Mobile TV standards: DVB-T vs. DVB-H

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Although there is widespread interest in mobile television, there are growing concerns over business model issues (infrastructure costs and revenue sharing). Many DVB-H launches are being delayed because of lack of agreements – between mobile network operators and broadcasters – on the best business model to use. Consequently, some MNOs have decided to launch mobile phones that take advantage of free-to-air DVB-T reception, such as in Germany, thus questioning the viability of DVB-H pay-TV services.

This article compares DVB-T and DVB-H coverage performance for several classes of receivers. It concludes that DVB-T will not kill DVB-H! Some countries will start with DVB-T and add DVB-H later, while others will do the opposite. In the end, DVB-T and DVB-H will co-exist.

DVB-T status across Europe

The DVB-T standard was planned to replace analogue TV progressively, and most analogue switch-offs are scheduled for around 2009 - 2012).

As the map in *Fig. 1* shows, it appears that the number of countries that opted for a sophisticated modulation scheme – such as 64-QAM which enables a bitrate of approximately 20 Mbit/s per multiplex (MUX), yielding roughly six TV channels – is greater than those that selected 16-QAM, which is more robust but limits the rate per MUX to about 10 Mbit/s (roughly four TV channels).

Despite the disparity in modes, new types of portable DVB-T receivers such as PC USB sticks, PMPs, PNDs, car STBs and even mobile phones (see *Fig. 2*) have surfaced on the market and work well in both outdoor and light-

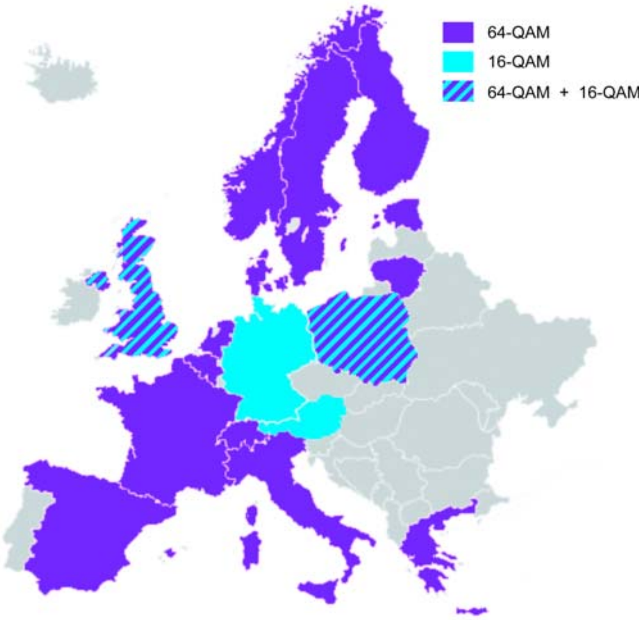


Figure 1
DVB-T across Europe

indoor environments.

In the most challenging cases (64-QAM, deep indoors or at high moving speeds), the quality of reception can be increased, thanks to the use of two antennas in "diversity mode".

Figure 2
New mobile phone offering DVB-T

DVB-H standard

In order to offer adequate and reliable reception on battery-powered handheld devices, such as mobile phones, a new transmission standard had to be developed.

DVB-H originates from DVB-T, and adds:

- A "time slicing" function which allows a 90% cut in power consumption, by functioning in "burst mode".
- An MPE-FEC code (forward error correction) which increases the sensitivity of the receiver.

However, business model issues (infrastructure cost and revenue split) between wireless operators and broadcasters are becoming a concern. Many DVB-H launches are being delayed because of lack of agreements on the business model. Consequently, some MNOs have decided to launch mobile phones that take advantage of free-to-air (FTA) DVB-T reception, such as in Germany.

This puts the viability of DVB-H pay-TV services in question.

So, DVB-T or DVB-H?

This article compares DVB-T and DVB-H coverage performances for several classes of receivers by mostly using:

- the Link Budget models developed by two independent organizations: the international *Broadcast Mobile Convergence Forum* (BMCO) and the French industry consortium *Forum TV Mobile*;
- two types of coverage prediction models: the basic *Okumura-Hata* model for main tendencies and the advanced *Volcano* tool developed by Siradel for more accurate coverage prediction.

Link budget evaluation

A three-step process, based on [1] and illustrated in *Fig. 3*, is used to compute the minimum median equivalent outdoor field strength required at 1.5m above ground level (agl).

1) we first calculate, in dBm, the *required minimum RF level* (C_{min}) at the front-end tuner input.
2) then we calculate, in dBµV/m, for a given antenna gain, the *required field strength* (E_{ant}) near the receiving antenna.
3) and finally we evaluate the *required outdoor field strength* (E_{out}), assuming good margins for indoor or outdoor coverage with a given percentage of covered locations (usually 95% or 99%).

