ETSI TR 102 401 V1.1.1 (2005-05)

Technical Report

Digital Video Broadcasting (DVB); Transmission to Handheld Terminals (DVB-H); Validation Task Force Report

European Broadcasting Union

Union Européenne de Radio-Télévision

EBU·UER

Reference

DTR/JTC-DVB-174

Keywords

broadcasting, digital, DVB, DVB-H, IP, terrestrial, TV, video

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights 6

Foreword....6

Introduction 6

1 Scope 9
1.1 Major findings 9
1.2 Interoperability: fully verified 9
1.3 Performance assessment: better than expected....10
1.4 Field trials: confirmation of laboratory tests 10
1.5 Further work needed....10

2 References 11

3 Definitions and abbreviations....11
3.1 Definitions....11
3.2 Abbreviations 12

4 Interoperability tests....13
4.1 List of Equipments 13
4.2 Interoperability of Contribution equipments 13
4.2.1 IP source set up....14
4.2.2 IP encapsulator set up 14
4.2.3 Multiplexer set up 15
4.2.4 Delta_T jitter evaluation 15
4.2.5 DVB-H multiplex recording 17
4.2.6 Verification of the DVB-H records....18
4.3 Interoperability of Distribution equipment....18
4.3.1 SFN Interoperability Tests....19
4.3.2 MFN interoperability tests 20
4.4 Interoperability tests conclusion....20

5 Performance measurements....23
5.1 Laboratory measurements performed....23
5.2 DVB-T versus DVB-H....23
5.3 MPE-FEC coding rate influence 24
5.4 Transmission mode influence....24
5.5 Absolute burst duration influence 24
5.6 Performance measurements conclusions....25

6 Field trials....30
6.1 Field trials performed 31
6.2 Mobile in-car reception 31
6.3 Pedestrian outdoor reception 33
6.4 Pedestrian indoor reception....35
6.5 Field trial conclusions 35

7 DVB-H VTF conclusions....36

Annex A: Test methodology 37

A.1 DVB-H VTF test bed 37

A.2 VTF Test Bed presentation....37
A.2.1 Contribution part 38
A.2.2 Distribution part 39
A.2.3 Transmission part 40
A.2.3.1 Propagation channel profiles....40
A.2.3.2 Impulse noise tests....41
A.2.4 Receiver part 41

A.3 DVB-H VTF laboratory tests 42
A.3.1 IT: Interoperability tests 43
A.3.1.1 Network equipment interoperability 43
A.3.1.1.1 Contribution and distribution equipment 43
A.3.1.1.2 Distribution Equipment 43
A.3.1.1.3 Transmission equipment 44
A.3.1.2 Test bed and receiver Interoperability 44
A.3.1.2.1 Interoperability at the RF level 44
A.3.1.2.2 Interoperability at the Service level 45
A.3.1.2.3 Receiver "wake-up" time 45
A.3.2 PM: Performance Measurement 46
A.3.2.1 PM: C/N versus Doppler 46
A.3.2.2 PM: Channel profiles 47
A.3.2.3 Quality of restitution criteria 48
A.3.2.4 MPE-FEC coding rate 48
A.3.2.5 Absolute burst duration 49
A.3.3 PM: Prioritization of tests 50
A.3.3.1 Network formats 51
A.3.3.2 Transmission and service formats 52

A.4 List of tests 52
A.4.1 Interoperability Test 52
A.4.2 Performance measurements 52
A.4.2.1 Comparison of DVB-H with DVB-T in mobile situations 52
A.4.2.2 Influence of burst duration 53
A.4.2.3 Influence of MPE-FEC coding rate 53
A.4.2.4 Influence of Transmission Modes 53
A.4.2.5 Influence of In-Depth interleaver 53
A.4.2.6 PM: Synthesis 54
A.4.2.6.1 Service formats 54
A.4.2.6.2 Transmission formats 55

A.5 Impulse noise tests 55

Annex B: Field trials methodology 58

B.1 Objectives of field trials 58
B.1.1 Types of field trials 58
B.1.2 Types of Analysis 58
B.1.3 Class of reception mode 59
B.1.4 Configurable parameters 59

B.2 Measurement criteria and failure point 60
B.2.1 Measurement criteria for DVB-H validation testing 60
B.2.1.1 MPE FER/MPE MFER 60
B.2.1.2 Measurement interval 60
B.2.2 Measurement criteria for DVB-H network planning 60

B.3 Measurement set-up 61
B.3.1 Transmission set-up 61
B.3.2 End-to-End system testing 61
B.3.3 Mobile in-car reception 62
B.3.4 Pedestrian outdoor reception 62
B.3.5 Pedestrian indoor reception 63
B.3.6 Requirements on the terminal 64

B.4 Raw data analysis methodology 64
B.4.1 TEST #1: Derivation of required C/N 64
B.4.1.1 Required measurements 64
B.4.1.2 Processing of measurements 64
B.4.1.3 Analysis 64
B.4.1.4 Results 65
B.4.2 TEST #2: Derivation of required received input power 66
B.4.2.1 Required measurements 66

B.4.2.2 Processing of measurements 66
B.4.2.3 Analysis 66
B.4.2.4 Results 67
B.4.3 TEST #3: Derivation of the maximum speed 67
B.4.3.1 Required measurements 67
B.4.3.2 Processing of measurements 67
B.4.3.3 Analysis 68
B.4.4 TEST #4: Derivation of coverage maps 68
B.4.4.1 Required measurements 68
B.4.4.2 Processing of measurements and visualization 69
B.4.5 TEST #5: Calibration of network predictions 69
B.4.5.1 Required measurements 69
B.4.5.2 Processing of measurements and visualization 69

Annex C: Lab tests - raw data....71

Annex D: Field trials - Raw data 74

Annex E: List of equipment 89

E.1 Laboratory tests 89

E.2 Field trials....90

Annex F: Credits....91

History 92

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

The present document is supplementary to the earlier document TR 101 190 [4]. The present document extends the scope of the implementation guidelines to include handheld reception as defined by EN 302 304 [1]. Many of the items specified in TR 101 190 [4] are not reproduced in the present document, as they are already available, even though they may be relevant to the implementation of a DVB-H network.

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

European Broadcasting Union
CH-1218 GRAND SACONNEX (Geneva)
Switzerland
Tel: +41 22 717 21 11
Fax: +41 22 717 24 81

Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

Introduction

The DVB-H transmission system, targeting Handheld Terminals, is defined by a series of features whose detailed specifications are embedded in various DVB standards: DVB-DATA (EN 301 192 [7]), DVB-SI (EN 300 468 [5]), DVB-T (EN 300 744 [3]). The overall transmission system is specified by the DVB-H standard itself (EN 302 304 [1]) together with the DVB-H Implementation Guidelines.

Following the standardization work occurring in 2003 and 2004, the DVB-H ad-hoc group of the DVB Technical Module decided to perform a validation exercise through Laboratory Tests and Field Trials, during the last quarter of 2004. The main objectives of this exploratory work were to assess the Interoperability of early DVB-H implementations and to explore the technical performance provided by DVB-H to the Handheld Terminals.

The laboratory tests included 25 pieces of equipment from 10 different manufacturers (including 8 DVB-H prototype receivers) and involved 12 companies and 30 participants.

Network equipment and receiver equipment interoperability were both explored, in all network configurations (i.e. MFN / SFN, Hierarchical / Non-hierarchical) and all transmission modes, including the DVB-H 4K mode and the in-depth interleaver provided for 2K and 4K transmissions. The Interoperability tests were very successful, confirming a common interpretation of the DVB-H standards portfolio.

Interoperability tests revealed the different multiplexing strategies to create the DVB-H service multiplex (i.e. IP encapsulators) which, whilst remaining fully compliant with the standard, provided different means of flexibility to trade-off power saving (i.e. time slicing parameters) and service access time (i.e. periodicity of the service bursts).

The interoperability tests also demonstrated full compliance and full interoperability between the modulators and receivers for all possible transmission modes offered by the extended DVB-T physical layer.

The most awaited study performed by the validation task force was the performance measurements. The tremendous combinations of Transmission and Services formats, highlighting the incredible flexibility provided by DVB-H, made exhaustive measurements impossible, but focusing on the most probable combinations, the DVB-H Validation Task Force obtained very impressive results in the laboratory tests (confirmed by the field trials), sometimes outperforming the expectations.

DVB-T versus DVB-H Mobile reception

The additional protection offered by DVB-H at the service level by the MPE-FEC, provides DVB-H transmissions with a 6 dB advantage at medium speed (even more in high speed), whilst making the DVB-H service availability quasi independent of the receiving speed.

Also, the MPE-FEC provides the demodulators with the ability to increase the maximum speed limit, or Doppler Noise resilience, at which the DVB-H service remains available.

Thanks to the MPE-FEC, the DVB-H transmission performance, assessed both in the laboratory and in the field, offers a similar improvement in C/N performance to that obtained in DVB-T receivers using antenna diversity (6 dB to 9 dB).

The influence of DVB-H parameters: MPE-FEC coding rate

The use of MPE-FEC (3/4) offers a spectacular improvement of the DVB-H coverage in general but the laboratory tests showed a small variation of the C/N gain (i.e. about 3 dB) when MPE-FEC coding rate varies from low (7/8) to high (1/2) values. In MPE-FEC (7/8) the results from the field trials were worse than in the laboratory, suggesting that the range of C/N gain is more proportional to the MPE-FEC overhead/coding rate.

Nevertheless, in all cases, the impressive C/N gains and the speed advantage provided by the MPE-FEC protection, have been confirmed in the laboratory and in the field.

The influence of DVB-H parameters: Transmission Format (FFT size)

Additional measurements have confirmed the strong link between the FFT size and the speed limit characteristic of the transmission. As a direct consequence of the inter-carrier spacing, the maximum speed in 2K transmissions is four times the 8K transmission one. This has been verified with and without the MPE-FEC protection. It is expected that the new 4K mode will fit exactly in between the 2K and 8K modes providing broadcasters with a new trade-off between transmission cell size and receiving speed.

The influence of DVB-H parameters: Service Format (burst shape)

The DVB-H burst shape (i.e. absolute duration of the service burst) has a strong influence on pedestrian receiving situations (i.e. below 10 Hz Doppler). The virtual time interleaving implemented in the MPE-FEC transmission scheme, provides a smoothing of any flat fading channels when the burst duration is sufficiently long with respect to the channel time-variations. Thus MPE-FEC protection efficiency is reinforced by long burst duration for low Doppler values (low speeds/pedestrian case) while burst lengths seems less important as Doppler values increase (high speeds/mobile case). Nevertheless, concerns remain about the suitability of the TU6 channel profile used in the laboratory to simulate pedestrian situations as the field trials gave different results for this case. This suggests further work is necessary to evaluate the DVB-H performances in the "pedestrian" cases.

The influence of DVB-H network topology

Unfortunately, the lack of time did not allow measurements of the performance of DVB-H transmissions using Hierarchical Modulation and Single Frequency Networks (SFN). However, the field trials that have been performed in Pittsburg (USA) in an SFN, have found results confirming those extrapolated from the laboratory tests to take in account the more difficult reception condition of a 5 MHz L-Band channel (1 670 MHz to 1 675 MHz). DVB-H VTF also believes that the nice virtue of the SFN to equalize the field strength over the coverage area, makes the reception and demodulation of the DVB-H signal easier.

In conclusion, the tests performed by the DVB-H Validation Task Force provided very good answers to the main questions:

- Consistency of DVB-H standards portfolio — Verified.
- DVB-H sharing DVB-T transmission — Verified.
- Transmitter / Receiver Interoperability @ All Physical Layer modes — Verified.
- MPE-FEC performance for Mobile reception — Wonderful.
- MPE-FEC performance for Pedestrian reception — Good.
- MPE-FEC coding rate influence — Verified.
- Transmission Format influence — Verified.
- Service Format influence — Verified.

But test tests also revealed areas where further study is needed:

- Pedestrian reception behaviour — Further study.
- Time Slicing efficiency for power saving and frequency handover — Further study.
- Hierarchical Modulation and Single Frequency Network — Further study.
- Performances evaluation of 4K and In-Depth interleaver — Further study.
- Performances in 5 MHz, 6 MHz and 7 MHz channel bandwidths — Further study.

The further work needed there will be taken over by the WING-TV and INSTINCT Research Collaborative Projects.

1 Scope

DVB-H consists of a collection of simple technical ingredients spread over several layers of the Digital TV production chain. Therefore, the DVB-H complexity is more related to the overall transmission system than to the individual techniques used to provide efficient delivery to handheld terminals.

This suggested to the DVB-H ad-hoc group of the DVB Technical Module to organize a validation exercise in order:

- To find any inaccuracies in the set of the standards related to DVB-H.
- To help early implementers of the DVB-H network and terminals equipments.
- To estimate the performance of DVB-H (as far as possible).

From September to December 2004, the VTF group defined a "Test Methodology" and performed two test sessions:

- Laboratory Tests took place during the second half of October, kindly hosted by T-Systems in Berlin (Germany).
- Field Trials took place in mid-December, kindly organized by Telediffusion de France in Metz (France).

The present document reports on the collaborative explorative work performed by the DVB-H Validation Task Force.

1.1 Major findings

As previously stated, full interoperability of the DVB-H equipment was demonstrated and the performance measurement programme has confirmed that: The DVB-H MPE-FEC provides a real, quantifiable and sometimes very surprising advantage to the Mobile reception for Handheld Receivers.

The main findings of the DVB-H Validation Task Force are summarized below.

1.2 Interoperability: fully verified

Even though the tests were of early implementations of the DVB-H standard, the quality of the implementations found in the submitted equipment was notable.

Interoperability of network equipment (data layer and physical layer) has been successfully verified and several DVB-H test sequences were recorded and have been used for performance measurements in laboratory and during the Field Trials.

The interoperability tests revealed the various strategies of IP encapsulation employed by various organizations to create the DVB-H service multiplex. Even when the DVB-H multiplex passes through several equipments, the service burst integrity was still maintained and the Delta-T jitter remained below the limit of 10 ms.

Testing of 3 modulators and 7 receivers demonstrated full interoperability of equipment at the physical layer level and full compliance of the generated signal with the DVB-H physical layer standard.

The only subtle point identified was related to the use of the in-depth interleaver in SFN operation: In order to respect the instant at which the first TS packet of each Mega-frame is radiated by the various transmitters involved in the SFN network, modulators need to anticipate the beginning of their processing by one OFDM symbols (4K) or three OFDM symbols (2K) in order to transmit the first complete OFDM symbol at the correct instant, the one imposed by the MIP-SFN packet (i.e. mega-frame timestamp).

In the conclusions of this interoperability test campaign, it will be reported that no discrepancies in the DVB-H standard portfolio has been detected as no misunderstanding from the implementers.

1.3 Performance assessment: better than expected

The assessment of the performance of DVB-H transmissions to mobile receivers showed an incredible improvement provided by the additional MPE-FEC protection.

- The C/N penalty, from fixed to mobile reception, is decreased by 5 dB to 8 dB.
- MPE-FEC makes the C/N threshold stays constant until the maximum speed.
- MPE-FEC pushes further the maximum speed at which the service remains available.

These results were similar to the effect of spatial diversity reception obtained while using two receiver front-ends combining the signals received from two separate antennas.

1.4 Field trials: confirmation of laboratory tests

The DVB-H VTF field trials performed in Metz confirm the results of the tests performed during the laboratory test session.

The C/N threshold for a given transmission mode and for a given type of reception are similar to those derived in the laboratory.

MPE-FEC is especially useful for mobile reception, but also performs quite well for outdoor and possibly indoor pedestrian reception.

MPE-FEC does not seem to produce the exact same effect on the two types of terminals, but it confirmed the ability of the MPE-FEC to compensate for any signal processing weakness in the receiver. Nevertheless, in all cases, MPE-FEC increases the location coverage ratio from 95 % or 99 %.

Finally, it should be noted that even in 8K, GI 1/4, 16QAM 2/3, the Doppler noise resilience implemented by both types of terminals is so efficient that receiving speed limitation is no longer an issue, as reception was still possible at 110 km/h in RF channel 50 (706 MHz).

1.5 Further work needed

Notwithstanding the Transmission and Service formats which are left to examine (i.e. the DVB-H transmission system flexibility does not ease exhaustive testing) some items have been found which suggest further work:

- The suitability of the TU6 channel model has not been verified to "simulate" a pedestrian receiving situation, and so a methodology to explore such situations still remains to be established.
- SFN operation, well-known to equalize the field strength within the covered service area, could provide a real advantage for indoor and outdoor reception. A methodology (channel profile) also needs to be defined in order to weight the effect of multi-transmitters serving the service area.
- Performance of the 4K mode and the use of the in-depth interleaver needs to be assessed (as soon as receivers become available) especially in the context of reception suffering interference from impulse noise.

It is expected that the on-going INSTINCT and WING-TV projects will examine these points.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] ETSI EN 302 304: "Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)".

[2] ETSI TR 102 377: "Digital Video Broadcasting (DVB); DVB-H Implementation Guide Lines". (DVB-H GL).

[3] ETSI EN 300 744: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television". (DVB-T).

[4] ETSI TR 101 190: "Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects".

[5] ETSI EN 300 468: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems". (DVB-SI).

[6] ETSI TR 101 211: "Digital Video Broadcasting (DVB); Guidelines on implementation and usage of Service Information (SI)".

[7] ETSI EN 301 192: "Digital Video Broadcasting (DVB); DVB specification for data broadcasting". (DVB-DATA).

[8] EICTA/TAC/MBRAI-02-16: "Mobile and Portable DVB-T Radio Access Interface Specification".

[9] ISO/IEC 7498-1: "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

[10] ISO/IEC 13818-1: "Information technology - Generic coding of moving pictures and associated audio information: Systems".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

burst size: number of Network Layer bits within a time sliced burst

datagram: network layer packet with full address information enabling it to be routed to the endpoint without further information

DVB-H services: content carried by the DVB-H system

off-time: time between two time sliced bursts

NOTE: During the off-time, no transport_packets are delivered on relevant elementary stream.

MPE-FEC: method to deliver additional Forward Error Correction to datagrams delivered in MPE sections, as defined in EN 301 192 [7]

network layer: OSI layer as defined in ISO/IEC 7498-1 [9]

soft handover: function offered by receivers able to render a service without interruption while changing the frequency from which the transport stream is demodulated.

NOTE: A soft handover is not required (nor possible) if no services are currently consumed.

time-slicing: method to deliver MPE sections and MPE-FEC sections in bursts, as defined in EN 301 192 [7]

transport_packet: data structure defined in ISO/IEC 13818-1 [10]

transport stream: stream of transport_packets, as defined in ISO/IEC 13818-1 [10]

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BER	Bit Error Rate
C/N	Carrier to Noise ratio
DVB	Digital Video Broadcasting
DVB-H	Digital Video Broadcasting to Handhelds
DVB-MUX	Digital Video Broadcasting - MUltipleX
DVB-SI	Digital Video Broadcasting - Service Information
DVB-T	Digital Video Broadcasting - Terrestrial
EIT	Event Information Table
END	Equivalent Noise Degradation
FEC	Forward Error Code
FER	Frame Error Rate
FFT	Fast Fourrier Transform
FPGA	Field Programmable Gate Array
GI	Guard Interval
HP	High Priority stream
ICI	Inter-Carrier Interference
INT	IP/MAC Notification Table
IP	Internet Protocol
IPE	IP Encapsulator
IT	Interoperability Tests
LP	Low Priority stream
MCP	Multimedia Car Platform
MER	Modulation Error Ratio
MFER	Multi Protocol Encapsulation frame Frame Error Rate
MFN	Multi Frequency Network
MIP	Mega-frame Initialization Packet
MPE	Multiprotocol Encapsulation
MPEG	Motion Picture Expert Group
MUX	MUltipleX
NIT	Network Information Table
OFDM	Orthogonal Frequency Division Multiplex
PAT	Program Association Table
PER	Packet Error Rate
PID	Packet IDentifier
PL	Physical Layer
PMT	Program Map Table
PSI	Program Specific Information
QoR	Quality of Restitution
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
SDT	Service Description Table
SFN	Single Frequency Networks
SI	Service Information
SI/PSI	Service Information / Program Signaling Information
TPS	Transmission Parameter Signalling
TS	Transport Stream
UHF	Ultra-High Frequency (300 MHz to 3 000 MHz)
VHF	Very High Frequency (30 MHz to 300 MHz)
VTF	Validation Task Force

4 Interoperability tests

The first week of the VTF laboratory session was devoted to discovery of the equipment and an assessment of their interoperability.

Two workshops have been organized focussing on Contribution equipment (i.e. DVB-H encapsulators and DVB multiplexers) and Distribution equipment (i.e. SFN-MIP inserters and DVB-T Modulator).

Interoperability of network equipment (data layer and physical layer) has been successfully verified and three DVB-H test sequences have been recorded for use in the Performance measurements.

4.1 List of Equipments

Up to 25 pieces of equipment from 10 different brands (including 8 DVB-H prototype receivers), have been provided to the Validation Task Force in order to test both interoperability and DVB-H performance. The equipment list is provided in annex E.

It needs to be noted that a significant amount of equipment was made available to the VTF. All receivers worked satisfactorily, even the early prototypes, and all showed full compliance with the standard and were more or less optimized for Mobile reception. Also two FPGA based platforms implemented demodulation of the new DVB-H transmission features: 4K mode and the in-depth interleaver.

4.2 Interoperability of Contribution equipments

This workshop used the contribution equipment available to constitute the test-bed depicted in figure 1.

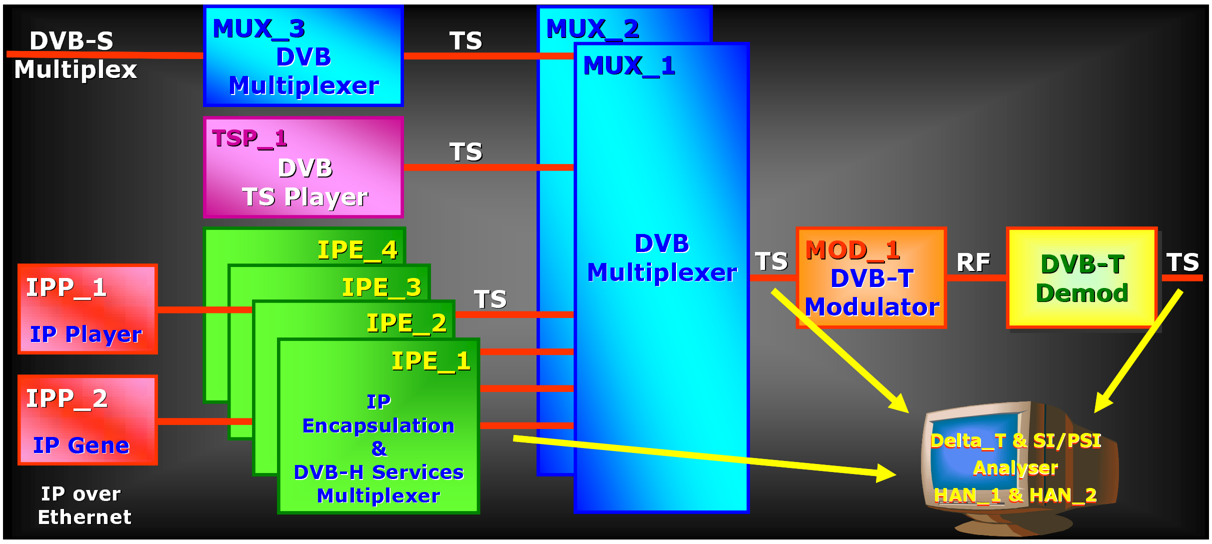


Figure 1: Contribution test-bed overview

The objective of these combinations was to verify the accuracy of the Delta_T information signalled in each section of the DVB-H service bursts.

It was checked that the basic SI/PSI signalling were correctly generated, without exploring the advanced signalling features (Cell_Id, etc.), as no receivers were able to use them (and no expert was available!).

For all equipment, it was verified that the Delta_T accuracy remains within the permitted 10 ms Delta_T jitter and that the various equipment making up the chain does not change the jitter by more than ±1 ms.

But, the bitrate adaptation feature embedded in equipment like the TS player, the MIP inserter and the DVB-T modulator needs to be used with extreme caution: If the bitrate adaptation process inserts large bursts of null packets into the TS stream, it can alter the DVB-H burst integrity and unfortunately the Delta_T information.

4.2.1 IP source set up

For all encapsulation tests, the IP Version 4 (IPv4) was used. IP players are more or less able to produce constant bitrate services, but as shown in figure 2, some concern remains on the bitrate accuracy (526 kbit/s instead of 512 kbit/s) and small peaks.

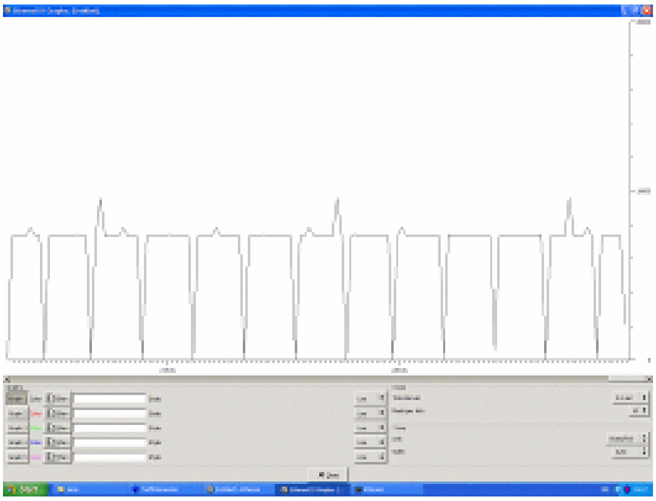


Figure 2: IP flow shape at the output of the IP source

4.2.2 IP encapsulator set up

For the purpose of the Delta_T measurement, various DVB-H burst organizations have been generated, as follows.

Table 1a

TS - Transport Stream	Set up 1	Set up 2	Set up 3	Set up 4
TS Bandwidth	5,5 Mbps	3,0 Mbps	4,0 Mbps	4,0 Mbps
SI/PSI Signalling	0,5 Mbps	0,5 Mbps	0 Mbps	0,5 Mbps
DVB-H multiplex	5,0 Mbps	2,5 Mbps	1,4 Mbps	3,5 Mbps
DVB-H Service				
Average rate	512 kbps	512 kbps	60 kbps	512 kbps

Table 1b

DVB-H Tables	Set up 1	Set up 2
MPE-FEC coding Rate	3/4	3/4
Data Columns	191	191
RS columns	64	64
Table Size		
Number of Rows	1 024	256

It was noticed that the DVB-H multiplexer strategy differs between the various pieces of equipment. Each produces a compliant DVB-H multiplex but the available input parameters are not equivalent.

In all implementations, the DVB-H constant bitrate generated as the burst cycle (i.e. the time-segment during which DVB-H services are multiplexed) was defined.

In one implementation, to populate the "cycle", each burst of service (i.e. MPE-DATA and MPE-FEC tables) were sequentially concatenated and the remaining part of the "cycle" is filled with null TS packets. Accordingly, burst duration can be accurately managed, can change from one cycle to the following and is at each cycle the minimum one.

In another implementation, the "cycle" was subdivided to constitute a collection of sub-channels having each the same duration. Then to populate such sub-channels, one or several bursts of service (i.e. MPE-DATA and MPE-FEC tables) were multiplexed at the TS packet level, together with null TS packets, to fill the complete the sub-channel bandwidth. As multiplexing within the sub-channel is performed onto TS packets having different PIDs, the integrity of each burst is guaranteed but each service bursts have the same "max_duration" (i.e. the duration of the sub-channel).

These multiplexing strategies drive to various set up as shown in the following tables.

Setup details for a given implementation (example):

DVB-H Multiplex Bandwidth	5,5 Mbps	4 Mbps
Cycle duration	2 600 ms	2 955 ms
SI/PSI Bandwidth	500 kbps	500 kbps
IP Service max bandwidth	600 kbps	540 kbps
IP Packet size	1 319 Bytes	1 319 Bytes

Setup details for a given implementation (example):

DVB-H Multiplex Bandwidth	5,5 Mbps
Cycle Duration	2,5 s
DVB-H Data Bandwidth	5 Mbps
MPE-FEC coding rate	3/4

4.2.3 Multiplexer set up

Various multiplex of MPEG2 and DVB-H multiplexes have been experienced has presented in table 2.

Table 2

	MUX_2	MUX_1	MUX_1	MUX_1	MUX_3
TS multiplex	14,75 M	14,75 M	14,75 M	18,75 M	14,79 M
MPEG2 services	3		3	3	3
DVB-H services	1	1	1	1	1
Stuffing	30 kbps	Mbps	400 kbps	9 Mbps	30 kbps

4.2.4 Delta_T jitter evaluation

For the purpose of this test, various combinations of equipment and measurements were done as shown in figure 2a.

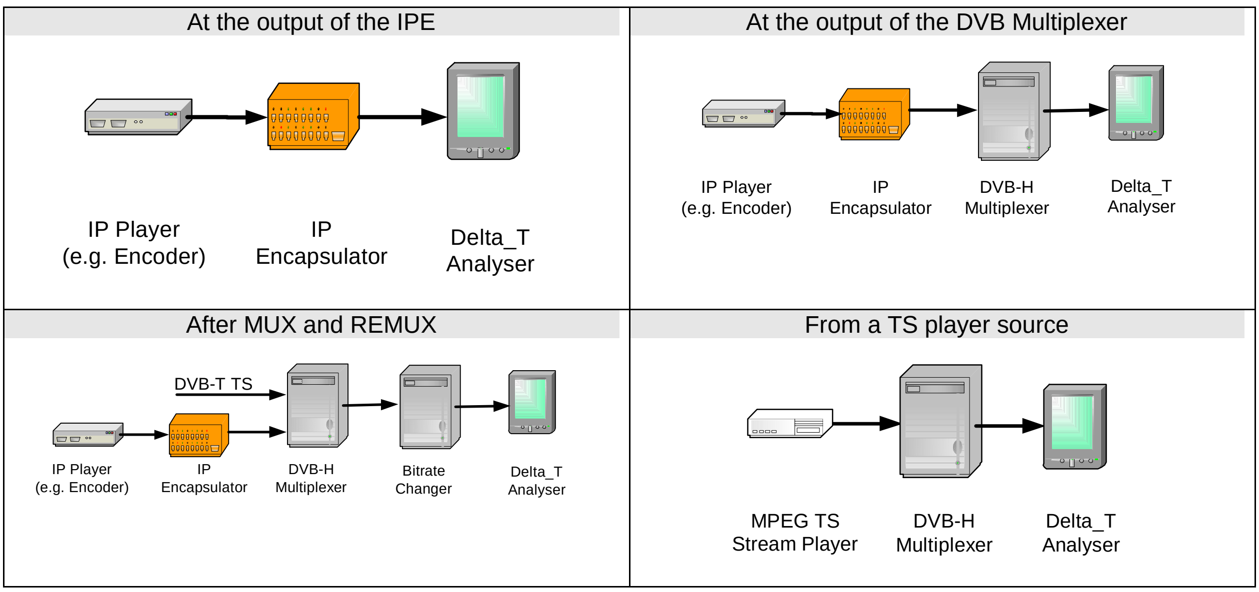


Figure 2a

The two DVB-H section analysers (HAN_1 and HAN_2) were used in order to verify the indications from the prototype equipment. The two pieces of equipment delivered exactly the same indications in all cases.

The following results were obtained.

Table 3

DVB-H Multiplexer	DVB Multiplexer	Delta_T jitter
IPE_1	none	< 10 ms
IPE_2	none	< 10 ms
IPE_3	none	< 10 ms
IPE_4	none	< 10 ms
IPE_1	MUX_1	10 ms
IPE_1	MUX_2	11 ms
IPE_1	MUX_2 and MUX_3	11 ms
IPE_2	MUX_1	10 ms
IPE_2	MUX_2	11 ms
IPE_2	MUX_2 and MUX_3	11 ms
IPE_3	MUX_1	10 ms
IPE_3	MUX_2	11 ms
IPE_3	MUX_2 and MUX_3	11 ms
IPE_4	MUX_1	10 ms
IPE_4	MUX_2	11 ms
IPE_4	MUX_2 and MUX_3	11 ms

Globally, the Delta_T Jitter remains in the vicinity of the allowed 10 ms even after two stages of multiplexing.

The following was recorded during the interoperability test involving MPEG2 services, DVB-H services and the re-multiplexer.

