DVB-RCT: THE MISSING LINK FOR DIGITAL TERRESTRIAL TV

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ABSTRACT

The Television Broadcasters are facing an exciting challenge: to invent the television of tomorrow.

While DVB-T (The European Terrestrial Digital TV system) continues its progression among the broadcaster community around the world, the interest for new services to sustain its successful commercial deployment grows tremendously.

The market introduction by the Digital Video Broadcasting forum (DVB) of the Multimedia Home Platform (MHP) provides the broadcasters with The Terminal able to implement many categories of Interactive new Services. MHP aims at serving Interactivity… Well, for a real interactivity from the customers to the providers, a return channel is needed. That is the objective of the DVB-RCT system: to offer to the terrestrial broadcasters a wireless return channel, to be deployed with the Digital Terrestrial TV platform (DVB-T).

DVB endorsed the DVB-RCT specification in April 2001, the ETSI (European Telecom Standard Institute) ratified & published it in March 2002 (as the EN 301 958 v1.1.1 (2002-03) and the International Telecom Union (ITU-R) recommended the DVB-RCT system as "the preferred wireless return path" for the DVB-T Digital Terrestrial TV.

Apart this recognition from prestigious standardisation bodies, technical works have been performed to make the DVB-RCT system a reality:

- The WITNESS project, founded by the European Community (IST program) and launched in October 2000, deployed two DVB-RCT platforms in Ireland (Dublin) & France (Rennes) and performed field trials to verify the suitability of the system in Rural & Urban environments.

- On the terminal side, the IM4DTTV project, founded by the European States (MEDEA+ program) and launched in May 2001, engaged the work to design silicon components to build the first ever DVB-RCT setop boxes. Also, IM4DTTV engaged the design of the network equipment allowing the deployment of DVB-T & DVB-RCT network infrastructures.

Following a short presentation of the DVB-RCT basics, this contribution reports on the major results obtained in the field, by the Witness partners and shortly presents the progress of the IM4DTTV project, in regard to the DVB-RCT platform component design.

Moreover, this contribution aims to inform the broadcasters community on the near reality of DVB-RCT systems, while making aware the Regulation bodies that the emerging DVB-RCT system will soon require spectrum licences in the UHF/VHF bands…

As the world conference of Administrations on spectrum regulation (WARC 2005) is in preparation, is not it a good time now to consider Wireless Interactive Television, then the DVB-RCT's spectrum needs?

INTRODUCTION

The Television Broadcasters are facing an exciting challenge: to invent the television of tomorrow… But the Television of the next millennium is not only matters of techniques, it implies the redefinition of the broadcast business model, which will involve use of the new technologies.

Even suffering hard days, the terrestrials digital TV platforms launched around the world are real technical successes. Hard days because, to balance their business plan, broadcasters shall offer bouquets of Services to encourage customers

to move from the era of the analog TV (which in many case fully satisfy their needs) to the promising one of the digital TV.

There is not secret recipe… From the early bird countries who launched commercial terrestrial digital TV, we learned that a single feature is not sufficient to attract a customer's massive adoption… Platforms using High Definition broadcast only, or multiprogramming broadcast only, or pay-TV bouquets broadcast only, have shown great difficulties to reach the break-even number of customers.

No, there is not secret recipe, but a prudent attitude is to understand that the customer's expectations are as varied as the new digital technologies arriving on the market. As customers seems ready to pay for new Services (not for new technologies), such prudent attitude could drive broadcasters to offer not only the digital broadcast technology, but a wide range of new services made possible by the existence of these new digital technologies.

DVB-T is a powerful means to provide wirelessly, broadband data to customers (either immobile or in motion), but by itself, it is a mono-directional means... With DVB-RCT the DVB-T platform could become a bi-directional, asymmetric, broadband and wireless path between broadcasters and customers, then could open the door to new services, to new business models!

DVB-T when completed with DVB-RCT can be use not only for Interactive TV (voting, quiz, etc.) but also for Interactive Web sessions and for light IP telecommunications services. Then DVB-RCT could be the instrument to reach the commercial success searched for the Terrestrial Digital TV platform.

As it is often the case for new technologies, they allow implementation of new services, but their success depends upon a good business model (which is not necessarily an adaptation of a former one) and upon the agreement the regulators will grant to them (especially when spectrum usage is concerned).

History of a Standard

Early in the 95's, DAVIC identified the need to provide a return channel to each Digital TV platforms in order to open the TV services to the interactivity. The DVB forum sustained by European Collaborative project (the Project RACE-Interact for instance), engaged first the work to define the technical specifications for "telecommunication" return channels (ie: PSTN, ISDN, DECT, etc.) and then for the "in-medium" return channels (ie: using the Cable, Satellite, Terrestrial mediums).

The sequence of publication of the Return Channel standards has been the same that the one occurred for the distribution platforms. The Cable and LMDS digital TV platforms enjoyed a DVB-RCCL standard in early 1998, the Satellite platform followed with the DVB-RCS standard in 2000 and finally the Terrestrial platform has been granted with the DVB-RCT standard in March 2002.

As a result of more than one-year works, the DVB-RCT technical subgroup submitted the DVB-RCT technical specifications to the DVB Technical Module in March 2001. DVB endorsed them in April 2001, the European Telecom Standard Institute (ETSI) ratified & published it in March 2002 (as the EN 301 958 v1.1.1 (2002-03).

Some DVB members submitted the system to the International Telecom Union (ITU-R) which issued a recommendation "to use the DVB-RCT system as the preferred wireless return path for the DVB-T Digital Terrestrial TV systems".

It is expected this International recognition will encourage the spectrum regulator to allow the use of DVB-RCT in the broadcast band. At least, it is expected that the DVB-RCT spectrum needs, will be positively considered during the forthcoming world conference of Administrations on spectrum regulation (WARC 2005).

On the way to Interactive TV

Various degrees of Interactivity should be offered, without implying any return channel back from the user to the Service Provider: Data carrousel or Electronic Programmes Guides (EPG) are examples of such Enhanced TV services which made use of "Local Interactivity", without any return path from customer to provider.

Other services like the T-Commerce are more demanding and require full interactivity between the users & the Service Providers. When using existing telecom networks (PSTN, ISDN or GSM), the connection time delay limits considerably the category of possible interactive services: pay-per-view and video-on-demand are examples of services which can cope with such long latency connection time.