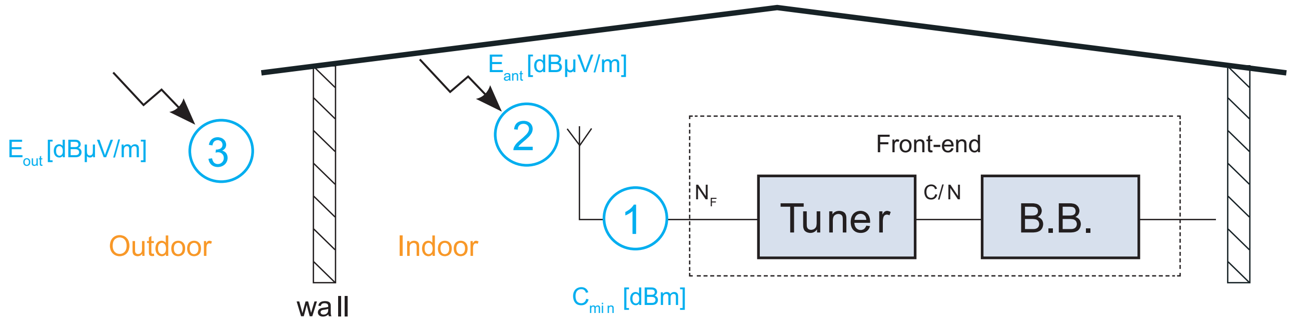


Figure 3
Reference model for link budget calculation

Step1: minimum RF level required at the receiver input

The minimum required RF input level (C_{min}) is related to the Carrier-to-Noise Ratio (C/N), the receiver Noise Figure (N_F) and the spectrum Bandwidth (B) by using the following formula:

$$\frac{C}{N} = \frac{C_{min}}{N_F k T_0 B}$$

Where: k = Boltzmann's Constant (k= 1.38 x 10^{-23} {Ws/K})
T_0 = Absolute temperature (T_0 = 290° {K})
B = Receiver noise bandwidth (B = 7.61 x 10^6 {Hz})

(1) $$C_{min_{[dBm]}} = \left(\frac{C}{N}\right)_{[dB]} + N_{F_{[dB]}} - 114 + 10\log(B_{[MHz]})$$

Table 1 gives the C/N values (MBRAI specification [2] and DiBcom values), for several classes of Single Receivers and the mostly used DVB-T/H constellations in Europe.

Table 1
Required (C/N) values for several classes of Single Receivers

				$(C/N)_{min}$ [dB] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		*Car/Roof-Antenna* or *Mobile In-Car*	
Mode	Constell.	Code rate	MPE-FEC	MBRAI	DiBcom	MBRAI	DiBcom	MBRAI	DiBcom
DVB-T	16-QAM	2/3		18.0	**16.5**	19.5	**18.0**	24.0	**23.0**
DVB-T	16-QAM	3/4		20.5	**19.0**	22.0	**20.5**		**26.0**
DVB-T	64-QAM	2/3		22.8	**21.0**	24.3	**22.5**	30.0	**29.0**
DVB-H	QPSK	2/3	7/8	10.4	**10.4**	11.4	**11.0**	14.5	**13.0**

In **diversity** mode, using two antennas and Maximum Ratio Combining (MRC), the required C/N values, shown in ***Table 1***, are 6 dB lower in PI/PO modes and 8 dB lower in TU6 mode [3].

Using the C/N values of *Table 1* together with N_F = 5 dB and B = 7.61 MHz in equation (1) above gives the minimum required RF input level (C_{min}) for Single Receivers *(Table 2)*.

Table 2
Required RF input level C_{min} for several classes of Single Receivers (N_F = 5 dB and B = 7.61 MHz)

				C_{min} [dBm] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		*Mobile In-Car* or *Car/ Roof-Antenna*	
Mode	**Constell.**	**code Rate**	**MPE-FEC**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**
DVB-T	16-QAM	2/3		-82.2	**-83.7**	-80.7	**-82.2**	-76.2	**-77.2**
DVB-T	16-QAM	3/4		-79.7	**-81.2**	-78.2	**-79.7**		**-74.2**
DVB-T	64-QAM	2/3		-77.4	**-79.2**	-75.9	**-77.7**	-70.2	**-71.2**
DVB-H	QPSK	2/3	7/8	-89.8	**-89.8**	-88.8	**-89.2**	-85.7	**-87.2**

Step2: Minimum field strength required at the antenna input

The input RF level (Watt or dBm) is usable in the laboratory, but in the field or in an anechoic chamber, we need to measure the field strength (dBµV/m) instead. Assuming a receiving antenna gain (G_{ant}) and a working frequency (F), the required field strength is calculated versus the minimum RF input level (C_{min}) by using the following formulas:

$C_{min} = Aa \times \Phi_{min}$

Aa = Effective antenna aperture {dBm²}
Φ_{min} = Minimum power flux density at receiving place {dBW/m²}

$$\text{with } \Phi_{min} = \frac{(E_{ant_{min}})^2}{120\pi}$$

$E_{ant_{min}}$ = Equivalent minimum field strength near the antenna {dBmV/m}

$$\text{and} \quad Aa = G_{ant} \times \frac{\lambda^2}{4\pi}$$

λ = Wavelength of the signal ($\lambda = c/F$) {m}
G_{ant} = Antenna Gain compared to isotropic antenna {dBi}

And finally, a combination of the three previous formulas gives:

$$E_{ant_{[dB\mu V/m]}} = C_{min[\mathrm{dBm}]} + 77.2 - G_{ant_{[dBi]}} + 20\log(F_{[\mathrm{MHz}]}) \quad (2)$$

Abbreviations

16-QAM 16-state Quadrature Amplitude Modulation
64-QAM 64-state Quadrature Amplitude Modulation
agl Above ground level
BMCO Broadcast Mobile Convergence Forum
http://www.bmcoforum.org/
C/N Carrier-to-Noise ratio
DVB Digital Video Broadcasting
http://www.dvb.org/
DVB-H DVB - Handheld
DVB-T DVB - Terrestrial
ERP Effective Radiated Power
FEC Forward Error Correction
FTA Free-To-Air
MNO Mobile Network Operator
MPE (DVB) Multi Protocol Encapsulation
MUX Multiplex / multiplexer
PMP Portable Multimedia Player
PND Portable Navigation Device
QoC Quality of Coverage
QPSK Quadrature (Quaternary) Phase-Shift Keying
STB Set-Top Box

As an example, the minimum field strength required at the antenna input is shown in *Table 3* for an antenna gain (G_{ant}) = –2.4 dBi (external antenna) and a carrier frequency F = 600 MHz.

