Comparison between DVB-T and DVB-T2

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Abstract - **The most widely adopted and deployed standard for Digital Terrestrial Television (DTT) is DVB-T, published in March 1997. Services are on air in more than 35 countries with many more set to launch in the coming years. A mature and well established standard, it benefits from economies of scale that lead to very low receiver prices and is flexible enough to enable a wide range of business models. Nonetheless, the approach of ASO (Analogue Switch-Off) in Europe and other developed DTT markets has generated an impetus to update the standard with new one DVB-T2. This paper addresses the analysis advantage of the new standard DVB-T2 (EN 302 755 v1.1.1 draft) comparison with existent DVB-T.**

Keywords – **GE06, DVB-T, DVB-T2, DVB-S, DVB-S2, HDTV, RPCs, SFN, DTT systems.**

I. INTRODUCTION

The GE06 digital broadcasting plan allows for implementation of HDTV services, i.e. using DVB-T. However, not all DVB-T plan entries offer the same opportunity for HDTV, primarily because of different reference planning configurations (RPCs) or system variants used to establish the GE06 Plan. Nevertheless, the GE06 Plan permits a significant degree of flexibility in the implementation of transmission networks that may be used in favour of HDTV. Using advanced transmission systems such as DVB-T2 it is possible to provide a higher transmission capacity than DVB-T without changes to the GE06 Plan. That is very important especially for Bulgarian administration. In fact in Bulgaria, TV spectrum is occupied for other services and that paper will be useful for telecommunication engineers.

II. FEATURES OF THE GE06 PLAN

The GE06 Plan covers the frequency band 174 - 230 MHz (Band III - arranged into seven or eight channels with 8 or 7 MHz bandwidth, respectively, depending on the country,) and the frequency band 470 - 862 MHz (Bands IV/V - subdivided into 49 channels, each with 8 MHz bandwidth). Bulgaria arranged one network in Band III with bandwidth 7 MHz and 7 networks in Band IV and V with bandwidth 8 MHz. Whilst a large number of combinations of DVB-T system variants and the reception modes (fixed, portable and mobile reception) are possible, their use would make the frequency planning extremely complicated. Furthermore, not all of these combinations are used in practice. In order to simplify the Conference planning process a limited number of Reference Planning Configurations (RPCs) was defined 7 representing, in an approximate way, the most common types of coverage. As a result, for each GE06 Plan entry an associated RPC (mainly in case of allotments), or a chosen combination of system variant and reception modes, are recorded in the Plan. In the implementation phase, broadcasters and network operators have the freedom to choose a system variant that best fits the real coverage requirements, while taking account of the recorded RPC of the corresponding digital entry in the Plan.

The three following RPCs have been defined for DVB-T:
- RPC1 - for fixed roof-level reception;
- RPC2 - for portable outdoor, lower coverage quality portable indoor, or mobile reception;
- RPC3 - for higher coverage quality for portable indoor reception.

Some examples of typical implementation parameters corresponding to these three RPCs are shown in the Table I below. Other system variants may be implemented under certain conditions.

TABLE I
INDICATES THE RECEPTION MODELS THAT ARE RECORDED IN GE06 PLAN BASED ON NATIONAL REQUIREMENTS

Reference planning configuration	RPC1	RPC2					RPC3
Reception mode	Fixed	Portable outdoor		Mobile		Portable indoor	Portable indoor
Modulation	64QAM	16QAM	64QAM	QPSK	16QAM	16QAM	16QAM
Code rate	3/4	2/3	2/3	2/3	1/2	2/3	2/3
Location probability for planning	95%	95%	95%	99%	99%	70%	95%
Max. net bit rate (Mbit/s)	27.14	16.09	24.13	8.04	12.06	16.09	16.09

The choice of Bulgarian administration was RPC2 for portable indoor reception like neighbours country. It is not obvious from GE06 how the Plan entries will be used in practice, since national objectives for DTT are different across Europe. The total capacity available in the GE06 Plan is often expressed in the number of multiplexes ('layers') that could be provided over the whole national territory. One layer represents a set of channels that can be used to provide one full, or partial, nationwide coverage. For most European countries this is equivalent to:
- three T-DAB layers in Band III;
- one DVB-T layer in Band III;
- seven to eight DVB-T layers in Bands IV/V.

It is up to the national administrations (see Fig.1) to decide how this capacity will be used. Some of the Plan entries are likely to be used to provide nationwide coverages while the other entries will be used for regional or local coverages.

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The number of multiplexes that can be achieved in practice sometimes exceeds the capacity that is theoretically available in the GE06 Plan.