To implement new interactive service having a strong & real-time relationship with the TV programmes, like interactive advertising, Tele-voting, Tele-quiz, etc. a low latency return channel technology is definitively mandatory… and this is the major goal of the DVB-RCT.

DVB-RCT is THE response that offers a wireless interaction channel for these real-time Interactive Digital Terrestrial Television Services:

- DVB-RCT is spectrum efficient, low cost, powerful and provide a flexible Wireless Multiple Access OFDM system,
- DVB-RCT can serve large cells, up to 65kms radius, providing a typical bitrate capacity of several kilobits per second, for each TV viewer, even at the edge of the coverage area. Typically, these large cells closely match the downstream coverage area of the Digital Television broadcast signal.
- DVB-RCT can handle very large peaks in traffic, as it has been specifically designed to process up to 20,000 short interactions per second in Tele-polling Mode, this in each sector of each cell.
- DVB-RCT can be employed with smaller cells, to constitute denser networks of up to 3.5km radius cells, providing to the user a bitrate capacity of several Megabits per second.
- DVB-RCT does not require access to spectrum on a primary basis, the system has been designed to use any gaps or under-utilised spectrum anywhere in Bands III, IV and V without interfering with the primary analogue and digital broadcasting services.
- DVB-RCT is able to serve portable devices; bringing interactivity everywhere the Terrestrial Digital broadcast signal is receivable,
- DVB-RCT can be used around the world, which uses the different DVB-T system: 6, 7 or 8 MHz channels,
- DVB-RCT does not require more than 1W (30 dBm) power transmission from the User Terminal or Set Top Box to the base station.

How DVB-RCT provides these performances…

The interactive system consists of a forward interaction channel (downstream) conveyed to the user via a DVB-T compliant terrestrial broadcast network, and a return interaction channel based on a Wireless VHF/UHF transmission (upstream) of the same type, as illustrated in Figure 1.

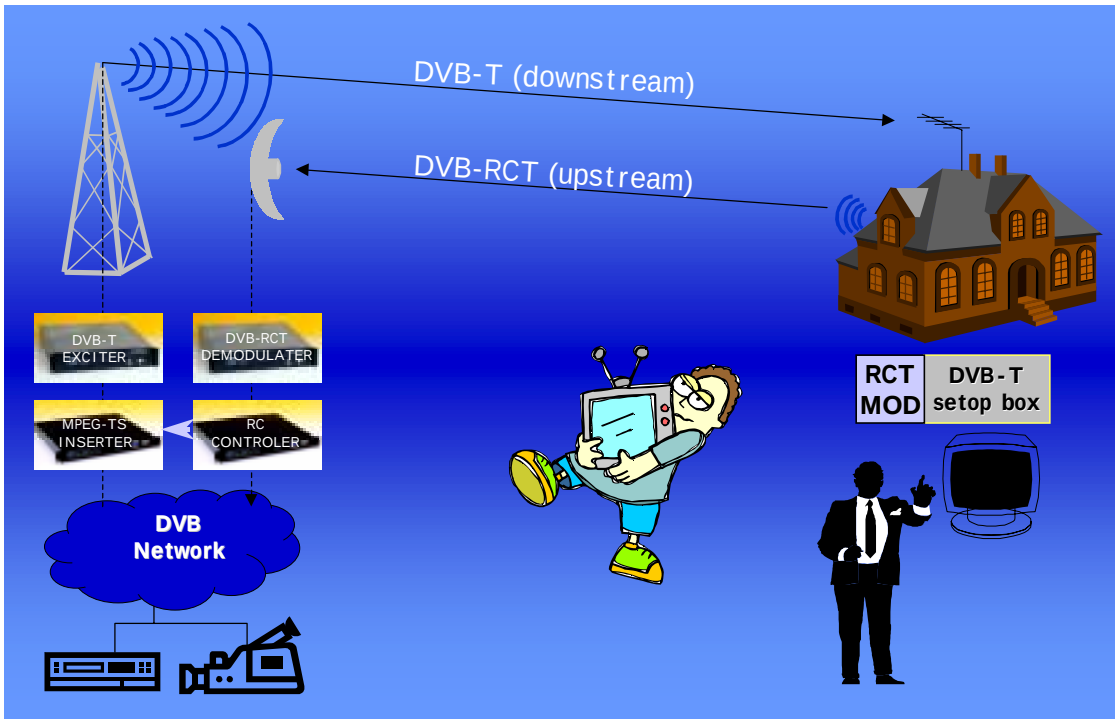


Figure 1: DVB-RCT network organisation

The downstream transmission from the Base Station provides synchronisation and information to all Terminals (RCTTs). That allows RCTTs to synchronously access the network and then to transmit upstream-synchronised information to the Base Station.

The DVB-RCT system obeys the following rules:

- Modulation scheme is OFDM for both downstream (fully DVB-T compliant) and upstream; therefore, several parallel carriers are available in the upstream to be allocated to different users, in different time slots, for transmitting data and commands back to the Base Station.
- Each authorised RCTT transmits one or several low bit rate modulated carriers towards the Base Station,
- The carriers are frequency-locked and power ranged and the timing of the modulation is synchronised by the Base Station.
- On the Base Station side, the Upstream signal is demodulated, using a FFT process, just like the one performed in a DVB-T receiver.

Channel Partitioning

To allow access by multiple users, the VHF/UHF return channel is partitioned both in the frequency domain and the time domain. This channel partitioning creates a grid of time-frequency slots, which becomes a powerful way to share the RF medium between RCTTs, as illustrated in Figure 2.