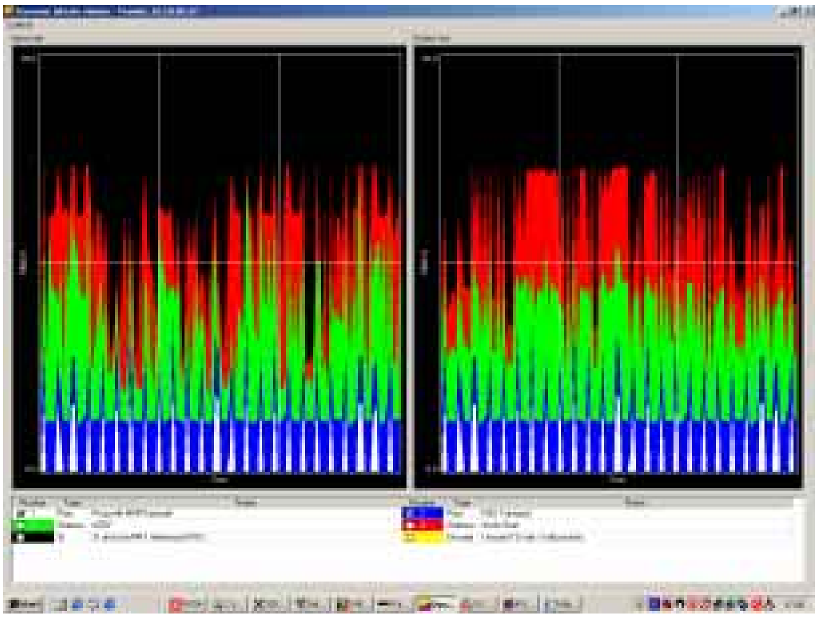


Figure 3: Transport stream organization after multiplex and re-multiplex

It shows clearly that the DVB-H burst shapes (in blue) are maintained even if the DVB-H multiplex shares the Transport Stream with statistically multiplexed MPEG2 contents.

In short, DVB-H sharing into an existing DVB-T multiplex has been successfully demonstrated.

4.2.5 DVB-H multiplex recording

In order to prepare the Performance measurements, the DVB-H IP encapsulators generated two transport streams with a collection of DVB-H services having various burst shapes as presented in table 4.

Table 4

	MPE-FEC Coding Rate	Row Number	Max Serv. Average Rate	Comments
PID = 100	3/4 (191/64)	1 024	512 kbps	Basic Sequence
PID = 101	7/8 (189/27)	1 024	512 kbps	MPE-FEC CR Influence
PID = 102	5/6 (190/38)	1 024	512 kbps	
PID = 103	2/3 (128/64)	1 024	512 kbps	
PID = 104	1/2 (64/64)	1 024	512 kbps	
PID = 105	3/4 (191/64)	768	512 kbps	Rows Influence
PID = 106	3/4 (191/64)	512	512 kbps	
PID = 107	3/4 (191/64)	256	512 kbps	
PID = 108	3/4 (191/64)	1 024	256 kbps	Lower Service average rate (for FEC decoding)
PID = 109	3/4 (191/64)	512	256 kbps	
PID = 110	3/4 (191/64)	256	256 kbps	

The DVB-H multiplex bitrate was fixed to 4 Mbps to which 400 kbps of SI/PSI signalling is added.

The DVB-H cycle periodicity was fixed to 4,16 seconds but, due to the different DVB-H multiplexing strategies, this lead to two burst organizations within the two generated transport streams, as depicted in the figure 4.

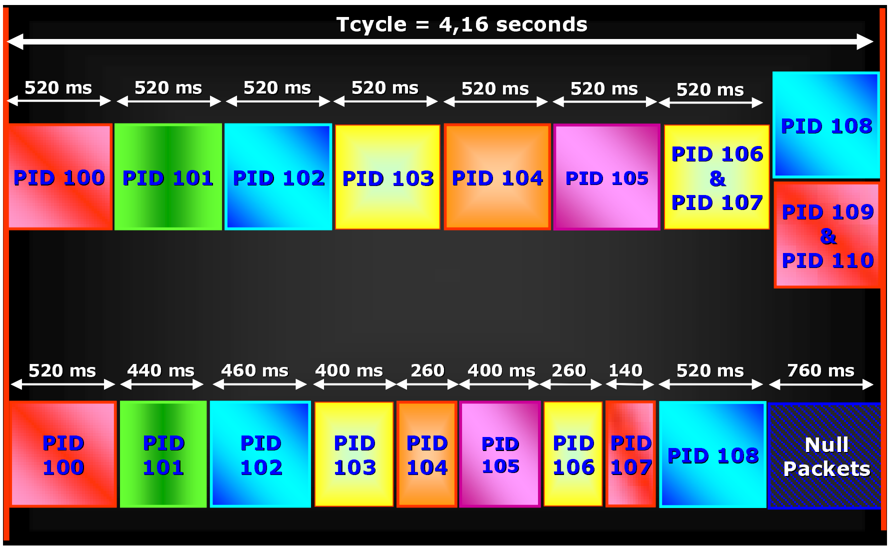


Figure 4: Burst shapes in reference Transport streams

In the first implementation, the null packets are spread within each sub-channel while in the second implementation, they are confined to the end of the cycle, waiting for additional bursts.

In the first implementation, the burst duration is constant whatever the average service bitrate (the service is "multiplexed" with null packets) while in the second implementation, bandwidth is privileged driving to allocate the full bandwidth to only useful data.

4.2.6 Verification of the DVB-H records

Verification of the recorded stream was done has shown in figures 5 and 6.

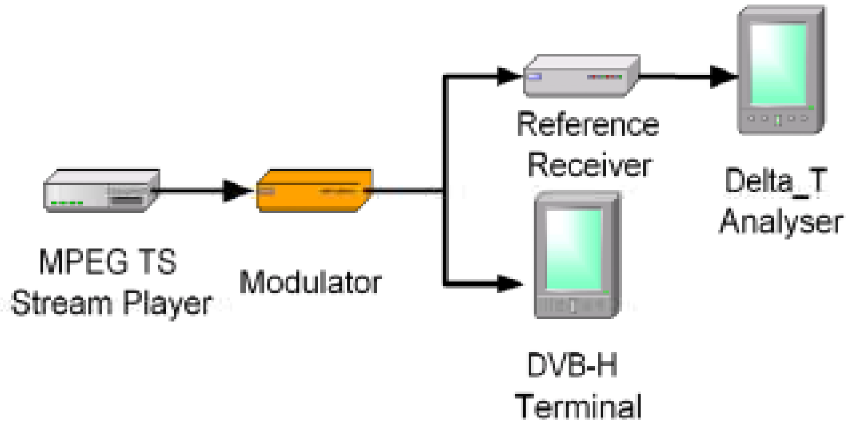


Figure 5: Basic verification of the recorded stream

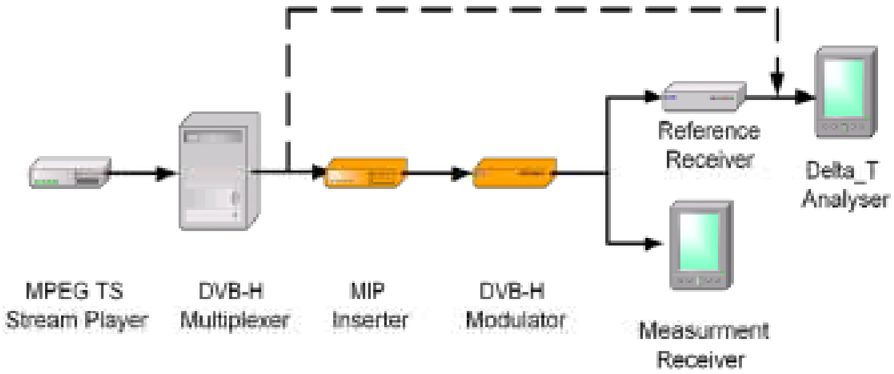


Figure 6: Recorded stream verification in the complete chain

The comparison of the Delta_T jitter delivered by the various analysers indicated a jitter confined to less than 10 ms and independent of the DVB Multiplexer load. A previous recorded transport stream was not retained as it presented Delta_T jitter over 40 ms.

As expected, the bitrate setting of the stream player needs to be finely adjusted to avoid inopportune bitrate adaptation.

Additional comments:

- IP errors/loss are not actually detected by the analyzer implementations and can be different from/non-dependent on the MPE frame error rate.
- Consistence analysis (correct filling of IP packets into the MPE-FEC Frame) could not be made due to lack of measurement equipment for that case.
- All the involved IPE follow different implementation approaches. The same IP input will lead in any case to different time slice structures.

4.3 Interoperability of Distribution equipment

This workshop experienced the various distribution equipments available to make up the test-bed depicted in figure 7.

With these set up, the various modulators generated a DVB-T signal in various channel bandwidths (5 MHz, 6 MHz, 7 MHz and 8 MHz), various FFT sizes (2K, 4K and 8K), various interleavers (native and in-depth) while using in the three constellations (QPSK, 16QAM, 64QAM).

A spectrum analyzer and a DVB-H receiver allowed us to verify the compliance of the generated signal (including the two FPGA based DVB-H demodulator platform able to use 4K and in-depth interleaver).

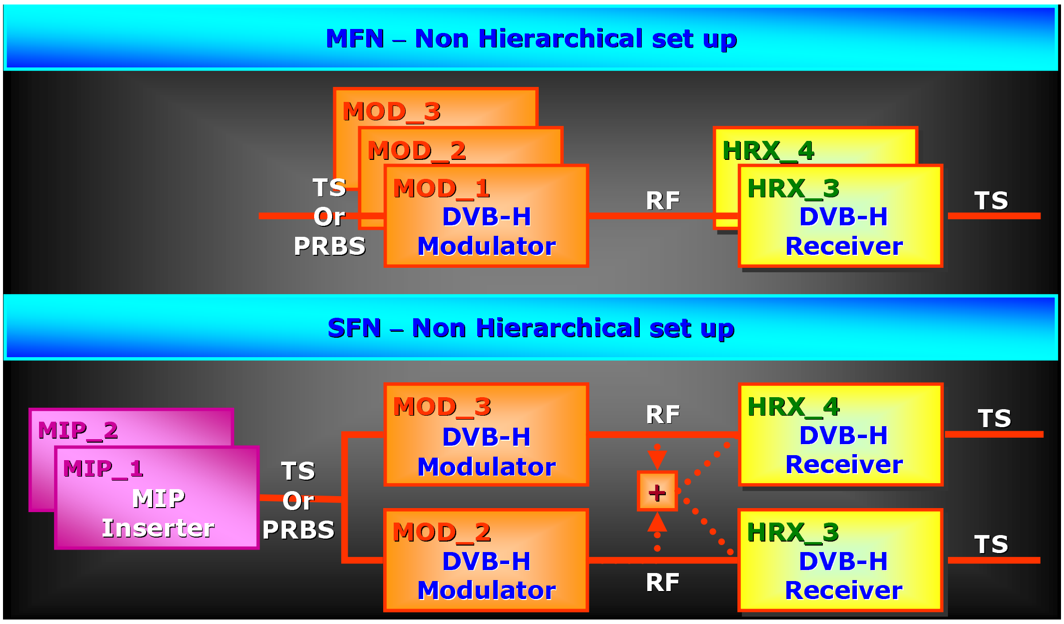


Figure 7: Interoperability at the Physical Layer level

Receivers were able to lock onto the every presented signal and reported on the TPS bits received (particularly on the Length indicator and the TPS bits related to DVB-H) and in some cases were able to indicate the Bit Error Rate (BER) and Packet Error Rate (PER).

In all, both MFN and SFN tests were very successful showing full interoperability between MIP inserters, DVB-H modulators and DVB-H receiver equipment.

Full interoperability for the DVB-H physical layer was verified for all channel bandwidths, FFT sizes and constellations, even hierarchical constellations!

4.3.1 SFN Interoperability Tests

Nevertheless, there is a subtlety regarding the usage of the in-depth interleaver in SFN configurations.

In addition to its launch instant, the MIP packet embeds a pointer to the first TS packet of the SFN Mega-Frame which needs to coincide with the first modulated symbol a DVB-T Super-Frame.

BUT, due to the in-depth interleaver definition (i.e. to interleave two successive OFDM symbols in 4K and four successive OFDM symbols in 2K), the first 2K OFDM symbol is available only after the internal generation of four OFDM symbols while in 4K, two OFDM symbols need to be internally processed before issuing the first OFDM symbol of the Super-Frame (which is also, by definition, the first OFDM symbol of the Mega-Frame).

In all, this subtlety introduces an additional processing delay in the modulator when using in-depth interleaver. Accordingly, the modulator needs to take account of this additional processing delay in order to be "ready-on-air" at the instant dictated by the MIP Timestamp.

This subtle problem has been resolved in the lab by introducing an artificial "time_offset_delay" in the modulator (delay of one OFDM symbol in 4K and three OFDM symbols in 2K) to reconstitute a correct RF SFN signal.

It is also interesting to report that receivers had no trouble in decoding the signal received from each individual SFN modulator. They only fail when the mixed RF signal was presented to them. This proven that the two modulators generated a fully compliant signal, but not at the same exact instant.

This detail shall not hide the major results of the physical layer interoperability tests: Full Interoperability has been assessed for all modulators and receivers used, as illustrated in figure 8.

SFN – Native Interleaver	5 MHz	6 MHz	7MHz	8 MHz
8k, 64QAM, CR ½, GI 1/8	+	+	+	+
8k, 16QAM, CR 2/3, GI 1/4	+	+	+	+
8k, QPSK, CR ½, GI 1/32	+	+	+	+
2k, 64QAM, CR 2/3, GI 1/32	+	+	+	+
2k, 16QAM, CR ½, GI 1/8	+	+	+	+
2k, QPSK, CR 2/3, GI 1/4	+	+	+	+
4k, 64QAM, CR ½, GI ¼	+	+	+	+
4k, 16QAM, CR 2/3, GI 1/32	+	+	+	+
4k, QPSK, CR ½, GI 1/8	+	+	+	+

In-Depth Interleaver	5 MHz	6 MHz	7 MHz	8 MHz
2k, 64QAM, CR 2/3, GI 1/8	+	+	+	+
2k, 16QAM, CR ½, GI ¼	+	+	+	+
2k, QPSK, CR 2/3, GI 1/32	+	+	+	+

In-Depth Interleaver	5 MHz	6 MHz	7 MHz	8 MHz
4k, 64QAM, CR ½, GI 1/8	+	+	+	+
4k, 16QAM, CR 2/3, GI 1/4	+	+	+	+
4k, QPSK, CR ½, GI 1/32	+	+	+	+

Figure 8: SFN interoperability tests with and w/o in-depth interleavers

4.3.2 MFN interoperability tests

In MFN operation, only one modulator feeds one receiver. The modulator produces various transmission formats and the receiver is used to verify the intelligibility and TPS bits of the generated signal.

A lot of modulator/receiver combinations were used and each combination obtained the same result: perfect receiver synchronization and demodulation whatever the mode in use.

The following table shows the systematic survey performed to assess physical layer interoperability, using a DVB-H 4K capable prototype receiver and two DVB-H modulators.

4.4 Interoperability tests conclusion

Even involving early bird implementation of the DVB-H standard, the quality of the implementation performed on the submitted equipment was notable.

Interoperability of network equipment (data layer and physical layer) was successfully verified and three DVB-H test sequences were recorded and have been used for Performance measurements in Laboratory tests and during the Field Trials.

Even interoperability tests revealed the various strategies of IP encapsulation from the various arrangements of the DVB-H service multiplex. Concatenation of equipment respected the service burst integrity, maintaining the Delta-T jitter below the 10 ms permitted jitter limit.

Cross-checking of 3 modulators and 7 receivers revealed full interoperability of equipment at the physical layer level and moreover full compliance of the generated signal with the DVB-H physical layer standard.

As the conclusion of this Interoperability Test campaign, it shall be reported that no discrepancies in the DVB-H standard portfolio has been detected as there was no misunderstanding by any of the implementers.

Table 5a

Matrix of Interoperability Tests for MOD-3 and HRX-4 (DVB-H Prototype Receiver) oct.-04

Test No	Test Result	Bandwidth MHz	Mode	Modulation	Guard	HP Code Rate	LP Code Rate	Hierarchy Alpha	Symbol Interleaver	Cell ID	HP Time Slice Bit	HP MPE-FEC Bit	LP Time Slice Bit	LP MPE-FEC Bit	Test Objective
1	ok	**8 MHz**	**2k**	QPSK	1/4	1/2		0	**Native**	&H1234	0	0	0	0	
2	ok	**8 MHz**	**4k**	16QAM	1/8	2/3		0	**Native**	&H1234	0	1	0	1	To test different modes guards code rates, symbo
3	ok	**8 MHz**	**8k**	64QAM	1/16	1/2		0	**Native**	&H1234	1	0	1	0	TPS
4	ok	**8 MHz**	**2k**	64QAM	1/32	3/4		0	**Indepth**	&HEDCB	1	1	1	1	
5	ok	**8 MHz**	**2k**	16QAM	1/4	1/2	3/4	1	**Native**	&H1234	0	0	1	1	
6	ok	**8 MHz**	**2k**	16QAM	1/4	1/2	3/4	2	**Native**	&H1234	0	1	1	0	2k hierarchy tests, symbol interleaver, reserved T
7	ok	**8 MHz**	**2k**	64QAM	1/4	1/2	3/4	4	**Native**	&HEDCB	1	0	0	1	
8	ok	**8 MHz**	**2k**	64QAM	1/4	1/2	3/4	4	**Indepth**	&HEDCB	1	1	0	0	
9	ok	**8 MHz**	**4k**	16QAM	1/4	1/2	3/4	1	**Native**	&H1234	0	0	1	1	
10	ok	**8 MHz**	**4k**	16QAM	1/4	1/2	3/4	2	**Native**	&H1234	0	1	1	0	4k hierarchy tests, symbol interleaver, reserved T
11	ok	**8 MHz**	**4k**	64QAM	1/4	1/2	3/4	4	**Native**	&HEDCB	1	0	0	1	
12	ok	**8 MHz**	**4k**	64QAM	1/4	1/2	3/4	4	**Indepth**	&HEDCB	1	1	0	0	
13	ok	**8 MHz**	**8k**	16QAM	1/4	1/2	3/4	1	**Native**	&H1234	0	0	1	1	
14	ok	**8 MHz**	**8k**	16QAM	1/4	1/2	3/4	2	**Native**	&H1234	0	1	1	0	8k hierarchy tests, symbol interleaver, reserved T
15	ok	**8 MHz**	**8k**	64QAM	1/4	1/2	3/4	4	**Native**	&HEDCB	1	0	0	1	
16	ok	**7 MHz**	**2k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
17	ok	**7 MHz**	**4k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	7MHz bandwidth channels
18	ok	**7 MHz**	**8k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
19	ok	**6 MHz**	**2k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
20	ok	**6 MHz**	**4k**	QPSK	1/4	2/3		0	**Indepth**	&H1234	0	0	0	0	6MHz bandwidth channels
21	ok	**6 MHz**	**8k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
22	ok	**5 MHz**	**2k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	5MHz bandwidth channels
23	ok	**5 MHz**	**4k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
24	ok	**5 MHz**	**8k**	QPSK	1/4	2/3		0	**Native**	&H1234	0	0	0	0	
25	ok	**5 MHz**	**4k**	QPSK	1/4	2/3		0	**Native**	&HEDCB	1	1	1	1	5MHz bandwidth + all DVB-H options, no hierarch
26	ok	**5 MHz**	**4k**	16QAM	1/32	1/2	3/4	4	**Indepth**	&HEDCB	1	1	1	1	5MHz bandwidth + all DVB-H options, with hierarc

Table 5b

Matrix of Interoperability Tests for MOD-2 and HRX-4 (DVB-H Prototype Receiver) déc-04

Test No	Test Result	Bandwidth MHz	Mode	Modulation	Guard	HP Code Rate	LP Code Rate	Hierarchy Alpha	Symbol Interleaver	Cell ID	HP Time Slice Bit	HP MPE-FEC Bit	LP Time Slice Bit	LP MPE-FEC Bit	Test Objective
1	✓	8 MHz	2k	QPSK	1/4	1/2		0	Native	&H1234	0	0	0	0	
2	✓	8 MHz	4k	16QAM	1/8	2/3		0	Native	&H1234	0	1	0	1	To test different modes guards code rates, symbo
3	✓	8 MHz	8k	64QAM	1/16	1/2		0	Native	&H1234	1	0	1	0	TPS
4	✓	8 MHz	2k	64QAM	1/32	3/4		0	Indepth	&HEDCB	1	1	1	1	
5	✓	8 MHz	2k	16QAM	1/4	1/2	3/4	1	Native	&H1234	0	0	1	1	
6	✓	8 MHz	2k	16QAM	1/4	1/2	3/4	2	Native	&H1234	0	1	1	0	2k hierarchy tests, symbol interleaver, reserved T
7	✓	8 MHz	2k	64QAM	1/4	1/2	3/4	4	Native	&HEDCB	1	0	0	1	
8	✓	8 MHz	2k	64QAM	1/4	1/2	3/4	4	Indepth	&HEDCB	1	1	0	0	
9	✓	8 MHz	4k	16QAM	1/4	1/2	3/4	1	Native	&H1234	0	0	1	1	
10	✓	8 MHz	4k	16QAM	1/4	1/2	3/4	2	Native	&H1234	0	1	1	0	4k hierarchy tests, symbol interleaver, reserved T
11	✓	8 MHz	4k	64QAM	1/4	1/2	3/4	4	Native	&HEDCB	1	0	0	1	
12	✓	8 MHz	4k	64QAM	1/4	1/2	3/4	4	Indepth	&HEDCB	1	1	0	0	
13	✓	8 MHz	8k	16QAM	1/4	1/2	3/4	1	Native	&H1234	0	0	1	1	
14	✓	8 MHz	8k	16QAM	1/4	1/2	3/4	2	Native	&H1234	0	1	1	0	8k hierarchy tests, symbol interleaver, reserved T
15	✓	8 MHz	8k	64QAM	1/4	1/2	3/4	4	Native	&HEDCB	1	0	0	1	
16	✓	7 MHz	2k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
17	✓	7 MHz	4k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	7MHz bandwidth channels
18	✓	7 MHz	8k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
19	✓	6 MHz	2k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
20	✓	6 MHz	4k	QPSK	1/4	2/3		0	Indepth	&H1234	0	0	0	0	6MHz bandwidth channels
21	✓	6 MHz	8k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
22	✓	5 MHz	2k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	5MHz bandwidth channels
23	✓	5 MHz	4k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
24	✓	5 MHz	8k	QPSK	1/4	2/3		0	Native	&H1234	0	0	0	0	
25	✓	5 MHz	4k	QPSK	1/4	2/3		0	Native	&HEDCB	1	1	1	1	5MHz bandwidth + all DVB-H options, no hierarch
26	✓	5 MHz	4k	16QAM	1/32	1/2	3/4	4	Indepth	&HEDCB	1	1	1	1	5MHz bandwidth + all DVB-H options, with hierarc

5 Performance measurements

The second week of the VTF laboratory session was focused on the validation of the receivers and the estimation of the performance of DVB-H (PM tests).

The performance measurement objectives are first to establish the "C/N versus Doppler" curves for DVB-T and DVB-H transmissions then to explore the influence of the DVB-H parameters, namely:

- MPE-FEC coding rate;
- Burst Duration;
- 4K; and
- In-Depth interleaver.

For this last parameter, the performance in Impulse Noise situations was also assessed.

5.1 Laboratory measurements performed

Figure 9 provides the list of Transmission and Service formats used in the DVB-H "Performance evaluation".

The VTF objective was to explore the DVB-H technology, and so the modes that were used are only a subset of the possibilities offered by the DVB-H transmission system.

For DVB-T / DVB-H comparison several coded constellations were used, while to evaluate the influence of the DVB-H parameters, only the most challenging 16QAM 2/3 was used.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Number of Rows				Gaussian	Rice	Rayleigh	TU6	IN1..IN6
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256					
PM-01	8K	1/4	Native	QPSK	1/2	4,98 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-02	8K	1/4	Native	QPSK	2/3	6,64 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-03	8K	1/4	Native	16QAM	1/2	9,95 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-04	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-05	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓	✓	✓	✓	✓	✓	✓				✓			✓	
PM-06	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓	✓	✓	✓	✓			✓	
PM-07	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-08	4K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-09	2K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-10	4K	1/4	n-deptl	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	✓
PM-11	2K	1/4	n-deptl	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	✓

Figure 9: Performance measurements

The main trends revealed by the experiments are given below.

5.2 DVB-T versus DVB-H

For this assessment, using MPE-FEC 3/4 service bursts, the C/N versus Doppler characteristic of two receivers was established, for QPSK and 16QAM, using coding rates 1/2 and 2/3.

Figure 10 shows the results in QPSK 1/2 and 16QAM 2/3 for two receivers. In these figures, the "FER5" curve corresponds to a DVB-T like situation, while the "MFER5" curve shows the DVB-H benefit brought by the MPE-FEC 3/4 protection.

When QPSK 1/2 is used in a Mobile situation (f_D > 10 Hz) the MPE-FEC decreases the C/N demand from 6 dB to 8 dB and makes the service availability independent of the receiving speed, until the maximum speed limit.

As far as maximum speed (high f_D) is concerned, the MPE-FEC gives assistance to the Inter-Carrier Interference (ICI) cancellation algorithms implemented in the demodulators to increase further the maximum speed limit.

When 16QAM 2/3 constellation is used, the 5 dB to 6 dB "C/N gain" brought by the MPE-FEC 3/4 can be observed but interestingly, the "speed gain" is more appreciable with this weak modulation scheme.

Tests using QPSK 2/3 and 16QAM 1/2 confirmed these results, showing that MPE-FEC allows the DVB-H transmission system to deliver a service multiplex of 5M bps to 14 Mbps from 500 km/h (Band III) to 130 km/h (Band IV)!

These results show the performance of the DVB-H MPE-FEC is similar to the C/N improvement obtained with antenna diversity reception.

5.3 MPE-FEC coding rate influence

To appreciate the effects of the MPE-FEC coding rate, a weak coded constellation (i.e. 16QAM 2/3) was used and various MPE-FEC coding rates were used. Results are shown in figure 11.

The "zoom" shown in the second graph highlights the tremendous effect of the MPE-FEC on the C/N (i.e. 5 dB to 6 dB).

In pedestrian situations (f_D below 10 Hz) the progressive effect of the virtual time interleaver can be observed which gradually allows it to reach the improved C/N.

In Mobile situations, the C/N gain is already effective with the lowest coding rate 7/8 (i.e. 12,5 % overhead) and it nicely increases proportionally with larger coding rates, to reach up to 9 dB gain for coding rate 1/2 (i.e. 50 % overhead). But, this result needs to be verified as the field trials performed in Metz revealed worse C/N than in the laboratory.

For all coding rates, the maximum speed remains outstandingly around a Doppler frequency of 120 Hz which corresponds to a speed range of 160 km/h or 100 mph @ 800 MHz (upper part of Band V) to 640 km/h or 400 mph @ 200 MHz (lower part of Band III).

5.4 Transmission mode influence

With the DVB-H extension, the DVB-T standard allows to use three transmission modes involving 2K, 4K or 8K sub-carriers. These three modes allow us to broadcast strictly the same bitrate range but, due to the orthogonal organization of the frequency division multiplex (i.e. OFDM), provide three trade-off between Inter-Carrier spacing (i.e. Doppler noise resilience) and Guard Interval duration (i.e. maximum echo delay and hence maximum transmission cell size).

Even if performance measurements have not been realized in the 4K transmission mode, two receivers have been tested in 2K and 8K transmissions, as shown in figure 12.

Figure 12 shows clearly that the C/N gain and the Doppler acceptance gain provided by the MPE-FEC remains available whatever the transmission mode. Moreover, the maximum speed remains in strict relation with the Inter-Carrier spacing implemented: the 2K mode is obviously four times more Doppler resilient than the 8K mode.

This confirmed that the DVB-H 4K mode will have median characteristics between 2K and 8K; which will be greatly appreciated to enlarge the 2K transmission cell size while maintaining receiving capabilities at high speed, for services targeting a high speed train for instance.

5.5 Absolute burst duration influence

The results obtained from this experiment were the most puzzling ones, suggesting further work is required to assess performance in Pedestrian situations.

Figure 13 shows the behaviour of two receivers receiving a 16QAM 2/3 modulated signal. Emphasis is also shown on what happened below 10 Hz of Doppler (i.e. very low speed corresponding to Pedestrian motion).

From "0 Hz to 10 Hz" of Doppler, the receiver suffers totally the penalty coming from the channel fading. Then, the MPE-FEC virtual time interleaver progressively helps the receiver to fight against the channel fading, spreading the lost data over the service burst content, then allowing the RS correction capability to operate.

But this nice effect can be obtained only if the burst duration is sufficiently long with regard to the channel fading duration.

Effectively, the virtual time interleave implemented in the MPE-FEC transmission scheme, provides a nice channel flat fading smoothing, when the burst duration is sufficiently long with regard to the channel time-variations.

Figure 13 shows clearly that the expected C/N is obtained for very low values of Doppler for the larger duration of bursts. If burst duration is short, the MPE-FEC gain is cancelled at very low speeds.

In short, the longer the service burst, the better the reception in Pedestrian situations.

Nevertheless, this temporary conclusion needs to be verified by further work. Effectively, concerns remain about the suitability of the TU6 channel profile used in the laboratory to simulate pedestrian situations as the field trials revealed different results.

The real conclusion of this test was that further work is needed to evaluate the DVB-H performances in the "pedestrian" cases.

5.6 Performance measurements conclusions

The exploration of the DVB-H performances for transmissions to receivers in motion revealed the incredible improvement provided by the additional protection of the MPE-FEC.

- The C/N penalty, from fixed to mobile reception, is decreased by 5 dB to 8 dB.
- MPE-FEC makes the C/N threshold stays constant until the maximum speed.
- MPE-FEC pushes further the maximum speed at which the DVB-H service remains available.

These results are similar to the nice effect of the spatial diversity reception obtained when using two receiver front-ends combining the signals received by two antennas.

