity offered with the traffic demand. Furthermore, SDL can use the entire additional RF bandwidth as it requires no centre gap - as opposed to FDD duplex scheme -- improving the overall spectrum efficiency. First SDL implementations in Europe are expected for the 1452 - 1492 MHz band. With such asymmetric architectures, the capacity offer can be optimised to the future content delivery services.

3 http://www.digitaleurope.org/DocumentDownload.aspx?Command=Core_Download&EntryId=522
4 https://www.itu.int/md/R12-WP5D-C-0824/en

The LTE specifications include a broadcast and multicast mode, the so called evolved Multimedia Broadcast Multicast Service (eMBMS) to efficiently address cases where many users within a cell or an area attempt to access the same specific content at the same time.

First eMBMS-capable chipsets and first eMBMS enabled devices are available, supporting limited bandwidth in current LTE bands licensed to mobile operators. First trials and small scale deployment have taken place since 2013. The primary use cases are sports events where a large number of people want to follow an event also on their mobile devices, like spectator watching replays in a football stadium. However, eMBMS is not currently capable of delivering large numbers of TV channels over large geographical areas. eMBMS can be further improved over the years, e.g. with the help of larger cyclic prefixes which allow for large area Single Frequency Network (SFN) deployments and/or to address more frequency resources for a wide offer of TV channels.

With the rapid evolution in mobile technology, work on its next generation termed 5G for beyond 2020 has started. 5G is currently in its initial research phase with a 5G Infrastructure Public Private Partnership (5GPPP5) established in the EU. 5G targets very low latency, very high bandwidth and access to additional spectrum in very high bands up to the mm wave length range for small cells to provide such bandwidths.

Evolution Cycles and Paths

Mobile technology evolves in rapid technology cycles with technology improvements every 12-18 months in new 3GPP standardisation releases. The standardisation cycles drive the release of new chipsets for end user equipment and new software releases for network infrastructure. This is mirrored in rapid end user equipment replacement cycles of 12 - 18 months driven by improvements in the end user equipment like screen, camera, design etc. as well as improved data transmission capabilities. Acceptance of these rapid terminal replacement cycles is additionally fuelled by handset subsidies of operators who retain their customers with attractive offers and hope to earn on increased utilisation of new devices with better performance. Despite the rapid replacement cycles of end user terminals, there remains a substantial legacy in devices and networks with 2G GSM and 3G UMTS services which are expected to remain in operation throughout the EU for quite some time. This limits the re-farming opportunities towards LTE within the respective bands 900 MHz for 2G and 2100 MHz for 3G, whereas the 1800 MHz band increasingly becomes subject to re-farming to LTE.

In the market, one can observe an increase in adoption of video consumption on mobile devices. The content can be pre-loaded, but increasingly video is streamed over the air interface. Non-linear content from sources like YouTube, embedded videos in web pages or the catch up services of broadcasters dominate, but increasingly linear content is included, in particular where specific live content such as sport events is offered. With eMBMS, LTE can flexibly address any mix of interactive data traffic, non-linear and linear audio visual content consumption.

4.3. Other Applications

4.3.1. TV White Spaces

There are trials in the UK, Ireland and Finland to share unlicensed spectrum in the UHF bands (TV White Spaces) using a geo-location database approach which provides the available frequency and maximum power at a specific location while taking into account any operational changes from the protected incumbents. A variety of enhanced services are being targeted to take advantage of TV White Spaces, e.g. longer range Wifi, Cellular Backhaul, Machine-to-Machine/Internet of Things sensor based applications in Agriculture, Energy, Environment and Health.

5 http://5g-ppp.eu/

In the US, the FCC has already enacted such legislation and other countries Singapore, Philippines, Kenya, Malawi, and South Africa are considering similar implementations with their own trials.

IEEE and ETSI are developing standards for both uncoordinated use of White Space where there is no attempt to manage the usage of channels by different White Space Devices as well as coordinated use of White Space where some form of interference management, channel management and coexistence techniques are employed to efficiently use the White Space.