Table 3
Required field strength (E_{ant}) values near the antenna for several classes of Single Receivers (N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

				E_{ant} [dBµV/m] SINGLE Antenna					
				PI		PO		TU6@10Hz	
				Light, Good, Deep *Portable Indoor*		Pedestrian *Portable Outdoor*		Mobile *In-Car or Car/Roof-Antenna*	
Mode	**Constell.**	**Code rate**	**MPE-FEC**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**	**MBRAI**	**DiBcom**
DVB-T	16-QAM	2/3		53.0	**51.5**	54.5	**53.0**	59.0	**58.0**
DVB-T	16-QAM	3/4		55.5	**54.0**	57.0	**55.5**		**61.0**
DVB-T	64-QAM	2/3		57.8	**56.0**	59.3	**57.5**	65.0	**64.0**
DVB-H	QPSK	2/3	7/8	45.4	**45.4**	46.4	**46.0**	49.5	**48.0**

Step3: Minimum outdoor median field strength with coverage margin

Macro-scale variations of the field strength are very important for the coverage assessment. For outdoor signals, the standard deviation value of σ_o= 5.5 dB is commonly used.

For indoor signals, the given variation corresponds to the cumulative of the outdoor signal variation and the indoor or in-vehicle variation. As outdoor and indoor macro-scale variations of the field strength were found to follow a "log Normal" law, the combined standard deviation (σ) is given by:

$\sigma = \sqrt{(\sigma_o^2 + \sigma_p^2)}$ where σ_p is the standard deviation of the indoor penetration loss.

For portable reception, the Quality of Coverage (QoC) is said to be "good" in a given area if at least 95% of receiving locations at the edge of the area are covered (for P = 95%, the corresponding inverse of the standard normal cumulative distribution is µ = 1.64). For mobile reception, the required QoC is usually 99% (µ = 2.33). Finally the minimum median electric field strength, assuming a given QoC, can be calculated as follows:

$$E_{out_{[dB\mu V/m]}} = E_{ant_{[dB\mu V/m]}} + L_p + \mu \times \sigma \quad (3)$$

Where L_p is the median indoor penetration loss and σ is the standard deviation, given in *Table 4*.

When using a simple propagation model like Okumura-Hata, the output of the third step given on *Page 2*, and shown in *Fig. 3*, consists of evaluating the *required outdoor field strength* (E_{out}) assuming a good indoor coverage with a given percentage of covered locations (95% or 99%).

According to the process previously defined, the minimum median outdoor electric field strength assuming a good coverage with a DiBcom receiver is calculated for the most used DVB-T/H modes across Europe and is shown in *Table 5*.

Table 4
Median penetration loss, standard deviation and quality of coverage

	Portable Indoor (PI)			Portable Outdoor (PO)	Mobile Car (TU6@10 Hz)	
	Light	Good	Deep		In-car	Car roof-top
L_p (dB)	11	14	17	0	7	0
Good QoC (%)	95	95	95	95	99	99
μ	1.64	1.64	1.64	1.64	2.33	2.33
σ_{out} (dB)	5.50	5.50	5.50	5.50	5.50	5.50
σ_p (dB)	5.00	5.00	6.00	0.00	0.00	0.00
σ (dB)	7.43	7.43	8.14	5.50	5.50	5.50
$L_p + \mu\sigma$ (dB)	**23.2**	**26.2**	**30.4**	**9.0**	**19.8**	**12.8**

Table 5
Minimum outdoor electric field strength required for a portable DiBcom receiver
(N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

					E_{out}[dBµV/m] for a DiBcom Single Antenna Receiver $E_{out} = E_{ant} + L_p + \mu\sigma$					
					Portable Indoor (PI) QoC=95%			Port. Outdoor (PO QoC= 95%	Mobile Car (TU6) QoC=99%	
Mode	Constel.	Code rate	MPE-FEC	Country	Light	Good	Deep		In-car	Car roof-top
DVB-T	16QAM	2/3		Germany	74.7	77.7	81.9	62.1	77.8	69.4
DVB-T	16QAM	3/4		Austria	77.2	80.2	84.4	64.6	80.8	72.4
DVB-T	64QAM	2/3		France	79.2	82.2	86.4	66.6	83.8	75.4
DVB-H	QPSK	2/3	7/8	France	68.6	71.6	75.8	55.1	67.8	59.4

When using a more sophisticated propagation model such as *Volcano* by Siradel, the penetration losses are inherently computed by the model. This mode directly provides an estimation of the outdoor and indoor fields. The service coverage maps are assessed by considering similar thresholds as those in *Table 5* but without L_p.

Outdoor and indoor coverage estimation in Greater Paris for DVB-T and DVB-H

Context

A large part of mobile multimedia communications takes place inside buildings, especially in densely populated areas (home, office, shopping mall, railway station, airport). Consequently a knowledge of indoor coverage is of great concern to Mobile TV network operators.

Numerous methods exist to provide an estimation of indoor coverage. After a short review of common methods, a refined solution designed by Siradel is presented. This method has been used to obtain the various signal strengths and service coverages for DVB-T 16-QAM / 64-QAM and DVB-H.

Summary and limitation of existing methods

Several approaches have been proposed in the literature for estimating the indoor and outdoor coverage.