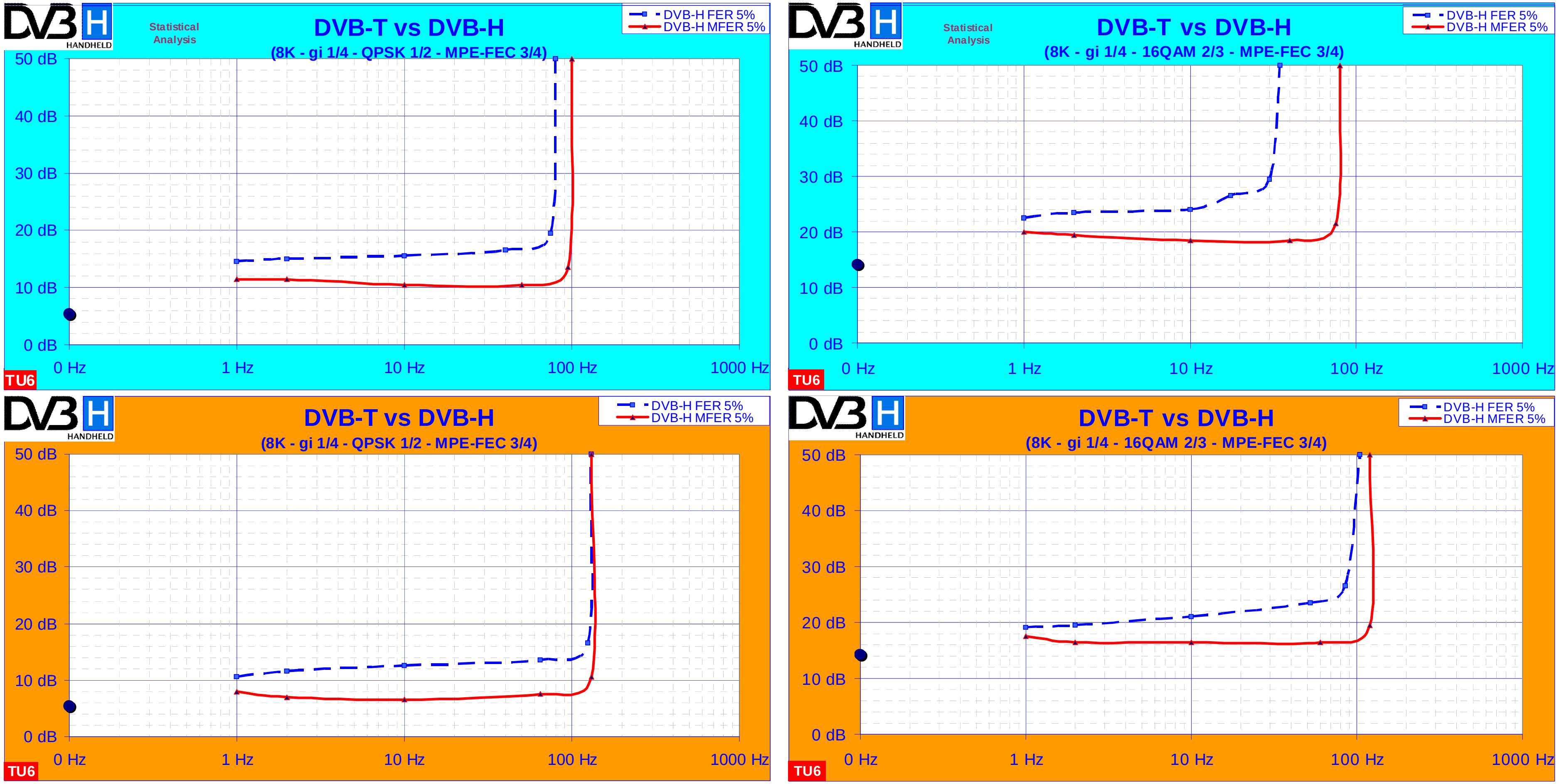


Figure 10: *DVB-T versus DVB-H* @ 8K 1/4 transmissions using QPSK 1/2 and 16QAM 2/3 constellations

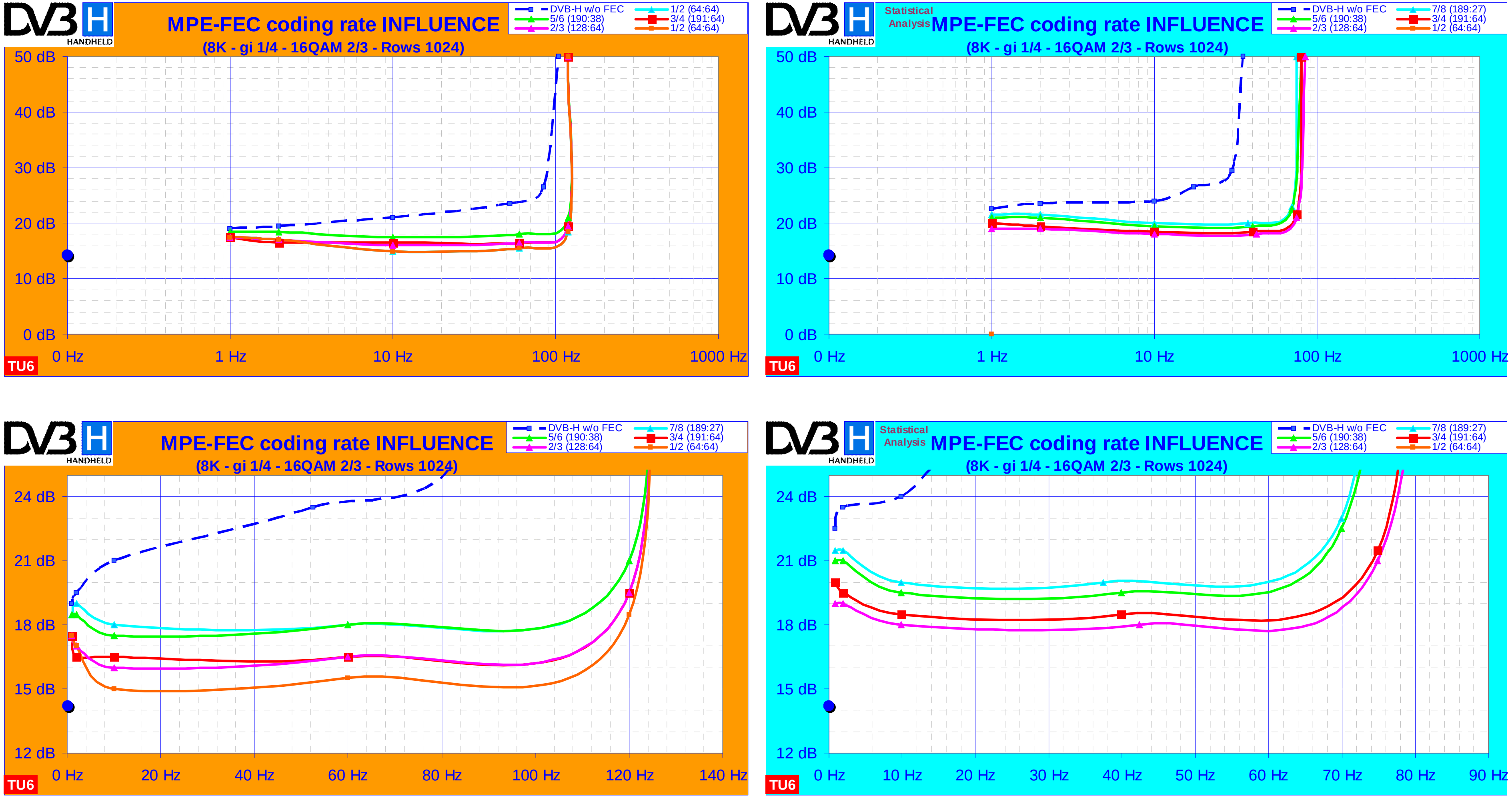


Figure 11: Using 8K 1/4, 16QAM 2/3, *MPE-FEC Coding Rate influence*

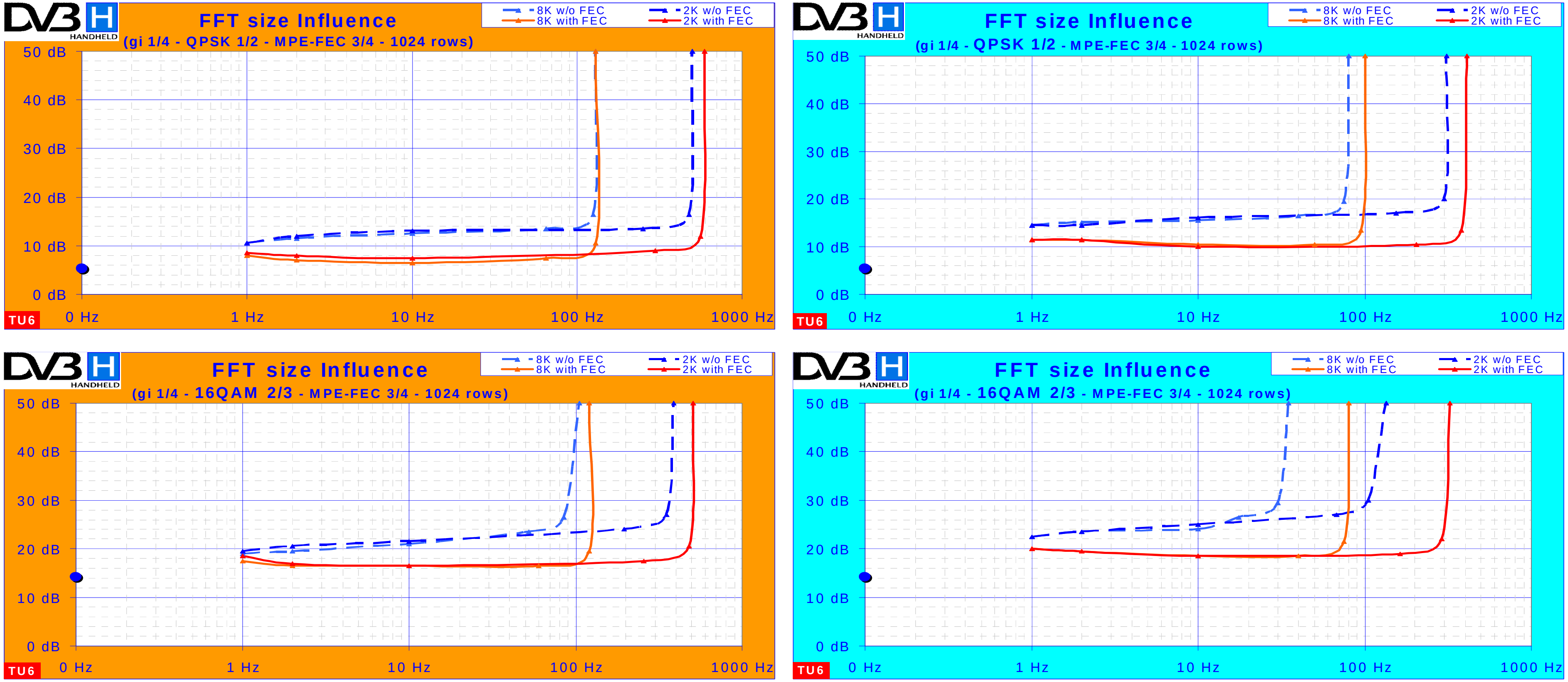


Figure 12: *FFT Size influence* using QPSK 1/2 and 16QAM 2/3

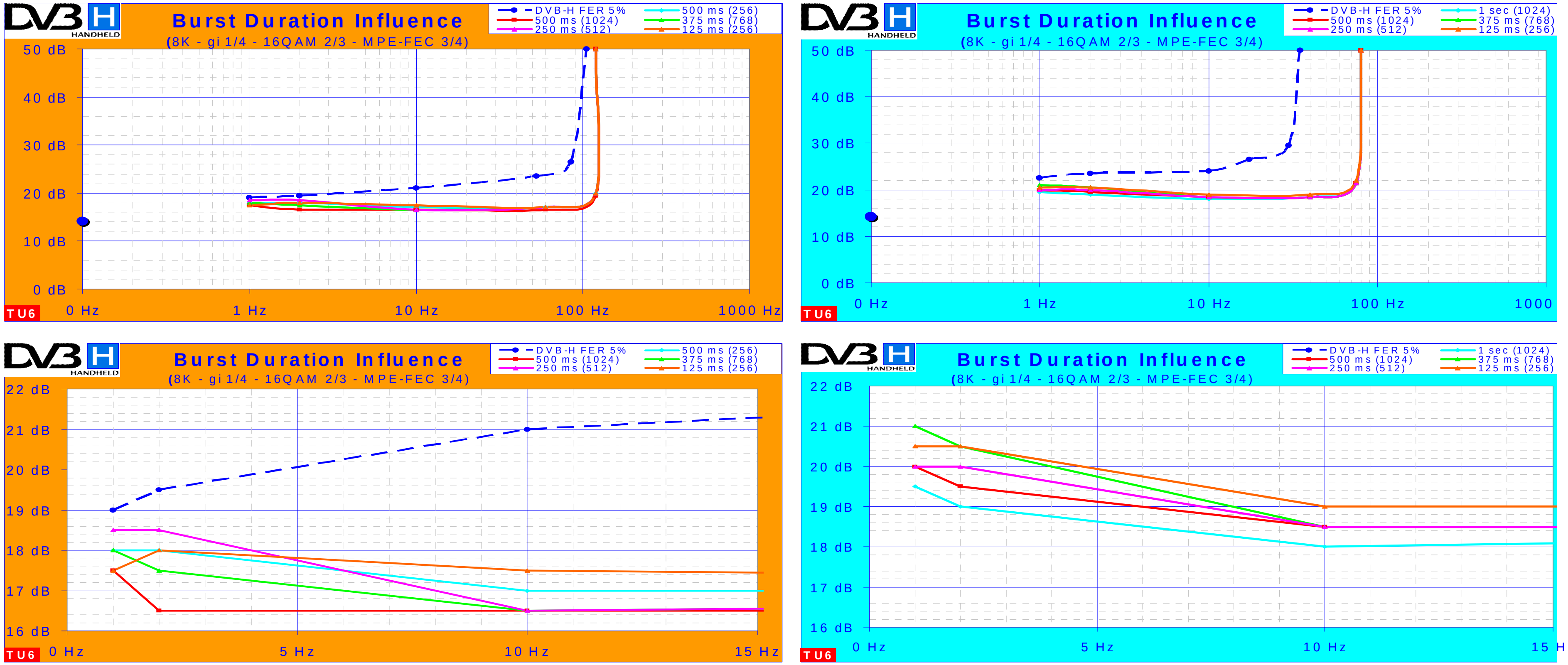


Figure 13: Using 8K 1/4, 16QAM 2/3, *Absolute Duration of the Burst influence*

6 Field trials

The second part of the VTF work was dedicated to field trials. Scheduled during the second fortnight of December 2004, the main objective of this session was to validate the VTF laboratory session results: receiver behaviour and DVB-H performance, especially that provided by the MPE-FEC.

Various types of reception conditions were studied: indoor, outdoor pedestrian and fast mobile in urban and sub-urban environments. Four different terminal devices from two manufacturers were tested, allowing cross-checking of performance.

The set-up used for these field trials was very similar to the one used for laboratory testing, thus enabling direct comparisons.

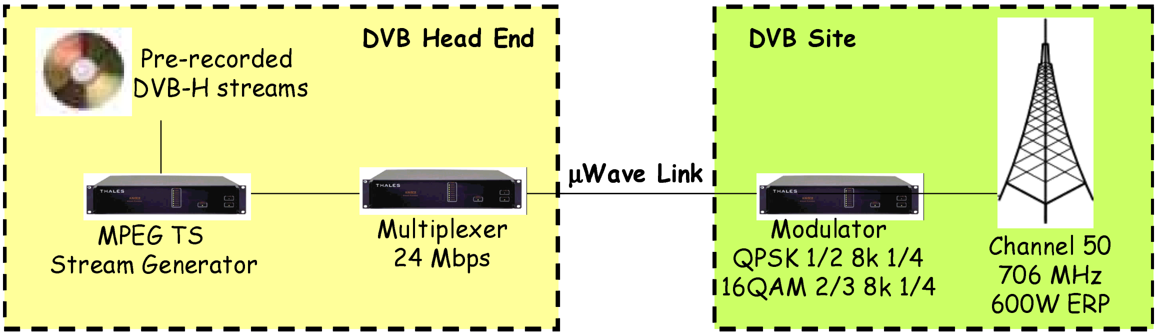


Figure 14: VTF field trials in Metz, transmission set-up

Transmission modes were strictly equivalent to the laboratory ones (only a subset was used in the field).

DVB-T				DVB-H		
Mode	FEC	FFT	GI	MPE-FEC	MPE table rows	Time Slice Burst size
QPSK	1/2	2k	1/4	1/2	256	256kbit/s
16QAM	2/3	4k	1/8	2/3	512	512kbit/s
64QAM	3/4	8k	1/16	3/4	768	1Mbit/s
			1/32	4/5	1024	2Mbit/s
				5/6		
				7/8		

Figure 15: VTF field trials in Metz, tested DVB-H modes

The major difference from the laboratory test session was the receiving situations.

As illustrated in figure 16, it was possible to use several reception modes (i.e. localization of the receiver and its antenna) in various environments (i.e. indoor/outdoor) and at various speed ranges.

Reception Mode		Speed Category	
(A)	Portable Outdoor	< 10 km/h	Pesdestrian
(B)	Portable Indoor	10 km/h to 50 km/h	Urban
(C)	Mobile Rooftop	50 km/h to 130 km/h	Highway
(D)	Mobile In-Car	> 130 km/h	High Speed Train

Figure 16: VTF field trials in Metz, tested reception modes and speed ranges

6.1 Field trials performed

Figure 17 shows the various transmission and service formats used during the field trials as the context in which measurements were performed.

8K 1/4	QPSK 1/2		MPE-FEC 3/4		1024 rows
		A	B	C	D
Mobile	Urban	X	X		X
Mobile	Highway	X	X		X
Pedestrian	Sub-urban	X	X	X	
Pedestrian	Urban	X	X	X	
8K 1/4	**16QAM 2/3**		**MPE-FEC 3/4**		**1024 rows**
		A	B	C	D
Mobile	Urban	X	X	X	X
Mobile	Highway	X	X	X	X
Pedestrian	Sub-urban	X	X	X	
Pedestrian	Urban	X	X	X	
Pedestrian	Indoor	X	X	X	
8K 1/4	**16QAM 2/3**		**MPE-FEC 7/8**		**1024 rows**
		A	B	C	D
Mobile	Urban	X	X		X
Mobile	Highway	X	X		X
8K 1/4	**16QAM 2/3**		**MPE-FEC 3/4**		**256 rows**
		A	B	C	D
Mobile	Urban	X	X		X
Mobile	Highway	X	X		X

Figure 17: Summary of tests performed for DVB-H VTF

Each test had roughly one hour in duration, allowing several thousand measurement points (in average one point every second) to be recorded from each receiver. Each record included localization, speed, C/N, received power and the FER0 and MFER0 criteria.

6.2 Mobile in-car reception

For these tests, mobile reception was carried out in a car travelling on a highway at "high speed" (figures 19 and 20) and in the city suburbs at "low speed" (figures 21 and 22), using QPSK 1/2 or 16QAM 2/3 transmissions.

No external antennas were used, thus corresponding to a kind of "indoor mobile" receiving situation, labelled "Mobile in-car" in the present document.

		DVB-T			DVB-H			MPE FEC gain	
		Highway	Urban	TU-6 Lab	Highway	Urban	TU-6 Lab	Field	Lab
A	QPSK 1/2	13,0 dB	8,5 dB	13,5 dB	8,5 dB	4,0 dB	7,5 dB	4,5 dB	6,0 dB
B	QPSK 1/2	16,0 dB	14,0 dB	16,5 dB	11,0 dB	11,0 dB	10,5 dB	4,0 dB	6,0 dB
A	16QAM 2/3	21,0 dB	24,0 dB	23,5 dB	16,0 dB	16,0 dB	16,5 dB	6,5 dB	7,0 dB
B	16QAM 2/3	26,5 dB	23,0 dB	26,5 dB	18,5 dB	18,0 dB	18,5 dB	6,5 dB	8,0 dB
C	16QAM 2/3	24,0 dB	30,0 dB	26,5 dB	16,5 dB	21,0 dB	18,5 dB	8,3 dB	8,0 dB

Figure 18: Mobile, comparison with TU6 @ FdMax / 3 dB

The summary table in figure 18 shows a few interesting trends:

- For all terminals A, B, C and whatever transmission mode is used, the MPE-FEC gain is confirmed in a mobile situation to be a minimum of 4 dB, and in some cases much more.
- For a given DVB-T transmission mode (QPSK 1/2 or 16QAM 2/3), the gain evaluated by terminals A and B is strictly the same.
- The MPE-FEC gain is +2 dB larger in 16QAM 2/3 than in QPSK 1/2.
- The MPE-FEC gain seems not as large as estimated in the laboratory (4 dB instead of 6 dB and "6 dB to 7 dB" instead of "7 dB to 8 dB").

The required minimum C/N is, in most cases, slightly lower than evaluated in the lab which indicates that the TU-6 model is appropriate but also slightly pessimistic.

For terminals B and C in 16QAM 2/3, the variation between the Field and Lab absolute measurements can be explained by the type of C/N calibration based on a computation of the margin of received input power versus noise. This makes measurements less accurate in the 20 dB to 30 dB interval. The relative measurements (MPE-FEC gain) can however be considered reasonably accurate.

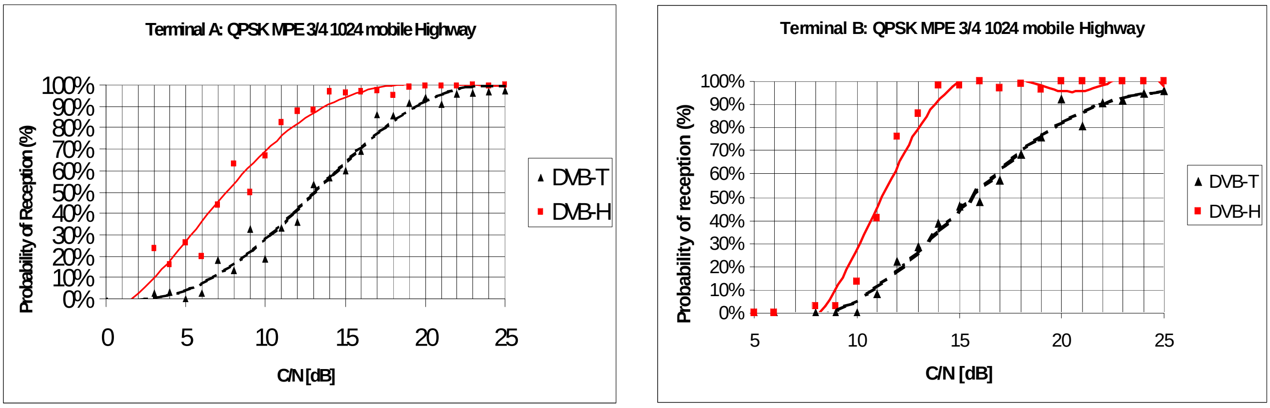


Figure 19: Mobile highway curves in QPSK 1/2 MPE-FEC 3/4

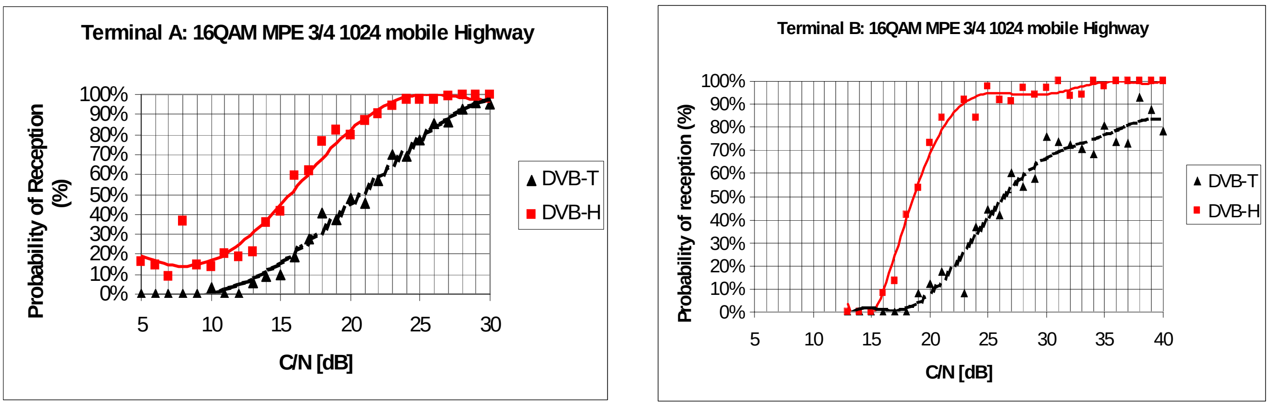


Figure 20: Mobile highway curves in 16QAM 2/3 MPE-FEC 3/4

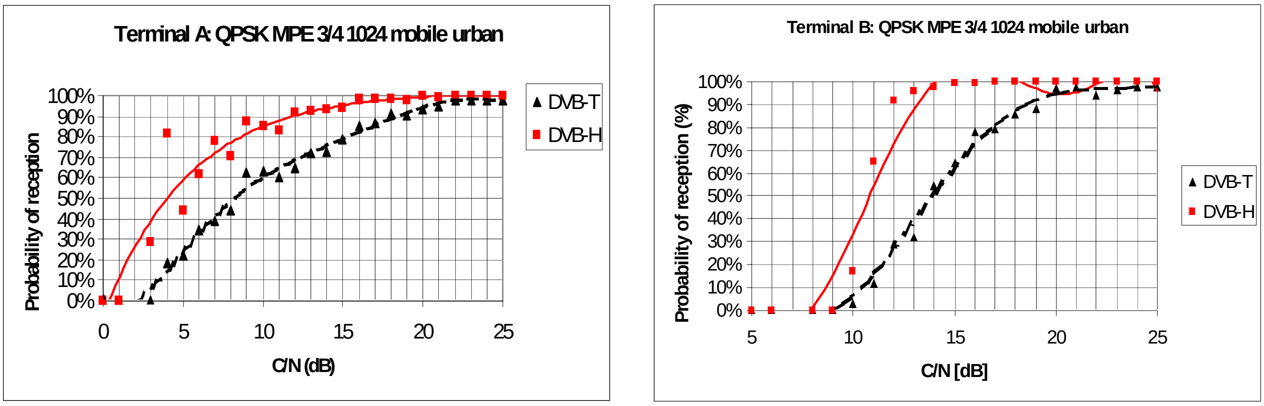


Figure 21: Mobile urban curves in QPSK 1/2 MPE-FEC 3/4

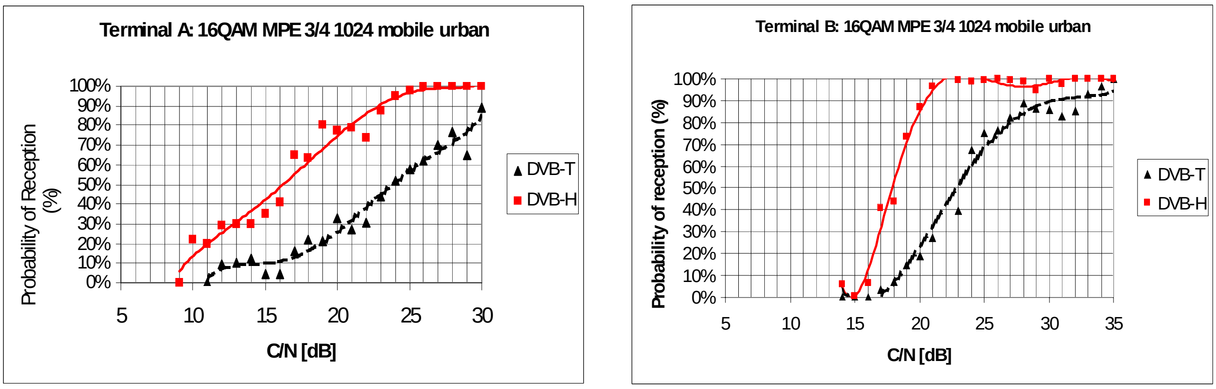


Figure 22: Mobile urban curves in 16QAM 2/3 MPE-FEC 3/4

6.3 Pedestrian outdoor reception

For these tests, pedestrian reception has been carried out while walking in the Metz city centre (figures 25 and 27) and its suburb (figures 24 and 26), using QPSK 1/2 or 16QAM 2/3 transmissions.

		DVB-T			DVB-H			MPE FEC gain	
		Sub-urban	Urban	TU-6 Lab	Sub-urban	Urban	TU-6 Lab	Field	Lab
A	QPSK 1/2	6,0 dB	7,0 dB	11,5 dB	5,0 dB	4,0 dB	7,0 dB	2,0 dB	4,5 dB
B	QPSK 1/2	12,5 dB	14,0 dB	15,0 dB	10,5 dB	10,5 dB	11,5 dB	2,8 dB	3,5 dB
C	QPSK 1/2	15,5 dB	17,0 dB	15,0 dB	13,5 dB	13,5 dB	11,5 dB	2,8 dB	3,5 dB
A	16QAM 2/3	15,5 dB	17,5 dB	19,5 dB	14,0 dB	14,0 dB	16,5 dB	2,5 dB	3,0 dB
B	16QAM 2/3	20,5 dB	24,5 dB	23,5 dB	17,5 dB	18,0 dB	19,5 dB	4,8 dB	4,0 dB
C	16QAM 2/3	24,0 dB	25,0 dB	23,5 dB	20,0 dB	20,0 dB	19,5 dB	4,5 dB	4,0 dB

Figure 23: Pedestrian outdoor, comparison with TU6 @ 2 Hz

When comparing these measurements with those derived in the laboratory with TU-6 at 2 Hz Doppler, we observe the following:

- The gain of MPE-FEC is comparable to that estimated in the lab (around 3 dB) whichever transmission mode is used and whichever terminal in used.
- The TU-6 at 2 Hz is a slightly pessimistic model for deriving minimum C/N values in the lab, but remains a better approximation than a Rayleigh channel.
- The MPE-FEC will perform better in an urban environment than in sub-urban environment where there are fewer reflections and less interference.

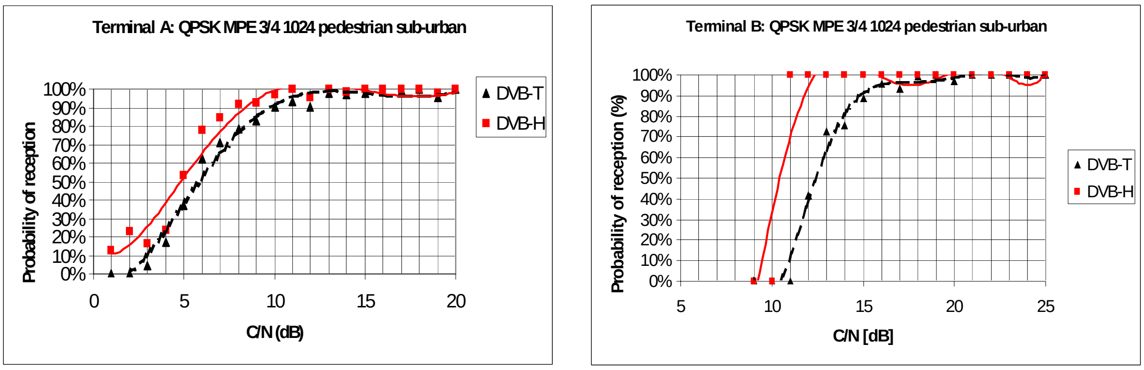


Figure 24: Pedestrian sub-urban curves in QPSK 1/2 MPE-FEC 3/4

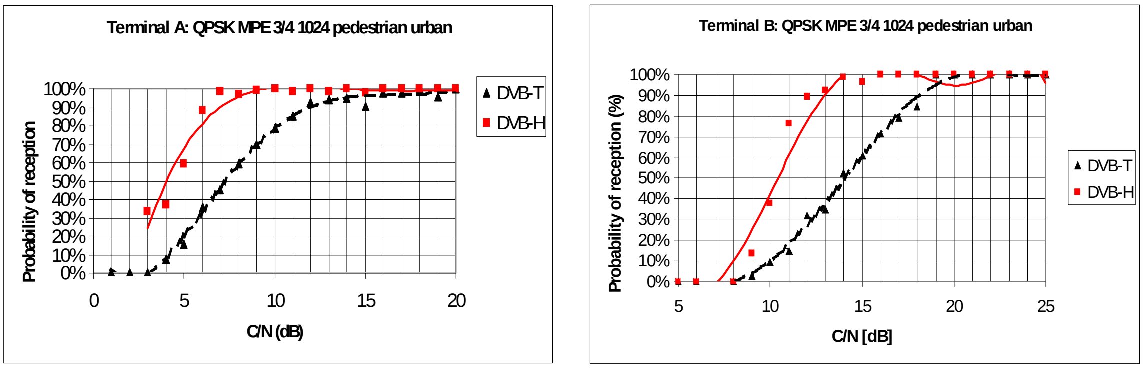


Figure 25: Pedestrian urban curves in QPSK 1/2 MPE-FEC 3/4

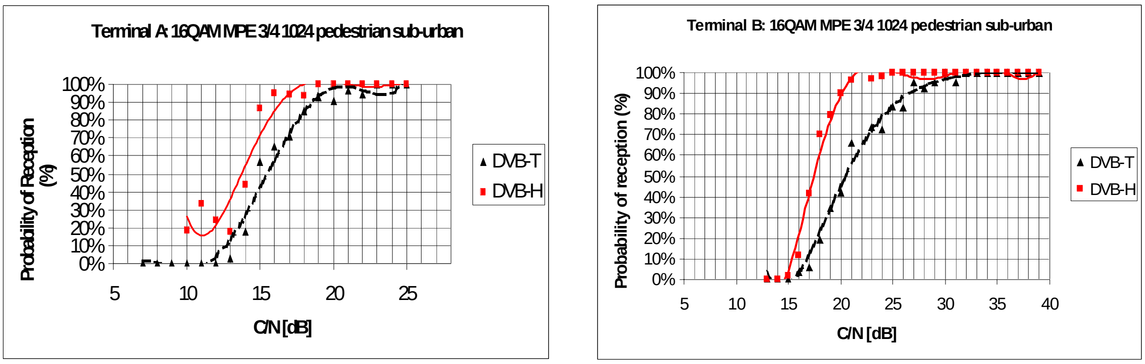


Figure 26: Pedestrian sub-urban curves in 16QAM 2/3 MPE-FEC 3/4

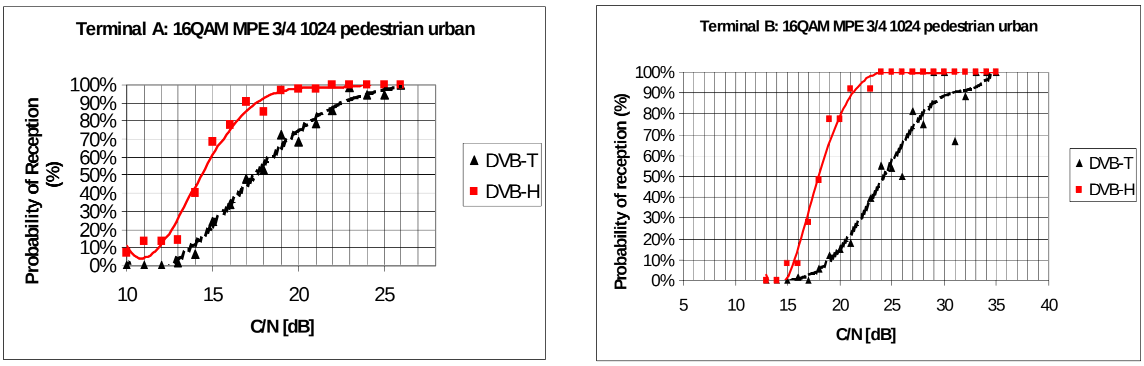


Figure 27: Pedestrian urban curves in 16QAM 2/3 MPE-FEC 3/4

6.4 Pedestrian indoor reception

For these tests, only the weakest transmission mode (16QAM 2/3) was used to assess reception performance while walking inside a building (i.e. the TDF Research Center) at various floor levels.