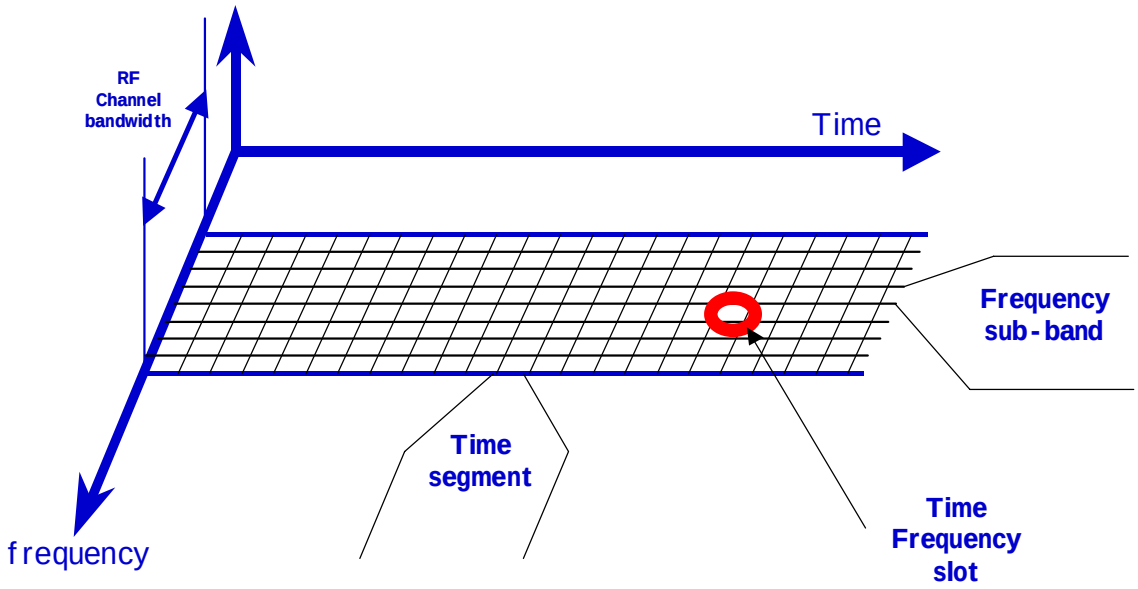


Figure 2: RCT radio frequency channel partitioning

Each available time-frequency slots can be allocated to a certain user under the control of the Base Station (BS). Multiple slots allocation is possible (both on the same carrier and onto different parallel carriers) to cope with bandwidth peak demands.

To avoid any interference between users, the system provides two options: to use a Nyquist filter or to arrange the subcarriers as orthogonal and to separate symbols per insertion of a Guard Interval. These two methods are exclusive and correspond to two scenarios of exploitations: large or reduced size transmission cells.

The DVB-RCT standard provides several partitioning characterised by their carrier spacing (~1 kHz, ~2 kHz, ~4 kHz), then the symbol duration (~1 ms, ~0,5 ms, ~0,25 ms), as illustrated in the Figure 3. These three basic modes refer to the downstream DVB-T reference clock. Accordingly, the DVB-RCT system can be used in every country around the world whatever the channel raster they operate (ie: 6, 7 or 8 MHz channels).

Furthermore, the DVB-RCT channel can be equipped with either 1024 or 2048 carriers. Due to the three carrier spacing offered, the bandwidth of the DVB-RCT channel can occupy 1 MHz or 2 MHz or 4 MHz or 8 MHz (or more precisely, 1/8, 1/4, 1/2 or 1/1 of the RF channel raster bandwidth).

In short, in addition to its intrinsic spectrum efficiency, the DVB-RCT uses any unused or underused megahertz of spectrum, to provide a DVB-T return path!

		8 MHz DVB-T System		7 MHz DVB-T System		6 MHz DVB-T System	
	Total System Carriers	**2048**	**1024**	**2048**	**1024**	**2048**	**1024**
	Used Carriers	1712	842	1712	842	1712	842
SC1	RCT system clock	0,438 us	0,875 us	0,500 us	1,000 us	0,583 us	1,167 us
	Useful Symbol Duration	896 us	896 us	1 024 us	1 024 us	1 195 us	1 195 us
	Carriers Spacing	**1 116 Hz**	**1 116 Hz**	**977 Hz**	**977 Hz**	**837 Hz**	**837 Hz**
	RCT channel bandwidth	1,911 MHz	0,940 MHz	1,672 MHz	0,822 MHz	1,433 MHz	0,705 MHz
SC2	RCT system clock	0,219 us	0,438 us	0,250 us	0,500 us	0,292 us	0,583 us
	Useful Symbol Duration	448 us	448 us	512 us	512 us	597 us	597 us
	Carriers Spacing	**2 232 Hz**	**2 232 Hz**	**1 953 Hz**	**1 953 Hz**	**1 674 Hz**	**1 674 Hz**
	RCT channel bandwidth	3,821 MHz	1,879 MHz	3,344 MHz	1,645 MHz	2,866 MHz	1,410 MHz
SC3	RCT system clock	0,109 us	0,219 us	0,125 us	0,250 us	0,146 us	0,292 us
	Useful Symbol Duration	224 us	224 us	256 us	256 us	299 us	299 us
	Carriers Spacing	**4 464 Hz**	**4 464 Hz**	**3 906 Hz**	**3 906 Hz**	**3 348 Hz**	**3 348 Hz**
	RCT channel bandwidth	7,643 MHz	3,759 MHz	6,688 MHz	3,289 MHz	5,732 MHz	2,819 MHz

Figure 3: DVB-RCT Modes vs DVB-T channel raster

Transmission frames

To further structures the RF channel, beyond the time-frequency partitioning, the DVB-RCT offers two transmission frame, organised as illustrated in Figure 4.