COST-HATA models [4] and ITU rec ITU-R P.1546 [5] are methods based on empirical results to obtain path-loss and field-strength estimations, depending on (i) the environment (rural, suburban, urban), (ii) the frequency and (iii) the height of the transmitters and receivers. A rough estimation of the covered surface is possible and the cell radii may be roughly determined. To obtain the indoor coverage, these models are associated with methods called *path loss margin* [6] that consist of adding to the outdoor path loss, a margin that can depend on the land usage type. Generally, low-resolution geographical map data (typically 50m) are used to classify the environments.

Recommendations ITU-R P.1546 [5] and P.1812 [7], and BMCO forum work [1] on planning for indoor fixed digital TV reception, present similar margins. The latter reference distinguishes between “light”, “good” and “deep” indoor conditions. Thus, most techniques recommended by the ITU, EBU and ETSI for the planning of mobile digital TV reception fall into this category. Besides, a “height loss” value, corresponding to a margin, is added to the predictions made at a receiver height of 10m to account for possible losses encountered at street level and inside the ground floor.

Some solutions called *height gain model* estimate the coverage according to floor levels by a semi-empirical height gain that may vary according to the LOS and NLOS conditions [8]. These methods are also used on high-resolution geographical map data.

However these methods fail to represent correctly the penetration of the direct path or the multipath occurring in urban areas. Alternative solutions, also based on high-resolution geographical map data, compute the outdoor-to-indoor field strength on several distinct floor levels.

Okumura-Hata coverage prediction method

The Okumura-Hata model gives the *median path loss* in urban areas. It is based on measurements carried out by Okumura, and parameterized by Hata [9].

The model does not provide any analytical explanation, but is only based on the measurement results collected by the campaign in Japan during 1968. The model is suited for base-station-to-mobile-station scenarios with large cell sizes (a transmitter-receiver separation of larger than 1 km). Furthermore it does not take into account the actual Earth relief. Consequently, this basic model cannot be used for accurate coverage estimation but only for rough evaluations. *Table 6* shows some covered distances, estimated from the field strength thresholds given in *Table 5*, using the Okumura-Hata method in the Paris area (Eiffel Tower transmitter with ERP = 20kW) – for urban, suburban and open/rural areas.

Fig. 4 illustrates the covered distance versus the electric field strength for “Outdoor Pedestrian” and “Good Indoor” reception at ground floor level in urban, suburban and rural areas. Around Paris the area is much more “urban”. But at a distance greater than 15-20 km, we can consider “suburban” as a valid propagation model in some places.

The maximum covered distance (around 69 km) is given by the horizon limit at 1.5m agl.

The DVB-T 64-QAM, DVB-T 16-QAM and DVB-H thresholds are shown horizontally in the graph of *Fig. 4*.

Table 6
Covered radius given by Okumura-Hata propagation model
***Receiver*: N_F = 5 dB, G_{ant} = –2.4 dBi, hm = 1.5m**

Eiffel Tower hb = 324m ERP = 20kW F = 600MHz		Good Indoor			Outdoor Pedestrian			Horizon
		DVB-T	DVB-T	DVB-H	DVB-T	DVB-T	DVB-H	
		64QAM 2/3	16QAM 2/3	QPSK 2/3	64QAM 2/3	16QAM 2/3	QPSK 2/3	
Thresholds ($E_{dB\mu V/m}$)		82.2	77.7	71.6	66.6	62.1	55.1	48.1
R (km) Okumura-Hata	**Urban**	**4.4**	**6.3**	**10.3**	**15.5**	**22.3**	**39.3**	
	Suburban	9.0	12.9	21.2	32.0	46.0	68.7	68.7
	Open Rural	38.4	55.3	68.7	68.7	68.7	68.7	

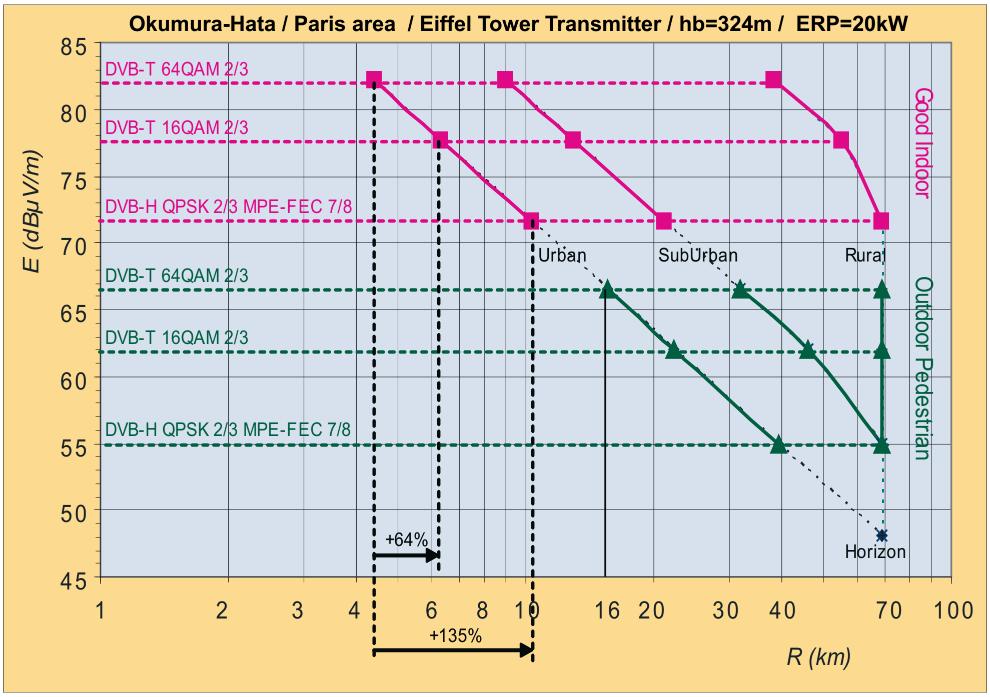


Figure 4
Covered distance vs. electric field using Okumura-Hata propagation model in the Paris area
***Receiver*: NF = 5 dB, G_{ant} = – 2.4 dBi, hm = 1.5m, F = 600 MHz**