		DVB-T		DVB-H		MPE FEC gain	
		Indoor	TU-6 Lab	Indoor	TU-6 Lab	Field	Lab
A	16QAM 2/3	14,5 dB	19,5 dB	13,5 dB	16,5 dB	1,0 dB	3,0 dB
B	16QAM 2/3	26,0 dB	23,5 dB	18,0 dB	19,5 dB	8,0 dB	4,0 dB
C	16QAM 2/3	31,0 dB	23,5 dB	21,0 dB	19,5 dB	10,0 dB	4,0 dB

Figure 28: Pedestrian indoor, comparison with TU6 @ 2 Hz

Due to the limited number of results, and the variety of observed tendencies, it is difficult to draw any conclusions about the behaviour of MPE-FEC for pedestrian indoor reception.

However, it seems that there is a large gain on terminals B and C (same kind), while terminal A sees a marginal MPE-FEC gain, probably due to its native performance.

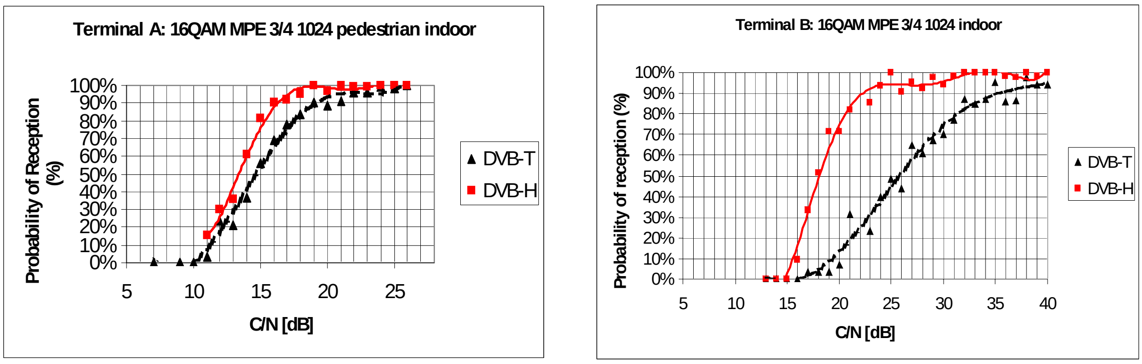


Figure 29: Pedestrian indoor curves in 16QAM 2/3MPE-FEC 3/4

6.5 Field trial conclusions

The DVB-H VTF field trials performed in Metz confirm the results of the tests performed during the laboratory test sessions.

- The absolute values derived in terms of C/N requirements for a given transmission mode and a given type of reception are similar to those derived in the laboratory.
- MPE-FEC is especially useful for mobile reception, but also shows very promising results in the case of outdoor and indoor pedestrian reception.
- MPE-FEC does not seem to produce the exact same effect on the two types of terminals but in both cases, it increases the location coverage ratio of 95 % or 99 %.

Finally, it can be noted that even in 8K, GI 1/4, 16QAM 2/3, the Doppler noise resilience implemented by both types of terminals is so efficient that receiving speed limitation is no longer an issue, as reception was still possible at 110 km/h in RF channel 50 (706 MHZ).

7 DVB-H VTF conclusions

The DVB-H Validation Task Force achieved the majority of its goals:

- Verification of the DVB-H equipment interoperability.
- Evaluation of DVB-H transmission performance in a mobile environment.
- Confirmation of the performance of DVB-H in the Field.

In short:

- The DVB-H standards portfolio is reliable: every early implementations demonstrated full interoperability and expected performances.
- The DVB-H MPE-FEC provides a real, quantifiable and very astonishing advantage to Mobile reception for the Handheld Receivers.

But also, doing its exploratory work, the DVB-H Validation Task Force revealed several items which require further work, as briefly summarized below:

- Pedestrian channel model (in-door and outdoor).
- Burst duration for pedestrian case.
- Recommendations for trade-off between physical layer and data link protection
(i.e. between DVB-T FEC and DVB-H MPE-FEC coding rates).
- Performance of 4K mode and In-depth interleaver.
- Hierarchical mode.
- Performances in SFN operation.
- Power saving and wake up time.
- Hand-over.
- 64QAM transmissions.

The DVB-H Validation Task Force involved up to 12 companies which delegated work to 34 engineers to perform a tremendous amount of work during the 3 full weeks of the VTF sessions.

Finally, particular thanks needs to be given to:

- Stefan KRUGER and the T-Systems team who made the Laboratory Test Session in Berlin possible (second fortnight of October 2004).
- Bertrand MAZIERES and the TDF team who organized an efficient and professional Field Trial session (second week of December 2004).
- Justin MITCHELL and the BBC team who heavily contributed to the redaction of the present document.

Annex A: Test methodology

To prepare the Validation Task Force work, in the Laboratory and in the field, a Methodology of Tests has been elaborated leading to the definition of:

- A generic test bed, able to reproduce the forecast network scenario.
- Channel Transmission profiles have been selected.
- Quality of Restitution criteria have been defined.
- Network formats, Transmission formats and Service formats have been selected.
- Measurement and Method of measure have been defined.

This annex provides the elements issued from this preparatory work.

A.1 DVB-H VTF test bed

The DVB-H VTF test bed aims:

- to reproduce in the laboratory various transmission network topologies, and therefore to check network equipment interoperability;
- to create in the laboratory various receiving situations, and therefore to estimate the improvement brought by DVB-H to services targeting mobile and portable handheld receivers;
- to help terminal manufacturers in tuning advanced features as frequency handover;
- to provide useful information to network planners and service providers in selecting DVB-H transmission parameters.

A.2 VTF Test Bed presentation

As depicted in figure A.1, the VTF test bed involved many pieces of equipment to create in the laboratory various types of:

- CONTRIBUTION networks: DVB-H only, mix of DVB-H and DVB-T;
- DISTRIBUTION networks: MFN or SFN in Regular or Hierarchical;
- TRANSMISSION networks: channel profiles, mono-cell / multi-cells;
- RECEPTION situations: resulting from combinations of the previous.

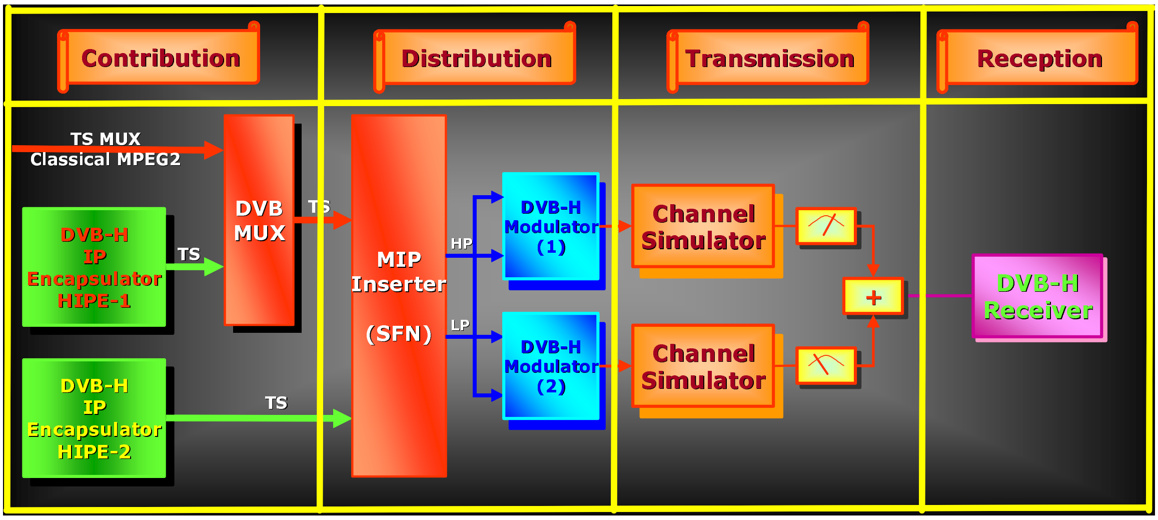


Figure A.1: DVB-H VTF Test Bed

A.2.1 Contribution part

Three basic Transport streams will be generated in the contribution by:

- **H-IPE1:** a DVB-H transport stream, including MPE-DATA and MPE-FEC sections and all necessary DVB-SI (see note 1) and DVB-H (see note 2) signalling. H-IPE1 will consist of a first TS of up to 5 Mbps and will be generated by a first DVB-H IP encapsulator.
- **H-IPE2:** a DVB-H transport stream, including MPE-DATA and MPE-FEC sections and all necessary DVB-SI (see note 1) and DVB-H (see note 2) signalling. H-IPE2 will consist of a second TS of up to 5 Mbps and will be generated by a second DVB-H IP encapsulator.
- **MP2-AV:** a traditional Transport Stream, with MPEG2 encoded audio and video contents, including all the necessary DVB-SI (see note 1) signalling.

NOTE 1: It is remembered that required PSI/SI signaling includes at least the PAT, PMT, NIT, SDT and EIT tables. Also NIT, SDT and PAT tables shall contains specific descriptors to allow Frequency handover in receivers using the mandatory Cell_Id information carried by the transmitted TPS bits (see DVB-SI EN 300 468 [5], clause 6 and SI-GL TR 101 211 [6], clause 4.5).

NOTE 2: It is remembered that MPE-DATA sections shall use Table_Id=oxo3E while MPE-FEC sections shall use Table_Id=oxo78.

The three Transport streams will have a "constant bitrate" meaning that the three multiplexers shall be able to insert the required number of null packets to reach the constant bitrate allocated to them.

A DVB (re-)multiplexer will be used to produce one finalized "TS-dual", made by the merging of DVB-H (H-IPE1 content) and DVB-T (MPEG2 content), with the consolidated DVB-SI signalling information. The second multiplex "TS-H" will include only DVB-H services but with all the signalling (SI/PSI and DVB-H).

As far as the DVB-H multiplexes are concerned, they will include several independent DVB-H services, each DVB-H service being carried in a dedicated burst. Then, the whole DVB-H multiplex will be at a constant bitrate, while the carried DVB-H services will implement various burst shapes (average service bitrate and absolute burst duration and distance between successive bursts).

The contribution part will issue one or two finalized transport stream in relation with the test bed configuration in use:

1) **Non-hierarchical:** either the TS-dual produced by the DVB re-Multiplexer OR the TS-H produced by the HIPE2 will be used to supply the Distribution part.

2) **Hierarchical:** the TS-dual (as LP) and the TS-H (as HP) will be used to supply two independent Transport Stream (HP and LP) to the distribution part.

A.2.2 Distribution part

The objective of this part is to perform the necessary adaptation to the hierarchical or non-hierarchical transport stream(s) before either MFN or SFN transmissions.

The contribution part will include:

- **One dual-TS MIP inserter or Two Single-TS MIP inserter:** such equipment will be in charge and will perform the following processes on the incoming Transport streams (HP and LP):
  - Bitrate adaptation: to adjust accurately the bitrate of each TS to the channel bitrate capacity, which depends on the DVB-T transmission mode. This is generally performed by deleting incoming null packets and inserting new null packets to reach an exact bitrate. Note that this process implies changes to the PCR (Programme Clock Reference) in the manipulated TS.
  - MIP packet insertion: to include Megaframe Information Packet (MIP), which shall include TPS bits compliant with DVB-H, giving Mega-Frame delimitation and the various delays implied by the SFN synchronization performed in the modulators.
  - NIT table update: to create the frequency list with regard to the transmission parameters.
- **Two DVB-H / DVB-T modulators:** these two equipments will process the two transport streams HP and LP supplied by the MIP inserter(s), to produce an RF DVB-T(-H) signal in various transmission formats.

The distribution part will issue one or two finalized transport stream in relation with the test bed configuration in use:

1) **MFN non-Hierarchical:** only the TS-LP will be modulated in the various trial transmission modes. The embedded MIP packet will not be used. The two modulators will produce a signal in two dedicated RF channels RF1 and RF2.

2) **SFN non-Hierarchical:** only the TS-LP will be modulated in the various trial transmission modes. The embedded MIP packet will be processed to perform time adjustment of the generated signal. The two modulators will produce a signal in one dedicated RF channels RF2.

3) **MFN Hierarchical:** both the TS-LP and TS-HP will be modulated in the various trial transmission modes. The embedded MIP packet will not be used. The two modulators will produce a signal in two dedicated RF channels RF1 and RF2.

4) **SFN Hierarchical:** both the TS-LP and TS-HP will be modulated in the various trial transmission modes. The MIP packets embedded in each transport stream will be processed to perform time adjustments both between the two TS (HP and LP) and between the two modulators. The two modulators will produce a signal in one dedicated RF channels RF2.

The various parameters settings will be as follows:

- RF channels are expected to be:
  - RF1 = channel 25 (low part of band IV) = 506 MHz center frequency;
  - RF2 = channel 45 (high part of band V) = 666 MHz center frequency.
- Channel Bandwidths are expected to be:
  - 5 MHz (see note 1) : outside the traditional Broadcast (in the L-Band channel "J");
  - 6 MHz[3] : in the Broadcast bands used outside Europe;
  - 7 MHz[3] : in the Broadcast bands used outside Europe;
  - 8 MHz : in the Broadcast bands used in Europe.

NOTE 1: These variants of the transmission parameters provides effectively some transmitted bitrate penalty but a trade-off evaluation of the inter-carrier spacing penalty versus absolute symbol duration gain, need to be done.

- Transmission Modes are expected to be:
  - fft: 8K, 4K, 2K;
  - interleaver: native and in-depth for 2K, 4K;
  - gi: 1/4, 1/8, (see note 2);
  - cr: 1/2, 2/3, 3/4;
  - constellation: 64QAM (H and non-H), 16QAM (H and no-H) and QPSK.

NOTE 2: As suggested in note 1, the exploration of lower values could be needed in case of 5 MHz and 6 MHz channel bandwidths.

A.2.3 Transmission part

The objective of the transmission part is to simulate in a controlled way the various channel propagation profiles expected for DVB-H terminals.

The transmission part will embed channel simulators able to implement the following channel profiles:

- FIXED Outdoor antenna: Rice with 6-Taps;
- FIXED Indoor antenna: Rayleigh with 6-Taps;
- Portable Indoor: TU6 for Low Doppler values (< 10 Hz);
- Mobile Outdoor: TU6 for High Doppler values (> 10 Hz);
- SFN: TU6 twice;
- Impulse Noise: Gated Gaussian Noise.

Then, apart from the Impulse Noise model, only three channel models are considered. Their relevance with real reception situations remains to be verified.

A.2.3.1 Propagation channel profiles

The details of the selected channel profiles are as follows:

Table A.1: RICEAN channel profile (Fix reception with outdoor antenna)

Tap number	Delay (μs)	Amplitude	Level (dB)	Phase (rad)
1	0	1	0	0
2	0,475	0,146	-16,71	0,363
3	0,645	0,119	-18,49	2,739
4	1,933	0,117	-18,64	-0,156
5	2,754	0,089	-21,01	-2,239
6	3,216	0,103	-19,74	-0,103

Table A.2: RAYLEIGH channel profile (Fix reception using Indoor antenna)

Tap number	Delay (μs)	Amplitude	Level (dB)	Phase (rad)
1	0,050	0,360	-8,87	-2,875
2	0,479	1	0,00	0
3	0,621	0,787	-2,08	2,182
4	1,907	0,587	-4,63	-0,460
5	2,764	0,482	-6,34	-2,616
6	3,193	0,451	-6,92	2,863

Table A.3: Typical Urban (TU6) channel profile (Mobile reception with Indoor / outdoor antenna)

Tap number	Delay (µs)	Power (dB)	Doppler Spectrum (see notes 1 and 2)
1	0,0	-3	Rayleigh
2	0,2	0	Rayleigh
3	0,5	-2	Rayleigh
4	1,6	-6	Rayleigh
5	2,3	-8	Rayleigh
6	5,0	-10	Rayleigh
NOTE 1: Low Doppler values (from 0 Hz to 10 Hz) simulate Mobile Indoor reception. Higher Doppler values (above 10 Hz) simulate Mobile Outdoor reception. NOTE 2: This profile should be used twice to simulate "SFN" situations.			

In any case of transmission (SFN or MFN), the signals sent from each modulator will be processed with the same channel propagation profile.

In order to simulate Frequency Handover in MFN (i.e. when a receiver leaves a transmission cell to enter in the adjacent one) it is proposed to balance the attenuation of the two RF signals (RF1 and RF2). It is expected this will allow receivers to test the use of the receiving "off-time" to discover the DVB-H service on alternative frequencies in adjacent transmission cells.

A.2.3.2 Impulse noise tests

For the purpose of the Impulse Noise resilience evaluation, it is proposed to use the six tests defined by the IEC/MBRAI group.

Details on the six tests summarized in table A.4 are provided at the end of this annex, as an extract of the ECTA/TAC/MBRAI-02-16 [8].

Table A.4: The Six tests related to Impulse Noise

N°	Pulses per Burst	Min/Max Pulse Spacing [us]		Burst Duration [us]	Tolerance Factor 2k [dB]	Tolerance Factor 4k [dB]	Tolerance Factor 8k [dB]
1	1	N/A	N/A	0,25	29,5	32,5	35,5
2	2	1,5	45	45,25	26,5	29,5	32,5
3	4	15,0	35	105,25	23,5	26,5	29,5
4	12	10,0	15	165,25	18,7	21,7	24,7
5	20	1,0	2	38,25	16,5	19,5	22,5
6	40	0,5	1	39,25	13,5	16,5	19,5

A.2.4 Receiver part

This part will examine various experimental receivers in order:

- to report on their acceptance of the signals generated by the test-bed;
- to evaluate performance of the DVB-H additions, namely MPE-FEC and Time-Slicing, in improving Mobile reception capabilities and Impulse Noise resilience.

As far as performance improvements are concerned, VTF tests are focused on DVB-H technology and NOT on the implementation performance. Accordingly it is proposed to perform estimation with no MPE-FEC (i.e. C/N and Max Doppler in a mimic of a pure DVB-T situation) then while adding MPE-FEC decoding, to measure the C/N and Max Doppler improvement.

It is hopped that this "relative" measurement from several receivers implementation will allow to extrapolate the "absolute" benefit brings by the DVB-H MPE-FEC and Time Slicing onto the Mobile performance and Impulse noise resilience.

To allow performance measurements it is expected the receivers will be able to provide:

1) The level of received signal.

2) An evaluation of the C/N.

3) An indication of the FER and MFER values of the received bursts.

4) The number of bursts: received, missed, corrected, not correctable.

Also, for time slicing efficiency in power saving, it is suggested that a receiver is able to:

5) Provide a signal showing the decoded time-on and time-off periods of the time slices and/or to provide such information with the software embedded in the terminal.

6) Provide a signal showing the activity of the demodulator (i.e. power-on / power-off) including the "wake-up" time and/or to provide such information with the software embedded in the terminal.

Also, various pieces of measurement equipment will be needed in the receiver part of the test bed. It is expected the company hosting the Laboratory Tests Session will be able to provide:

- a power meter, (to measure signal presented to receiver);
- a spectrum analyser, (to watch the signal spectrum);
- an oscilloscope, (to watch signals sent by the receivers);
- a MPEG2-TS analyser, (to analyse the DVB-SI and possibly the MPE Sections);
- an IP "traffic" analyser, (to watch the "time-slices" at the IP level);
- a regular DVB-T set top box, (to verify any DVB-H "pollution"), etc.

A.3 DVB-H VTF laboratory tests

The DVB-H VTF tests include two dimensions:

- Interoperability Tests of network equipment and receivers.
- DVB-H Performance estimation in various transmission situations.

More precisely, the Interoperability Tests (IT) will focus on:

- Equipment Interoperability checking.
- Service Information checking.
- Time-Slicing signalling and decoding (including duty cycle effects).
- Mixing of DVB-T and DVB-H.
- Possibly Cell Handover signalling and Decoding.
- Possibly Hierarchical and SFN Hierarchical transmission checking.
- Possibly checking of 5 MHz, 6 MHz, 7 MHz and 8 MHz channel bandwidths.

And the Performance Measurement (PM) will focus on:

- Flexible MPE-FEC coding rate, (Effect on Mobile Performances).
- Flexible Burst Shapes, (Effect on Mobile Performances).
- Impulse noise resilience of MPE-FEC and Time-Slicing.

A.3.1 IT: Interoperability tests

The IT tests will mainly consist of the verification of the signals outputted by the network equipment and ultimately by their acceptance and usage by the experimental DVB-H receivers.

It is proposed to build up progressively the VTF test bed while verifying with measurement equipment the signal generated for each test configuration.

Final validation of the test bed setup will be performed using the set of receivers participating in the tests.

A.3.1.1 Network equipment interoperability

The VTF test bed uses the following set of equipment:

- DVB-H IP encapsulator(s) (IPE);
- DVB Multiplexer;
- MIP Inserter(s);
- DVB-H(-T) modulator(s);
- DVB-H(-T) receiver(s);

A.3.1.1.1 Contribution and distribution equipment

H-IPE, DVB-MUX and MIP Inserter elaborate each a MPEG Transport stream. Unitary tests will be performed on each of them using MPEG-TS analyser. The following will particularly be explored:

- compliance of MPE-DATA and MPE-FEC tables;
- FEC and Slice signalling within DVB sections;
- DVB-H Burst Duration and Periodicity (Delta_T);
- DVB Signalling (PSI / SI including PAT, PMT, NIT, SDT and EIT tables);
- MIP and SFN signalling.

Then H-IPE, DVB-MUX and MIP Inserter will be chained and set up to produce:

- The various tests sequences.
- The MFN regular and hierarchical TS signal(s).
- The SFN regular and hierarchical TS signal(s).

Going through the complete chain, DVB-H services experience several multiplexing or bitrate adaptations. The potential distortion onto the DVB-H signalling (i.e. Max Burst Duration and the inter-burst Delta_T) shall be verified. Particularly, the Delta_T real-time parameter, carried in the MAC_address of each transmitted section, shall point before the start of the following burst.

These tests will be completed by experiencing various H-IPE, DVB-MUX and MIP inserter available in the contribution chain.

A.3.1.1.2 Distribution Equipment

Modulators produce an RF signal. Their test will involve a professional test receiver able to perform the estimation of the basic parameter of the DVB-T physical layer.

In particular the following will be explored:

- Compliance of TPS signalling.
- MER / BER / END performance.

The different pieces of modulator equipment will be coupled with the contribution equipment and identical measurements will be done in the various transmission modes MFN regular / MFN hierarchical and SFN regular / SFN hierarchical.

A.3.1.1.3 Transmission equipment

Finally the channel simulator will be coupled with the distribution equipment and the RF signal will be checked. In particular, the following will be checked and measured:

- power level produced for various channel profiles;
- distribution to the various receivers;
- connections to the measurement equipments (spectrum analyser, power meter, reference measurement receivers).

A.3.1.2 Test bed and receiver Interoperability

This primary tests focus on assessing the compatibility between receivers and the signals generated by the VTF test bed.

A.3.1.2.1 Interoperability at the RF level

Using a Gaussian channel propagation profile, the various signals MFN Regular / SFN Regular / MFN Hierarchical / SFN Hierarchical will be presented to the receivers.

The Test will assess that the:

- Receiver is able to lock onto the signal.
- Receiver decodes TPS and correctly discovers the transmission mode.
- Receiver is able to engage the decoding process on every transport stream(s) transmitted (i.e. HP or LP transport streams in Hierarchical transmissions).

Also the following will be verified for the receiver under test:

- RF power level.
- BER after Viterbi.
- PER after RS decoding.
- END measurement.

A.3.1.2.2 Interoperability at the Service level

Using a Gaussian channel propagation profile, an MFN Regular DVB-H(-T) signal will be presented to receiver.

The Test will focus on the DVB-H decoding capability:

- Decoding of the TPS bits related to DVB-H and Cell_ID.
- Decoding of SI/PSI signalling.
- Access to DVB-H services.
- Checking of the indications provided by the receiver regarding MPE-FER (before and after MPE-FEC decoding),
- Checking of the indications related to the Time-Slicing (on-time, off-time, burst jitter, etc.).

A.3.1.2.3 Receiver "wake-up" time

NOTE: This test requires further study, as the way to obtain "wake-up" time information from the receiver is not well established.

The Time Slice feature is provided by the DVB-H standards to allow receiver to implement a power saving strategy within DVB-H terminals.

The optimization of the power saving leads to spacing of the DVB-H service bursts. Increasing time between bursts also provides room for the management of the seamless Frequency Handover. Unfortunately, increasing time between service bursts also increases significantly the service access time.

The time between bursts is efficient for power saving if it is greater than the "wake-time" of the receiver.

To explore this limit, as depicted in figure A.2, it is forecast to use a burst having a repetition rate of half a second and to use various numbers of row in the MPE-DATA / MPE-FEC tables to obtain various burst duty cycles.

It is expected this will allow the evaluation of the impact of the receiver "wake-up" time in regard to burst duty cycle, then to provide indications on the relevant trade-off between power saving and service access time (i.e. to which minimum the "off-time" can be reduced).

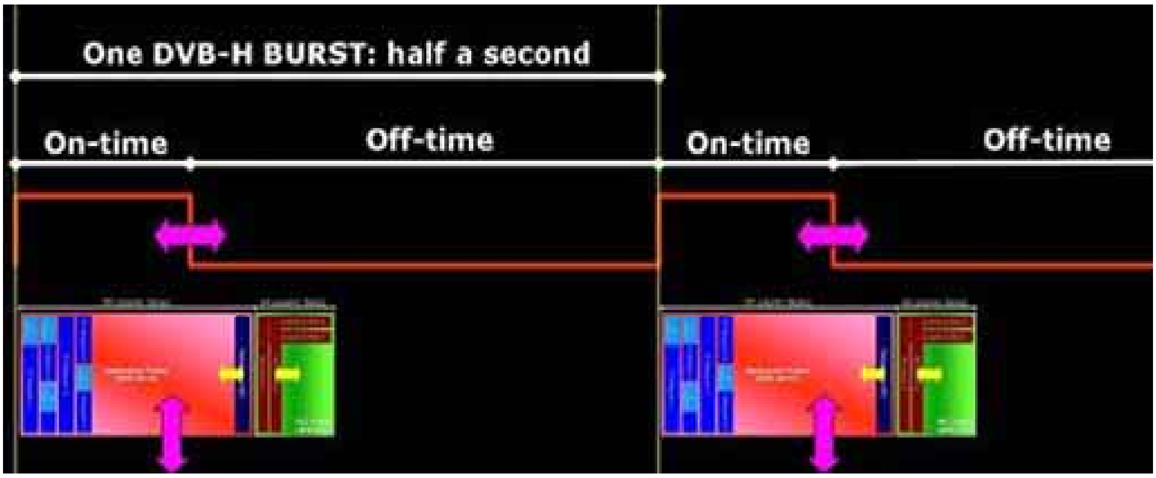


Figure A.2: Burst Duty Cycle

It is proposed to explore the four table dimensions given in table 39 of EN 301 192 [7].

- 1/1: 1 024 rows;
- 3/4: 768 rows;
- 1/2: 512 rows;
- 1/4: 256 rows.

For each of these table configurations, the time needed to deliver the following information after a reset (or power on) of the receiver will be estimated:

- Access to DVB-H services.
- Indications relating to the Time-Slicing (on-time, off-time, burst jitter, etc.).
- Indications relating to the receiver wake-up time (when possible).

A.3.2 PM: Performance Measurement

As targeting Mobile Handheld terminals, DVB-H performance measurement focuses on the determination of the C/N versus Doppler curve, for given Quality of Restitution criteria (QoR), in various reception situations (channel models), transmission modes (DVB-T transmission parameters) and burst shapes (absolute duration of the DVB-H service burst).

The PM tests are the most interesting for the DVB community, especially as the VTF laboratory tests will experience several receiver implementations. It is expected the obtained results will allow estimation of average performance figures relating to the DVB-H technical components.

These aspects are analyzed in the following clauses.

A.3.2.1 PM: C/N versus Doppler

According to the work performed in the Motivate and MCP projects, the behaviour of receiver placed in portable / mobile situations can be estimated by the (blue) curve presented in figure A.3.

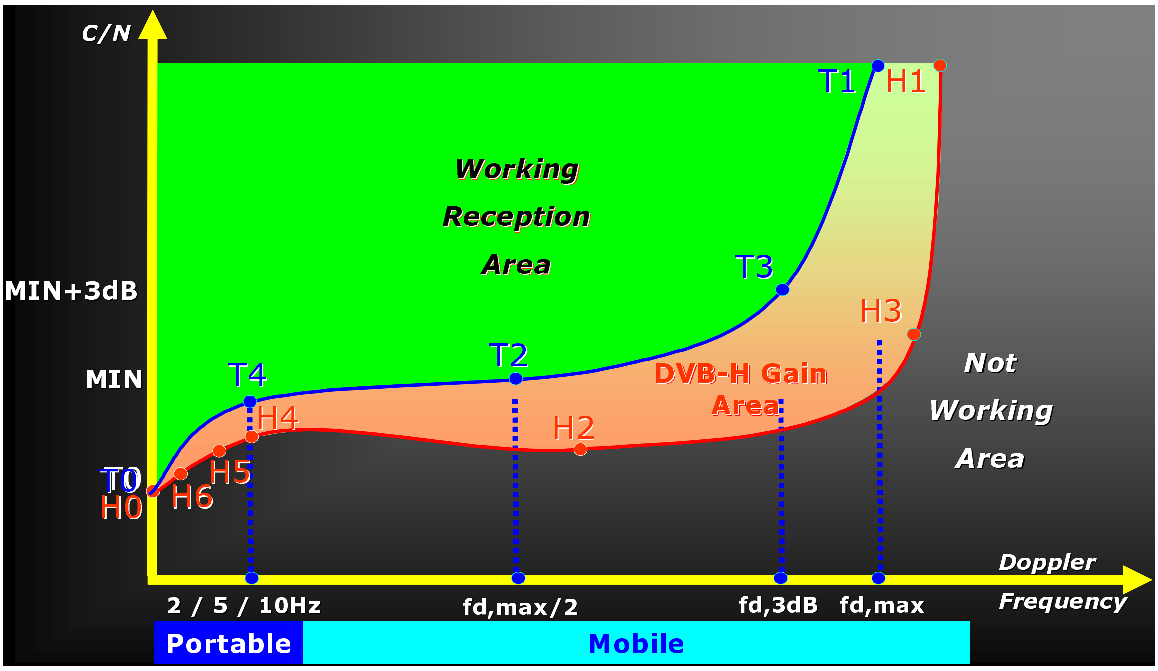


Figure A.3: C/N versus Doppler curve

Basically, figure A.3 presents two curves showing the C/N (Carrier on Noise ratio) level required to perform successful demodulation in relation with the Doppler Frequency (i.e. speed) included in the "noise" presented to the receiver.

The blue curve is related to a DVB-T situation, while the red curve is the one expected from DVB-H reception. The orange area corresponding to the improvement brought by the use of the MPE-FEC additional protection.

From the "0 Hz" Doppler, corresponding to the DVB-T "not receiving a mobile signal" situation, to the "Max" Doppler, corresponding to a maximum receiving speed, the C/N level needed to provide a given Quality of Restitution shall be assessed.