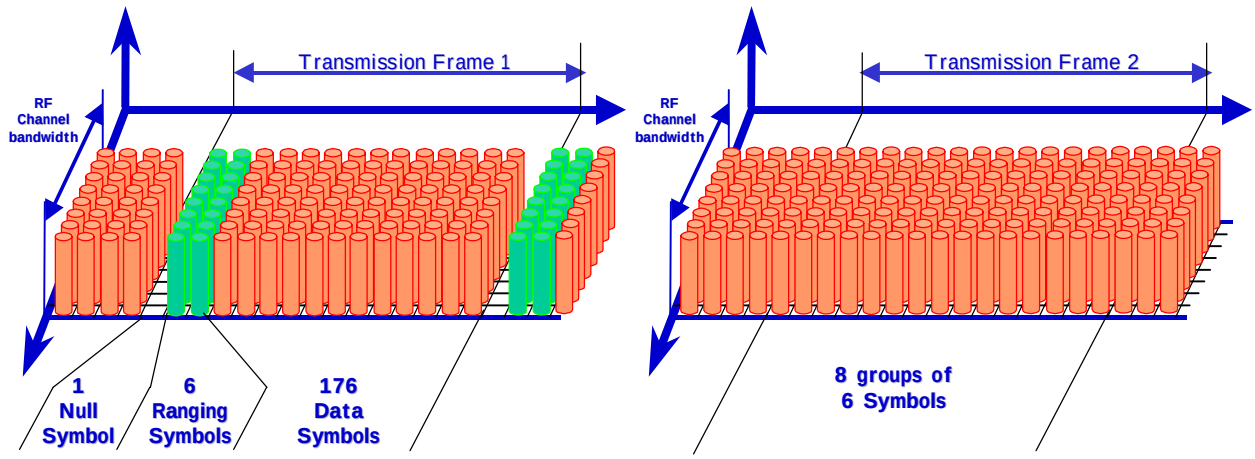


Figure 4: DVB-RCT's transmission frames

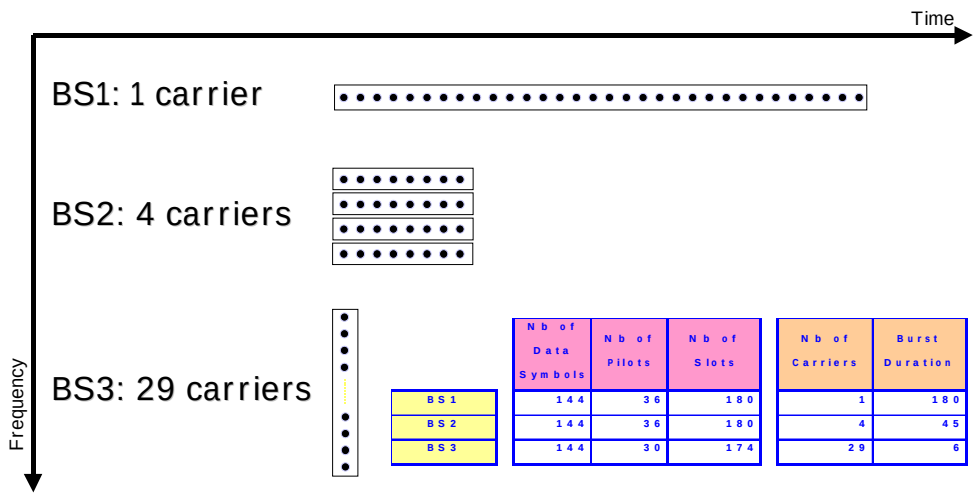
The First transmissions frame (TF1) makes use of each OFDM symbol period for a dedicated activity. Thus the first symbol of the frame is null (that is to allow base station to detect jammers), the six following symbols a devoted to the ranging procedure while the remaining 176 symbols of the frame, are used by RCTT to transmit data.

The second transmissions frame (TF2) does not implement null symbol but is made of general-purpose symbols. It has a duration of 48 symbols, organised as 8 groups of six consecutive symbols. Within each group, the 1K or 2K carriers are distributed over sub-channels (made of 4, 29 or 145 carriers), these last category devoted to ranging functions using MC-CDMA technique. In short, TF2 structure the activities in the frequency domain while TF1 performs it in the time domain.

Burst Structures

Within the data transmission resources provided by the transmission frames, the RCTT can perform data transmissions using three types of time-frequency patterns called burst structures. Whatever the pattern used, the data burst is made of 144 modulated symbols in which 30 or 36 pilots carriers are inserted (for the purpose of a coherent demodulation in the base station).

The three burst structures are illustrated in the Figure 5.



	Nb of Data Symbols	Nb of Pilots	Nb of Slots	Nb of Carriers	Burst Duration
BS1	144	36	180	1	180
BS2	144	36	180	4	45
BS3	144	30	174	29	6

Figure 5: DVB-RCT Burst structures

The three Bursts Structures, as illustrated in Figure 5, constitute various trade-off between burst duration and frequency diversity they provide. Shorter burst duration is more robust against interference but requires the user to use several carriers in parallel, then to spread the available power over them. In short, each Burst Structure allows to cover various cell radiuses.

Bitrate capacity

Under the control of the Base station, to transmit data the RCTT modulate the carrier(s) of the burst structure using either a 4QAM, 16QAM or 64 QAM constellation, protected with a coding rate of 1/2 or 3/4.

Figure 6 shows the range of available bit-rate when using BS1 or BS2 with the Rectangular shaping. Values are given for the three modes (i.e.: carrier spacing) as a function of the coded modulation. Small variations represented in each case come from the four possible Guard Interval (1/4, 1/8, 1/16, 1/32 of the useful symbol duration).

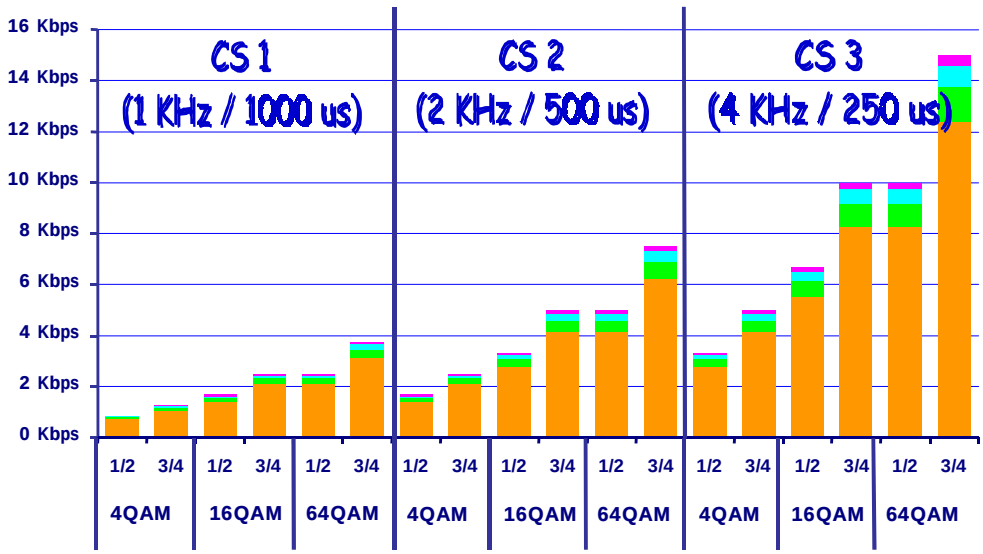


Figure 6: Bitrate range per Carrier

Globally, in typical applications, the DVB-RCT system offers a net bit-rate per carrier ranging from 0,6 Kbps to 15 Kbps. When all carriers are used, the Base Station is able to collect from 1 Mbps to 30 Mbps of user data from the DVB-RCT channel.