4.3.2. Public Protection and Disaster Relief (PPDR)

Public Safety organisations are currently using narrowband digital Professional Mobile Radio systems in a harmonised 380 to 400 MHz frequency band, but have recognised the need to improve the efficiency of their field work by adopting state of the art broadband communication technologies that support high speed data and multimedia applications. DIGITALEUROPE's position on Broadband PPDR emphasises the freedom of Member States to decide on their own business model on the basis of national political and economical preferences when arranging their PPDR communication facilities.

DIGITALEUROPE promotes technology neutrality but concluded that for a user community of limited size such as PPDR the most efficient way to take advantage on technology developments is to align with main stream technologies and considered LTE - with the additions planned to meet specific PPDR needs in 3GPP - to be the safest choice for PPDR organisations.

When developing its position on the 700 MHz band usage in 2013, DIGITALEUROPE introduced a possible option to identify some spectrum just below the LTE band 28 for mission critical usage such as PPDR, both to satisfy some PPDR user needs and to improve the overall utilisation of the 700 MHz band. ECC Report 199 determined that the overall capacity demand to for BB PPDR is 2 x 10 MHz.

CEPT has further developed what they call flexible harmonization concept. It consists of three major elements:

- common technical standard (LTE)
- national flexibility to decide how much spectrum should be designated for PPDR within a harmonised tuning range, according to national needs
- the harmonization should enable national choice of the most suitable service provision model (either dedicated, commercial or hybrid)

CEPT is developing ECC Report 218 comparing spectrum options (to meet the BB PPDR needs and studying the 400 MHz and 700 MHz candidate bands. CEPT aims at producing an ECC Decision in early 2015. CEPT's ongoing work on PPDR spectrum is consequently reflected to positions in preparation of Agenda Item 1.3 of WRC-15.

4.3.3. Programme Making and Special Events (PMSE)

The band 470 to 694 MHz is also the core spectrum for audio PMSE (radio microphones and In Ear monitoring). PMSE uses this frequency range by operating in the interleaved spectrum between the TV transmitters. PMSE devices operate in different conditions from permanent sites, large scale/high profile short term events (e.g. Formula 1 Grand Prix) to small scale short term events (e.g. Electronic News Gathering). ERC/REC 25-10 provides a list of tuning ranges that CEPT administrations may consider for audio (and Video) PMSE applications. Within a tuning range, frequencies are identified nationally for PMSE each with their own licensing arrangements.

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5. Supplemental Downlink as flexible win-win approach

Pascal Lamy in his report to the European Commission following the HLG meetings attempts to meet both the requirements of DTT broadcast for longer term stability and further evolution as well as the requirements of MBB for further dynamic growth. He recommends:

- By 2020 +/- 2 years to re-purpose the 700 MHz band for MBB use across EU member states
- By 2025 to review the use of the remaining 470 - 694 MHz part of the UHF band
- Until 2030 prioritise DTT delivery in the remaining 470 - 694 MHz part of the UHF band

He furthermore follows DIGITALEUROPE's proposal to further investigate Supplemental Downlink (SDL) as a flexible way to allow for MBB use in 470 - 694 MHz before 2030 while protecting DTT in the band.

5.1. Outline of the proposal

The Supplemental Downlink concept is to use available spectrum resources where not used by DTT for additional downlink capacity. Hereby, in line with the path described by Pascal Lamy, such a use of spectrum occurs that existing and future DTT deployments and DTT installations are not constrained in any way.

As the evolution of DTT is difficult to predict and heterogeneous, DIGITALEUROPE believes that SDL is the possible option to allow for innovation in DTT and mobile:

- In countries or areas where DTT uses the totality of spectrum, DTT can continue to use the whole band and evolve in an unconstrained way. Unused resources by DTT could become usable at later stage.
- In countries and areas where a (partial) IP/hybrid migration takes place, some spectrum resources can be made progressively available to mobile.
- In countries and areas where DTT is reduced or low, the band can be used completely for Supplemental Downlink.
- In a possible converged scenario, a cooperation ranging from the simple infrastructure sharing to cooperative spectrum sharing or service cooperation could be envisaged.