It clearly appears that, for the same ERP, DVB-H (QPSK 2/3 MPE-FEC 7/8) performs much better than DVB-T, especially in 64-QAM mode. For example, for "Good Indoor", in both Urban and Suburban areas, the covered DVB-H radius improvement is around 135% compared to DVB-T 64-QAM, and 64% compared to DVB-T 16-QAM.

Note: The normally accepted limitations for the Okumura-Hata simulation method are 200m for the transmitter height and 1 to 20 km for the covered distance range. Nevertheless, even with hb = 324m and a calculated coverage radius up to 55 km, correlation between the basic Okumura-Hata model and the sophisticated Volcano simulations remains acceptable (see *Tables 6* and *8*). The Okumura-Hata model can be considered here as a theoretical extension for providing an overview. If one wants a better accuracy, ITU-R Rec. P.1546 or Volcano can be used.

Advanced outdoor-indoor penetration methods

The approach implemented by Siradel was partly designed and developed in the frame of the French research project RECITENT and the European project FP6-IST-PLUTO [10] to predict large DVB-T and DVB-H indoor coverage maps. The in-building penetration is now implemented in the core Volcano products.

The main characteristics of the advanced outdoor-indoor penetration method is that the rays (radio waves) resulting from the (possibly multiple) interaction with the outdoor urban environment are prolonged and fully exploited from outdoor to indoor.

In the present method, all ray contributions penetrate inside the buildings. The propagation of rays inside the building is done along straight horizontal paths. An interface loss is added to the path loss while penetrating inside the building. The interface loss can be different for different land usages (e.g. monument, building, shopping mall) of the geographical map data. An in-building loss is added to the path loss while propagating inside the building. It is calculated from a statistical linear clutter loss γ (in dB/m) that can vary according to the land usage.

γ represents the average loss per metre caused by in-building walls, objects and furniture.

At greater reception heights, the ray can penetrate inside the building through the rooftop and top floors. In that case, the interface loss associated with the land usage is used to compute the floor attenuation. The floor horizontal surfaces are assumed to be separated by 3 metres.

The global indoor path loss results from the combination of all the ray contributions intercepted at the receiver location. Large measurement campaigns were realized in the framework of the afore-mentioned research projects for testing DVB-T/H networks to validate the approach [11][12].

In cases where no high-resolution geographical map data are available, techniques similar to the path loss margin are used. Dedicated methods provide a seamless coverage between heterogeneous areas, avoiding a break at the interface between low and high resolutions.

The main advantages of this solution for predicting outdoor-to-indoor propagation are:

- to provide a fast and precise prediction of the wave propagation from one outdoor base station to mobile or portable stations located inside buildings on different floors.
- to provide in-building coverage maps for outdoor radio networks for fixed and mobile digital TV, over large urban area; the coverage can be predicted on the ground floor only, to assess the worst coverage case, or on different floors.

Application

A transmitter located at 324m agl, on the Eiffel Tower, illuminates a large part of the Greater Paris area. A transmitter omni-directional antenna is used in this scenario and the ERP is 20 kW.

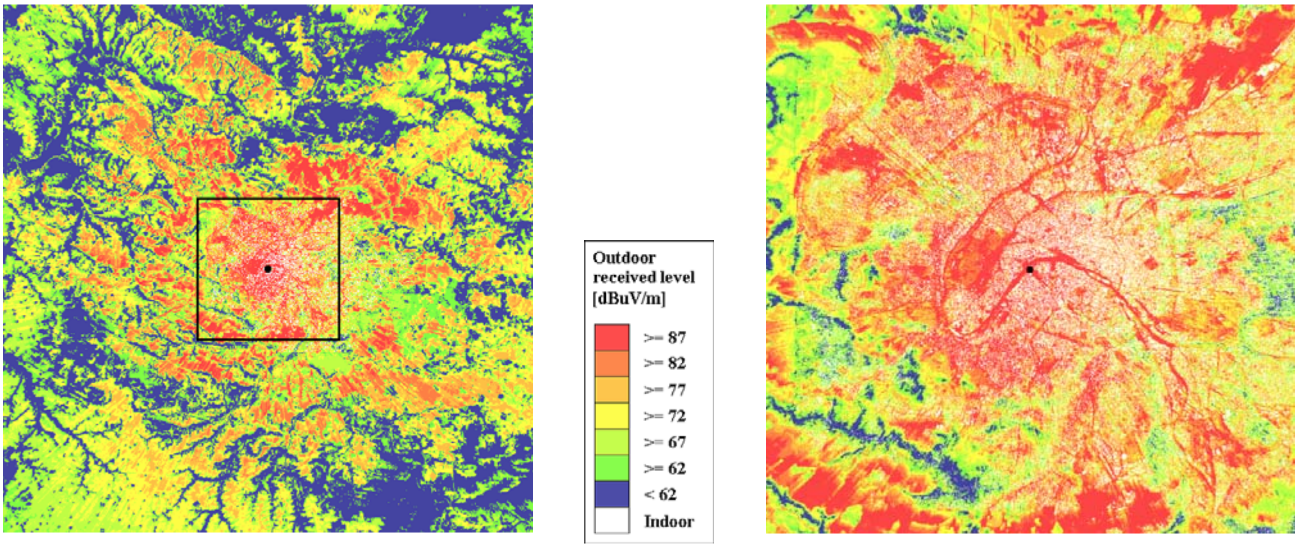


Figure 5
(Left) **Outdoor field strength in Greater Paris area, 120km*120km**
(Right) **Zoom in Central Paris, 32km*32km. Indoor field strength is not computed (white colour)**