Regarding the measurement method, the reference points "Xi" have to be evaluated sequentially, by injecting "noise" in the signal received, such noise being manipulated either in terms of level or Doppler Frequency values, to obtain the targeted Quality of Restitution:

X0: with 0 Hz Doppler this allows calibration of the C/N for each receiver;

X1: will estimate the "Max Doppler frequency" acceptable by each receiver;

X2: using half of the "Max Doppler frequency", to determine the "C/N floor";

X3: using "C/N floor" +3 dB, to determine the Doppler Frequency "break";

X4: using 10 Hz Doppler, to determine the C/N penalty between non-mobile and mobile receiving situations.

Additionally, to explore DVB-H reception behaviour in situations of low Doppler frequencies (related either to low speed motion around an indoor antenna or pedestrian motion of a handheld terminal) two reference points H5 and H6 have been defined:

H5: using 5 Hz Doppler, to determine the C/N threshold;

H6: using 2 Hz Doppler, to determine the C/N threshold.

The five reference points will be estimated in the "DVB-T" case being simulated either by using service bursts without FEC or by computing the FER before and after MPE-FEC processing within the receiver. The additional reference points (H5, H6) shall be estimated in the DVB-H cases.

A.3.2.2 PM: Channel profiles

The Rice (table A.1) and Rayleigh (table A.2) channel profiles which mimic a static - not mobile - receiver will be used to state on the basic receiver performance when stationary.

The six tests related to Impulse noise impairments (table A.4) will be performed. For these tests, only the X0 reference point shall be determined.

The TU6 profile (table A.3) will be used to perform a performance evaluation related to a receiver in motion. Low values of Doppler (from 0 Hz to 10 Hz) correspond to Indoor/Outdoor portable reception while higher Doppler values represent a Mobile situation.

In all cases, accurate "C/N vs Doppler" curves are needed as they provide very useful information for the Service Implementers:

- The C/N "floor" helps network planning and coverage simulation.
- The Doppler Frequency range provides indications on Service availability in various mobile situations within the covered area.

A.3.2.3 Quality of restitution criteria

Instead of Motivate/MCP which used a "subjective" failure point based on a "20 second observation of the impairments in the received service" (see note 1), the DVB-H VTF intends to use, in the Laboratory, an "objective" measurement based on the MPE frame error rate.

NOTE 1: It shall be noted that this criteria is very suitable in Laboratory even being time consuming. For Field Trials, Motivate explored Packet Error Ratio (PER) and Erroneous Second Rate (SER) as they were most suitable in situation of real motion!

Thanks to the DVB-H features, measurement focused on the MPE-DATA and MPE-FEC frames allows to us to estimate accurately the "Quality of Restitution" (QoR) for each given DVB-H service. Inspired by the European Quasi-Error-Free (perfect quality = no error) and the American Threshold-of-Visibility (unacceptable quality = failure point), it is proposed to use the MPE Frame Error Ratio (MFER).

MFER is the ratio of the number of residual erroneous frames (i.e. not recoverable) to the number of received frames. To provide sufficient accuracy, at least 100 frames shall be analysed.

$$\text{MPE} - \text{FER}\ (\%) = \frac{\text{Number of residual erroneous frames} \times 100}{\text{Number of Received frames}}$$

When no MPE-FEC is provided in the received burst (or if MPE-FEC decoding is not provided in the receiver), the status of the received frame can be established by the following method (see note 2):

1) count the number of "null" bytes remaining in the used bytes of each row of the MPE-DATA table (and MPE-FEC table if received);

2) compare row by row this "null" byte number with the number of bytes in an (eventually punctured) RS code-word:

   - if "null" byte number > RS bytes : residual error in the row;

   - if "null" byte number ≤ RS bytes : error can be corrected.

3) if the whole table (i.e. all rows) does not include a residual error, the table is stated as "correctly received". In other cases, the table is stated "errored".

NOTE 2: It must be remembered that according to the DVB-DATA standard (clause 9.3.3), the standardised method to use MPE-DATA and MPE-FEC tables in the receiver is to fill tables with "null" bytes before reception, then to fill the tables with received IP packets / FEC columns only if the CRC32 carried in the DVB sections is successfully verified.

Regarding the Quality of Restitution criteria, the QoR_5 corresponding to MFER = 5 % (5 frames lost among 100 received) will be used.

NOTE 3: Work performed in the INSTINCT project revealed that the MFER5 objective criteria corresponded to a "good/fair" recovery of audiovisual programmes subjectively reported by two observers. It has been also revealed that an MFER10 (10 %) corresponds to annoying recovery. The C/N difference between MFER5 and MFER10 is less than half a dB (within the test precision at the time).

A.3.2.4 MPE-FEC coding rate

For the purposes of the VTF laboratory tests, there is a requirement to experiment with various MPE-FEC coding rates to judge on its effectiveness in Mobile and Impulse noise situations.

To permit various coding rates the DVB-H standard allows padding (to reduce the number of transmitted columns of the MPE-DATA table) and puncturing (to reduce the number of transmitted columns of the MPE-FEC table).

For the purpose of the VTF laboratory tests it is proposed to use this feature to create various MPE-FEC coding rates as shown in figure A.4.

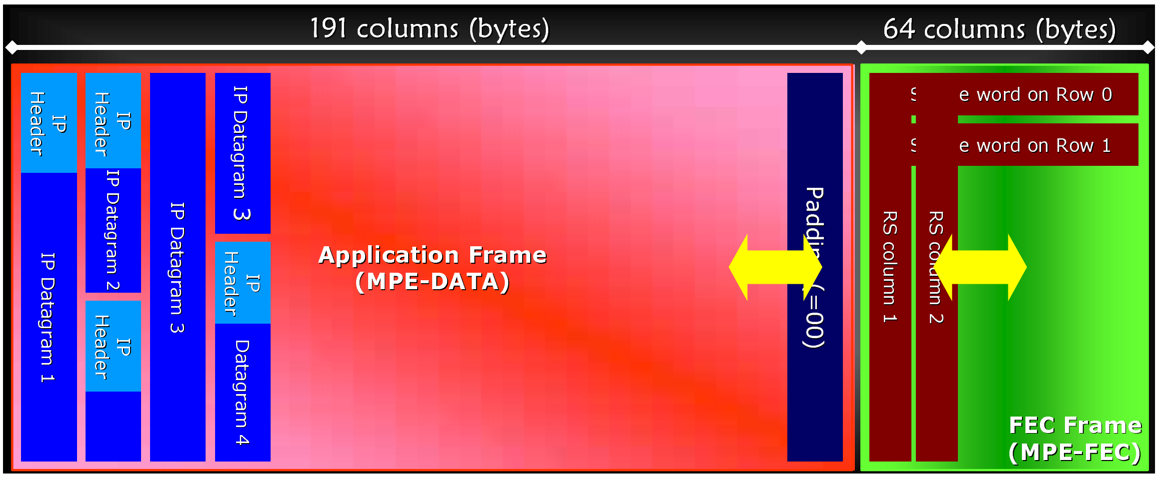


Figure A.4: MPE-FEC Coding Rate

By varying the number of padded MPE-DATA columns (not-transmitted) and punctured MPE-FEC columns (not transmitted) it is possible to adjust the coding rate to the following values. These provide a decreasing level of protection for the coded modulation of DVB-T:

- 1/2 (0,50) 64/128: MPE-DATA= 64 columns, MPE-FEC = 64 columns;
- 2/3 (0,66) 128/192: MPE-DATA= 128 columns, MPE-FEC = 64 columns;
- 3/4 (0,75) 191/255: MPE-DATA= 191 columns, MPE-FEC = 64 columns;
- 5/6 (0,83) 190/228: MPE-DATA= 190 columns, MPE-FEC = 38 columns;
- 7/8 (0,87) 189/216: MPE-DATA= 189 columns, MPE-FEC = 27 columns;
- 1/1 (1,00) 191/191: MPE-DATA= 191 columns, MPE-FEC = 0 columns.

The coding rate level "1/1" corresponds obviously to "no MPE-FEC protection", providing a mimic of the regular mobile DVB-T reception case. This cr = 1/1 will be used to calibrate the intrinsic receiver performance, taking in account the unavoidable implementation losses.

Also, if MPE-FEC decoders are able to provide the "erroneous table" information before and after MPE-FEC correction, this coding rate could be ignored and the MPE-FEC effectiveness can be assessed for each coding rate with regard to a virtual DVB-T receiving situation.

The other coding rate values (stronger and weaker protection than the native MPE-FEC = 3/4 coding rate) aim to accurately define the gain of MPE-FEC (this also means the protection overhead at the expanse of the useful bitrate) when using various transmission formats.

In summary, it is expected that a trade-off will be possible between robustness provided by the network planning (i.e. given coverage with a given transmission power for a given broadcast bitrate) and the service planning (i.e. level of additional MPE-FEC protection to obtain a given quality of restitution at a given speed or in a given location "indoor/outdoor").

A.3.2.5 Absolute burst duration

The MPE-FEC protection embedded in the DVB-H standard also includes a "virtual" time interleave of the MPE-FEC table, the MPE-DATA table being transmitted without any interleaving. The "virtual" time interleaving efficiency is directly correlated with the absolute duration of the transmitted burst, as mobile channels are characterized by time varying channel propagation profiles.

For the purposes of the VTF laboratory tests, there is a requirement to experiment with various Burst durations to appreciate the effect of the virtual time interleaver in Mobile and Impulse noise situations.

The DVB-H multiplex is delivered by the DVB-T transmission layer at a constant bitrate. The absolute duration of each burst depends only on the sizes of the MPE-DATA and MPE-FEC tables it carries (see note) with regard to the overall DVB-H multiplex bitrate (nb: not the DVB-T overall transmission resource). The delay between the bursts of a given DVB-H service is then constrained by the "max_average_rate" of this service (which could vary from one burst to the following).

NOTE: Sections overhead as TS packet overhead shall be considered also.

As far as "Max_Burst_Duration" is concerned, it is proposed to use various numbers of rows for the MPE-DATA and MPE-FEC tables, which maintain a given MPE-FEC coding rate whatever the burst duration. The four possible values given in the DVB-DATA standard will be explored:

- (0x00) 1/4 256 rows;
- (0x01) 1/2 512 rows;
- (0x02) 3/4 768 rows;
- (0x03) 1/1 1 024 rows.

As far as "Delta_T" is concerned (time between consecutive bursts), it is desirable to reduce this value to a minimum and so decrease the measurement period (i.e. the time needed to receive 100 bursts). But it is also desirable to create realistic a DVB-H service delivery, which means "max_average_rate" between 256 kbps and 512 kbps (i.e. as far as IP video streaming services are forecast).

Accordingly, only services / bursts having an average rate of 512 kbps will be explored (at the expanse of the needed measurement time).

A.3.3 PM: Prioritization of tests

According to the previous definitions and the various signals the VTF test bed is able to produce, the number of combinations of tests is really huge.

Nevertheless, it is possible to determine classes of formats, as presented in the following tables.

Table A.5: Netword format

NETWORK FORMATS			
Channel Bandwidth	MFN / SFN	REG / HM	Propagation
8 MHz 7 MHz 6 MHz 5 MHz	MFN SFN	REG HM	Rice Rayleigh TU6 IN1..IN6

Table A.6: Transmission format

TRANSMISSION FORMATS				
FFT	GI	INTL	Constellation	CR
8K 4K 2K	1/4 1/8 1/16 1/32	Native In-depth	QPSK 16QAM 64QAM	1/2 2/3 3/4 5/6 7/8

Table A.7: Service format

SERVICE FORMATS				
MPE-FEC Coding Rate	*Data Columns*	*RS Columns*	Burst Duration (Rows Number)	Delta_T (Average Rate)
1/1	*191*	*0*	1024	512 Kbps
7/8	*189*	*27*	768	512 Kbps
5/6	*190*	*38*	512	512 Kbps
3/4	*191*	*64*	256	512 Kbps
2/3	*128*	*64*		
1/2	*64*	*64*		
-	-	-		

Also, as the DVB-H VTF test-bed uses "OBJECTIVE" criteria (i.e. MFER), if its usage is validated during primary test session, it will be possible to implement an "automatic" measurement procedure, then to perform exhaustive tests without consuming man-power; but that is for future work.

A.3.3.1 Network formats

To be exhaustive, the various network formats need be used which means: Regular/Hierarchical, SFN/MFN within the various channel bandwidths 8 MHz, 7 MHz, 6 MHz and 5 MHz.

It is expected that some variants could be extrapolated from the basic tests:

- Regular/Hierarchical: it has been shown in the past (Motivate / MCP) that the Hierarchical LP stream (QPSK) suffers a penalty when compared with Regular QPSK, suggesting a translation of the C/N curve.
- SFN/MFN: has no effect on the C/N curve but an impact on the synchronization algorithm performed within the receiver.

Regarding Channel Bandwidth that is the more questionable variant, as the physical parameters of the transmitted signal varies largely from the 8 MHz to the 5 MHz situation.

It is highly desirable to use the 5 MHz behaviour, but it is not sure the VTF test-bed will be able to implement this variant in the L-Band channel (1 670 MHz to 1 675 MHz) aimed at areas outside Europe.

Accordingly, instead of making performance measurements in the various "network format" combinations, it is proposed to check only these test bed configurations within the "Interoperability Test" part.

A.3.3.2 Transmission and service formats

As already stated, the combinations of transmission formats with each service formats drive to a tremendous number of cases, which makes exhaustive tests impossible to perform in a "manually" controlled test-bed.

It is therefore proposed to focus on the exploration of:

- DVB-H MPE-FEC advantage in comparison to DVB-T.
- Influence of Absolute Burst Duration (1 024 rows, 768 rows, 512 rows, 256 rows).
- Influence of the MPE-FEC coding rate (1/2, 2/3, 3/4, 5/6, 7/8).
- Influence of the transmission mode (2K/ 4K / 8K).
- Influence of the in-depth interleaver (native / In-depth).

A.4 List of tests

A.4.1 Interoperability Test

As far as Interoperability of equipment is concerned, it is proposed to perform the following tests:

IT-01	Verification of Multiplexers
IT-02	DVB-H Modulator Test
IT-03	IP Encapsulator Test
IT-04	MPE-FEC / Time Slicing
IT-05	Channel Models
IT-06	SFN/MFN Tests
IT-07	DVB-T/-H Cohabitation Compliance

A.4.2 Performance measurements

The first session of the laboratory tests intends to focus on the improvement provided by DVB-H in regard to DVB-T and in addition to explore the influence of the various parameters introduced by DVB-H.

A.4.2.1 Comparison of DVB-H with DVB-T in mobile situations

The purpose of these measurements is to obtain the curve "C/N vs Doppler" for various physical layer coded constellations.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Burst Duration								
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256	Gaussian	Rice	Rayleigh	TU6	IN1..IN6
PM-01	8K	1/4	Native	QPSK	1/2	4,98 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-02	8K	1/4	Native	QPSK	2/3	6,64 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-03	8K	1/4	Native	16QAM	1/2	9,95 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-04	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	

Figure A.5: DVB-H versus DVB-T

The service format is then unique while the transmission format only involves four types of coded constellations. The experiments will use the TU6 channel profile, paying particular attention to low Doppler values.

A.4.2.2 Influence of burst duration

The purpose of these measurements is to obtain the curve "C/N vs Doppler" for various durations of the service burst.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Number of Rows								
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256	Gaussian	Rice	Rayleigh	TU6	IN1..IN6
PM-06	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓	✓	✓	✓	✓			✓	

Figure A.6: Influence of Burst Duration

In this test the transmission format and the MPE-FEC coding rate are fixed, while various burst durations are produced using the four possible table row numbers. The experiments will use the TU6 channel profile, paying particular attention to low Doppler values.

A.4.2.3 Influence of MPE-FEC coding rate

The purpose of these measurements is to obtain the curve "C/N vs Doppler" for various service coding rate.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Number of Rows								
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256	Gaussian	Rice	Rayleigh	TU6	IN1..IN6
PM-05	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓	✓	✓	✓	✓	✓	✓				✓			✓	

Figure A.7: Influence of MPE-FEC coding rate

In this test the transmission format and the burst duration are fixed while services are protected with five different values of MPE-FEC coding rate. The experiments will use the TU6 channel profile, paying particular attention to low Doppler values.

A.4.2.4 Influence of Transmission Modes

The purpose of these measurements is to obtain the curve "C/N vs Doppler" for various FFT oriented transmission modes.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Number of Rows								
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256	Gaussian	Rice	Rayleigh	TU6	IN1..IN6
PM-07	8K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-08	4K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	
PM-09	2K	1/4	Native	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	

Figure A.8: Influence of FFT size

In this test the constellation, the MPE-FEC coding rate and the burst duration are fixed, while the FFT size is varied. The experiments will use the TU6 channel profile, paying particular attention to low Doppler values.

A.4.2.5 Influence of In-Depth interleaver

The purpose of these measurements is to obtain results with the native and the in-depth interleavers.

	Transmission			Modulation		Channel	DVB-H	MPE-FEC Coding Rate						Number of Rows								
	FFT	GI	INTL	Constellation	CR	BitRate	Multiplex Bitrate	1/1	7/8	5/6	3/4	2/3	1/2	1024	768	512	256	Gaussian	Rice	Rayleigh	TU6	IN1..IN6
PM-10	4K	1/4	In-depth	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	✓
PM-11	2K	1/4	In-depth	16QAM	2/3	13,27 Mbps	4,00 Mbps	✓			✓			✓				✓			✓	✓

Figure A.9: Influence of In-Depth Interleaver

In this test the constellation, the MPE-FEC coding rate and the burst duration are fixed, while the two permitted FFT sizes are used. To establish the "Mobile" gain, the TU6 channel profile will be used and to obtain the Impulse noise resilience, the six IN tests will be performed.

A.4.2.6 PM: Synthesis

Various parameters to be used in the performance measurements are given below.

A.4.2.6.1 Service formats

The following table gives the burst signalling parameters "Max_Burst_Duration" and "Delta_T" (of the first MPE-DATA section within the burst) for various combinations. It needs to be noted that values are rounded to take into account the standardized resolution of these parameters: 20 ms for "Max_Burst_Duration" and 10 ms for "Delta_T" and to guarantee that Delta_T will always give an indication "just before" the effective start of the following burst (nb: Delta_T jitter).

The observation period to permit an accurate evaluation of the MFER is given. Two values are shown which correspond to the observation of Doppler frequency lower and higher than 10 Hz respectively. These values remain very long. Further work remains to be done to shorten this observation period. Finally, the duty cycle value is given for information.

DVB-H	MPE-FEC Coding Rate	Burst Shape		BURST PARAMETERS				
Multiplex Bitrate	CR	Rows Number	Max Average Rate	Max Burst Duration	Delta_T (First Section)	Observation Fd <10 Hz	Period Fd >10 Hz	Duty Cycle
4,00 Mbps	1/1	1024	512 Kbps	400 ms	2 980 ms	298 sec	119 sec	11/82
4,00 Mbps		768	512 Kbps	300 ms	2 230 ms	223 sec	89 sec	7/52
4,00 Mbps		512	512 Kbps	200 ms	1 490 ms	149 sec	60 sec	11/82
4,00 Mbps		256	512 Kbps	100 ms	740 ms	74 sec	30 sec	5/37
4,00 Mbps	7/8	1024	512 Kbps	440 ms	2 950 ms	295 sec	118 sec	10/67
4,00 Mbps		768	512 Kbps	340 ms	2 210 ms	221 sec	88 sec	2/13
4,00 Mbps		512	512 Kbps	220 ms	1 470 ms	147 sec	59 sec	3/20
4,00 Mbps		256	512 Kbps	120 ms	730 ms	73 sec	29 sec	12/73
4,00 Mbps	5/6	1024	512 Kbps	460 ms	2 960 ms	296 sec	118 sec	7/45
4,00 Mbps		768	512 Kbps	360 ms	2 220 ms	222 sec	89 sec	6/37
4,00 Mbps		512	512 Kbps	240 ms	1 480 ms	148 sec	59 sec	6/37
4,00 Mbps		256	512 Kbps	120 ms	740 ms	74 sec	30 sec	6/37
4,00 Mbps	3/4	1024	512 Kbps	520 ms	2 980 ms	298 sec	119 sec	15/86
4,00 Mbps		768	512 Kbps	400 ms	2 230 ms	223 sec	89 sec	7/39
4,00 Mbps		512	512 Kbps	260 ms	1 490 ms	149 sec	60 sec	15/86
4,00 Mbps		256	512 Kbps	140 ms	740 ms	74 sec	30 sec	7/37
4,00 Mbps	2/3	1024	512 Kbps	400 ms	1 990 ms	199 sec	80 sec	1/5
4,00 Mbps		768	512 Kbps	300 ms	1 490 ms	149 sec	60 sec	1/5
4,00 Mbps		512	512 Kbps	200 ms	990 ms	99 sec	40 sec	20/99
4,00 Mbps		256	512 Kbps	100 ms	490 ms	49 sec	20 sec	10/49
4,00 Mbps	1/2	1024	512 Kbps	260 ms	990 ms	99 sec	40 sec	26/99
4,00 Mbps		768	512 Kbps	200 ms	740 ms	74 sec	30 sec	10/37
4,00 Mbps		512	512 Kbps	140 ms	490 ms	49 sec	20 sec	2/7
4,00 Mbps		256	512 Kbps	80 ms	240 ms	24 sec	10 sec	1/3

Figure A.10: Service Formats

A.4.2.6.2 Transmission formats

8 MHz		FFT	ICS	Tu	Ts 1/4	Ts 1/8	Ts 1/16	Ts 1/32
		8K	1 116 Hz	896 µs	1120 µs	1008 µs	952 µs	924 µs
		4K	2 232 Hz	448 µs	560 µs	504 µs	476 µs	462 µs
		2K	4 464 Hz	224 µs	280 µs	252 µs	238 µs	231 µs
C/N Gaussian	**C/N Rice**	**C/N Rayleigh**	**Modulation Constellation**	**CR**	**Bit Rate 1/4**	**1/8**	**1/16**	**1/32**
3,1 dB	**3,6 dB**	**5,4 dB**	**QPSK**	**1/2**	**4,98 Mbps**	5,53 Mbps	5,85 Mbps	6,03 Mbps
4,9 dB	**5,7 dB**	**8,4 dB**	**QPSK**	**2/3**	**6,64 Mbps**	7,37 Mbps	7,81 Mbps	8,04 Mbps
5,9 dB	6,8 dB	10,7 dB	**QPSK**	**3/4**	7,46 Mbps	8,29 Mbps	8,78 Mbps	9,05 Mbps
6,9 dB	8,0 dB	13,1 dB	**QPSK**	**5/6**	8,29 Mbps	9,22 Mbps	9,76 Mbps	10,05 Mbps
7,7 dB	8,7 dB	16,3 dB	**QPSK**	**7/8**	8,71 Mbps	9,68 Mbps	10,25 Mbps	10,56 Mbps
8,8 dB	**9,6 dB**	**11,2 dB**	**16QAM**	**1/2**	**9,95 Mbps**	11,06 Mbps	11,71 Mbps	12,06 Mbps
11,1 dB	**11,6 dB**	**14,2 dB**	**16QAM**	**2/3**	**13,27 Mbps**	14,75 Mbps	15,61 Mbps	16,09 Mbps
12,5 dB	13,0 dB	16,7 dB	**16QAM**	**3/4**	14,93 Mbps	16,59 Mbps	17,56 Mbps	18,10 Mbps
13,5 dB	14,4 dB	19,3 dB	**16QAM**	**5/6**	16,59 Mbps	18,43 Mbps	19,52 Mbps	20,11 Mbps
13,9 dB	15,0 dB	22,8 dB	**16QAM**	**7/8**	17,42 Mbps	19,35 Mbps	20,49 Mbps	21,11 Mbps
14,4 dB	14,7 dB	16,0 dB	**64QAM**	**1/2**	14,93 Mbps	16,59 Mbps	17,56 Mbps	18,10 Mbps
16,5 dB	17,1 dB	19,3 dB	**64QAM**	**2/3**	19,91 Mbps	22,12 Mbps	23,42 Mbps	24,13 Mbps
18,0 dB	18,6 dB	21,7 dB	**64QAM**	**3/4**	22,39 Mbps	24,88 Mbps	26,35 Mbps	27,14 Mbps
19,3 dB	20,0 dB	25,3 dB	**64QAM**	**5/6**	24,88 Mbps	27,65 Mbps	29,27 Mbps	30,16 Mbps
20,1 dB	21,0 dB	27,9 dB	**64QAM**	**7/8**	26,13 Mbps	29,03 Mbps	30,74 Mbps	31,67 Mbps

Figure A.11: Transmission Formats

A.5 Impulse noise tests

Extract from the IEC / MBRAI document:

"10.12 Tolerance to Impulse Interference

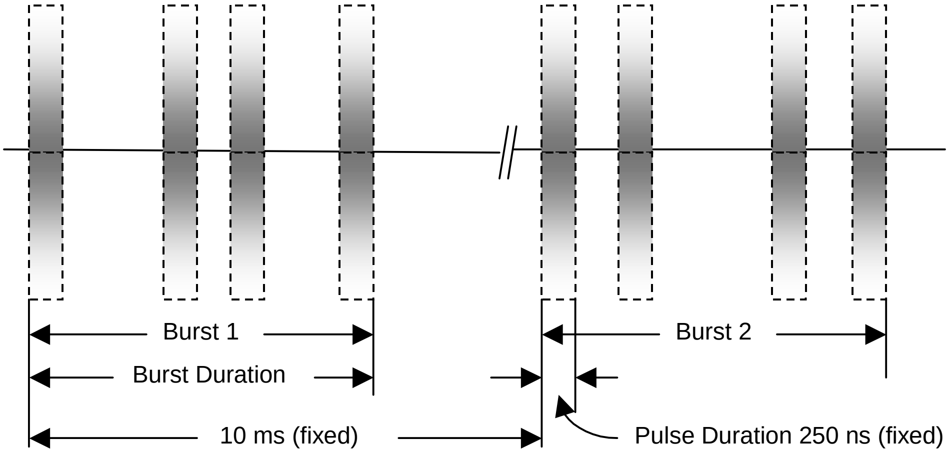
10.12.1 General

Impulse interference is different from other forms of interference, in that it is generated in short bursts. Sources include car ignition systems and domestic appliances such as switches and electric motors. In portable and mobile environment the impulse interference will reach the receiver directly through the antenna. The damage is potentially serious because a single impulse burst can destroy a complete symbol's worth of data. Research work on the impulse interference has been mainly carried out in the UK Digital Television Group. The specifications presented here are results of that work.

10.12.2 Test Patterns

Various test signals comprising gated bursts of Gaussian noise are defined. The theoretical tolerance of the standard receiver for these can be calculated as follows. The interference power is integrated over a symbol period; then the energy of the wanted signal within that symbol period is divided by this figure. Should the result fall below the minimum C/N requirement for the particular modulation mode, the system will fail.

Six different test patterns have been defined. The figure 6 illustrates the terminology used with the test patterns.



The number of pulses per burst is defined, but the spacing between pulses is allowed to vary randomly between given maximum and minimum values.

Figure 6: Definition of the impulse interference test pattern

Each burst is relatively short compared with the symbol period, so that most bursts only affect a single symbol. The separation between bursts is sufficiently great for them to behave as isolated events: any errors resulting from the first burst will have been flushed from the system by the time the second burst is received.

All pulses are generated by gating a Gaussian noise source of power P. Hence the noise energy in a burst is the product of P and the total duration of the gating pulses, Te, within the burst.

Since the total signal energy is the product of the carrier power, C, and the active symbol duration, Tu, the ratio of wanted signal energy to interference energy is

$$(C \times Tu) / (P \times Te) .$$

The theoretical failure point corresponds to this quantity equalling the minimum carrier-to-noise requirement, (C/N)ref, for the system. In other words, the tolerance of the receiver to the test signal should exceed its tolerance to ungated Gaussian noise by a factor (Tu / Te). This so-called "tolerance factor" is generally expressed in dB. Note that it is independent of modulation mode, receiver implementation margin and degradation criterion, but that the FFT-size affects it via the Tu duration, giving 6 dB higher figures for 8k than for 2k and 3 dB higher figures for 4k than 2k. In case the in-depth interleaver is used with 2k or 4k mode, the 8k tolerance factor should be used.

The tests so far defined are detailed in the table below, together with their associated "tolerance factors".

Table 23: Impulse Interference Test Patterns

Test No.	Pulses per Burst	Minimum/Maximum Pulse Spacing [us]		Burst Duration [us]	Tolerance Factor 2k [dB]	Tolerance Factor 4k [dB]	Tolerance Factor 8k [dB]
1	1	N/A	N/A	0,25	29,5	32,5	35,5
2	2	1,5	45	45,25	26,5	29,5	32,5
3	4	15,0	35	105,25	23,5	26,5	29,5
4	12	10,0	15	165,25	18,7	21,7	24,7
5	20	1,0	2	38,25	16,5	19,5	22,5
6	40	0,5	1	39,25	13,5	16,5	19,5

As an example, suppose that a receiver reaches "picture failure" when C/N = 18 dB with a 2k mode. The expected picture failure point for Test 2 then corresponds to a pulse power of -18 dBc + 26,5 dB, or +8,5 dBc. A convenient way of measuring the pulse power is to switch off the gating, so that the noise is present continuously.

A receiver which employs countermeasures against impulse interference should have tolerance factors in excess of those given in table 23 for one or more tests. The higher the Test Number, the greater the difficulty in designing effective countermeasures.

DVB-H receivers with MPE-FEC or receivers using the indepth interleavers with 4k or 2k are expected to have an improved performance against impulse interference over the DVB-T receivers."

Annex B: Field trials methodology

As part of the DVB-H Validation Task Force, the IST INSTINCT project partners performed a number of DVB-H tests in the laboratory and in the field, mainly in Berlin @ T-Systems and in Metz @ TDF RandD, which enabled a methodology for DVB-H field trials to be defined.

The methodology presented below has been used for the DVB-H VTF field trial session hosted in Metz in December 2004 and is suitable for further DVB-H investigations.

B.1 Objectives of field trials

B.1.1 Types of field trials

There are two main types of field trials for which specific objectives can be defined.

- Field Trials for the Validation of the DVB-H standard:
  - Evaluate the benefits of MPE-FEC error correction. Various DVB-H modes can be compared to evaluate the impact of other parameters, e.g. time slicing, on MPE-FEC performances.
  - Evaluate the benefits of time slicing for power saving.
  - Evaluate the benefits of a 4k mode and an in-depth interleaver.
  - Evaluate the performance of hand-over.
  - Define a reference DVB-H receiver (C/N, required received input power, polarization discrimination, max speed).
- Field Trials for the Validation of a DVB-H network plan:
  - Characterize the coverage (coverage map derivation).
  - Compare the actual coverage with predictions (comparison of field strength predictions with measured received input power).

B.1.2 Types of Analysis

To fulfil these objectives, the various types of analyses that can be conducted are:

- TEST #1: Derivation of the C/N (mean, std) required at the input of the terminal for a given reception mode, if possible for various speed ranges, with and without MPE-FEC correction.
- TEST #2: Derivation of the received input power (mean, std) required at the input of the terminal for a given reception mode, if possible for various speed ranges, with and without MPE-FEC correction.
- TEST #3: Derivation of the maximum speed of the terminal for a given reception mode, with and without MPE-FEC correction.
- TEST #4: Derivation of the coverage maps.
- TEST #5: Calibration of the coverage predictions.

	DVB-H standard validation				DVB-H network planning	
Type of Analysis	Benefits of MPE FEC	Benefits of time slicing	benefits of 4k & in-depth interleaver	Definition of reference DVB-H receiver	Characterisation of coverage	Calibration of predictions
C/N vs mode, speed	X		X	X		
Rx input power vs mode, speed	X		X	X		
Max speed of terminal	X					
Derivation of coverage maps					X	
Calibration of network predictions						X

Figure B.1: Types of tests vs objectives

B.1.3 Class of reception mode

There are four classes of reception mode:

Class	Reception Mode
A	Portable outdoor
B	Portable indoor
C	Mobile roof-top
D	Mobile in-car

Figure B.2: Classes of handheld reception

The field trials should cover all the classes of reception mode, except possibly class C that does not strictly correspond to a handheld terminal class as the antenna is not integrated in the receiver.