In this way, a seamless transition between DTT and IP (where and if it occurs) can take place without disruption of DTT services, whilst serving the increased need for spectrum resource of mobile/wireless broadband and without prejudging any future scenario. Figure 2 shows possible spectrum usage of SDL.

Countries with low dependency on terrestrial TV distribution or changing use patterns of terrestrial TV may look into ways to open spectrum not in use for 470 - 694 MHz for MBB early, possibly even limited to parts of the country. Supplemental Downlink (SDL) complements LTE networks and provides an option to enhance MBB networks in the direction where additional capacity is most needed.

At the same time, Supplemental Downlink allows to manage co-existence with remaining TV services within that country and along its boarders as both services provide downlink from a limited amount of known transmitters. This helps significantly to avoid close-proximity scenarios and to mitigate potential adjacency issues in frequency domains and along service border areas.

Technically, Supplemental Downlink allows for flexible design of receivers that support different spectrum allocations within 470 - 694 MHz in different countries and regions – a necessary precondition for common harmonised products for markets moving at different paces. Capacity provided by Supplemental Downlink can be used for transporting individual internet-type content and streaming audio-visual content on a unicast base, but also for broadcasting linear content efficiently via eMBMS.

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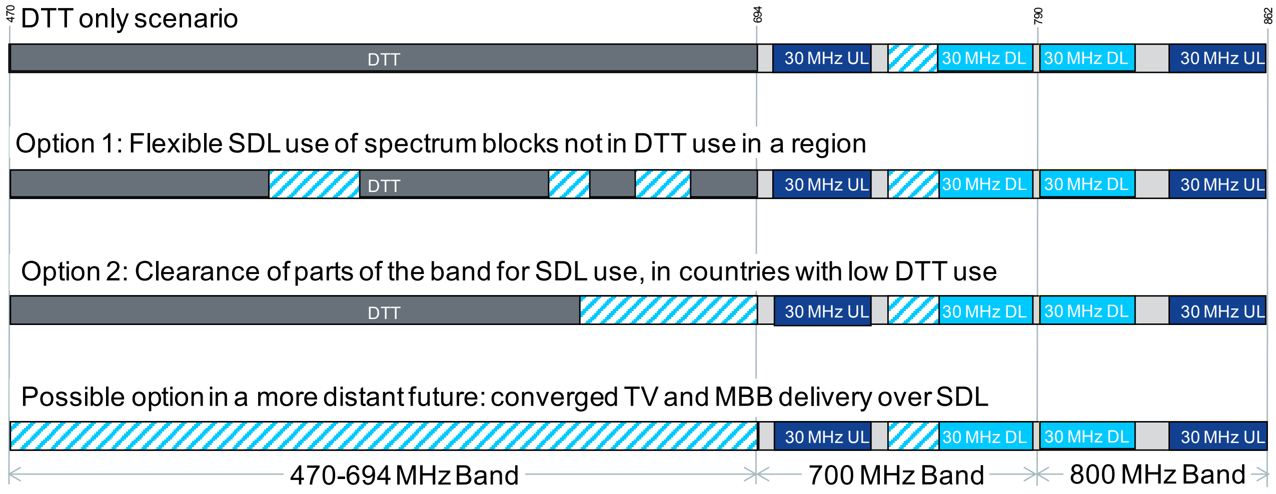

Figure 2: Generic example of options to introduce SDL in the 470-694 MHz band

Technically, Supplemental Downlink allows for flexible design of receivers that support different spectrum allocations within 470 - 694 MHz in different countries and regions – a necessary precondition for common harmonised products for markets moving at different paces. Capacity provided by Supplemental Downlink can be used for transporting individual internet-type content and streaming audio-visual content on a unicast base, but also for broadcasting linear content efficiently via eMBMS.