The most robust modes offer the lowest bit-rate, over a large radius cell whilst the weakest modes offer the largest bit-rate over a small radius cell.

Dynamically-Assignable Adaptive Modulation

Instead of having static assignment of constellation/code rate for all RCTT, simultaneous usage of all combinations is allowed with DVB-RCT. This feature called "Dynamically-Assignable Adaptive Modulation" enables to control the level of interference from a given cell into neighbouring co-channel cells while, at the same time it provides the maximum bitrate to each users, optimising the spectrum usage.

For instance, the most robust form of modulation (e.g. 4QAM 1/2 rate) can be assigned to users near the outer boundary of the cell allowing them to use the minimum possible amount of power to transmit back to the Base Station. Conversely, users nearer the base station can be assigned less robust modulation (e.g.: 64QAM, 3/4) using the appropriate transmission power level. Even these users, will use more power to enjoy higher data throughput, as they are further away from other cells, they will cause less interference into the other co-channel cells.

Advanced DVB-RCT features

In addition to the dynamically assignable adaptive modulation, DVB-RCT includes many advanced features, of interest:

- DVB-RCT authorises the usage of both Concatenated Coding (Reed Solomon and convolutional coding) or Turbo-Coding. This last can provide a further 2 dB (or more) reduction of the C/N threshold for a given BER,
- DVB-RCT provides a scheme to "time-interleave data" when mapping over the burst structures. This could provide at least an additional 5dB improvement against Impulsive Interference,
- DVB-RCT provides a "power ranging" feature, which reduces interference and increases the system's spectrum efficiency.

As a conclusion, from the technical point of view, DVB-RCT is built around the most recent developments in algorithms and techniques for digital transmission and it constitutes the first system in the world using Multiple Access OFDM technique to provide a Wireless Interactive channel.

What happened since the DVB-RCT system definition…

DVB-RCT largely benefits from the experience of the European-funded research project iTTi ("interactive Terrestrial TV integration" – 1997-1999), where a first solution for terrestrial interactivity was developed and demonstrated. Two projects are running to support DVB-RCT: WITNESS ("Wireless Interactive Terrestrial Network System and Service") and IM4DTTV ("Integrated Modem fo(u)r Digital Terrestrial TV).

The MEDEA+ "IM4DTTV" project

IM4DTTV project (2001-2003), aims at validating DVB-RCT specification, developing a prototype VLSI solution for the DVB-RCT terminal, as well as to support all necessary investigations and tests needed to assess the DVB-RCT specification towards the ETSI standardisation process. IM4DTTV will provide a 1G-silicon solution and a complete hardware validation platform covering all aspects of the DVB-RCT system, including both user terminal side (i.e.: RCTT) and broadcast side (i.e.: Base Station). IM4DTTV is chaired by ST Microelectronics (Italy).

Tremendous works have been already accomplished by the IM4DTTV project:

- The detailed specifications of every equipment as the functional & physical interface have been established,
- Deep simulations have been done to verify the performance of the DVB-RCT modes and to verify a common understanding of the standard between the partners who design ASIC,
- Design of network equipment constituting the Base Station (DVB-RCT demodulator, MAC controller, MAC inserter, etc.) have been engaged by the Industrial companies involved in the project,
- Design of VHDL models are engaged within the Chip Manufacturers companies involved in the project,
- Implementation of some part of the DVB-RCT modulator has been performed using FPGAs,
- Definition of the test protocols & procedures have been engaged and are discussed between all partners.

In short, the technical work in IM4DTTV is well engaged and give first tangible results, as shown in Figure 7.

Figure 7: DVB-RCT equipment designed within the IM4DTTV project (courtesy of RUNCOM)

IM4DTTV's partners believe that the first DVB-RCT ASIC (probably including both DVB-T demodulator & DVB-RCT modulator) will be available early in 2003. As for the first prototypes of Interactive set-top box using DVB-T & DVB-RCT, they will be probably issued by the project in the second half of 2003.

The IST "WITNESS" project

WITNESS (2000-2002) aims to upgrade, test, and validate equipment and planning algorithms to aid in the standardisation of digital terrestrial TV return channel (DVB-RCT). WITNESS main mission is to validate the operation of a Terrestrial Return Channel service by deploying up-graded interactive wireless terminals in the two test sites of Ireland (Dublin) and France (Rennes); then to develop spectrum planning and frequency usage recommendations for Terrestrial TV services. The WITNESS project is chaired by RTE Networks (Ireland).

The "Witness" field trials

The project devoted its resources to build up two DVB-RCT pilot networks in Rennes (France) and Dublin (Ireland), in order to verify DVB-RCT coverage and to verify the suitability of DVB-RCT from fix & portable receivers.

Figure 8: DVB-RCT field trials in Rural & Urban area of Rennes (France)

A base station, made of a DVB-T transmission chain & a DVB-RCT receiving chain, has been designed using the prototype demonstrator produced by the former iTTi project. In the base station, a "DVB-RCT Metrology" application

has been designed to measure the received & demodulated DVB-RCT signal. The Metrology application inserts the measurement results in the DVB-T downstream to make it available in the DVB-RCT terminal.

A van equipped with a telescopic antenna (in order to reproduce the environment of a “rooftop” antenna located at 10m above the ground level) has been equipped with an Interactive terminal made of a DVB-T receiver and a DVB-RCT emitter. Running the Metrology application, this terminal shows to the operator in the van, the result of the last DVB-RCT transmission (BER, received level, etc.) as it has been perceived in the Base Station.

The “Witness” pilot networks

Rennes area

The DVB-T downstream was broadcast from a main TV transmission site located in Saint Pern, at up to 30 kms North West from the Rennes city. The DVB-T transmitter produced 1kW ERP in channel 61 (794 MHz) using a strong modulation scheme (2K, gi: 1/32, 16QAM, cr:2/3) allowing to broadcast 16,09 Mbps over a radius of up to 70..80 kms.