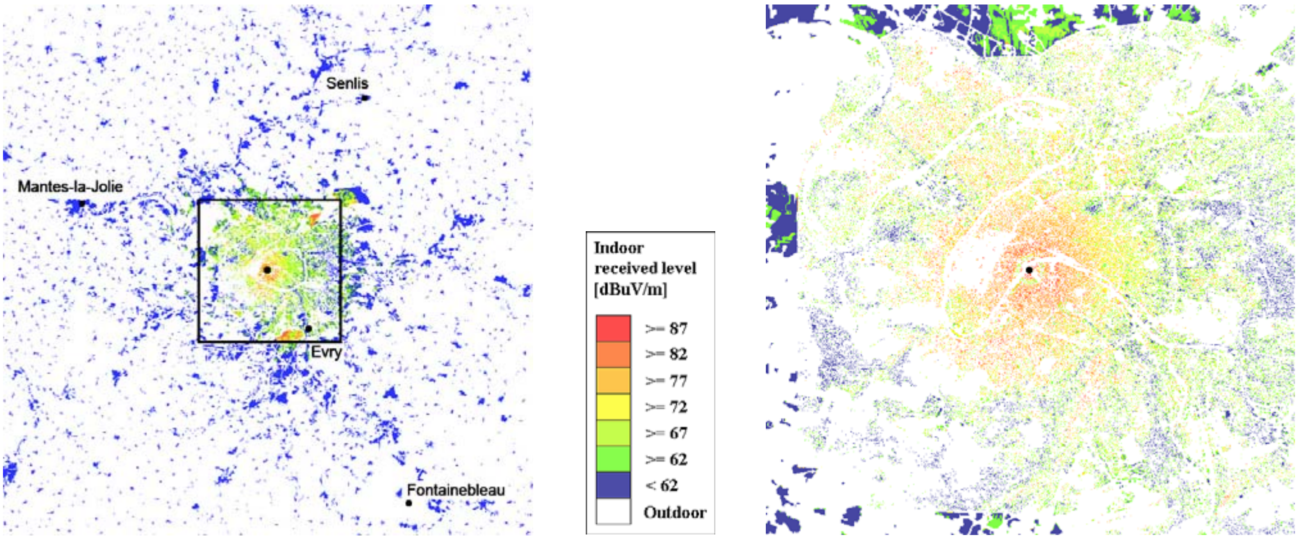


Figure 6
(Left) **Indoor field strength (at 1.5m agl) in Greater Paris area, 120km*120km**
(Right) **Zoom in Central Paris, 32km*32km. Outdoor field strength is not computed (white colour)**

The outdoor and indoor coverages are evaluated for three DVB schemes: DVB-T 64-QAM 2/3, DVB-T 16-QAM 2/3 and DVB-H QPSK 2/3 MPE-FEC 7/8.

Fig. 5 shows the outdoor field strength estimated by the described method. The higher levels are observed around the transmitter and at larger distances with a line-of-sight. The impact of relief and land usage (buildings, vegetation) is observed. On the left-hand side of *Fig. 5*, a 120km*120km area is represented and the computation was made with low- and high-resolution geographical map data. On the right-hand side, a zoom at high resolution is made for a 32km*32km area. In this Figure the indoor reception fields are not computed (represented in white).

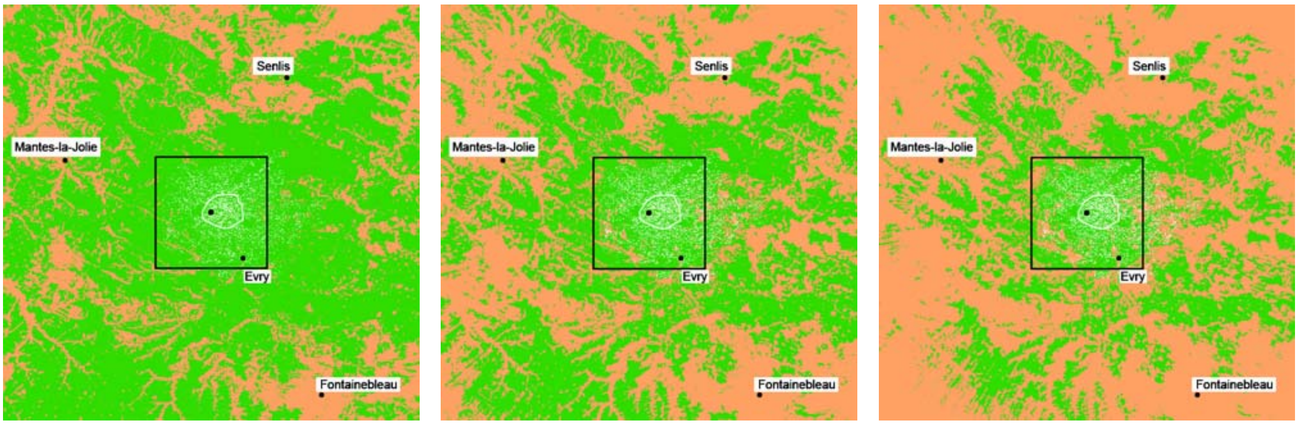
On the contrary, in *Fig. 6* only the indoor fields are illustrated for the same areas. Here, the outdoor fields are represented in white.