As a conclusion, Supplemental Downlink provides flexibility in more than one aspect:

- Flexibility to fit into remaining High Power High Tower broadcast patterns
- Flexibility to allow for a common ecosystem across countries and regions migrating at different pace
- Flexibility to allocate its capacity for whatever is needed

5.2. Flexibility in frequency management

5.2.1. Advantages of SDL compared to bidirectional usage

Typically, mobile use in a band targets the possibility of two way communication with a Downlink (DL) from base stations to mobile terminals and an Uplink (UL) in the reverse direction. Any mobile UL requires specific protection from other services in the same band as base stations feature very high sensitivity receivers typically above roof top level. Within a common band, mobile UL is particularly hard to protect from DTT signals as these High Power High Tower transmissions can lead to high blocking levels in base station receivers in large areas due to line of sight conditions between TV tower and base station, unless signals can be separated by band filters. Also mobile terminals close to TV receivers or their antennas can inject substantial interfering power into these. Consequently, operating a mobile UL in a band requires a re-purposing of the band defining new band edges and band filters. Such filters typically need to be implemented in non-tuneable hardware with rather limited pass band widths, in particular for the terminals due to size and cost constraints.

Furthermore, FDD systems require rigid band plans with band sections reserved for DL and UL, respectively, plus a centre-gap to separate these in the base station and in the terminal. Again, this translates into typically non-tunable hardware with rather limited pass band widths. Consequently, a harmonised band plan and a harmonised implementation across the member states of the EU or larger geographies are required to reach sufficient economies of scale and provide the targeted benefits to the consumer. As Europe has very different levels of DTT utilisation across member states and even within member states' regions, such a harmonised implementation seems unlikely over years to come.

Together with the growing asymmetrical capacity needs as outlined in section 4.2, SDL seems to be a promising approach. The UL capability and capacity required for mobiles systems can be provided in existing mobile broadband frequency bands.

5.2.2. Wideband requirements

Transmitters in base stations and receivers in terminals for SDL can also be designed for much wider pass band widths than their FDD peers, assisted by technology progress in wide band solution design. This allows addressing larger sections of the 470 - 694 MHz band and adds flexibility in frequency management. On the base station side, reusing existing mobile sites could take place to allow a cost effective deployment by upgrading antennas to wide band antennas and wide band transceivers. For example, such wide band transmitters could be realized by further evolutions of software defined radio which could enable frequency agility and aggregation in a larger dimension than today. In that sense, frequency usage in the band 470 – 694 MHz can take place in very dynamic way.

On terminal side, wideband antennas would need to be introduced, which place some technical challenges and may have to be realized with relaxed performance requirements.

The same wide-band devices, tuneable over large ranges, can be used in different parts of that band in different member states as band width not utilised for DTT can be made available. So a common device eco-system can exist for different degrees of utilisation of DTT and MBB in the UHF frequency range 470 694 MHz and thus provide for the flexibility required to address the diversity in the European DTT landscape.

At the same time, such an evolution could facilitate integration of broadcast reception standards into terminals, which could deliver linear content where handset reception is possible.

SDL allows also – should it be the decided approach – to reuse the existing infrastructure on the mobile side, on the broadcast side or even on a converged approach:

- Existing DTT infrastructure or DTT system could be used for additional downlink capacity.
- Existing mobile infrastructure or mobile system could be used for linear content distribution
- A converged system could use commonly both infrastructures

The technology put in place for SDL can facilitate such scenarios.

5.2.3. Frequency regulation

Ideally, an SDL approach allows for a flexible usage of the band 470 – 694 MHz band without the need for changes in the international regulatory framework, in particular the Geneva 06 (GE-06) agreement. Implementing SDL in unused channels within the GE-06 coordinated DTT transmitter landscape may require careful selection of base station locations, transmit powers and antennas to provide for the priority of DTT in the band as recommended by Pascal Lamy (see 5.3).

On national basis, the adequate licensing regime can regulate the frequency usage for Supplemental Downlink or – if applicable – a partly cooperative system or infrastructure. The priority of DTT broadcast over a mobile SDL carrier should be clearly indicated to meet Pascal Lamy's recommendation for the band.

Within a cooperative approach such licences could dynamically evolve between broadcasters and mobile network operators.

There are merits on studying furthermore the technical challenges and solutions to reach cost effective and innovative solutions to the mutual benefit.