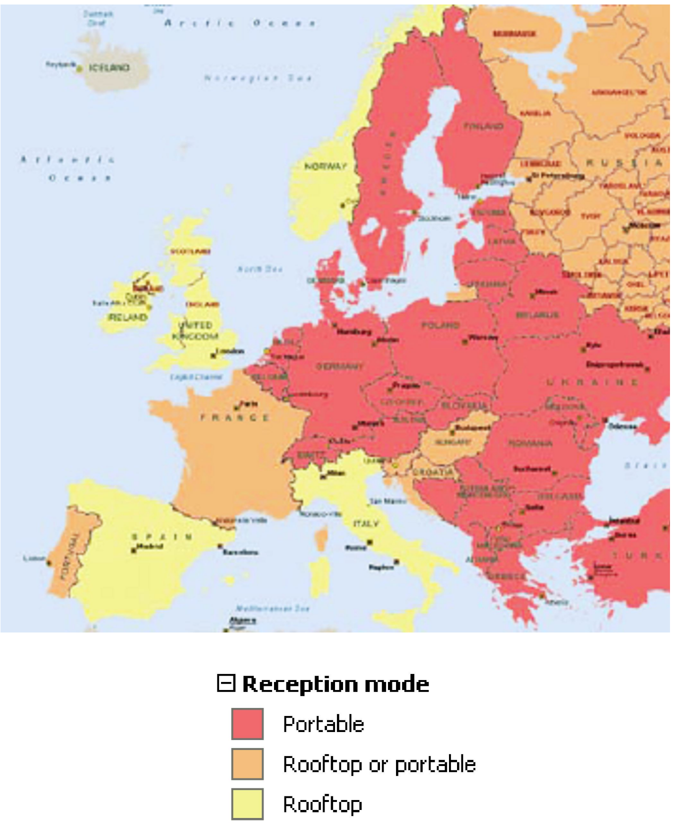

Fig. 1. Reception models recorded in GE06 Plan

III. Assumption on the technology evolution

There are important developments taking place that would provide for a significant increase in the transmission capacity on the terrestrial platform. These relate to improvements in the standards used for coding (compressing) information and in transmission systems.

• **MPEG-4** is an improved video and audio coding compression standard. This is expected to operate at up to double the efficiency of the coding standard MPEG-2 that is currently used for most of the digital terrestrial transmissions. This means that a DTT multiplex could carry up to twice as many services using MPEG-4 as can currently be achieved using MPEG-2, whilst maintaining similar picture quality.

• **DVB-T2** is a new transmission standard. Early estimates of performance of the baseline specification suggest over 45% bit rate capacity gain for a typical application for the same reception conditions. It has been estimated 8 that the introduction of these two technologies could, if combined, increase the capacity of a multiplex by up to 160% for fixed reception although some experts consider 100% to be a more realistic estimate. It is also assumed that the capacity gain in the case of portable or mobile reception will be similar to that of fixed reception.

Furthermore, as a trade off, implementation of new DTT systems such as DVB-T2 may:

• Require different approaches concerning network planning and may also have an impact on the frequency planning. In particular, if GE06 Plan entries are to be used for DVB-T2 instead of DVB-T the conditions for such substitution need to be determined and the implications in terms of interference, protection requirements and coverage parameters have to be investigated

• Induce extra cost for the broadcaster (transmitter, aerial if MISO) and for the viewers (new set up box) which should be taken into account regarding other available digital television platforms at the time of the considered introduction of DVB-T2.

As with its predecessor, DVB-T2 uses OFDM (orthogonal frequency division multiplex) modulation, with a large number of sub-carriers delivering a robust signal. Also in common with DVB-T, the new specification offers a range of different modes making it a very flexible standard. In the realm of error correction, DVB-T2 uses the same coding that was selected for DVB-S2. LDPC (Low Density Parity Check) coding combined with BCH (Bose-Chaudhuri-Hocquengham) coding offers excellent performance in the presence of high noise levels and interference, resulting in a very robust signal. Several options are available in areas such as the number of carriers, guard interval sizes and pilot signals, so that the overheads can be minimised for any target transmission channel. A new technique, called Rotated Constellations, provides significant additional robustness in difficult channels. Also, a mechanism is provided to separately adjust the robustness of each delivered service within a channel to meet the required reception conditions (e.g. in-door antenna/roof-top antenna). This same mechanism allows transmissions to be tailored such that a receiver can save power by decoding only a single programme rather than a whole multiplex of programmes. DVB-T2 also specifies a transmitter diversity method, known as Alamouti coding, which improves coverage in smallscale single-frequency networks.