The DVB-RCT receiving antenna has been installed on the Saint Pern mast at a height of 160 Meters above the ground level. The channel 55 (746 MHz) has been allocated for DVB-RCT transmission (from the van back to the “base station”).

Dublin area

For the Dublin experimentation, the DVB-T downstream was broadcast from a main analog TV transmission site located in Three Rock, on a 450m hilltop at 10 kms South of Dublin. The DVB-T transmitter produced 9kW ERP in channel 26 (513 MHz) using a modulation scheme (8K, gi: 1/32, 64QAM, cr:2/3) allowing to broadcast 24,13 Mbps over the Dublin’s region.

The DVB-RCT receiving antenna has been installed on the Three Rock mast. The channel 48 (690 MHz) has been allocated for DVB-RCT transmission.

DVB-RCT coverage for fix antenna

The objective of this first measurement campaign was to verify that, even with a limited power of 1W (30 dBm), the upstream DVB-RCT transmission cell replicate the downstream DVB-T distribution one. Also, to verify that the DVB-RCT receiver is able to demodulate a weak powered DVB-RCT signal when located in a TV transmission site radiating Kwatts of TV signals.

Figure 9 gives a map of the points where measurements were performed, covering the DVB-T service area in Rural & Urban environment of Rennes & Dublin.

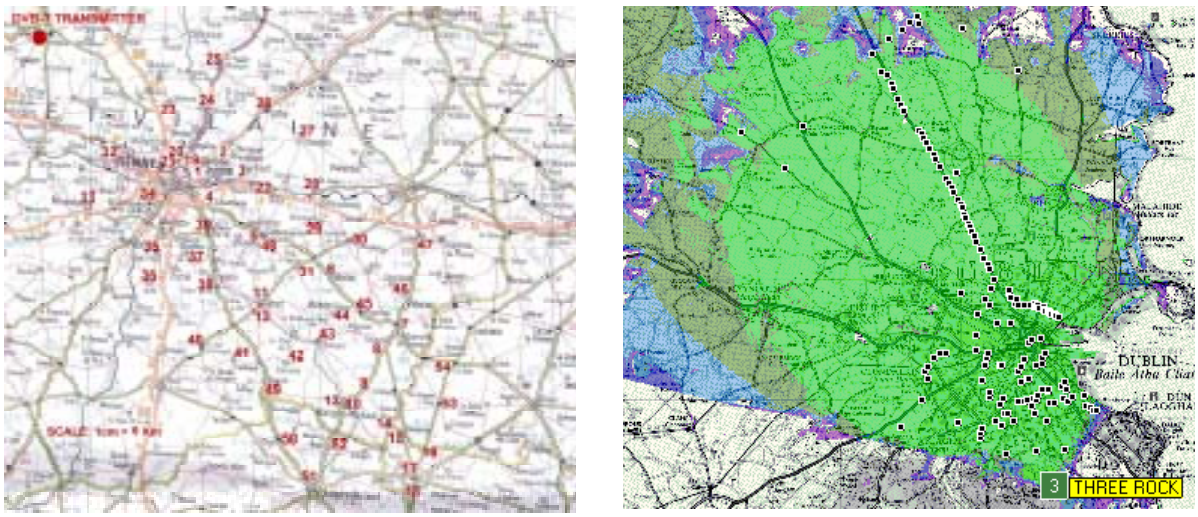


Figure 9: Measurement points in Rennes & Dublin areas

To weight the DVB-RCT upstream power level, the primary test was to evaluate the DVB-T downstream received level in the van, at each tested point.

Figure 10 gives this DVB-T level in relation with the distance from the transmitting site (Saint Pern) where the "base station" operates.

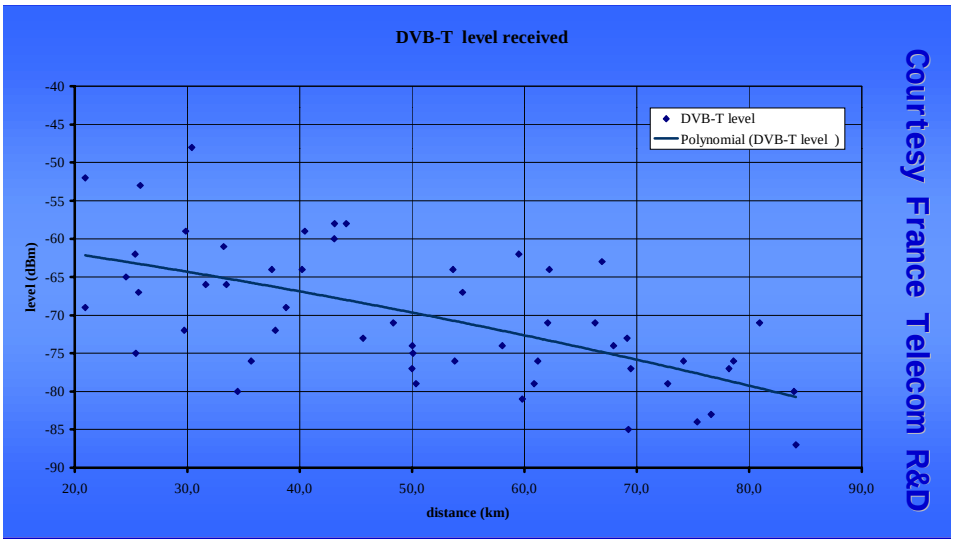


Figure 10: Level of DVB-T downstream signal received vs distance of the measurement point

Without surprise, at up to 80 kms, the DVB-T signal is well demodulated even with a received level of less than -80 dBm (thanks to the 16QAM, 2/3 used which offers a C/N threshold of –87 dBm).

The result of the field trials campaigns in Rennes & Dublin surpassed all expectations: they demonstrate very clearly that DVB-RCT services can be provided everywhere the DVB-T signal is available and also that even in an saturated spectrum environment DVB-RCT reception remains possible.

But, what will be the upstream power level from the set-top box using the rooftop antenna, in this situation? Figure 11 gives the required DVB-RCT power level needed for successful transmission, in relation with the received DVB-T signal power.