Since the speed (/Doppler) is known to have an impact on the quality of the reception, classes are then subdivided into sub-categories that take the speed into account. So as to have a large enough number of samples per sub-category while keeping the trials duration reasonable, only four sub-categories are defined:

Speed	Category
Below 10 km/h	Pedestrian
10 km/h to 50 km/h	Urban
50 km/h to 130 km/h	Highway
130 km/h to 300 km/h	High speed train

Figure B.3: Classes of speed

B.1.4 Configurable parameters

For each class of reception mode, it is possible to select the parameters of the configuration between:

DVB-T				DVB-H		
Mode	FEC	FFT	GI	MPE-FEC	MPE table rows	Time Slice Burst size
QPSK	1/2	2k	1/4	1/2	256	256kbit/s
16QAM	2/3	4k	1/8	2/3	512	512kbit/s
64QAM	3/4	8k	1/16	3/4	768	1Mbit/s
			1/32	4/5	1024	2Mbit/s
				5/6		
				7/8		

Figure B.4: Possible DVB-H configuration modes

This yields about 10 000 possibilities for the configuration of a typical DVB-H service.

The parameters highlighted in blue are those that should be tested and compared as a priority as they seem to be the most likely to be used in real networks.

B.2 Measurement criteria and failure point

B.2.1 Measurement criteria for DVB-H validation testing

B.2.1.1 MPE FER/MPE MFER

For a given time interval:

- MPE FER is the ratio of MPE tables erroneous BEFORE MPE-FEC correction.
- MPE MFER is the ratio of MPE tables erroneous AFTER MPE-FEC correction.

For every measurement interval, a set of measurements will be produced (Position, C/N, Rx Input Power, etc.). For this measurement interval:

The signal is considered a valid DVB-T signal if and only if MPE FER = 0 %
The signal is considered a valid DVB-H signal if and only if MPE MFER = 0 %

The failure point is set to 0 % as the measurement interval is by nature very short. It is not possible to set it to 5 % as this would require the measurement of a minimum of 20 cycles.

A 0 % MPE FER/MPE MFER failure point conveys the idea that, for a given location, the quality of the reception will be faultless for the next few seconds that the DVB-H cycle lasts.

Preliminary test validations in INSTINCT have presented a comparison of this criterion with BER 2.10-4 after Viterbi, based on real field data, showing the validity of such a criterion.

B.2.1.2 Measurement interval

The measurement interval is such that it should ensure that at least one full MPE table has been sent during this time interval.

In other words, the measurement interval should be equal to or a multiple of the burst cycle duration.

B.2.2 Measurement criteria for DVB-H network planning

For DVB-H network planning, it might be interesting to be even closer to the actual perception of the quality by the user. This could be possible by using longer observation periods.

A period of 20 seconds during which 5 % of the MPE tables or less are erroneous will correspond to a valid reception.

In this case, only network coverage maps can be derived as the estimates of C/N, received input power and to a lesser extent speed, will vary too much over such a time interval.

B.3 Measurement set-up

B.3.1 Transmission set-up

For DVB-H validation field trials, the transmission power should preferably be tuneable and set at reasonably low powers so that the limits of the system can be easily observed.

For DVB-H network validation field trials, the configuration of the transmission power should be that of the final commercial-like system.

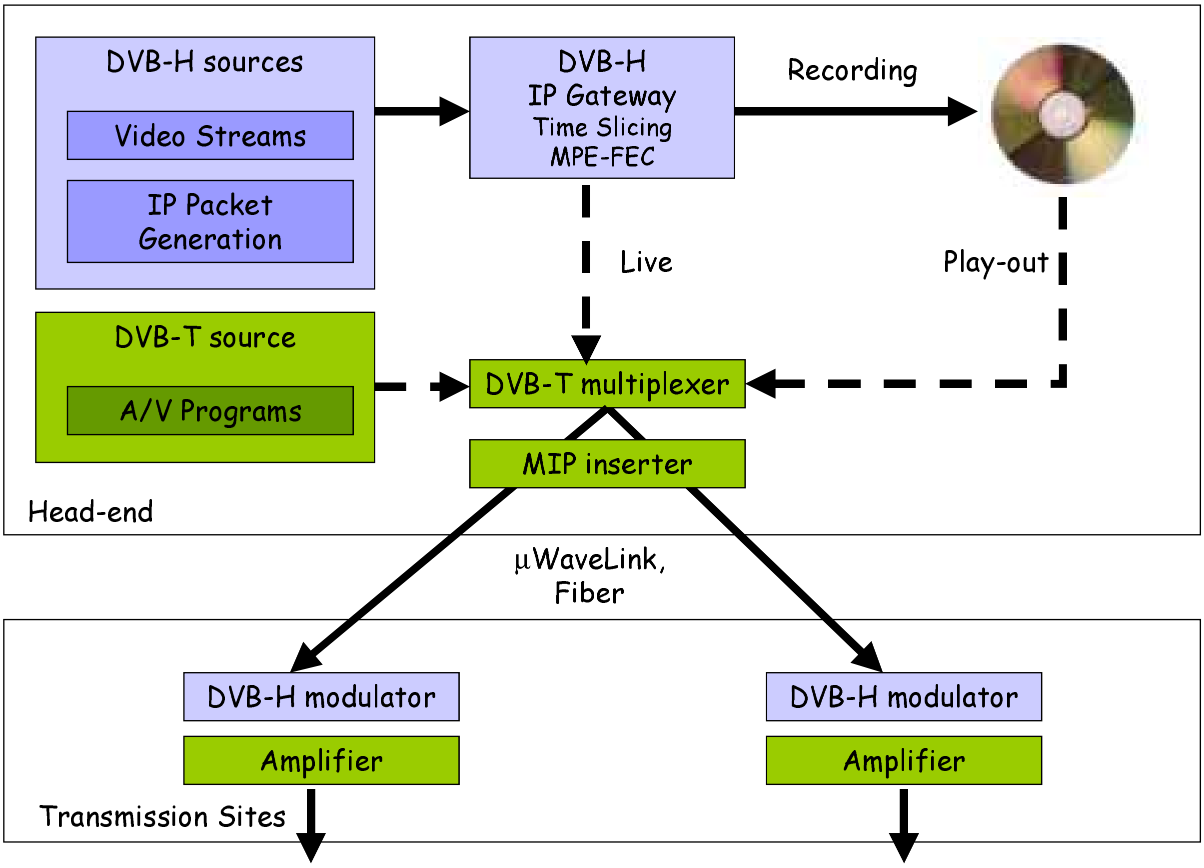


Figure B.5: Typical transmission set-up for field trials

For the generation of the DVB-H contribution to the multiplex, the stream can be generated then recorded and played out from a file or generated and used live as an input to the multiplexer.

B.3.2 End-to-End system testing

Before proceeding with any field trial, either in mobility or in pedestrian mode, it must be ensured that the set-up is valid for all the tested terminals.

In particular, it must be checked that:

- The terminal will indicate 0 % signal loss or disruption in perfect reception conditions.
- A video streaming application at typical bit rate (300 kbps) can properly be transmitted, decoded and displayed with this set-up in perfect conditions.
- In case of real MPE-FEC implementations, the video streaming application still displays a good image quality when the reception operates in the range where correction by the MPE-FEC is necessary. This verifies that the implementations of MPE-FEC are compliant and interoperable on both transmission and reception sides.

Additionally, for further use of the C/N and/or received input power, the calibration of the measurements made by the receiver should be verified so that the measurements made in the terminal can be considered valid. The precision of the measurements can also be assessed.

B.3.3 Mobile in-car reception

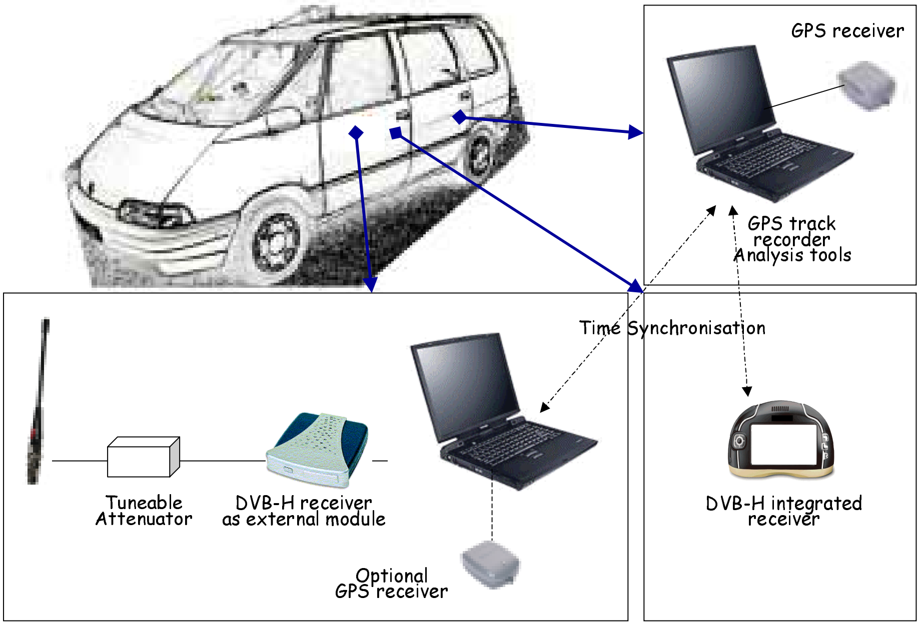


Figure B.6: Mobile in-car set-up

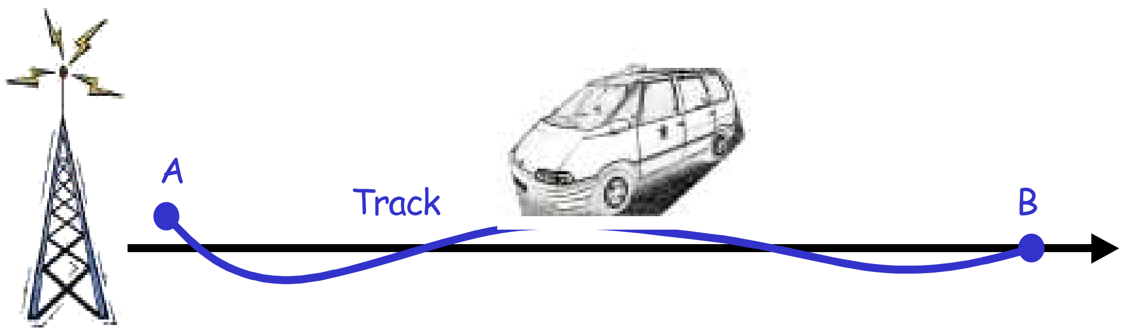


Figure B.7: Track for mobile in-car tests

Tests in mobility should be carried out along a track that remains along a beam of the transmission, rather than perpendicular to it so as to maximize the Doppler Effect.

As far as possible, it is recommended to start from a location close to the transmitter then gradually increase the distance from this transmitter until the reception is fully degraded.

For DVB-H validation tests, attenuators should be used to cover the whole range of received input power at the terminal. In this case, the vehicle should drive over the exact same track with 0 dB attenuation, 5 dB then 10 dB, etc., until a degraded signal is observed.

B.3.4 Pedestrian outdoor reception

For pedestrian outdoor reception, a similar set-up to the one used for mobile tests is used. The only difference is that it becomes difficult to have attenuators and GPS synchronization with external devices.

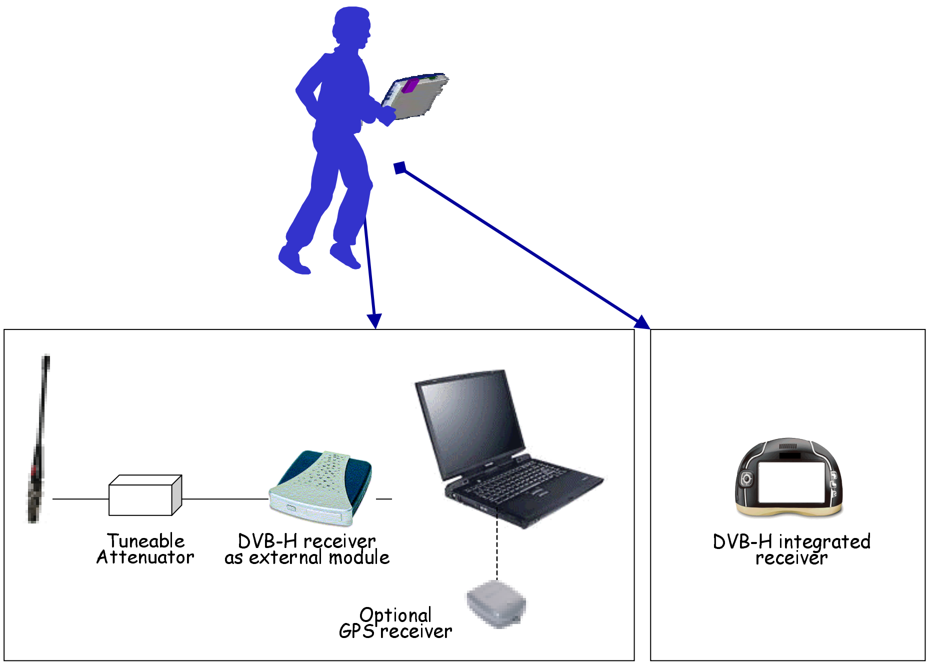


Figure B.8: Pedestrian outdoor tests

B.3.5 Pedestrian indoor reception

For a number of chosen locations, the reception is checked following a similar pattern in different rooms, at various levels of the buildings. The penetration losses between the roof-top and the floors below can be measured.

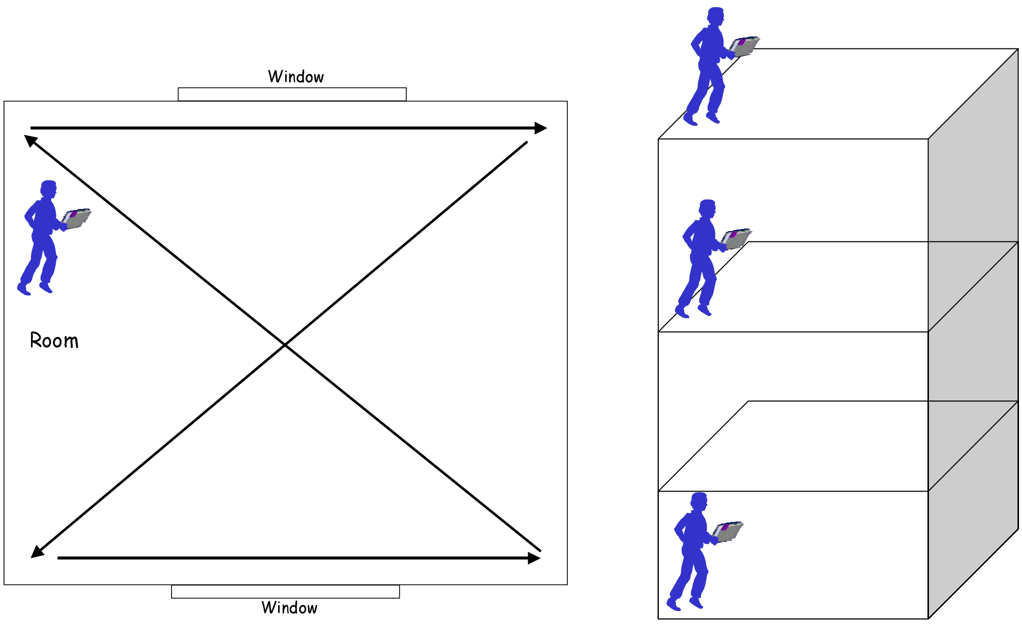


Figure B.9: Pedestrian indoor tests

B.3.6 Requirements on the terminal

Parameters
Date & Time Position Speed
C/N Rx Input Power
Total MPE tables received MPE Tables in error before correction MPE Tables in error after correction MPE FER MPE MFER

Figure B.10: Necessary parameters for recordings

If the terminal is not capable of recording its position it should record the date and time and be capable of synchronizing with an external unit (e.g. a PC) that will record the GPS track position information.

At least one set of measurements must be made for every time slice cycle.

B.4 Raw data analysis methodology

B.4.1 TEST #1: Derivation of required C/N

B.4.1.1 Required measurements

Measurements every second.

Speed (km/h)	C/N (dB)	MPE FER (%)	MPE MFER (%)
25	12,3	100	0

Figure B.11: Example of measurements required for C/N analysis

A precision of 1 dB should be achieved on C/N.

A precision of 10km/h should be achieved on the speed.

B.4.1.2 Processing of measurements

- Rounding of the C/N to the next integer value.
- Computing of speed category.

Speed (km/h)	C/N (dB)	MPE FER (%)	MPE MFER (%)	Speed Category	Rounded C/N (dB)
25	12,3	100	0	Urban	12

Figure B.12: Parameters derived from measurements for C/N analysis

B.4.1.3 Analysis

For all ranges of C/N between 0 and 25, and for a given speed category (pedestrian, urban, highway) the percentage of recorded measurements for which MPE FER/MPE MFER was valid (0 %) is plotted against the C/N value.

This should yield a figure as below:

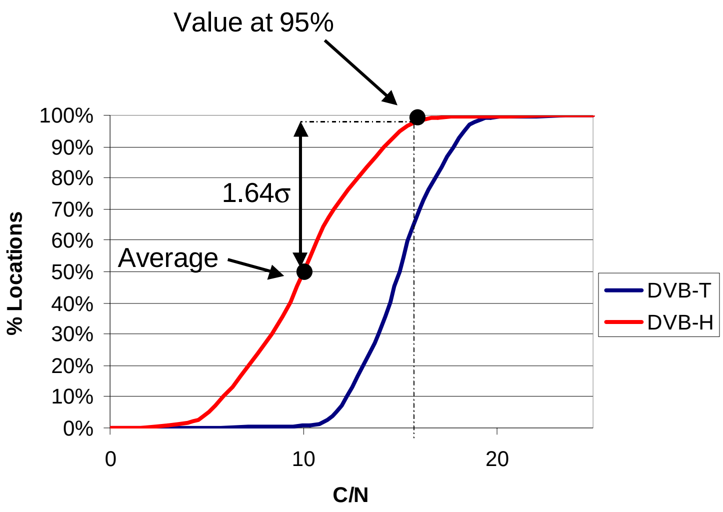


Figure B.13: Analysis of C/N measurements

For each 1 dB C/N range and speed category, it must be verified that there are **a minimum of 20 samples** so that the "%locations" can be accurately computed for this bin.

The average C/N required for a valid reception in DVB-T (MPE FER in blue) and DVB-H (MPE MFER in red) is the value of C/N where 50 % of the locations have been achieved.

Assuming a gaussian distribution of the required C/N, the standard deviation of C/N can then be computed as

$$std_{C/N} = \frac{C/N_{95\%} - C/N_{50\%}}{1,64}$$

B.4.1.4 Results

The results are expressed in terms of the mean C/N and the deviation of the required C/N as a function of the mode and speed so they can be compared to the lab measurements.

			Lab Results		Field Results	
DVB Mode	**Class of Reception**	**Speed Category**	**Model**	**Mean C/N (dB)**	**Mean C/N (dB)**	**Standard Deviation C/N (dB)**
QPSK, ½, 8k, MPE FEC 1/2	Class A Portable outdoor	Pedestrian (<10km/h)	Rayleigh	8	8	2
	Class D Mobile in-car	Pedestrian (<10km/h)	TU6 10Hz	8	8	2
		Urban (10-50km/h)	TU6 50Hz	8	10	2
		Highway (50-130km/h)	TU6 100Hz	8	10	3

Figure B.14: Example of formatted C/N test result

B.4.2 TEST #2: Derivation of required received input power

In the same way as the C/N values were derived, the required received input power can be measured.

B.4.2.1 Required measurements

Measurements every second.

Speed (km/h)	Received input power (dBm)	MPE FER (%)	MPE MFER (%)
25	-61,8	100	0

Figure B.15: Example of measurements required for C/N analysis

A precision of 3 dBm should be achieved on the received input power.

A precision of 10 km/h should be achieved on the speed.

B.4.2.2 Processing of measurements

- Rounding of the received input power to the next integer value *modulo 3* (3 dB precision).
- Computing of speed category.

Speed (km/h)	Received input power (dBm)	MPE FER (%)	MPE MFER (%)	Speed Category	Rounded C/N (dB)
25	-61,8	100	0	Urban	-63

Figure B.16: Parameters derived from received input power analysis

B.4.2.3 Analysis

For all 3 dBm ranges of received input powers between -100 dBm and -30 dBm, and for a given speed category (pedestrian, urban, highway) the percentage of recorded measurements for which MPE FER/MPE MFER was valid (0 %) is plotted against the received input power value. This should yield a figure as below:

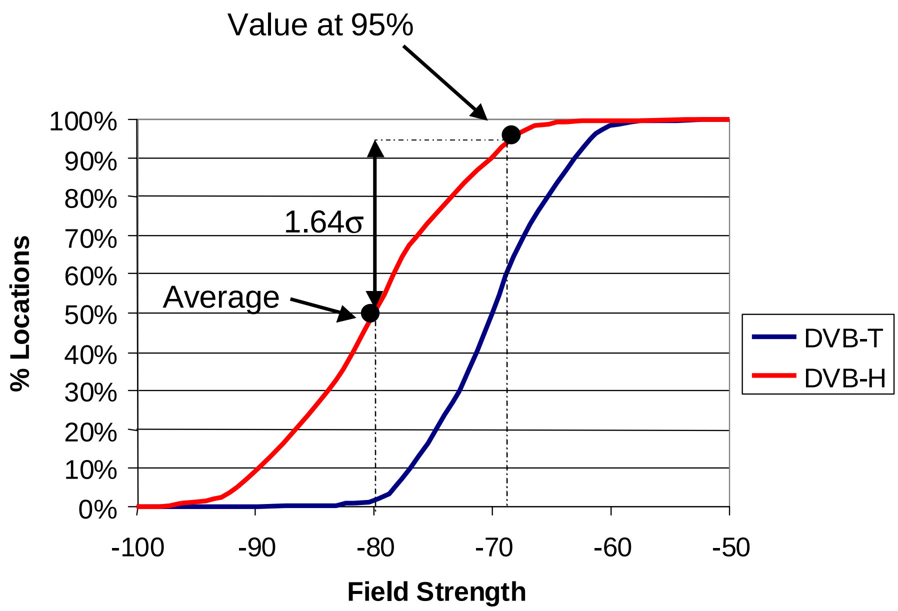


Figure B.17: Analysis of Received input power measurements

For each 3 dB received input power range and speed category, it must be verified that there are a minimum of 20 samples so that the "%locations" can be accurately computed for this bin.

The average received input power required for valid reception in DVB-T (MPE FER in blue) and DVB-H (MPE MFER in red) is the value of the receiver input power where 50 % of the locations have been achieved.

Assuming a gaussian distribution of the required receiver input power, the standard deviation of the receiver input power can then be computed as:

$$std_{RxInputPower} = \frac{RxInputPower_{95\%} - RxInputPower_{50\%}}{1{,}64}$$

B.4.2.4 Results

The results are expressed in terms of the mean received input power and the deviation of the required received input power as a function of the mode and speed so they can be compared to the lab measurements.

			Lab Results		Field Results	
DVB Mode	**Class of Reception**	**Speed Category**	**Model**	**Mean Rx Input Power (dB)**	**Mean Rx Input Power (dB)**	**Standard Deviation (dB)**
QPSK, ½, 8k, MPE FEC 1/2	Class A Portable outdoor	Pedestrian (<10km/h)	Rayleigh	-70	-66	8
	Class D Mobile in-car	Pedestrian (<10km/h)	TU6 10Hz	-60	-60	5
		Urban (10-50km/h)	TU6 50Hz	-55	-53	6
		Highway (50-130km/h)	TU6 100Hz	-55	-53	6

Figure B.18: Example of formatted received input power test results

B.4.3 TEST #3: Derivation of the maximum speed

B.4.3.1 Required measurements

Measurements every second.

Speed (km/h)	C/N (dB)	MPE FER (%)	MPE MFER (%)
25	12,3	100	0

Figure B.19: Example of measurements required for C/N analysis

A precision of 1 dB should be achieved on the C/N.

A precision of 10 km/h should be achieved on the speed.

B.4.3.2 Processing of measurements

Rounding of C/N to the next integer value.

Rounding of speed to the next integer value modulo 10.

Speed (km/h)	C/N (dB)	MPE FER (%)	MPE MFER (%)	Round Speed (km/h)	Rounded C/N (dB)
25	12,3	100	0	30	12

Figure B.20: Parameters derived from measurements for C/N analysis

B.4.3.3 Analysis

For all ranges of speeds, for each 1 dB C/N range, the probability of valid reception is represented by a colour ranging from dark red (0 % probability) to light green (100 % probability).

The probability that the reception is valid corresponds to the percentage of measurements made for this category of speed and C/N value such that MPE FER/MPE MFER was valid (0 %).

For every bin [10 km/h speed, 1 dB C/N], at least 20 measurements must be obtained. A plot of the number of measurements per bin can also be useful to ensure that a critical number of measurements have been obtained.

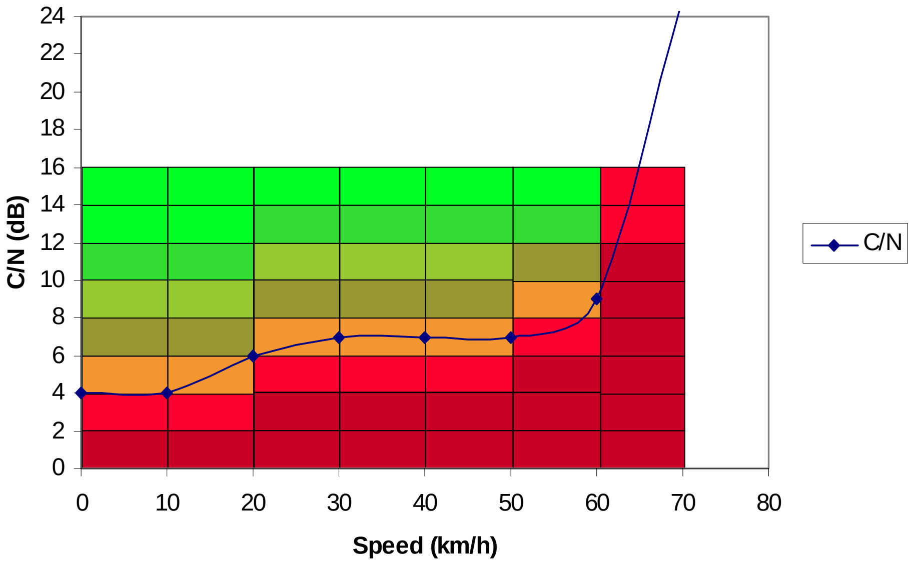


Figure B.21: Analysis of speed

Then the 50 % probability limit (orange colour) can be observed from the graph, yielding a blue curve of average required C/N value to ensure valid reception at a given speed.

The maximum speed for DVB-T and DVB-H can then be visually assessed reasonably easily if it was achieved for DVB-T and DVB-H respectively.

B.4.4 TEST #4: Derivation of coverage maps

B.4.4.1 Required measurements

Measurements every second.

Date and Time	Speed (km/h)	Position	Rx Input Power (dBm)	MPE FER (%)	MPE MFER (%)
11 Nov 2004 14:00	25	45,5 N 6,5 W	-65	100	0

Figure B.22: Example of measurements required for C/N analysis

A precision of 1 dB should be achieved on the C/N.

A precision of 10 km/h should be achieved on the speed.

B.4.4.2 Processing of measurements and visualization

If the position is not given by the DVB-H receiver, it is required that the receiver be synchronized with an additional GPS position recorder so that only time indication is sufficient to derive the position for every date and time.

To compare DVB-T and DVB-H reception, a rendering of MPE FER and MPE MFER can be done as follows:

MPE MFER > 0 %: MPE table(s) received but not fully corrected after FEC decoding or not received at all.

MPE MFER = 0 %, MPE FER > 0 %: Erroneous MPE table(s) received and fully corrected after FEC decoding.

MPE FER = 0 %, MPE table(s) received and error-free.

On other words, when the reception is valid in DVB-T, the location will be marked in light green.

- When the reception is valid in DVB-H (with MPE-FEC) but not in DVB-T, the location will be marked in dark green.
- When the reception is not valid even in DVB-H, it is marked in red.

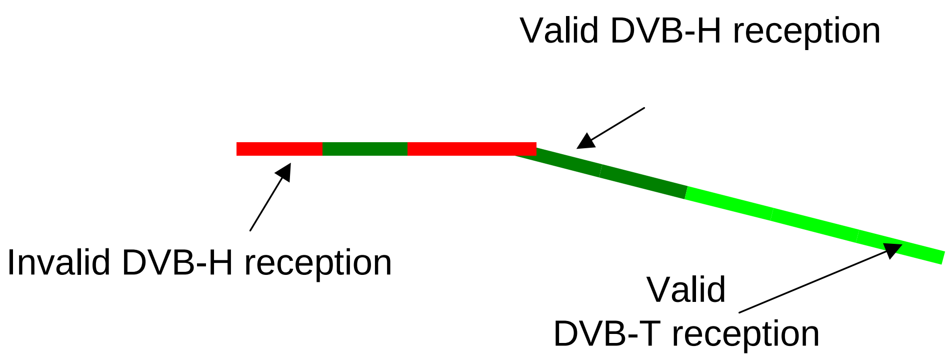


Figure B.23: Coverage map with DVB-T/DVB-H comparison

B.4.5 TEST #5: Calibration of network predictions

B.4.5.1 Required measurements

Measurements every second.

Date and Time	Speed (km/h)	Position	Rx Input Power (dBm)	MPE FER (%)	MPE MFER (%)
11 Nov 2004 14:00	25	45,5 N 6,5 W	-65	100	0

Figure B.24: Example of measurements required for C/N analysis

A precision of 1 dB should be achieved on the C/N.

A precision of 10 km/h should be achieved on the speed.

B.4.5.2 Processing of measurements and visualization

If the position is not given by the DVB-H receiver, it is required that the receiver be synchronized with an additional GPS position recorder so that the time indication is sufficient to derive the position for every date and time.

For each measurement, computing of the difference between the field strength predicted and the observed Rx input power.

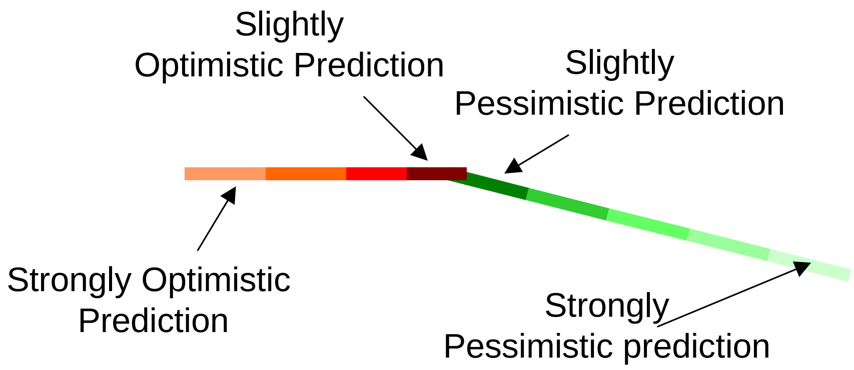


Figure B.25: Rendering of field strength predictions vs measured Rx power

The colour indicates how different the prediction was from the reality.

- When the colour is green, the prediction is pessimistic so that the result is better in real life.
- When the colour is red, the prediction is optimistic so that the result is worse in real life.

