ACTS VALIDATE project

REPORT ON MULTIDIMENSIONAL DVB-T INTERWORKING TESTS

Rennes, 8-12 June 1998

Summary

VALIDATE partners carried out multidimensional interoperability tests in June 1998. Test signals were broadcast from a transmitter at St-Pern and received at CCETT in Rennes. A wide range of DVB-T equipment from different manufacturers was tested:

- Seven different modulators including first generation prototypes and industrial products
- Nine different receivers including first generation prototypes, commercial professional receivers and consumer chip-sets.

61 different DVB-T modes were tested; these included examples of all the possibilities and options offered by DVB-T specification.

- Interoperation of hierarchical modes was successfully demonstrated for the first time.
- Single Frequency Network (SFN) operation was successfully demonstrated using modulators from different manufacturers.

The successful results of all of these tests prove the interoperability of DVB-T equipment from different manufacturers. Network operators can safely mix equipment from different manufacturers in their networks. These results provide a sound basis for the launch of commercial services.

Introduction

The main aim of the VALIDATE project is the verification of the DVB-T specification. An important part of this verification is the demonstration of interoperability between modulators and demodulators from different laboratories (in the early stages of the Project) and from different manufacturers as DVB-T heads towards launch. The first demonstration of interworking, between the modem from the RACE dTTb project and the BBC modem took place in December 1996 and since then there have been a number of bilateral interworking tests. As the VALIDATE project ends at the end of June 1998 Partners decided to organise a final multidimensional interoperability test, bringing together as many DVB-T modulators and demodulators as possible and testing them in as many modes as practicable; the tests should include hierarchical modes and SFN configurations.

This document gives a summary of the tests; a fuller description with complete results (68 pages) is available from http://www.bbc.co.uk/validate.

CCETT kindly offered to host these tests at their laboratories in Rennes during the period 8-12 June 1998. The tests were organised by CCETT and ITIS; seven other Partners took part. It was agreed that equipment made by manufacturers outside the Project would be included in the tests provided that it was supported by one of the Partners present.

The seven modulators tested were: a BBC laboratory prototype and commercial modulators from Bosch, ITIS, Rohde & Schwarz, Itelco, and NDS (SFN and MFN types). The nine demodulators tested were a BBC laboratory prototype, an evaluation board containing the LSI 2K/8K chipset, an evaluation board containing the Motorola 2K chipset, the dTTb2 prototype receiver, the STERNE5 receiver based on the CNET/SGS Thomson chip-set, and professional receivers from ITIS (2K/8K), NDS (2K), NDS (8K) and NDS (2K/8K).

It must be stressed that the objective of these tests was to demonstrate the conformance of each equipment to the DVB-T specification, by checking its interworking with the other equipments, not to test relative performance.

Test methodology

General method

All the tests used an over-air path. The main transmitter was at Saint-Pern, about 30 km away; for SFN configurations an additional transmitter in the CCETT tower was used. The test period was organised in time-slots during which one modulator (or two for SFN modes) was used to produce the on-air DVB-T signal in one dedicated DVB-T mode. During each time-slot, all receivers were used in parallel to demodulate the on-air DVB-T signal. The result of the test was recorded for each receiver in regard to its capacity to demodulate the on-air signal provided by the given modulator.

This method implies that the tests were ‘modulator driven’. Owing to the very large number of options in the DVB-T specifications it was impracticable to use all modes with all modulators. It did not seem desirable to establish a restricted list of modes that would be mandatory for the equipment submitted to the test. Instead, the modulator providers were asked to submit a priority list of modes they wanted to check. However, a common subset of two modes was tested with each modulator :

2K, 64QAM, Rate = 2/3, Delta = 1/32

8K, 64QAM, Rate = 2/3, Delta = 1/8

In order to allow SFN interoperability tests with different modulators, the following SFN mode was included in the list of modes to be tested :

8K, 64QAM, Rate = 2/3, Delta = 1/4 (for SFN modulators)

After the first day the tests proceeded so there was time to perform all of the tests in the priority list of each modulator provider – a total of 61 modes. A list of the modes tested with the numbers of modulators and demodulators actually used in each test is given in an Annex.

