REPORT ITU-R BT.2035-2

Guidelines and techniques for the evaluation of digital terrestrial television broadcasting systems including assessment of their coverage areas

(Question ITU-R 31/6)

(2003-2004-2008)

CONTENTS

1 Introduction

The objective of digital terrestrial television broadcasting (DTTB) testing and trials is to evaluate the performance of an available system or systems in a variety of transmission configurations and reception conditions. These may include:

– urban, suburban, and rural conditions;

– indoor as well as rooftop reception;

– reception on portable and mobile receivers in a variety of circumstances.

The range of possible operational requirements is summarized in Table 1, together with the key factors and parameters that affect performance in the various operational circumstances.

These requirements form the basis for the derivation of the laboratory and field trial programmes described in § 2 and 3, as well as for providing the framework for the brief description of the three ITU-R recommended DTTB systems briefly described in § 5.

TABLE 1

Operational requirement		Primary factors affecting operational requirements
Receiving modes	Indoor fixed reception	Multipath, non-line of sight, building penetration loss (on-frequency repeater)
	Outdoor fixed reception	Multipath (static), low signal strength
	Portable reception	Multipath (static and dynamic), low signal strength (on-frequency repeater)
	Mobile reception	Multipath (dynamic), signal fading (single frequency network (SFN))
	Personal reception	Multipath (static and dynamic), signal fading, penetration loss
Channel bandwidth (6, 7 or 8 MHz)		Determined by regulatory and/or licensing authority
SFN		Strong static and low-speed multipath distortion
On-frequency repeaters (gap fillers)		Static multipath
Multimode operation		Different types of modulation and coding, hierarchical transmission
Maximum coverage		System *C*/*N* requirement
UHF only or UHF and VHF operation		Sensitivity to impulse noise at VHF

While tests and measurements may be planned and conducted for specific reasons and objectives, others may analyse the resultant data with different reasons and objectives. Consequently, it is recommended that all tests, measurements and data-gathering herein documented be conducted according to these sets of principles and general procedures, in order that the resulting analysis and conclusions concerning different tests are consistent and meaningful.

2 Laboratory test plans

The following procedures are intended to verify the performance of the DTTB modulators and receivers. These tests include measurements of receiver performance in the presence of:

– random noise;

– input RF signal dynamic range;

– static multipath interference;
– dynamic multipath interference;
– co-channel interference;
– lower and upper adjacent channel interference;
– impulse noise;
– phase noise.

2.1 Random noise impairment

The purpose of these tests is to determine the DTTB receivers' robustness to random noise impairment.

The DTTB desired signal shall be adjusted at four different RF levels: very strong (−15 dBm), strong (−28 dBm), moderate (−53 dBm) and weak (−68 dBm). The noise level shall be increased until the threshold of visibility (TOV) is reached and the *C*/*N* value shall be recorded. The signal levels in brackets are suggested typical signal levels.

In the scope of laboratory tests, the TOV is considered to be reached when trained observer is able to detect some kind of artefact on the image after ONE minute of observation.

2.2 Input RF signal dynamic range

The ability of receivers to receive very strong to very weak signals shall be tested. The maximum and minimum RF signal level shall be determined by increasing and decreasing respectively the RF power signal level at the receiver's input until the TOV level is reached.

At the maximum and minimum RF signal level, the noise level shall be increased until the TOV is reached and the *C*/*N* value shall be recorded. It is recommended that this test be performed at the lower, middle and upper parts of the VHF and UHF bands.

2.3 Static multipath interference

The performance of the DTTB receiver for diverse combinations of multipath representative of various reception environments shall be measured. The purpose of multipath testing is to measure the DTTB receiver's robustness in the presence of multipaths with and without random noise.

For each test the noise level shall be increased until the TOV is reached and the *C*/*N* value shall be recorded. All the multipath tests shall be done with the DTTB signal RF level adjusted to the moderate level (−53 dBm). Note that for consistence on the *C*/*N* values, signal power level shall be the result of the combination of the main and the echo signals.

Single echo: A single echo test shall be done, including pre and post-echo, with and without phase rotation. This test verifies the robustness of the receiver to decode the signal satisfactorily over a wide range of time delays (negative and positive) with and without phase rotation. Suggested values are delays in the range of −80 μs to 80 μs and phase rotation in the range of 0 to 5 Hz.

Multiple echoes: In previous tests in different locations and by different organizations various multipath ensembles have been used. Examples of such ensembles are given in Annex 4.

2.4 Dynamic multipath interference

The purpose of this test is to measure if the DTTB receivers' robustness in the presence of a combination of multipath that are representative of various dynamic receiving conditions. Much of the experience gained about the performance of DTTB receiver was derived from experiments using urban mobile channel developed for GSM and for UMTS tests.

It is appropriate to leave the development of specific dynamic channel profiles tailored for DTTB to an expert group that would be tasked to develop a detailed test plan.

2.5 Co-channel interference

The purpose of this test is to determine the DTTB receivers' performance under analogue TV and DTTB co-channel interference.