Annex C: Lab tests - raw data

DVB-H HANDHELD VALIDATION TASK FORCE

Performance in STATIC channels

HRX_5

AWGN	DVB-T ESR 5%: QEF	DVB-T ESR 5%: ESR5	DVB-T ESR 5%: DVB-H FER 5%	DVB-T ESR 5%: DVB-H MFER 5%	DVB-T @ QEF: AWGN
8k 1/4 QPSK 1/2	4,0 dB	3,0 dB	3,0 dB	2,5 dB	**3,1 dB**
8k 1/4 QPSK 2/3	5,0 dB	4,5 dB	4,5 dB	4,0 dB	**4,9 dB**
8k 1/4 16QAM 1/2	8,5 dB	8,0 dB	8,0 dB	7,5 dB	**8,8 dB**
8k 1/4 16QAM 2/3	11,0 dB	10,5 dB	10,5 dB	10,0 dB	**11,1 dB**

Rayleigh	DVB-H FER 5%: QEF	DVB-H FER 5%: ESR5	DVB-H FER 5%: DVB-H FER 5%	DVB-H FER 5%: DVB-H MFER 5%	DVB-T @ QEF: Rayleigh
8k 1/4 QPSK 1/2	6,0 dB	5,0 dB	5,0 dB	5,5 dB	**5,4 dB**
8k 1/4 QPSK 2/3	9,0 dB	8,0 dB	8,0 dB	7,5 dB	**8,4 dB**
8k 1/4 16QAM 1/2	11,0 dB	10,5 dB	10,5 dB	10,0 dB	**11,2 dB**
8k 1/4 16QAM 2/3	14,0 dB	13,5 dB	13,5 dB	13,0 dB	**14,2 dB**

Rice
8k 1/4 QPSK 1/2
8k 1/4 QPSK 2/3
8k 1/4 16QAM 1/2
8k 1/4 16QAM 2/3

Performance in MOBILE channels

Effect of modulation

DVB-T ESR 5%

Effect of modulation	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	130 Hz	14,0 dB	125 Hz	12,0 dB	11,5 dB	10,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	120 Hz	18,0 dB	100 Hz	16,0 dB	15,0 dB	14,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	100 Hz	25,0 dB	100 Hz	19,0 dB	18,5 dB	17,5 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	100 Hz	26,0 dB	80 Hz	23,5 dB	22,0 dB	20,0 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	500 Hz	13,5 dB	480 Hz	13,0 dB	12,0 dB	10,5 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	330 Hz	26,0 dB	280 Hz	23,5 dB	22,0 dB	20,0 dB

DVB-H FER 5%

Effect of modulation	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	130 Hz	13,5 dB	125 Hz	12,5 dB	11,5 dB	10,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	120 Hz	18,0 dB	100 Hz	16,0 dB	15,0 dB	14,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	120 Hz	19,0 dB	100 Hz	18,5 dB	16,5 dB	16,5 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	105 Hz	23,5 dB	85 Hz	21,0 dB	19,5 dB	19,0 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	500 Hz	13,5 dB	480 Hz	13,0 dB	12,0 dB	10,5 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	390 Hz	24,0 dB	350 Hz	21,5 dB	20,5 dB	19,5 dB

Effect of modulation	Fd Max	Fd Max / 3
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	130 Hz	7,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	130 Hz	11,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	120 Hz	13,5 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	120 Hz	16,5 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	590 Hz	9,0 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	510 Hz	17,5 dB

Effect of MPE-FEC code rate

DVB-H MFER 5%

Effect of MPE-FEC code rate	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (FEC: 1/2)	120 Hz	15,5 dB	120 Hz	15,0 dB	17,0 dB	17,5 dB
8k 1/4 16QAM 2/3 (FEC: 2/3)	120 Hz	16,5 dB	120 Hz	16,0 dB	17,0 dB	17,5 dB
8k 1/4 16QAM 2/3 (FEC: 3/4)	120 Hz	16,5 dB	120 Hz	16,5 dB	16,5 dB	17,5 dB
8k 1/4 16QAM 2/3 (FEC: 5/6)	120 Hz	18,0 dB	120 Hz	17,5 dB	18,5 dB	18,5 dB
8k 1/4 16QAM 2/3 (FEC: 7/8)	120 Hz	18,0 dB	120 Hz	18,0 dB	19,0 dB	18,5 dB

Effect of burst length

DVB-T ESR 5%

Effect of burst length	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (3/4) 256 [xx%] 500 ms						
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms						
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms						
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms						
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms						

DVB-H FER 5%

Effect of burst length	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (3/4) 256 [xx%] 500 ms						
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms						
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms						
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms						
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms						

Effect of burst length	Fd Max	Fd Max / 3
8k 1/4 16QAM 2/3 (3/4) 256 [xx%] 500 ms	120 Hz	17,0 dB
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms	120 Hz	16,5 dB
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms	120 Hz	17,0 dB
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms	120 Hz	17,0 dB
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms	120 Hz	17,0 dB

Impulse noise measurements

8k 1/4 16QAM 2/3 (3/4) 1024 500ms

	DTG2		DTG3		DTG4		DTG5		DTG6	
	no FEC	FEC	no FEC	FEC	no FEC	FEC	no FEC	FEC	no FEC	FEC
I/C AWGN	>50 dB	>50 dB	42 dB	>50 dB	17 dB	24 dB	13 dB	16 dB	9 dB	11 dB
I/C Rayleigh	>40 dB	>40 dB	24 dB	38 dB	-	-	8 dB	11 dB	5 dB	8 dB
I/C TU6 (10Hz)	16 dB	>40 dB	10 dB	>40 dB	-	-	2 dB	11 dB	-2 dB	7 dB

2k 1/4 16QAM 2/3 (3/4) 1024 500ms

	DTG2		DTG3		DTG4		DTG5		DTG6	
	no FEC	FEC	no FEC	FEC	no FEC	FEC	no FEC	FEC	no FEC	FEC
I/C AWGN	16 dB	33 dB	10 dB	19 dB	5 dB	10 dB	3 dB	6 dB	1 dB	2 dB
I/C Rayleigh	9 dB	21 dB	7 dB	13 dB	-	-	0 dB	3 dB	0 dB	3 dB
I/C TU6 (10Hz)	7 dB	23 dB	3 dB	14 dB	-	-	-4 dB	3 dB	-4 dB	3 dB

Figure C.1

DVB-H HANDHELD VALIDATION TASK FORCE

Performance in STATIC channels

HRX_2

AWGN	DVB-T ESR 5% QEF	DVB-T ESR 5% ESR5	DVB-H FER 5%	DVB-H MFER 5%	DVB-T @ QEF AWGN
8k 1/4 QPSK 1/2	5,6 dB	4,7 dB	4,7 dB	4,2 dB	3,1 dB
8k 1/4 QPSK 2/3	7,1 dB	6,3 dB	6,3 dB	5,8 dB	4,9 dB
8k 1/4 16QAM 1/2	11,2 dB	9,9 dB	9,9 dB	9,3 dB	8,8 dB
8k 1/4 16QAM 2/3	13,3 dB	12,2 dB	12,2 dB	11,6 dB	11,1 dB

Rayleigh	QEF	ESR5	DVB-H FER 5%	DVB-H MFER 5%	DVB-T @ QEF Rayleigh
8k 1/4 QPSK 1/2	8,8 dB	7,6 dB	7,6 dB	6,7 dB	5,4 dB
8k 1/4 QPSK 2/3	11,4 dB	10,4 dB	10,4 dB	9,7 dB	8,4 dB
8k 1/4 16QAM 1/2	14,4 dB	12,7 dB	12,7 dB	11,7 dB	11,2 dB
8k 1/4 16QAM 2/3	17,8 dB	16,0 dB	16,0 dB	15,1 dB	14,2 dB

Rice
8k 1/4 QPSK 1/2
8k 1/4 QPSK 2/3
8k 1/4 16QAM 1/2
8k 1/4 16QAM 2/3

Performance in MOBILE channels

Effect of modulation

DVB-T ESR 5%

Effect of modulation	Fd Max	Fd Max / 3	3 dB	10 Hz	2 Hz	1 Hz
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	80 Hz	16,5 dB	75 Hz	15,5 dB	15,0 dB	14,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	75 Hz	20,5 dB	60 Hz	20,0 dB	17,0 dB	17,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	55 Hz	22,5 dB	50 Hz	21,0 dB	21,0 dB	20,0 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	310 Hz	17,0 dB	300 Hz	16,0 dB	14,5 dB	14,5 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	135 Hz	27,0 dB	105 Hz	25,0 dB	23,5 dB	22,5 dB

DVB-H FER 5%

Effect of modulation	Fd Max	Fd Max / 3	3 dB	10 Hz	2 Hz	1 Hz
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	80 Hz	16,5 dB	75 Hz	15,5 dB	15,0 dB	14,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	75 Hz	20,5 dB	60 Hz	20,5 dB	17,0 dB	17,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	55 Hz	22,5 dB	50 Hz	21,0 dB	21,0 dB	20,0 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	310 Hz	17,0 dB	300 Hz	16,0 dB	14,5 dB	14,5 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	135 Hz	27,0 dB	105 Hz	25,0 dB	23,5 dB	22,5 dB

Effect of modulation	Fd Max	Fd Max / 3
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	100 Hz	10,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	95 Hz	12,5 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4	90 Hz	15,5 dB
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	80 Hz	18,5 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4	410 Hz	10,5 dB
2k 1/4 16QAM 2/3 (30%) - FEC:3/4	325 Hz	19,0 dB

Effect of MPE-FEC code rate

DVB-H MFER 5%

Effect of MPE-FEC code rate	Fd Max	Fd Max / 3	3 dB	10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (FEC: 1/2)						
8k 1/4 16QAM 2/3 (FEC: 2/3)	85 Hz	18,0 dB	75 Hz	18,0 dB	19,0 dB	19,0 dB
8k 1/4 16QAM 2/3 (FEC: 3/4)	80 Hz	18,5 dB	75 Hz	18,5 dB	19,5 dB	20,0 dB
8k 1/4 16QAM 2/3 (FEC: 5/6)	80 Hz	19,5 dB	70 Hz	19,5 dB	21,0 dB	21,0 dB
8k 1/4 16QAM 2/3 (FEC: 7/8)	75 Hz	20,0 dB	70 Hz	20,0 dB	21,5 dB	21,5 dB

Effect of burst length

DVB-T ESR 5%

Effect of burst length	Fd Max	Fd Max / 3	3 dB	10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (3/4) 1024 [15%] 1s	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms	35 Hz	26,5 dB	30 Hz	24,5 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB

DVB-H FER 5%

Effect of burst length	Fd Max	Fd Max / 3	3 dB	10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (3/4) 1024 [15%] 1s	35 Hz	26,5 dB	30 Hz	25,5 dB	24,0 dB	23,0 dB
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms	35 Hz	26,5 dB	30 Hz	24,0 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms	35 Hz	26,5 dB	30 Hz	24,5 dB	23,5 dB	22,5 dB
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms	40 Hz	25,5 dB	35 Hz	24,0 dB	22,5 dB	22,0 dB
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms	40 Hz	26,5 dB	35 Hz	23,5 dB	22,5 dB	21,0 dB

Effect of burst length	Fd Max	Fd Max / 3
8k 1/4 16QAM 2/3 (3/4) 1024 [15%] 1s	80 Hz	18,5 dB
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms	80 Hz	18,5 dB
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms	80 Hz	18,5 dB
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms	80 Hz	18,5 dB
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms	80 Hz	19,0 dB

Impulse noise measurements

8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms

	DTG1		DTG3		DTG6	
	no FEC	FEC	no FEC	FEC	no FEC	FEC
AWGN	41 dB	42 dB	40 dB	42 dB	11 dB	17 dB
I/C Rayleigh	37 dB	38 dB	34 dB	38 dB	6 dB	11 dB
TU6 - 10Hz	28 dB	36 dB	13 dB	35 dB	-1 dB	14 dB

4k 1/4 16QAM 2/3 1024 [30%] 500ms

"ESR5", NoFEC	DTG1		DTG3		DTG6	
	native	ind	native	ind	native	ind
4k - I/C AWGN	54 dB	57 dB	38 dB	48 dB	21 dB	24 dB
8k ref	60 dB		51 dB		28 dB	

4k 1/4 16QAM 2/3 1024 [30%] 500ms

	DTG1		DTG3		DTG6	
FEC (1024, 3/4)	native	ind	native	ind	native	ind
4k - I/C AWGN	57 dB	60 dB	54 dB	56 dB	25 dB	27 dB

Figure C.2

DVB-H VALIDATION TASK FORCE

Performance in STATIC channels

HRX_7	DVB-T ESR 5%					DVB-T @ QEF	DVB-H FER 5%					DVB-T @ QEF	
	AWGN	QEF	ESR5	DVB-H FER 5%	DVB-H MFER 5%	AWGN	Rayleigh	QEF	ESR5	DVB-H FER 5%	DVB-H MFER 5%	Rayleigh	Rice
	8k 1/4 QPSK 1/2	4,5 dB	3,5 dB		3,0 dB	3,1 dB	8k 1/4 QPSK 1/2					5,4 dB	8k 1/4 QPSK 1/2
	8k 1/4 QPSK 2/3	6,0 dB	5,0 dB		4,5 dB	4,9 dB	8k 1/4 QPSK 2/3	10,5 dB	9,0 dB		8,5 dB	8,4 dB	8k 1/4 QPSK 2/3
	8k 1/4 16QAM 1/2					8,8 dB	8k 1/4 16QAM 1/2					11,2 dB	8k 1/4 16QAM 1/2
	8k 1/4 16QAM 2/3	12,3 dB	11,4 dB	11,4 dB	10,6 dB	11,1 dB	8k 1/4 16QAM 2/3	16,0 dB	14,5 dB	14,5 dB	13,5 dB	14,2 dB	8k 1/4 16QAM 2/3

Performance in MOBILE channels

Effect of modulation

	DVB-T ESR 5%						DVB-H FER 5%							
Effect of modulation	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz	Fd Max	Fd Max / 3 dB		5 Hz	2 Hz	1 Hz	Fd Max	Fd Max / 3
8k 1/4 QPSK 1/2 (80%) - FEC:3/4	13 Hz	14,5 dB	11 Hz	14,5 dB	12,5 dB	12,0 dB	13 Hz	14,5 dB	11 Hz	14,5 dB	12,5 dB	12,0 dB	18 Hz	6,5 dB
8k 1/4 QPSK 2/3 (60%) - FEC:3/4	13 Hz	20,0 dB	10 Hz	17,5 dB	16,0 dB	15,0 dB	13 Hz	20,0 dB	10 Hz	17,5 dB	16,0 dB	15,0 dB	18 Hz	10,0 dB
8k 1/4 16QAM 1/2 (40%) - FEC:3/4														
8k 1/4 16QAM 2/3 (30%) - FEC:3/4	12 Hz	28,0 dB	9 Hz	24,0 dB	23,0 dB	21,5 dB	12 Hz	28,0 dB	9 Hz	24,0 dB	23,0 dB	21,5 dB	16 Hz	15,3 dB
2k 1/4 QPSK 1/2 (80%) - FEC:3/4														
2k 1/4 16QAM 2/3 (30%) - FEC:3/4														

Effect of MPE-FEC code rate

	DVB-H MFER 5%					
Effect of MPE-FEC code rate	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz
8k 1/4 16QAM 2/3 (FEC: 1/2)						
8k 1/4 16QAM 2/3 (FEC: 2/3)						
8k 1/4 16QAM 2/3 (FEC: 3/4)						
8k 1/4 16QAM 2/3 (FEC: 5/6)						
8k 1/4 16QAM 2/3 (FEC: 7/8)						

Effect of burst length

	DVB-T ESR 5%						DVB-H FER 5%							
Effect of burst length	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz	Fd Max	Fd Max / 3 dB		10 Hz	2 Hz	1 Hz	Fd Max	Fd Max / 3
8k 1/4 16QAM 2/3 (3/4) 1024 [15%] 1s														
8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms														
8k 1/4 16QAM 2/3 (3/4) 768 [30%] 375ms														
8k 1/4 16QAM 2/3 (3/4) 512 [30%] 250ms														
8k 1/4 16QAM 2/3 (3/4) 256 [30%] 125ms														

Impulse noise measurements

8k 1/4 16QAM 2/3 (3/4) 1024 [30%] 500ms		DTG1		DTG3		DTG6	
		FER5	MFER5	FER5	MFER5	FER5	MFER5
(SFQ)	I/C AWGN						
	I/C TU6 (10Hz)						
	I/C Rayleigh						

4k 1/4 16QAM 2/3 1024 [30%] 500ms	"ESR5", NoFEC	DTG1		DTG3		DTG6	
		native	ind	native	ind	native	ind
	4k - I/C AWGN						
(AGC corrected)	8k ref						

4k 1/4 16QAM 2/3 1024 [30%] 500ms		DTG1		DTG3		DTG6	
	FEC (1024, 3/4)	native	ind	native	ind	native	ind
	4k - I/C AWGN						

Figure C.3

Annex D: Field trials - Raw data

Validation Task Force				Field Trials performed by TDF in Metz (from 13th to 16th December 2004)				(C/N for 50%) and (C/N for 95%) of coverage probability			
Transmission Format		**Burst Shape**		**Speed Category**	**Environment**	**Criteria**	**Level**	**Terminal A**	**Terminal B**	**Terminal C**	**Terminal D**
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Urban	DVB-T (FER)	C/N 50%	8,5 dB	14,0 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Urban		C/N 95%	21,0 dB	20,0 dB		Not computed
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Urban	DVB-H (MFER)	C/N 50%	4,0 dB	11,0 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Urban		C/N 95%	15,0 dB	13,5 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Highway	DVB-T (FER)	C/N 50%	13,0 dB	16,0 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Highway		C/N 95%	21,0 dB	24,0 dB		Not computed
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Highway	DVB-H (MFER)	C/N 50%	8,0 dB	11,0 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Mobile	Highway		C/N 95%	15,0 dB	14,5 dB		
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban	DVB-T (FER)	C/N 50%	6,0 dB	12,5 dB	15,5 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban		C/N 95%	11,0 dB	15,5 dB	19,0 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban	DVB-H (MFER)	C/N 50%	5,0 dB	10,5 dB	13,5 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban		C/N 95%	9,0 dB	12,0 dB	17,0 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Urban	DVB-T (FER)	C/N 50%	7,0 dB	14,0 dB	17,0 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Urban		C/N 95%	13,0 dB	19,0 dB	23,0 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Urban	DVB-H (MFER)	C/N 50%	4,0 dB	10,5 dB	13,5 dB	
8K 1/4	QPSK 1/2	MPE-FEC 3/4	rows 1024	Pedestrian	Urban		C/N 95%	7,5 dB	13,5 dB	16,5 dB	
Transmission Format		**Burst Shape**		**Speed Category**	**Environment**	**Criteria**	**Level**	**Terminal A**	**Terminal B**	**Terminal C**	**Terminal D**
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Urban	DVB-T (FER)	C/N 50%	24,0 dB	23,0 dB	30,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Urban		C/N 95%	??	35,0 dB	??	Not computed
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Urban	DVB-H (MFER)	C/N 50%	16,0 dB	18,0 dB	21,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Urban		C/N 95%	24,0 dB	21,0 dB	27,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Highway	DVB-T (FER)	C/N 50%	21,0 dB	26,5 dB	24,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Highway		C/N 95%	29,0 dB	??	??	Not computed
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Highway	DVB-H (MFER)	C/N 50%	16,0 dB	18,5 dB	16,5 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Mobile	Highway		C/N 95%	23,0 dB	25,0 dB	21,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban	DVB-T (FER)	C/N 50%	15,5 dB	20,5 dB	24,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban		C/N 95%	19,0 dB	28,0 dB	29,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban	DVB-H (MFER)	C/N 50%	14,0 dB	17,5 dB	20,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Sub-urban		C/N 95%	17,0 dB	21,0 dB	24,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Urban	DVB-T (FER)	C/N 50%	17,5 dB	24,5 dB	25,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Urban		C/N 95%	24,0 dB	34,0 dB	29,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Urban	DVB-H (MFER)	C/N 50%	14,0 dB	18,0 dB	20,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Urban		C/N 95%	19,0 dB	22,0 dB	26,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Indoor	DVB-T (FER)	C/N 50%	14,5 dB	26,0 dB	31,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Indoor		C/N 95%	20,0 dB	39,0 dB	??	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Indoor	DVB-H (MFER)	C/N 50%	13,5 dB	18,0 dB	21,0 dB	
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 1024	Pedestrian	Indoor		C/N 95%	17,0 dB	26,0 dB	31,0 dB	
Transmission Format		**Burst Shape**		**Speed Category**	**Environment**	**Criteria**	**Level**	**Terminal A**	**Terminal B**	**Terminal C**	**Terminal D**
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Urban	DVB-T (FER)	C/N 50%	26,0 dB	26,0 dB		
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Urban		C/N 95%	30,0 dB	??		Not computed
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Urban	DVB-H (MFER)	C/N 50%	22,0 dB	21,0 dB		
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Urban		C/N 95%	29,0 dB	27,0 dB		
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Highway	DVB-T (FER)	C/N 50%	19,0 dB	See results above		
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Highway		C/N 95%	28,0 dB	combining urban		Not computed
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Highway	DVB-H (MFER)	C/N 50%	15,5 dB	and highway		
8K 1/4	16QAM 2/3	MPE-FEC 7/8	rows 1024	Mobile	Highway		C/N 95%	22,0 dB			
Transmission Format		**Burst Shape**		**Speed Category**	**Environment**	**Criteria**	**Level**	**Terminal A**	**Terminal B**	**Terminal C**	**Terminal D**
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Urban	DVB-T (FER)	C/N 50%	23,0 dB	25,5 dB		
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Urban		C/N 95%	28,0 dB	??		Not computed
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Urban	DVB-H (MFER)	C/N 50%	18,0 dB	20,0 dB		
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Urban		C/N 95%	24,0 dB	26,0 dB		
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Highway	DVB-T (FER)	C/N 50%	16,0 dB	See results above		
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Highway		C/N 95%	23,0 dB	combining urban		Not computed
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Highway	DVB-H (MFER)	C/N 50%	14,0 dB	and highway		
8K 1/4	16QAM 2/3	MPE-FEC 3/4	rows 256	Mobile	Highway		C/N 95%	17,5 dB			

Figure D.1: Field Trials summary of measurements

DVB-H HANDHELD Validation Task Force	8K 1/4	QPSK 1/2	MPE-FEC 3/4	1024 rows

MOBILE URBAN (up to 50 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception

Terminal A	Terminal B

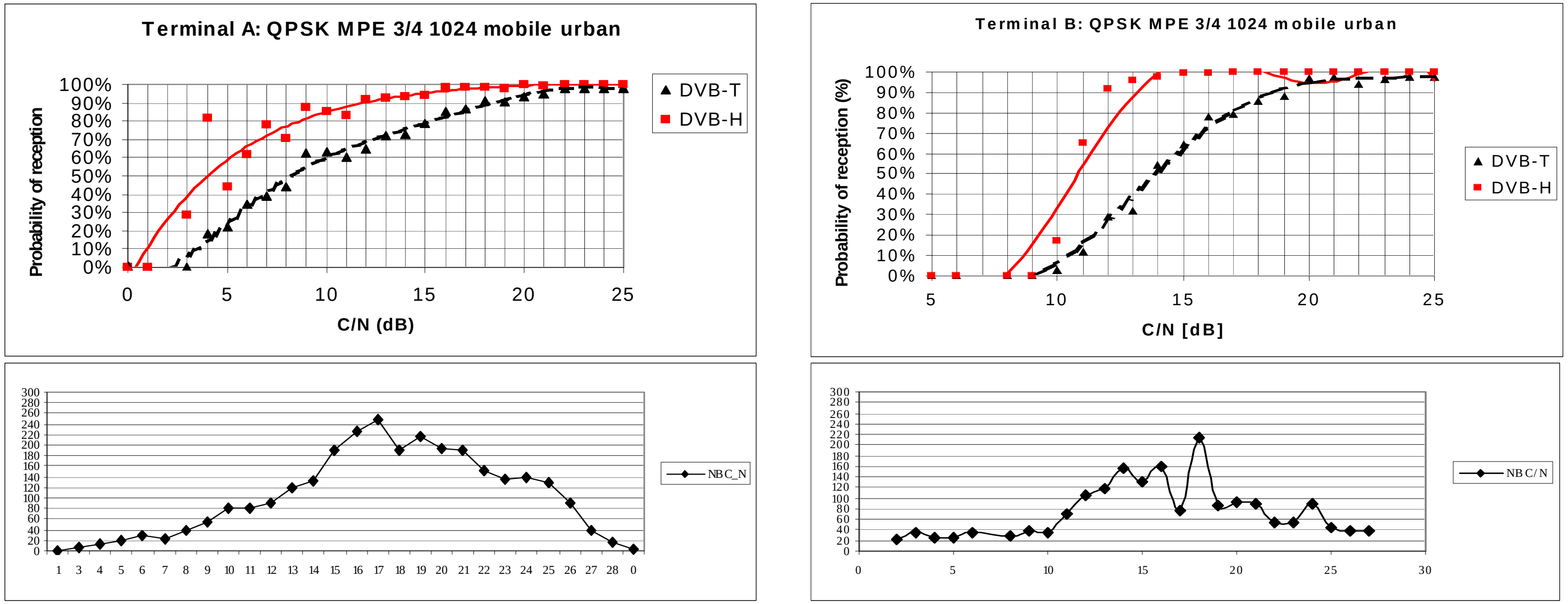


Figure D.2

DVB-H HANDHELD	Validation Task Force	8K 1/4	QPSK 1/2	MPE-FEC 3/4	1024 rows
MOBILE HIGHWAY (up to 130 km/h)		(following curves provides "Probality of Reception vs C/N" and "Number of good reception			
Terminal A		Terminal B			

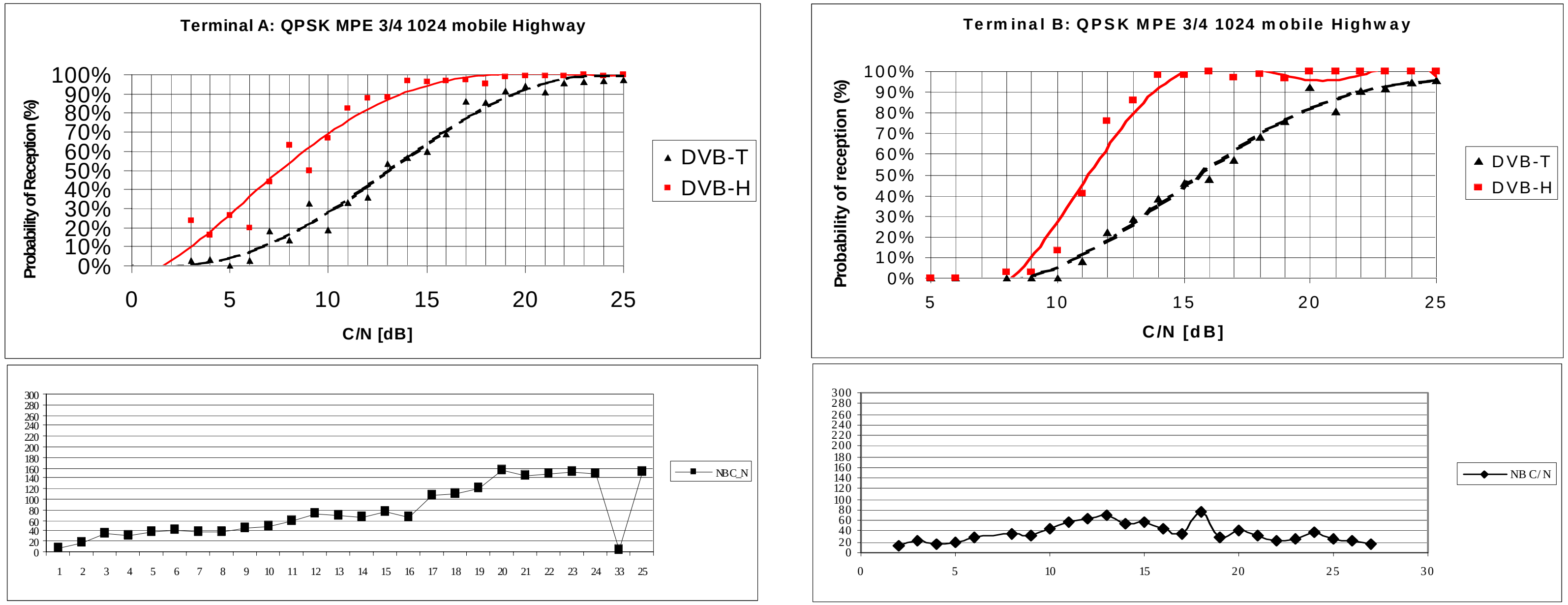


Figure D.3

DVB-H HANDHELD Validation Task Force	8K 1/4	QPSK 1/2	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

PEDESTRIAN SUB-URBAN (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

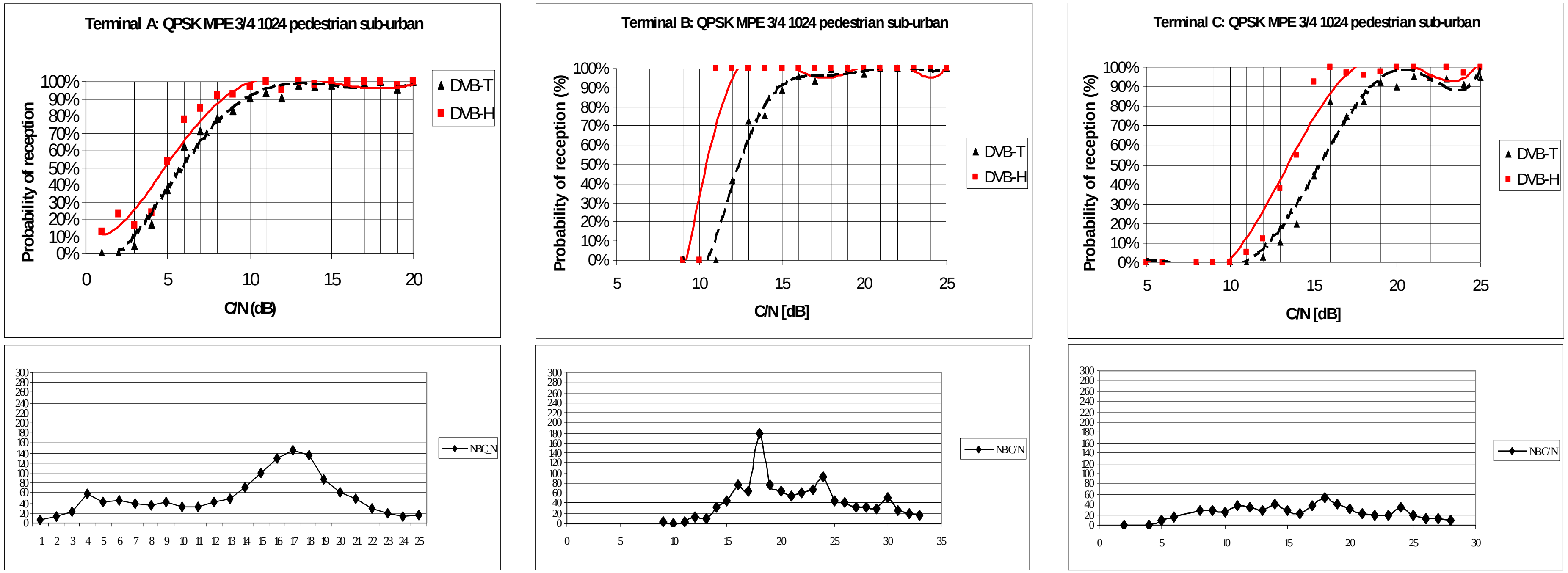


Figure D.4

Validation Task Force	8K 1/4	QPSK 1/2	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

PEDESTRIAN URBAN (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

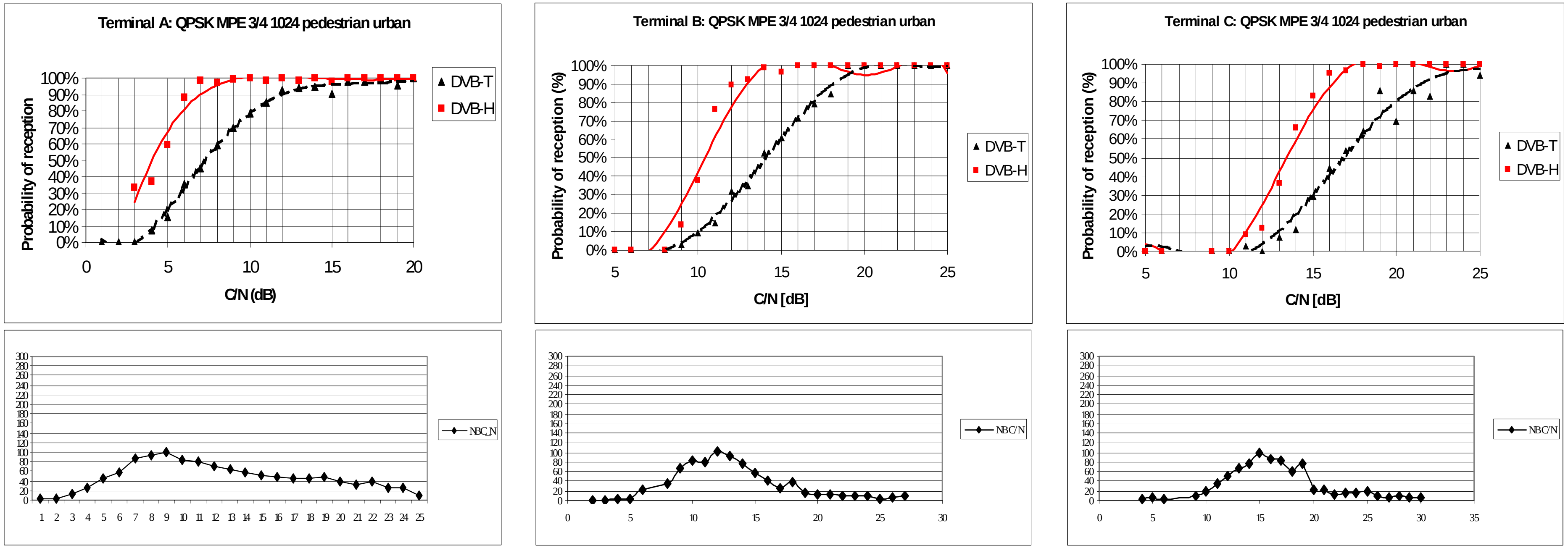


Figure D.5

Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

MOBILE URBAN (up to 50 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A | Terminal B | Terminal C