The RF signal received off air was distributed to all receivers in parallel. Each receiver consisted of a DVB-T demodulator, an MPEG-2 decoder, and a TV monitor. An Arbitration Committee recorded the result for each receiver as either 'No Visible Errors' if there were no errors visible on the picture during the observation period of 15 s chosen for the test, 'Visible Errors' if errors were visible during the 15 s, or 'Not Implemented' if the mode being tested was not implemented in the receiver. Not all the receivers were available during the whole week of the tests, so an additional result could be recorded: 'Implemented but Not Tested'.

Test platform

CCETT provided an MPEG-2 Transport Stream (TS) which was basically constituted of one video programme (about 4 Mbit/s) and one audio programme. The total useful bit rate did not exceed 4.8 Mbit/s. This enabled operation in any DVB-T transmission mode without changing the MPEG2-TS configuration. A bitrate adapter was provided which could automatically adjust the TS bitrate to the channel capacity of the tested mode.

The baseband DVB-T signal generated by the modulator under test was carried, over an FM link, to Saint-Pern (30 km) to feed this regular transmitter site (2 kW ERP on channel 61 – 794 MHz). In addition, for SFN operation, the MPEG2-TS source was carried, over a PDH 34 Mbit/s link, to the top of the CCETT tower where a second DVB-T modulator fed a second transmitter (1 kW ERP on channel 61 – 794 MHz) to provide a co-channel DVB-T signal.

A rotary roof top antenna was used to receive the on-air signal. A band-pass filter and an amplifier were used to feed an RF splitter which produced an independent signal to each DVB-T receiver under test. For the SFN tests the secondary signal coming from the CCETT tower transmitter was 3 to 6 dB below the main signal and was delayed in order to be received about 15 µs after the main signal. The frequency difference between the two transmitters was about 3 Hz.

Results

It was expected that some problems might be shown up by these tests: that was part of the justification for doing them. The DVB-T specification is flexible, with a large number of modes to suit different applications, and much of the equipment available for test is in a pre-operational form or the very early stages of commercial exploitation. In the event, there were remarkably few problems. The tables in Annex 1 give a total of 646 different combinations of mode, modulator, and demodulator. Of these, no visible errors were seen 584 combinations. 42 of the cases of visible errors were due to one receiver that was not able to start correctly during some tests owing to a fault in its control software; however, the results in other tests with this receiver show that the hardware implementation is fully conformant. One modulator was found to have one problematical mode, and one receiver was found to have two problematical modes; these were clearly implementation problems rather than conformance issues; the respective manufacturers have been informed. One of the SFN modes (mode 54) was a condition at the limit where we can

expect the receivers to achieve correct operation for the SFN configuration described above and some receivers showed visible errors; again this is not a conformance issue.

Conclusions

The positive results of these tests show that there are no conformance issues associated with the DVB-T specification. This is a major achievement. Modulators and demodulators from different manufacturers can be expected to interwork reliably so Network Operators can safely mix equipment in their networks. These results provide a sound basis for the launch of commercial services.

Annex 1 List of modes tested

These tables give details of the modes and configurations tested and the numbers of modulators and demodulators involved in each test. One of the NDS modulators was used only for the SFN tests, so the maximum number in any mode is six; in many cases the number of modulators is less than six because the mode is not one that the modulator provider had chosen as a priority. Not all the receivers were available for the whole week, and not all of them implemented all modes (one NDS receiver was 2K only and another was 8K only), so the number of receivers is less than nine in all cases.