Analogue TV to DTTB: The interference level (D/U) at TOV shall be recorded for three typical undesired analogue TV test signals and at least one should be a dynamic signal. The suggested interference signals are the dynamic Zoneplate and the colour bars at 75% saturation. These tests shall be done with the DTTB signal RF level adjusted to moderate level (−53 dBm).

DTTB to DTTB: The interference level (D/U) at TOV shall be recorded for one undesired DTTB signal with and without frequency offset of 10 kHz. These tests shall be done with the DTTB signal RF level adjusted to moderate level (−53 dBm).

2.6 Lower and upper adjacent channel interference

The purpose of this test is to determine the DTTB receivers' performance under analogue TV and DTTB lower and upper adjacent channel interference.

Analogue TV to DTTB: The interference level (D/U) at TOV shall be recorded for three typical undesired analogue test signals and at least one should be a dynamic signal. The suggested interference signal is the dynamic Zoneplate. These tests shall be done with the DTTB signal RF level adjusted to moderate level (−53 dBm). Note that for lower adjacent channel interference test, the audio deviation shall be set to the maximum allowed, for example, complete BTSC (Broadcast Television Systems Committee) signal (stereo + secondary audio program (SAP) + professional audio channels (PRO).

DTTB to DTTB: The interference level (D/U) at TOV shall be recorded for one undesired DTTB signal. These tests shall be done with the DTTB signal RF level adjusted to moderate level (−53 dBm).

2.7 Impulse noise

The purpose of this test is to determine the DTTB receivers' robustness to impulse noise impairment. Adding thin pulses of white noise to the RF signal may simulate the effect of impulse noise. For similarity with real conditions it is important to produce pulses of white noises, which varies in amplitude, repetition rate and pulse width. For each pulse width the noise level shall be increased until the TOV is reached. This test will be made in conformance with the following technical points:

– Due to practical difficulties in generating high-level gated Gaussian noise the wanted signal level should be –60 dBm.
– The gated noise signal should be divided into elements of approximately 250 ns. E.g. a 1 µs test is made up of four consecutive 250 ns pulses, with random separations, contained within one orthogonal freguency division multiplexing (OFDM) symbol and within the ATSC frame. Despite the fact that such segmentation makes no difference to an ordinary receiver, real impulsive noise is like this after band limiting in the receiver, and it may lead to a difference in performance in receivers designed to provide countermeasures to impulse interference. It will also prevent receivers being designed to pass a simpler test.
– The total effective periods (sum of all elements) in tests should be, 0.25, 0.5, 1, 3, 5 or 10 µs.

The impulse noise simulation should also include a similar test using fast edges instead of gated Gaussian noise. It expected that tests with fast edges would be effective for testing tuners and devices ahead of tuners.

2.8 Phase noise impairment

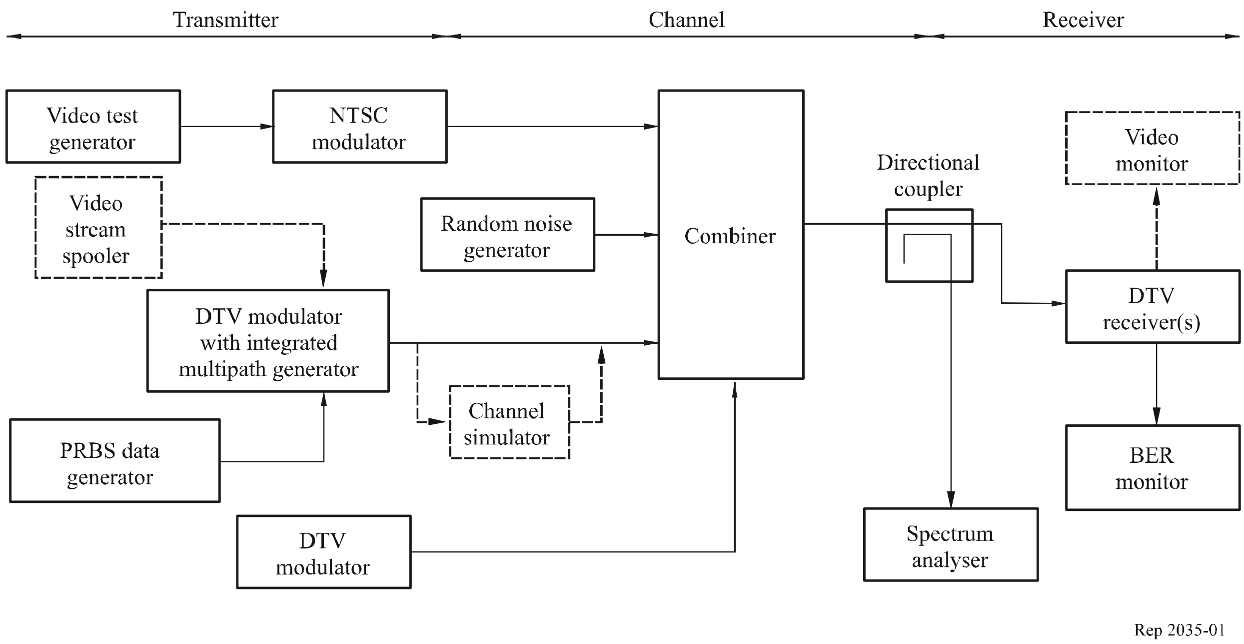
The purpose of this test is to determine the DTTB receivers' robustness to phase noise. Phase noise is an inherent part of the RF systems and might be of significant relevance in the case of multiple frequency conversions.