IV. Main advantage of new system DVB-T2

DVB-T standard was developed more than 10 years ago. Since then, several radio communication standards based on OFDM have been defined, employing different coders, interleavers, modulators, pilot distributions, transmission and reception diversity, MIMO's etc. offering better features than those of the DVB-T standard.

The main requirements of DVB-T2 are:

• Shall be designed for stationary reception but it shall be possible to design DVB-T2 networks for all three receiving conditions, fixed, portable and mobile.

• Transmissions shall meet the interference levels and spectrum mask requirements and not cause more interference than DVB-T would do.

• Should target the maximum increase in net payload capacity over DVB-T with similar or better robustness than DVB-T under similar conditions.

• Shall provide a minimum increase in net payload capacity of 30% greater than DVB-T for any given channel profile under similar conditions. This shall be provided using existing transmitter sites and masts broadcasting to existing DVB-T domestic antenna and cable installations being backward compatible with DVB-T.
• Should offer improved robustness against interference from other transmitters, compared to DVB-T, potentially improving frequency reuse.
• Higher coverage area: 30% of increase in lateral spacing between transmitters in a Single Frequency Network (SFN).
• Shall offer a choice of various robustness and protection levels to be applied equally on all data of a transport stream carried by a DVB-T2 signal in a particular channel.
• Should offer a choice of various robustness and protection levels for each service separately, within a transport stream carried by a DVB-T2 signal in a particular channel. When more than one transport stream is carried by a DVB-T2 signal in a particular channel, the DVB-T2 specification should offer a choice of various robustness and protection levels for each transport stream separately.
• Shall provide a QoS (quality of service) across the whole channel that approximates to no more than one corrupted event (to any audio, video or data services) per hour for HDTV and SDTV services.
• Shall enable changes in modulation mode to be detected automatically within 0,5s. However, the receiver may not be capable of performing seamless changeover.

To achieve all these performance goals the physical layer should be redefined. Test and development methodologies are thus required to compare the different strategies proposed by researchers and institutions.

V. BENEFITS OF DVB-T2 COMPARED TO DVB-T

As a result of the technologies introduced in DVB-T2, the potential gain in capacity that could be achieved in the some European country for example (with that's parameters - see Table II) are nearly 50% compared to the current situations in same country mode of DVB-T (see Table II). In addition to the increased capacity, the proposed DVB-T2 mode is expected to offer greater tolerance of multipath and impulsive interference than the current DVB-T mode.

Even greater increases in capacity could be achieved in modes designed for single-frequency network (SFN) operation, because of the large fractional guard intervals used in these modes. Table III shows the comparison between DVB-T2 and DVB-T for a long guard interval (SFN) mode, with the same absolute guard interval in both cases. This provides a 67% increase in capacity for DVB-T2 over DVB-T. A longer guard interval mode is also available (nearly 20% increase), which would give improved SFN coverage for only a small loss of capacity (around 3%).

VI. THE CONCEPT OF A DVB-T2 SYSTEM

The DVB-T2 specification uses the phrase "T2 System" in different senses. In some places it is used in a general.way to refer to the DVB-T2 standard and the various elements which make it up. However, "T2-System" is also used in a specific way to refer to a particular layer-1 concept, which is a generalisation of the concept of a multiplex in DVB-T and other DVB standards.

TABLE II
POTENTIAL CAPACITY INCREASE OF ALMOST 50% COMPARED WITH CURRENT HIGHEST CAPACITY DVB-T MODE USED IN SOME EUROPEAN COUNTRY

	Current EU mode	DVB-T2
Modulation	64 - QAM	256 - QAM
FFT size	2K	32K
Guard Interval	1/32	1/128
FEC	2/3CC + RS	3/5LDPC + BCH
Scattered Pilots	8,3%	1,0%
Continual Pilots	2,0%	0,53%
L 1 overhead	1,0%	0,53%
Carrier mode	Standard	Extended
Capacity	24,1Mbit/s	36,1Mbit/s

Note 1: includes only Continual Pilot cells which are not also Scattered Pilots
Note 2: TSP for DVB-T; L1-signalling, P1 and exrta P2 overhead for DVB-T2

TABLE III
POTENTIAL CAPACITY INCREASE OF 67 % FOR AN SFN MODE

	DVB-T	DVB-T2
Modulation	64 - QAM	256 - QAM
FFT size	8K	32K
Guard Interval	1/4	1/16
FEC	2/3CC + RS	3/5LDPC + BCH
Scattered Pilots	8,3%	4,2%
Continual Pilots	2,0%	0,39%
L 1 overhead	1,0%	0,65%
Carrier mode	Standard	Extended
Capacity	19,9Mbit/s	33,2Mbit/s