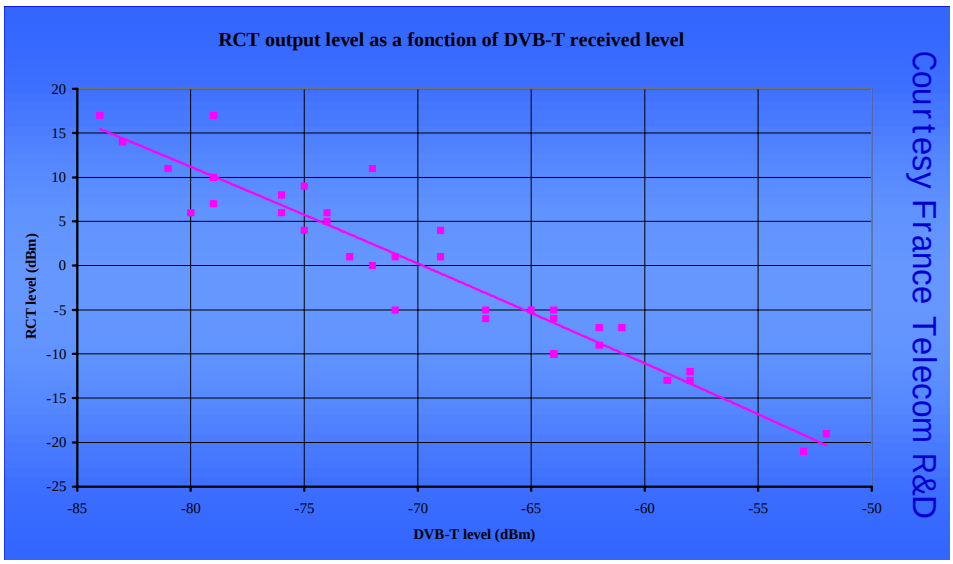


Figure 11: DVB-RCT level used for transmission in relation with the DVB-T signal level received

Figure 11 shows clearly that even at the extreme border of the DVB-T service area (up to 80 kms from the DVB-T downstream source) successful DVB-RCT return transmission have been realised using a transmitting power of 15 to 20 dBm, far from the maximum allowed of 30 dBm!

This DVB-RCT transmission power measurement has been systematised in order to verify if, even in dense urban area, the DVB-RCT can provide an efficient return path for the every DVB-T user. The result of this campaign in Rennes & Dublin is given in Figure 12.

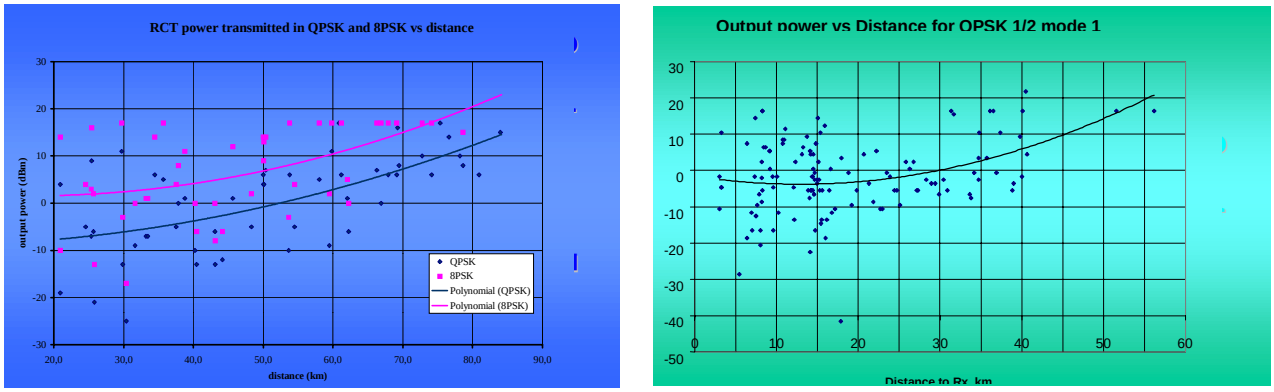


Figure 12: DVB-RCT transmission power vs distance using QPSK (and 8PSK)

The DVB-RCT mode 1 (QPSK, coding rate 1/2 modulation and Burst Structure 1) has been used for this measurement. Figure 12 shows that similar results have been obtained both in Rennes & Dublin, even if the geographical topology & the transmission facilities of these sites differ.

In Rennes, the power level needed with a non-standardised 8PSK modulation has been evaluated, at least to prove that successful services can work with denser constellations (ie: 16QAM & 64 QAM) than QPSK.

The most interested result of these field trials is that the “maximum workable distance” of DVB-RCT is greater than the usual range of DVB-T services! WITNESS partners get then confidence that the DVB-RCT wireless return path can work everywhere the DVB-T signal is received!

DVB-RCT used with indoor installation

Further works have been engaged to determine the usability of DVB-RCT backward transmission with indoor installation. To simulate this situation, two indoor antennas (one directional and one whip omni-directional) have been installed in the van, as shows in Figure 13.

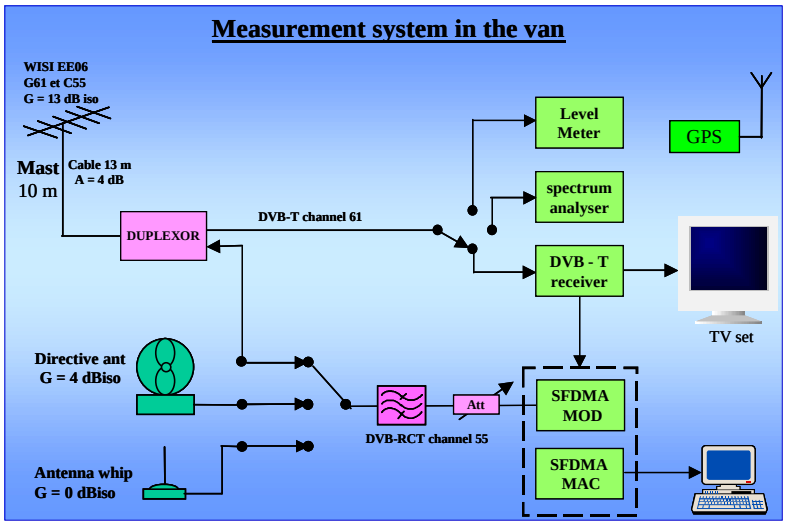


Figure 13: Measurement Van installation with “indoor” transmitting antennas

To validate suitability of DVB-RCT for services to indoor terminals and to understand the ways a network can be deployed, two “base station” receiving sites have been experienced:

- The first makes use of a tower located in the vicinity of the FT R&D centre, on the north east of Rennes as marked on the map in Figure 14. In this tower, the base station (ie: both DVB-T transmitter & DVB-RCT receiver) has been installed. This arrangement allows DVB-RCT transmission within the city, then to assess the robustness of the DVB-RCT signal against multipath situation.
- For the second set-up, the base station has been installed in the Saint Pern site, as it has been the case for the coverage evaluation. In the Rennes tower, instead of the base station equipment, an on-channel re-transmitter has been installed. This co-channel re-transmitter is able to re-amplify the DVB-RCT signal produced indoor by the set-top box, then to retransmit it in direction of the Saint Pern site located at 30 kms (North West) from the Rennes city.

A specific campaign of measurement to assess the coverage of the Rennes city has been performed, as shows the measurement point presented in Figure 14.

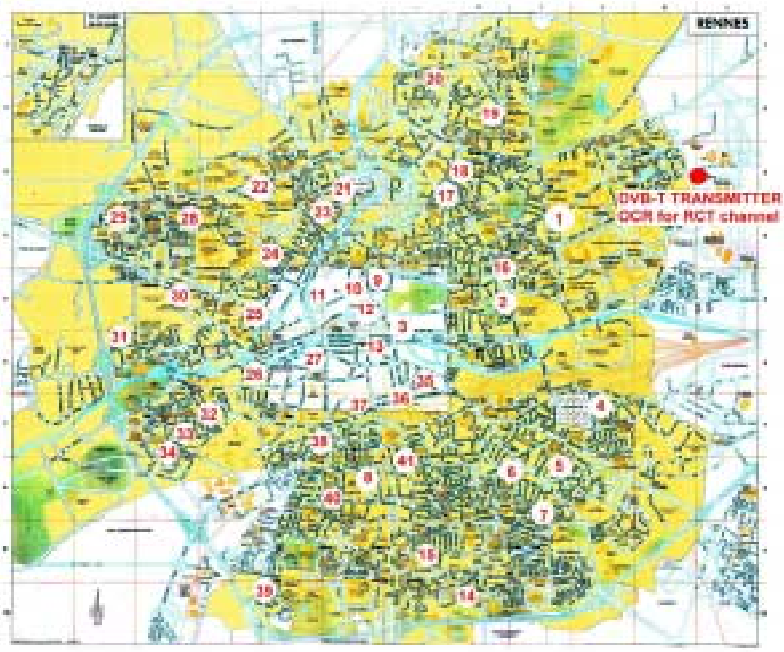


Figure 14: DVB-RCT “indoor” transmission test points in Rennes city

The preliminary results of this DVB-RCT “indoor” test campaign are extremely positives:

- Using the Rennes base station, 100% of the tested point have worked successfully, without requesting more than 20 dBm DVB-RCT power level. Globally, the attenuation from outdoor to indoor transmission is about 9 to 12 dB and it does not compromise the DVB-RCT suitability.
- The on-channel re-transmitter has also recorded excellent results. Giving a 95 dB amplification on the weak signal provided by the “indoor” DVB-RCT terminal, it retransmitted it back to Saint Pern. That allowed a successful demodulation 30 kms away of the “RF boosted” DVB-RCT signal!

From these preliminary results, it is suggested to the network engineer that planning of DVB-RCT networks can be simplified & improved by the use of “channel boosters” or “on-channel re-transmitter”.

For instance, a large DVB-RCT cell around a main DVB-T transmitter can be deployed to cover outdoor transmission from Rural users at up to 80 kms. Also, to offer an DVB-RCT access to the indoor portable terminal inside city, it is possible to install an on-channel re-transmitter. That will avoid to ask for additional spectrum! Obviously, this will save spectrum but will not increase the total available DVB-RCT bitrate shared between users!

To conclude on these WITNESS field trials, the suitability of DVB-RCT for outdoor and indoor wireless return channel transmissions has been demonstrated: Everywhere ones can receive the DVB-T signal, it can successfully uses DVB-RCT to enjoy Interactive DVB-T services!

Conclusions

This paper has highlighted the progress occurring for DVB-RCT both on the standardisation and technical sides. The ETSI published the DVB-RCT standard (EN 301 958 v1.1.1 2002-03), the WITNESS project performed the first DVB-RCT field trials, while the IM4DTTV project engaged the design of both ASIC for set-top boxes and DVB-RCT network equipment.

More than a technical standard, DVB-RCT will become soon a commercial reality, if the regulation bodies endorse, like the ITU-R, its use in the UHF/VHF broadcast bands.

Even works remains to accomplish, the DVB-RCT constitutes already a real – not to say THE - asset for a successful deployment of the interactive terrestrial digital TV worldwide.

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SUMMARY OF DVB-RCT PHYSICAL PARAMETERS	
Return Interaction Channel	Multiple Access OFDM (MA-OFDM)
OFDM Carrier set	1024 (1K), 2048 (2K)
OFDM Carrier spacing (CS)	~1KHz, ~2KHz, ~4KHz
Transmission modes	6 modes (as combination of 3 Carrier Spacing and 2 OFDM Carrier sets)
Carrier shaping	Nyquist, Rectangular
Guard Interval	1/4, 1/8, 1/16, 1/32 (for Rectangular shaping only)
Transmission Frames	TF1, TF2
Modulation	QPSK, 16QAM, 64QAM
Encoding rates	½ , ¾
Channel codes	Turbo or concatenated (Reed-Solomon + Convolutional)
Burst Structures	BS1, BS2, BS3
Net Bit rate /carrier (range)	0.6 Kbps – 15 Kbps (depending on the mode)
Service range	Up to 65 km (cell radius)
Channel raster	6, 7, 8 MHz channels are supported
PROTOCOLS incorporated in DVB-RCT	
Medium Access Control (MAC)	Specifications mostly derived from EN 200 800
Access options	Fixed rate access, Contention access, Reservation access
Security	Supported (derived from EN 200 800)

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