Note that the predicted field strengths already include the losses from in-building penetration. Therefore the thresholds for indoor coverage do not have to take into account an additional median indoor penetration loss. Applying the thresholds given in *Table 7* over the areas shown in *Fig. 5* and *Fig. 6*, the service areas are assessed and represented in *Fig. 7* and *Fig. 8* respectively for outdoor and indoor conditions.

Table 7
Minimum indoor electric field strength required in Volcano's simulations for a portable DiBcom receiver (N_F = 5 dB, G_{ant} = –2.4 dBi, F = 600 MHz)

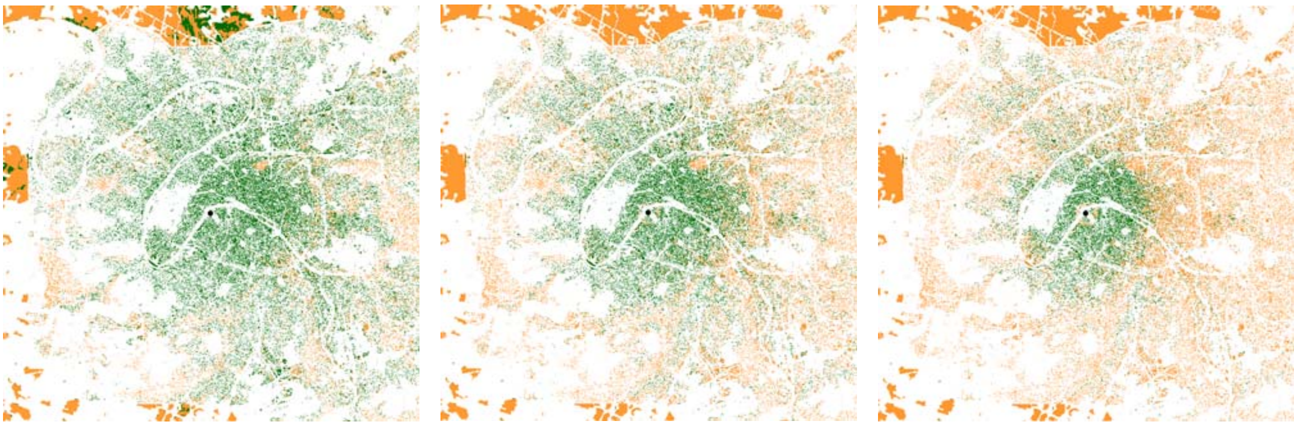
					Thresholds ($E_{dB\mu V/m}$) as shown in *Table 7* for a DiBcom single antenna receiver $E_{indoor} = E_{ant} + \mu\sigma$	
					Portable Indoor (PI) QoC = 95%	Portable Outdoor (PO) QoC = 95%
Mode	**Constel.**	**Code rate**	**MPE-FEC**	**Country**	**Good Indoor**	
DVB-T	16QAM	2/3		Germany	63.7	62.1
DVB-T	64QAM	2/3		France	68.2	66.6
DVB-H	QPSK	2/3	7/8	France	57.6	55.1

The covered areas (green colour) are larger for DVB-H than for DVB-T. The 16-QAM DVB-T scheme is received at larger distances than the 64-QAM scheme.



DVB-H 2/3 MPE-FEC 7/8 **DVB-T 16-QAM 2/3** **DVB-T 64-QAM 2/3**

Figure 7
Outdoor coverage for a 95% QoC
(green = covered; ochre = non-covered; white = not computed, i.e. indoor)
120km*120km area



DVB-H 2/3 MPE-FEC 7/8 **DVB-T 16-QAM 2/3** **DVB-T 64-QAM 2/3**

Figure 8
Indoor coverage at ground level for a 95% QoC
(green = covered; ochre = non-covered; white = not computed, i.e. outdoor)
32km*32km area

Table 8
Covered radii given by Volcano propagation model
***Receiver*: N_F = 5 dB, G_{ant} = –2.4 dBi, hm = 1.5m**
***Transmitter*: hb = 324m, ERP = 20 kW**

				Mean radius of coverage in km			
				Outdoor		Indoor (urban)	
Mode	**Constel.**	**Code rate**	**MPE-FEC**	**Rural**	**Urban**	**Ground floor**	**3rd floor**
DVB-T	64QAM	2/3		31.5	14.8	4.9	8.8
DVB-T	16QAM	2/3		42.9	20.3	7.7	12.4
DVB-H	QPSK	2/3	7/8	>60.0	31.5	11.0	22.6

The estimation of the Volcano coverage mean radii for the different DVB schemes are summed up in *Table 8*. We observed that the mean radii are of the same order of magnitude as the ones computed by Okumura-Hata (see *Table 6*). However the coverages are quite different and only the service coverages presented in *Fig. 7* and *Fig. 8* can be used for reliable radio network planning for heterogeneous areas (urban, suburban and rural).

Moreover, deterministic tools such as Volcano offer the possibility to compute finely the multi-floor coverage. It is observed from the radii given in *Table 8* that the coverage on the third floor is about twice as large as the ground floor coverage.