5.3. Addressing coexistence issues

As outlined in 5.2.1, a major source of mutual interference between DTT and MBB is eliminated by not using mobile uplink in the band, but limit the use to DL only via SDL. There remain, however, potential interference scenarios to be investigated. In the same manner as DTT transmitters could cause interference to mobile terminals, base stations operating in vicinity to DTT reception antennas may cause interference.

Interference of DTT high power high tower transmit into terminal receivers can occur in line-of-sight (LOS) scenarios in particular where the mobile terminal receives high signal levels of DTT somewhere in its receive band which may impair the mobile terminal reception sensitivity. As line-of-sight conditions between DTT towers and mobile terminals (e.g. on a street or even indoors) may be limited, one can expect these effects to be restricted to a limited geography. Furthermore, the assignment of SDL resources to a mobile terminal within the base station scheduler can account for the terminals' receive conditions in the SDL band based on the terminals' measurement reports and thus opportunistically assign resources in the SDL bands to those terminals capable of using them, i.e. those not in LOS conditions. Consequently, substantial DL capacity gains by using SDL in 470 - 694 MHz seem to be feasible without creating too much technological challenges in terms of immunity.

For the opposite way, i.e. interference of base station transmitters into DTT receivers, the deployment of base stations, their transmit powers and their antennas need to be subject to careful planning in order to avoid those interference cases. Some typical measures would be:

- Base stations have to be operated in a way that they are sufficiently far away from DTT aerials in order to avoid any amplifier saturation. Several studies show that distances of kilometres are sufficient to achieve such conditions. Such studies have to be refined to consider typical legacy wideband amplifiers and negligible impact on DTT reception
- Channels directly adjacent to DTT channels in use in areas shall be avoided
- Maximum allowed power radiation on other channels shall be determined in a way that there should be no impact on coverage probability for legacy DTT receivers with the chosen waveform and emission mask.

Under these conditions, DIGITALEUROPE assesses that band usage by Supplemental Downlink is possible without impact on existing and future DTT installations and DTT deployments.

5.4. What SDL can do for broadcast services

As outlined above, SDL capacity can be used for different purposes. Besides plain MBB use for individual content, it can also be used to configure broadcast channels with the help of eMBMS. Thus, capacity can be created to deliver linear content over MBB networks to mobile terminals with a technology supported by their projected chipset implementations. This creates an opportunity for a true mobile delivery of linear content on the coverage footprint of MBB networks, i.e. including e.g. moving trains or even underground lines. This would not be feasible from the existing High Power High Tower infrastructure only. This may create substantial additional value for TV content providers by opening a delivery path to the highly personalised and convenient mobile devices often in the hands of the younger in addition to the conventional large screen stationary use case. Furthermore, mobile devices inherently come with a return channel providing control over linear and non-linear content and allowing for interaction. As these devices typically feature cameras, microphones, touch screens with keyboards etc., new TV formats with live texting, audio and even video interaction of consumers are imaginable.

In addition to benefits for mobile broadcast, SDL can also provide benefits to stationary broadcast distribution:

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Stationary TV sets even today can receive their content via different paths. Besides DTT, there are cable, satellite and increasingly fixed broadband connections. In most cases, they rely on external broadband connections to provide for reverse channel capability and broadband downstream capacity to support interactive and connected TV services and carry the non-linear content. Stationary TV sets get increasingly connected to broadband, mainly through a router via W-LAN or Ethernet. Some routers are already proposing LTE access and this trend could be growing with higher and affordable LTE accesses.

In a further step, which would assume a potential progressive or partial substitution of DTT by LTE or a converged system, stationary TV sets become equipped with receivers capable of decoding eMBMS on SDL channels in the 470 - 694 MHz bands and general LTE connectivity, and eventually they could exclusively rely on these for the full set of linear and non-linear offers.

Provided that there would be sufficient SDL coverage and capacities secondary TV sets in homes or camper cars would not require any external antenna connections but could use the mobile network capabilities also in stationary or nomadic scenarios. Eventually, this could lead to fully converged services over converged networks.