A1.1 Regular modes

Mode number	FFT size	Guard interval	Constellation	Code rate	Number of modulators tested	Number of receivers tested
1	2K	1/32	64QAM	2/3	6	8
2	8K	1/8	64QAM	2/3	6	7
3	2K	1/16	64QAM	1/2	3	5
4	2K	1/8	64QAM	2/3	3	6
5	2K	1/4	16QAM	3/4	3	5
6	2K	1/8	16QAM	5/6	3	5
7	2K	1/16	QPSK	7/8	3	5
8	2k	1/32	QPSK	3/4	1	5
9	8K	1/16	64QAM	1/2	2	5
10	8K	1/32	64QAM	2/3	2	5
11	8K	1/4	16QAM	3/4	2	4
12	8K	1/8	16QAM	5/6	1	4
13	8K	1/8	QPSK	7/8	1	4
14	8K	1/16	QPSK	2/3	2	4
15	8K	1/32	QPSK	3/4	1	4
16	2K	1/32	QPSK	2/3	2	5
17	8K	1/16	64QAM	3/4	1	4
18	8K	1/32	64QAM	5/6	1	4
19	8K	1/4	16QAM	1/2	2	4
20	8K	1/16	16QAM	3/4	2	5
21	8K	1/32	16QAM	7/8	1	4
22	8K	1/32	QPSK	2/3	1	4
23	8K	1/16	QPSK	3/4	1	4
24	2K	1/32	64QAM	7/8	4	7
25	2K	1/32	64QAM	1/2	1	6
26	8K	1/32	64QAM	7/8	1	4
27	8K	1/32	64QAM	1/2	1	5
28	2K	1/4	QPSK	1/2	4	7
29	8K	1/4	QPSK	1/2	1	4

Mode number	FFT size	Guard interval	Constellation	Code rate	Number of modulators tested	Number of receivers tested
30	2K	1/4	16QAM	1/2	1	5
31	2K	1/4	QPSK	3/4	3	7
32	8K	1/4	QPSK	3/4	1	4
33	2K	1/8	16QAM	2/3	1	5
34	8K	1/8	16QAM	2/3	1	4
35	8K	1/4	64QAM	1/2	2	6
36	8K	1/4	64QAM	7/8	2	6
37	8K	1/32	16QAM	1/2	2	6
38	8K	1/32	16QAM	2/3	2	6
39	8K	1/32	QPSK	1/2	2	6
40	8K	1/32	QPSK	7/8	2	6
41	2K	1/4	64QAM	1/2	2	7
42	2K	1/32	64QAM	5/6	2	7
43	2K	1/16	16QAM	1/2	2	7
44	2K	1/16	16QAM	2/3	2	7
45	8K	1/8	64QAM	7/8	1	5
46	2K	1/8	QPSK	2/3	1	6
47	2K	1/8	16QAM	1/2	1	7
48	2K	1/32	QPSK	5/6	1	6

A1.2 Hierarchical modes

Mode number	FFT size	Guard interval	Constellation	a	HP Code rate	LP Code rate	Number of modulators tested	Number of receivers tested
49	2K	1/8	16QAM	2	2/3	2/3	1	3
50	8K	1/4	64QAM	1	1/2	2/3	1	3
51	2K	1/8	64QAM	2	1/2	3/4	1	3
60	2K	1/4	64QAM	2	1/2	3/4	1	4

A1.3 SFN modes

Mode number	FFT size	Guard interval	Constellation	Code rate	Number of modulators tested	Number of receivers tested
52	8K	1/4	64QAM	2/3	1, 1+1 **(Note 1)**	6
53	8K	1/4	QPSK	1/2	2, 1+1 **(Note 1)**	6
54	8K	1/4	64QAM	5/6	1	5
55	8k	1/4	64QAM	1/2	2	6
56	8K	1/4	16QAM	1/2	2	6
57	8K	1/4	16QAM	1/2	1	5

58	2K	1/4	64QAM	1/2	2	7
59	2K	1/4	64QAM	1/2	2	7
61	2K	1/4	QPSK	1/2	1	6

Note 1: In the configuration noted as 1+1, the two transmitters were modulated by modulators from different manufacturers.