DVB-T coverage measurements in Europe

Fig. 9 and *Fig. 10* show outdoor field tests carried out respectively in Berlin and Paris. It clearly appears that the Berlin DVB-T coverage using 16-QAM 2/3 performs much better that the Paris DVB-T coverage using 64-QAM 2/3.

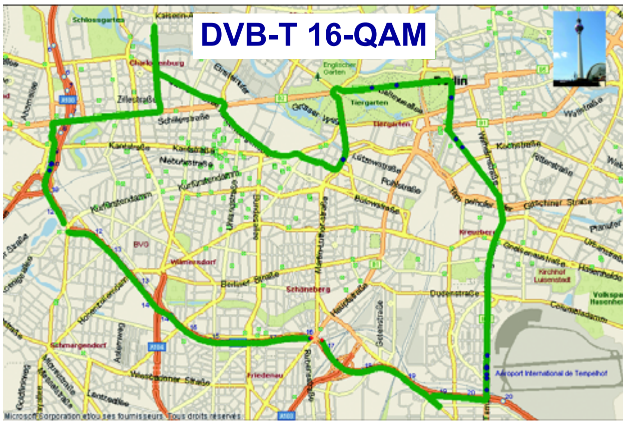


Figure 9
Perfect DVB-T coverage over Berlin from Alex-anderPlatz, with a single-antenna receiver

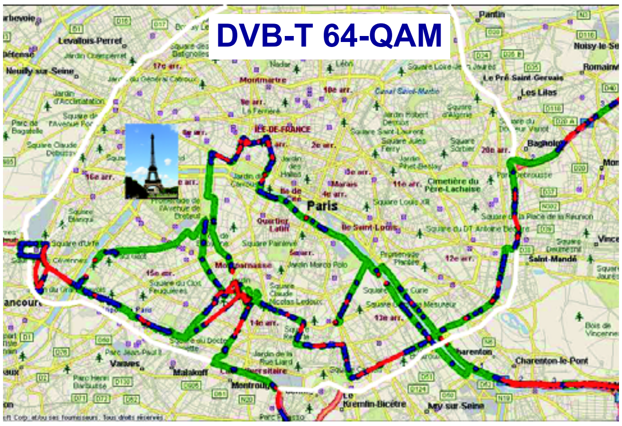


Figure 10
Far-from-perfect DVB-T coverage over Paris from the Eiffel Tower, with a single-antenna receiver

Will DVB-T kill DVB-H, or can they co-exist?

No, DVB-T will not kill DVB-H! Some countries will start with DVB-T and add DVB-H later, while others will do the opposite and finally DVB-T and DVB-H will co-exist.

As shown in this article, the feasibility of receiving Mobile TV via DVB-T is much easier in countries using 16-QAM (C/N in the range of 17-23 dB) while it is clear that DVB-T 64-QAM is not perfectly suited for mobile TV reception (C/N in the range of 21-29 dB), except if diversity reception mode is used. Performance is key for Mobile TV reception, not only to attract a large number of users but also to retain them.

Another important element to enable the market is the availability of devices to provide users with a large choice of models. Manufacturers can design DVB-T devices today for the 16-QAM markets, and update them later with DVB-H (software upgrade only, with low to zero cost!) for the many countries that are launching a handheld service soon.

Although the main attraction of DVB-T is free-to-air TV, DVB-H brings many other benefits such as:

- deep indoor reception (C/N in the range of 7-14 dB thanks to MPE-FEC and denser infrastructure);
- reception at high-speeds (thanks to MPE-FEC);
- enabling Interactivity for a better user experience and revenue generation (advertisements);

- low power consumption for longer battery life (5 to 7 hours with DVB-H thanks to Time Slicing, instead of 3 to 4 hours with DVB-T).

Conclusions

DVB-H offers an opportunity to gain new revenues by delivering existing and mobile-specific content to a new audience of mobile viewers watching at new prime times.

DVB-T and DVB-H are both very viable for Mobile TV offerings. They can complement each other nicely, even within the same market, by attracting users with FTA TV and then offering them more flexibility, new services, and specialized and adapted content. The number of users that will want DVB-T free-to-air as a gizmo will initially be higher than the ones ready to pay for DVB-H. So DVB-T will be a market enabler, since manufacturers will be more willing to add it to their line-up for immediate higher volumes, whereas operators will seek more DVB-H capable models, hence accelerating their return on investment with a faster growing subscriber base.

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Before joining DiBcom in 2001, Mr Pousset was Product Leader and Account Manager for DTT set-top boxes at Sagem. Prior to that, and after graduating, he joined SAT/Sagem where he managed several projects on radio links, digital TV and signal processing, which involved the development of complex integrated circuits (equalizers, digital demodulators, etc...).

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DiBcom is an active member of both "bmcoforum" and the French "Forum TV Mobile".

The **Broadcast Mobile Convergence Forum** (bmcoforum) is an international non-profit organization, aiming to shape an open market environment for mobile broadcast services.

The more than 110 members of bmcoforum join forces to identify relevant content and services, support technology standardization and implementation, as well as lobbying for spectrum and a suitable regulatory framework, to accelerate commercial implementations of new user experiences in receiving broadcast services and initiating interactivity on mobile devices.

Website: http://www.bmcoforum.org/

The **Forum TV Mobile** comprises 50 active companies today, covering the whole eco-system: wireless operators, terrestrial and satellite broadcasters, content providers, TV channels, device manufacturers, network operators, SW vendors, audience measurement institutes…

The forum was established in 2004 by the French Ministry of Industries and has since contributed a great deal to the development of Mobile TV in France.

Website: **http://www.forum-tv-mobile.com/fr/index.php**