With a trend of ever more TV services, many of which target small audiences, services in the so called long tail of viewers' attention can be put in unicast mode, if the demand for these is low within a cell. Here the dimension of the cell determines the threshold to more efficient unicast. Also an increase in use of the non-linear offer of broadcasters could results in less demand on linear channels at certain times. If in a cell such a service finds no demand at all at certain times, it would not even require any capacity. Valuable frequency resources would be dynamically allocated only when needed. The released DTT capacity in return can be used for Supplemental Downlink hosting the long tail channels where required.

Such a scenario, although not excluded, cannot be established as a general trend or taken as given, but has to be seen as only one possibility of evolution, as a number of regulatory and business questions would have to be solved upfront. Nevertheless, there are cases appearing realistic already today in which SDL is complementing DTT coverage and offering IP-OTT via LTE broadband where fixed line broadband is not available.

5.5. Regulatory and business aspects

Fully converged networks would trigger a plethora of regulatory and business model discussions. As public broadcast distribution typically comes with massive coverage obligations, a must-carry mandate and free-to-air requirements, it is far from obvious how this can be combined with MBB operators' interests. In addition, there are differences in copyright treatment of primary content distribution (such as over DTT) vs. secondary distribution (e.g. via cable, IP-TV) that add to the complexity.

As SDL seems to offer opportunities to provide extra downlink capacity while not touching the existing regulatory and business environment of DTT, it may be the enabler for optional, complementary content delivery and could avoid being subject to all regulatory considerations that would come with a fully converged approach. SDL operation could happen without specific cooperation between DTT and MBB operators, but could evolve and be enhanced in cooperation based on mutual agreements, comparable to those in place for today's over the top models in IP-TV using LAN and WLAN connectivity. If mutual benefits of tighter cooperation exist, eventually tighter integration of DTT and eMBMS towards converged platforms is imaginable over time.

Consequently, SDL besides its flexibility in frequency usage could even provide the flexibility required to deal with the regulatory and business model challenges arising from tight integration of DTT and MBB towards a converged platform.

6. Conclusions

DIGITALEUROPE has shown in the previous sections of the document that there could be conditions under which DTT and SDL coexistence is possible within the 470 - 694 MHz band without impacting DTT. There are merits to explore these in more detail. SDL offers the flexibility to carefully start MBB use of the 470   694 MHz band while protecting DTT and its vital interests in the band:

- SDL can flexibly reach different levels of use subject to national plans to maintain, grow or slowly reduce the respective DTT offer and the resulting spectrum demand for DTT
- SDL as downlink only technology substantially eases co-existence with DTT compared to the requirements imposed by protecting a mobile uplink. It requires, however, further analysis in how far SDL can be used commonly with DTT in the 470 - 694 MHz band.

DIGITALEUROPE endorses and offers to work together with respective stakeholders to study acceptable and mutually beneficent frequency usage, license conditions and coexistence conditions in 470 - 694 MHz. Such explorative projects should not interfere with the 700 MHz release and the LTE700 deployments. While studies can commence any time, actual results may only be achieved after the re-purposing of the 700 MHz band to MBB.

DIGITALEUROPE confirms that 700 MHz availability for mobile broadband and subsequent broadcast replanning should have priority over potential SDL usage in 470 - 694 MHz. Any studies on SDL should take this priority into account.

In the meantime, potential opportunities on a converged system could be discussed between broadcast content providers, telecommunication operators and broadcast network operators. It has to be considered, however, that the natural replacement cycle of Integrated Digital TV sets is about 7 – 10 years so that the migration towards a complete converged system would last about a decade. Consequently, a fully converged scenario is unlikely to happen before 2025.

A Supplemental Downlink usage, however, could be envisaged as early as around 2020, if it does not impose disruption to DTT:

- Should the trend of progressive reduction of DTT spectrum usage be confirmed, new frequency resources could be made available gradually to mobile on the basis of SDL.
- Should the trend be opposite with constant or more intense usage of DTT, SDL could remain attractive in areas with little DTT frequency usage and/or in countries where DTT has a low frequency usage.

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ABOUT DIGITALEUROPE

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