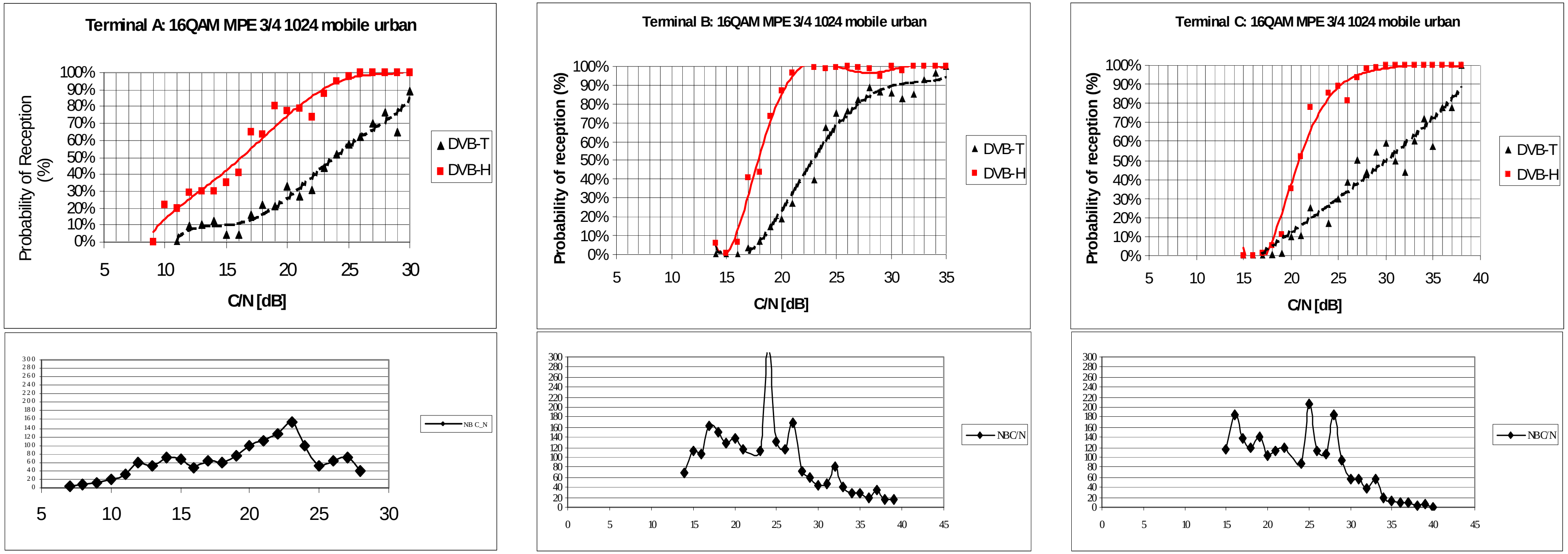


Figure D.6

Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

MOBILE HIGHWAY (up to 130 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

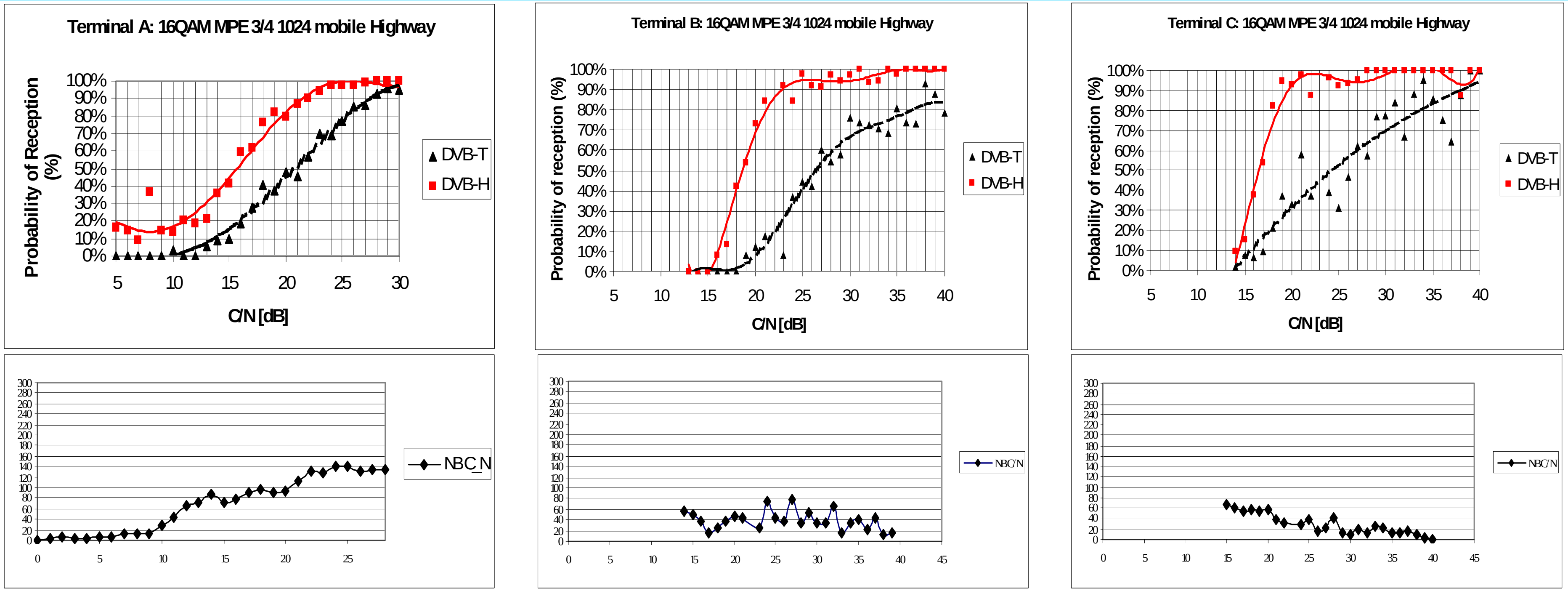


Figure D.7

DVB-H Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

PEDESTRIAN SUB-URBAN (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

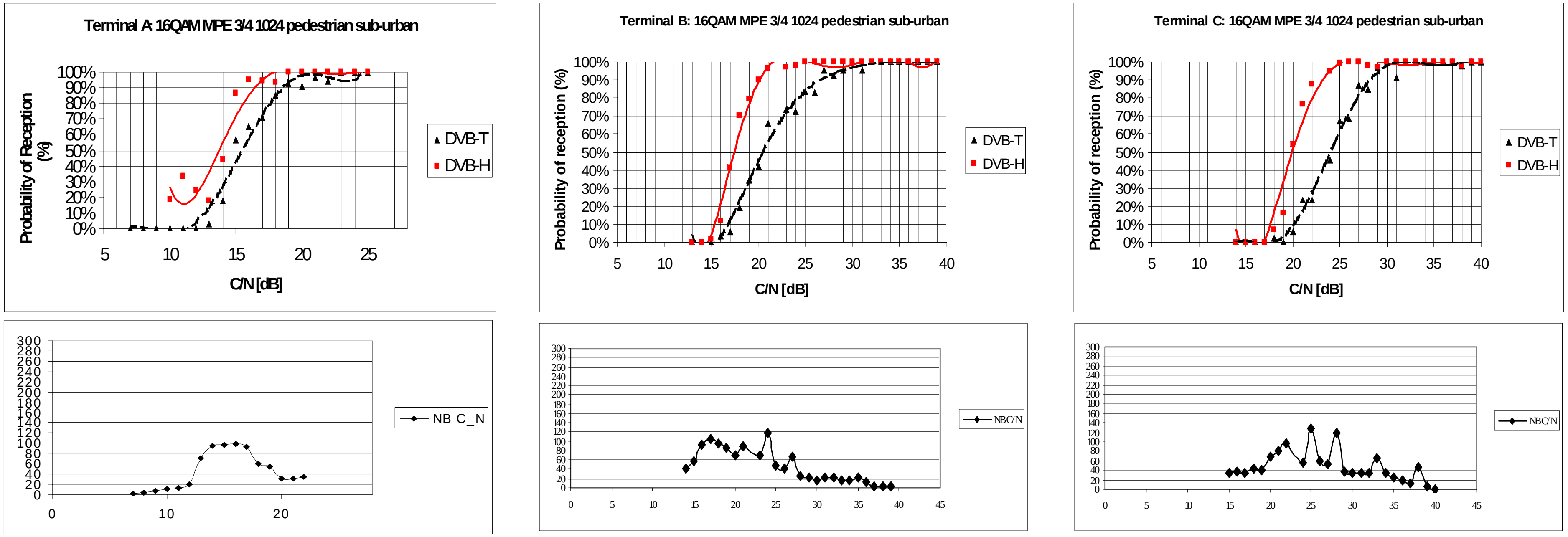


Figure D.8

DVB-H HANDHELD	Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)
PEDESTRIAN URBAN	(following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")					
Terminal A		Terminal B			Terminal C	

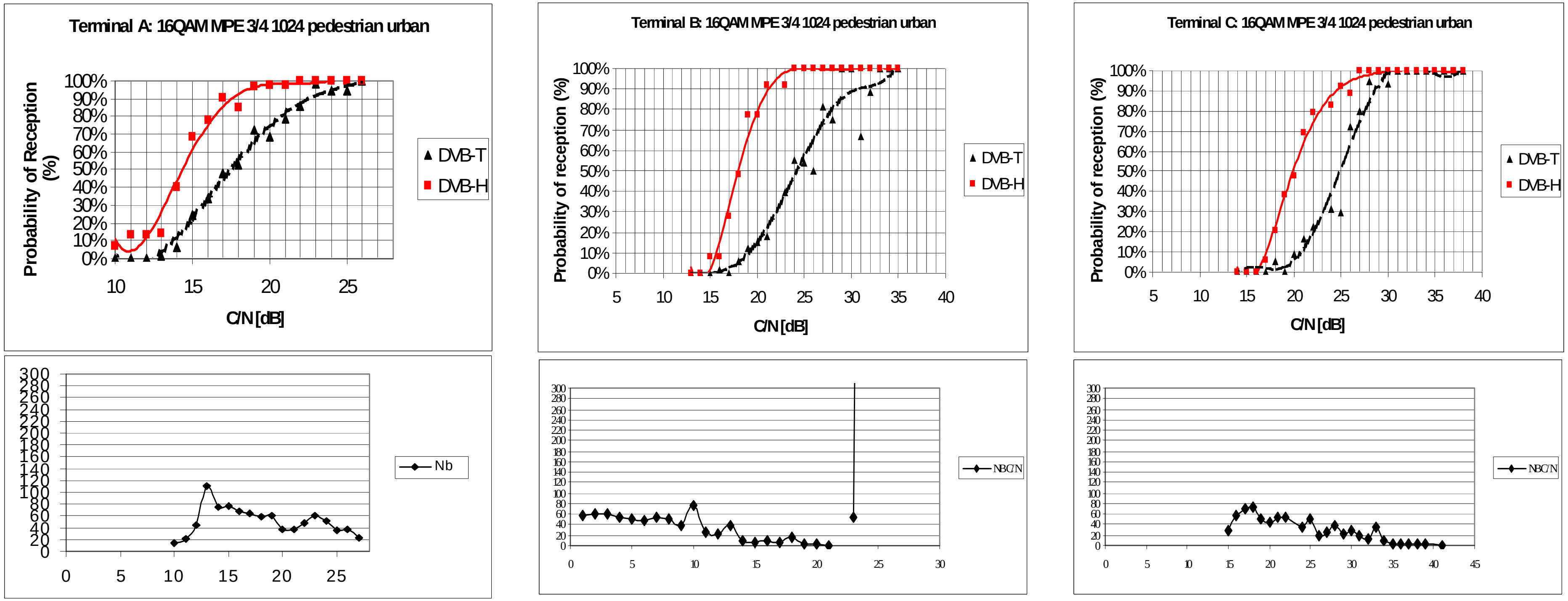


Figure D.9

DVB-H Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

PEDESTRIAN IN-DOOR (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

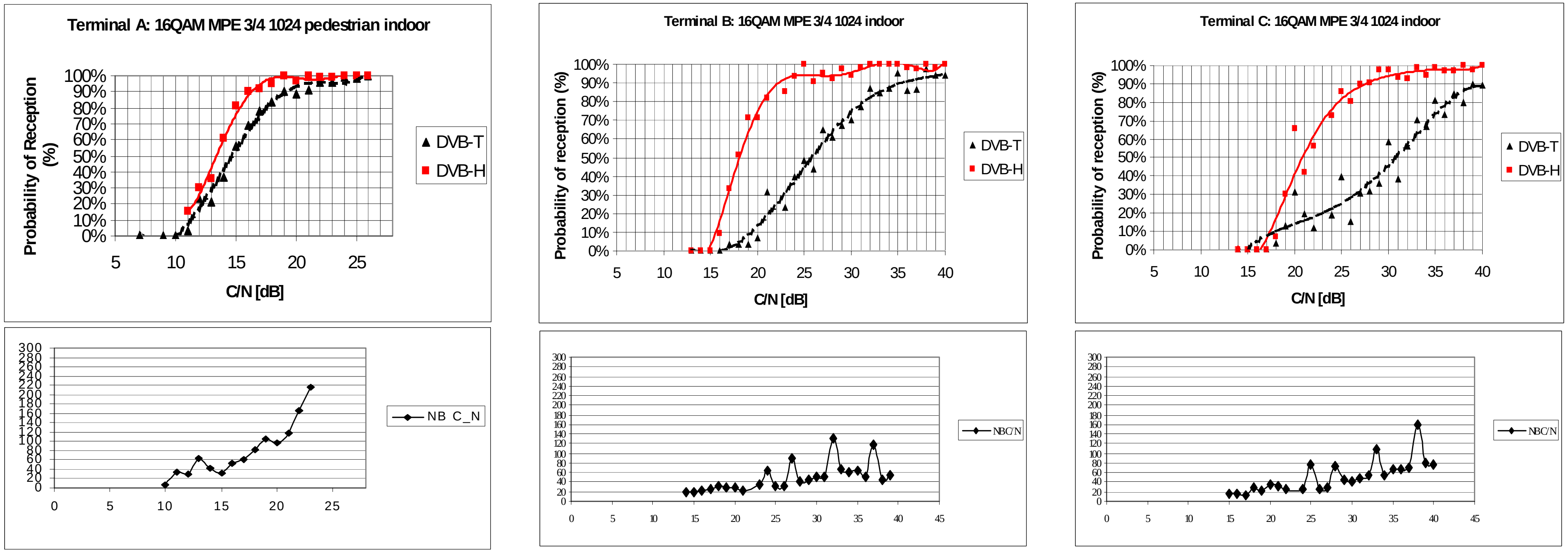


Figure D.10

DVB-H HANDHELD Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 7/8	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)
MOBILE URBAN (up to 50 km/h)	(following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")				
Terminal A	Terminal B				Terminal C

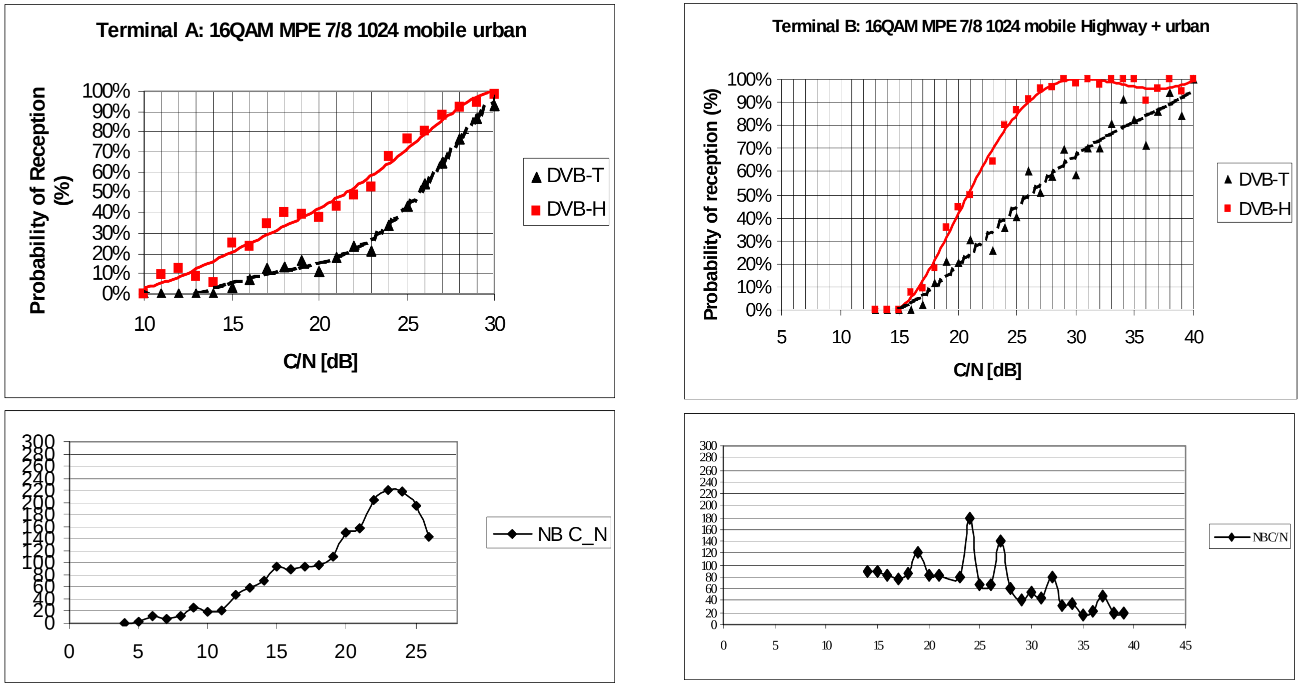


Figure D.11

DVB-H Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 7/8	1024 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

MOBILE HIGHWAY (up to 130 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

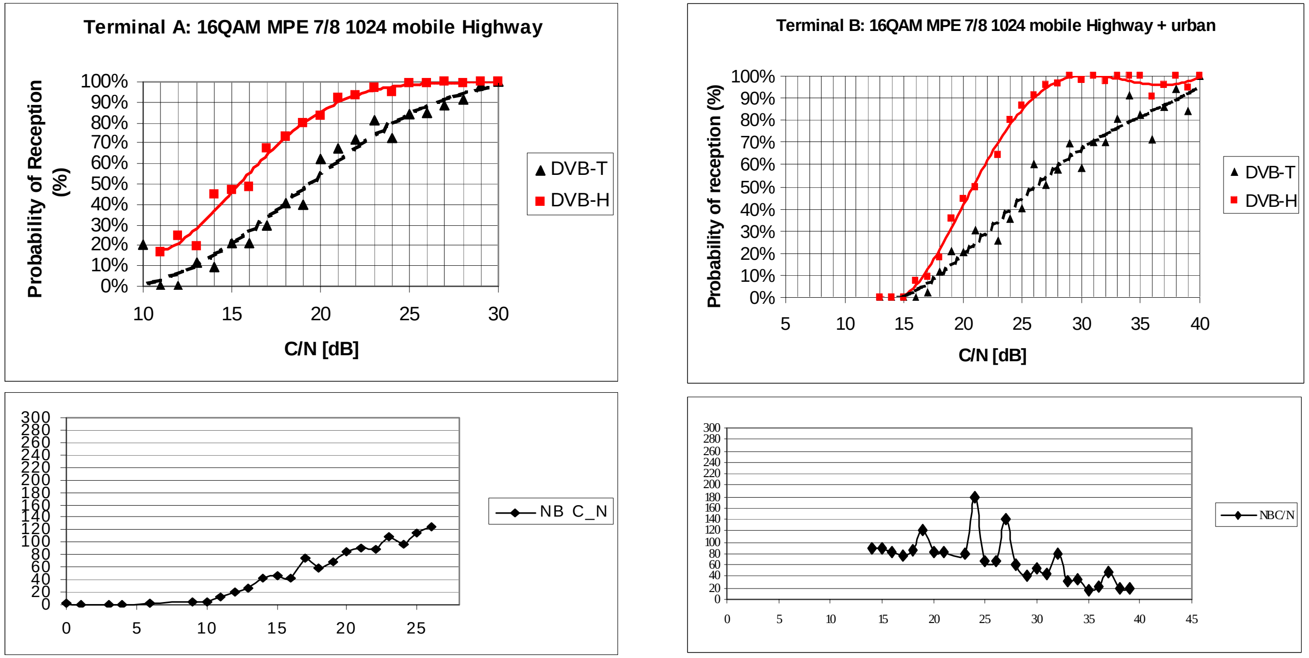


Figure D.12

DVB-H HANDHELD Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	256 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

MOBILE URBAN (up to 50 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C

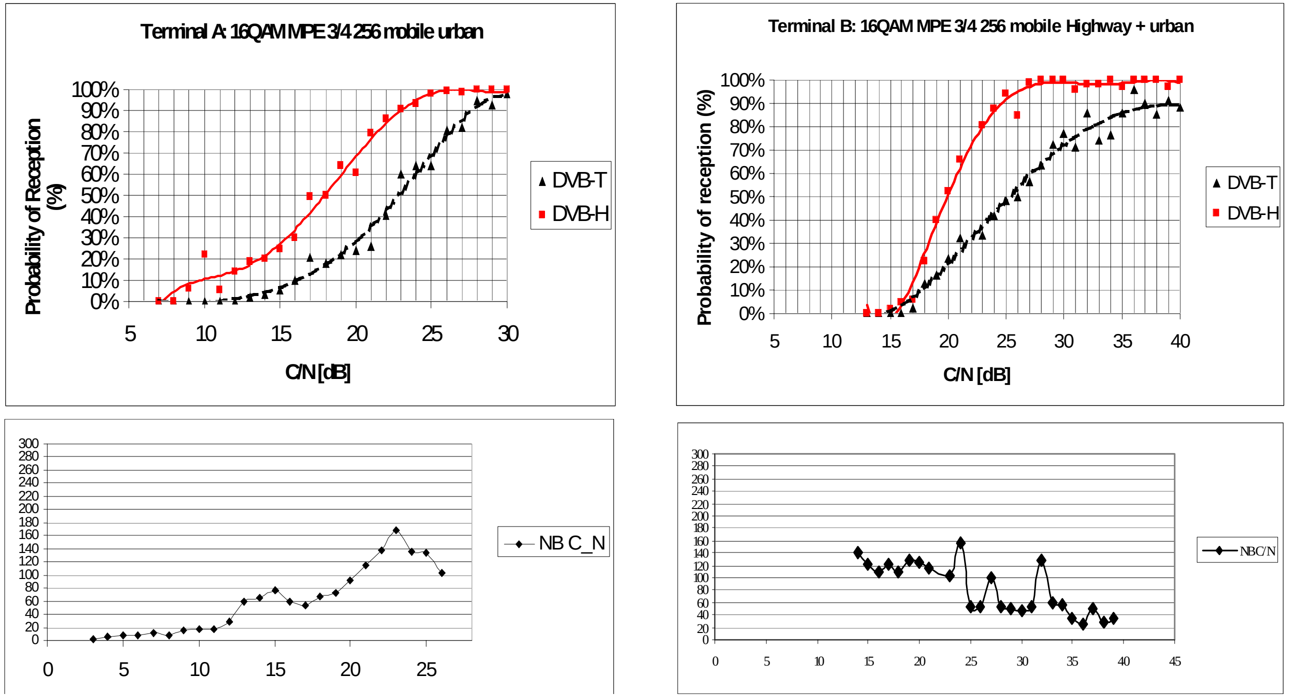
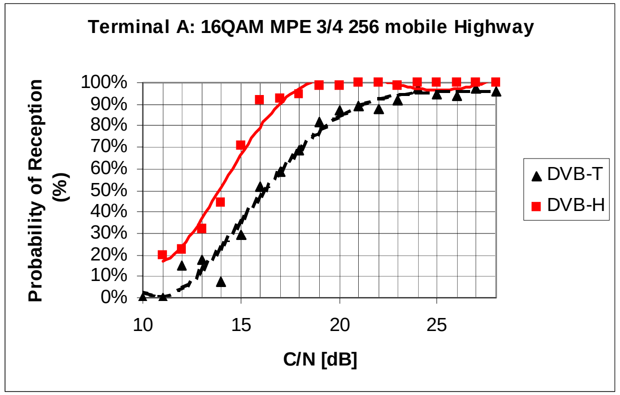


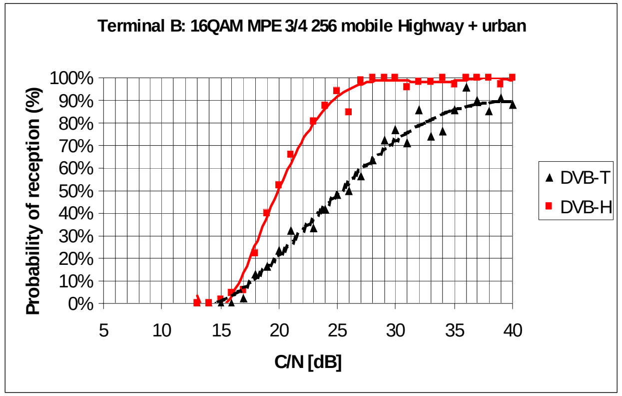
Figure D.13

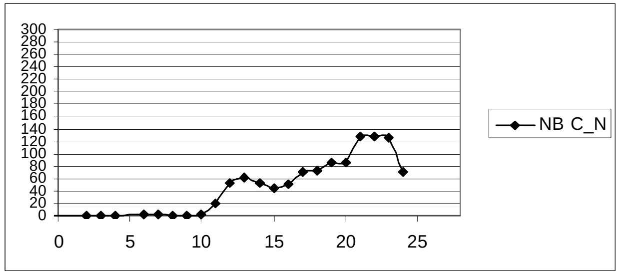
DVB-H HANDHELD	Validation Task Force	8K 1/4	16QAM 2/3	MPE-FEC 3/4	256 rows	Field Trials performed by TDF in Metz (from 13th to 16th December 2004)

MOBILE HIGHWAY (up to 130 km/h) (following curves provides "Probality of Reception vs C/N" and "Number of good reception points for each C/N values")

Terminal A	Terminal B	Terminal C







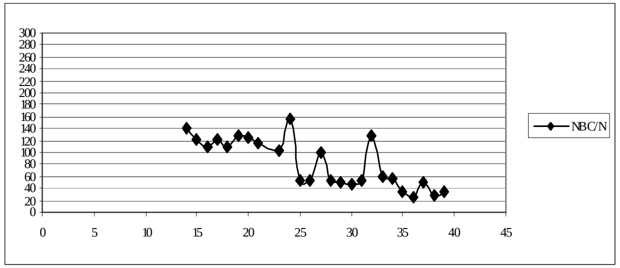


Figure D.14

Calibration with SFQ in gaussian channel

		Terminal A	Terminal B	Terminal C	Terminal D
		HW	508	220	Board
Criterion		DVB-H MFER 5%	DVB-T BER 2.10-4	DVB-T BER 2.10-4	DVB-T BER 2.10-4
Minimum Received Input Power	QPSK, 1/2	-95dBm	*-95dBm*	*-96dBm*	-95dBm
	16QAM, 2/3	-88dBm	*-86,5dBm*	*-87,5dBm*	-86,5dBm
Minimum C/N	QPSK, 1/2	2,6dB	*5,9dB*	*5,9dB*	5,9dB
	16QAM, 2/3	10,3dB	*13,7dB*	*13,7dB*	13,7dB

Figures in italic have been estimated outside the VTF session in Metz

Calibration with roof-top antenna pointing to transmitter

		Terminal A
		HW
Criterion		DVB-H MFER 5%
Minimum Received Input Power	QPSK, 1/2	-95dBm

Figure D.15

Annex E: List of equipment

E.1 Laboratory tests

Table E.1

DATA Sources			
IPP_1	IP Player	Product	Restitution of recorded IP flows
IPP_2	IP Player	Freeware	Generator of IP streams numbered sequence
TSP_1	TS Player	Product	Restitution of recorded TS flows
DVB-H : Analyser			
HAN_1	DVB-H Delta_T Analyser	Prototype	From TS (ASI) input, it analyses DVB-H sections and evaluate the Delta_T jitter.
HAN_2	DVB-H Delta_T Analyser	Prototype	From TS (ASI) input, it analyses DVB-H sections and evaluate the Delta_T jitter.
DVB-H : IP Encapsulator & DVB-H Services Multiplexer			
IPE_1	DVB-H IP encapsulator	Product	Provides TS with a constant bitrate DVB-H multiplex,
IPE_2	DVB-H IP encapsulator	Product	Provides TS with a constant bitrate DVB-H multiplex,
IPE_3	DVB-H IP encapsulator	Product	Provides TS with a constant bitrate DVB-H multiplex,
IPE_4	DVB-H IP encapsulator	Prototype	Provides TS with a constant bitrate DVB-H multiplex,
DVB : Multiplexer			
MUX_1	DVB Multiplexer	Product	TS with Multiplex of DVB-H and other MPEG2 services
MUX_2	DVB Multiplexer	Product	TS with Multiplex of DVB-H and other MPEG2 services
MUX_3	DVB Re-Multiplexer	Product	Add/Drop of MPEG2 services in a constituted TS multiplex
DVB : MIP inserter for SFN operation			
MIP_1	SFN – MIP inserter	Product	Insert the synchronisation MIP in TS for SFN operation
MIP_2	SFN – MIP inserter	Prototype	Insert the synchronisation MIP in TS for SFN operation
DVB-T : Modulator			
MOD_1	DVB-H modulator	Product	H modes & SFN capable,
MOD_2	DVB-H modulator	Product	H modes & SFN & HM capable
MOD_3	DVB-H modulator	Product	H modes & SFN & HM-SFN capable
DVB-H : Receivers			
HRX_1	DVB-H Receiver	Terminal	DVB-T rx with Time Slicing
HRX_2	DVB-H Receiver	Board	DVB-T rx with FEC decoder
HRX_3	DVB-H Receiver	Platform	Full DVB-H receiver
HRX_4	DVB-H Receiver	Platform	Full DVB-H receiver
HRX_5	DVB-H Receiver	Board	DVB-T with H process in FPGA
HRX_6	DVB-H Receiver	Module	DVB-T with H process in PC
HRX_7	DVB-H Receiver	Platform	DVB-T with H process in FPGA
HRX_8	DVB-H Receiver	Board	DVB-T with H process in PC

E.2 Field trials

Table E.2

DVB-H : Receivers			
A	DVB-H Receiver	Board	Full DVB-H Hardware implementation
B	DVB-H Receiver	Terminal	DVB-T rx with Statistical Analysis
C	DVB-H Receiver	Terminal	DVB-T rx with Statistical Analysis
D	DVB-H Receiver	Board	DVB-T rx with Statistical Analysis

Annex F: Credits

Although unusual in such Technical Report, credit needs to be given to the numerous DVB forum members who made this DVB-H Validation exercise possible.

Warm thanks are offered to the Validation Task Force participants listed below, for their efficient contributions and for the professionalism and good spirit that continuously sustained our collaborative work.

Justin MITCHELL
Khaled MAALEDJ
Stephane DE MARCHI
Nicolas LASCAR
Gerard POUSSET
Oleg CHEKULAEV
Tommi AURANEN
Jukka HENRIKSSON
Antti INNAMAA
Ismo KAUNISTO
Rami SUOMINEN
Pekka TALMOLA
Thomas KURSAWE
Lise HAMMER
Torsten GÖRIG
Jacek SCHWIERTZ
Carlos PARDO
Stephen BECK
James WILKINSON
John WILSON
Hervé BELLAMY
David DE MORAIS
Christophe LAFOUGE
Bertrand MAZIERES
Jean RIBEIRO
Christian VISSE
Gerard FARIA
Stephane LETHIMONIER
Jean-Luc PAVY
Ralf BUROW
Stefan KRUEGER
Frank KATTANEK
Frank LOECHNER
Pierre CLEMENT
Jerome DAVID
Bernard PICHOT

History

Document history		
V1.1.1	May 2005	Publication