Note 1: includes only Continual Pilot cells which are not also Scattered Pilots
Note 2: TSP for DVB-T; L1-signalling, P1, and exrta overhead in P2 and Frame Closing for DVB-T2

A T2-system in this specific sense is a set of transmissions with time-synchronised frame structure, using the same physical parameters (e.g. bandwidth, FFT size), carrying the same number and type of PLPs, and using the same physical parameters for each of the Physical-Layer Pipes (PLPs) it carries. The L1 signalling will therefore be identical for all transmissions in a T2-system, except for the cell_id which may differ. However, DVB-T2 allows for regional content insertion, so that the same T2 System may therefore carry different sets of Transport Streams (and/or Generic Streams) and use different transmission frequencies in different geographical areas. All of the transmissions making up a T2-system will originate from a single T2-gateway, generating an original T2-MI stream, so that the framing structure and scheduling is determined in one place and is common to all transmissions. The T2-MI will propagate through a distribution network in which some of the content may be replaced. In principle, all of the content of the PLPs might be replaced by the time a signal is transmitted, though in practice there will probably be some content which is the same for all transmissions. Fig. 2 gives an example distribution network. Since all transmissions in a T2-system come from transmitters which are ultimately connected to the same T2-gateway, the term "T2-system" can also be equivalently applied to the system of equipment and distribution networks starting from the input to the T2-gateway through to the outputs of the transmitters.

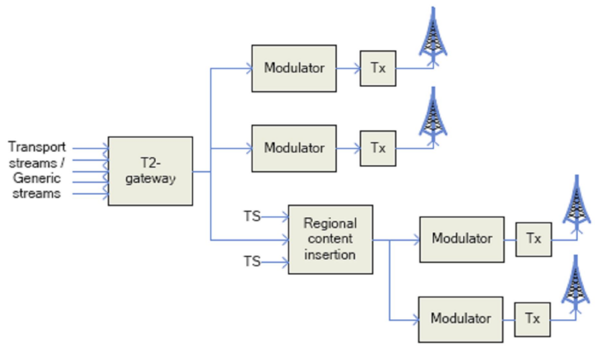

Fig. 2. Transmission in a DVB-T2-system

VII. Over air distribution

Where a master transmitter acts as the distribution mechanism for a separate SFN on a different frequency (see Fig. 3), all the information required to generate identical co-timed SFN signals must be carried over air.

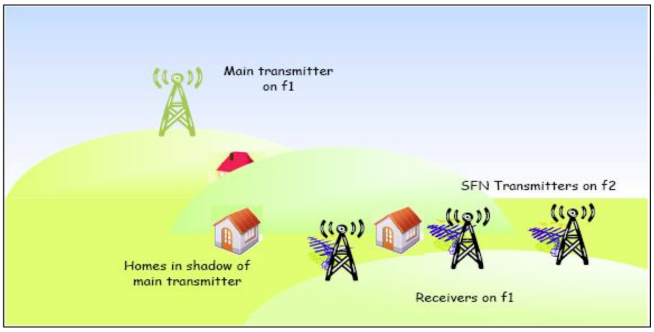

Fig. 3. Use of main transmitter to feed SFN relays

This topology has been successfully deployed in DVB-T/H networks in trial and commercial networks, as it represents a low cost solution to service distribution. In DVB-T, SFN synchronisation information is contained within Transport Streams (TS) as Megaframe Initialisation Packets (MIPs), which may then be carried over air and are ignored by consumer receivers. This approach is retained in DVB-T2, where the necessary PLP construction and timing information is carried in dedicated TS packets, with a new Synchronisation_Id value, to differentiate them from those used in DVB-T. DVB-T2 MIPs contain all of the information required by each modulator to ensure that it builds the broadcast stream in the same way, and that it outputs the stream at the appropriate time. In the use case discussed here the first of these issues is not a problem, since the DVB-T2 signal has already been constructed at the Master Station, and the relays merely need the timing information to ensure time synchronisation. However, there is a special case where some of the relays are line fed from the Master Station, whilst the remainder are fed over air. In this situation the Master Station would need to build its DVB-T2 Frame in exactly the same way as the relays in the SFN, even though it itself is not part of this network. It would therefore need to be fed with information generated by a DVB-T2 Gateway as well as the line fed relays, but must ignore the “emission time” and any frequency control information.

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