The phase noise is simulated by injecting an FM modulated white noise signal at the local oscillator used in the up-conversion (IF to RF) of the DTTB modulated signal. The DTTB signal is adjusted and measured as for interference testing. This test shall be done with the DTTB signal RF level adjusted to moderate level (−53 dBm).

The phase noise is generated with an RF signal generator and a random noise generator. The output of the random noise generator feeds the external FM source input of the RF signal generator used as the local oscillator of the DTTB up-converter (IF to RF). By selecting different peak deviations (0-50 kHz), a phase noise is created on the carrier output of the RF signal generator. The phase noise shall be measured with a spectrum analyser, such as the HP8560E, with the phase noise measurement option. The phase noise level shall be increased until TOV is reached and measured in dBc/Hz at 100 Hz, 1 kHz, 5 kHz, 10 kHz and 20 kHz at either side of the peak carrier.

FIGURE 1

Equipment set-up for laboratory tests (except for phase noise)



3 Field test plans

This section presents the objectives, and general methodology for conducting field tests of over-the-air digital terrestrial television systems. Field test plans are useful tools to gather field data of digital television systems in order that useful conclusions about DTTB signal coverage, service receivability and channel characteristics can be obtained.

Paragraph 3 is organized in six major sections. The first section contains a general description of a field test plan and applies to all field tests proposed. The following three sections detail the procedures that are specific to each kind of field test: coverage measurement, receivability evaluation and channel characterization. The fifth section comments on incorporating analogue television broadcast signal for coverage and receivability comparison with DTTB systems. The last section provides guidelines to implement comparative DTTB field tests.

The scope of the work includes reception, demodulation, and recovery of the transmitted data. The scope of the work herein is not concerned with the decoded data or analogue signals except when these signals are used as a means to determine that the data has been correctly recovered.

3.1 Recommended practices for developing field test plan

3.1.1 Use of normative references

Normative references should be added to any test plan document developed. References should be included to any measurement methods used that are established by regulating authorities or are in accordance with recognized standard-setting bodies.

3.1.2 Field testing objectives

Test plan implementations may focus on certain aspects of the objectives depending upon the immediate requirements of the testing entity. Thus, plans developed using this Report, have one or more of the following objectives:

– identify the variables in the environment and recommend the minimum set of variables to be measured;

– measure actual "service" versus predicted "coverage";

– to collect data useful in improving the DTTB system performance;

– evaluate the receivability of DTTB systems for a broad range of different receiving modes.

The goal is to provide a uniform series of test procedures whose results and data can be compared with results of other tests conducted by various organizations in different locations, or at different times, or both.

Testing may be conducted for specific goals and objectives that include but are not limited to the following:

0 Comparison of one digital transmission system to another

1 Comparison of a digital transmission system to an analogue system

2 Comparison of various transmission and receiving components

3 Comparison of different generations of components

4 Comparison of different environments

5 Statistical characterization of the RF environment.

3.1.3 Definitions

3.1.3.1 Coverage testing

Coverage is defined as the determination of actual field strengths measured for a given transmission facility. There are generally two purposes for coverage measurements:

– ascertain the proper functioning of the transmit antenna, and

– provide supplementary data for terrain propagation algorithms that could be used for spectrum allocation planning and estimation of potential interference.

Coverage measurements are conducted using standardized test methods which typically use antennas calibrated to a standard dipole and placed at 9.1 m (30 ft) height above ground, are used worldwide for verifying coverage, verifying transmit antenna radiation patterns, and providing data to develop propagation algorithms used for the planning factors for allocating broadcast station spectrum.

Coverage tests are often carried out in formal fashion with measurements made along radials, arcs, grids and clusters. A sample containing a large number of measurements needs to be taken to develop statistically significant results. Limited coverage tests may be planned to achieve particular goals and objectives such as determining that a directional transmit antenna pattern is achieved or maintained, or to measure the effects of terrain that blocks broadcast signals in certain areas. Such tests will not predict overall coverage.

3.1.3.2 Service (receivability) testing

Service or Receivability testing for purposes of this Report is defined as the process of determining the conditions under which digital television signals can be received and decoded under various actual operating conditions. Such operating conditions include any location where viewers normally use television receivers for entertainment and information for short and long periods of time. These operating conditions include use of antennas selected as those likely to be used with the receiving mode or modes under test.

Service (Receivability) measurements normally use digital television receivers designed to be connected to recording equipment to obtain signal level, carrier-to-noise ratio, margin-to-threshold, error rate, antenna orientation criticality and other information. These measurements may not be as easily repeatable as the coverage measurements.

A sample containing a large number of measurements needs to be taken to develop statistically significant results. By adhering to a standard set of service test procedures consistent with this document, data obtained from these tests can be used to develop a statistical database from which a level of service can be derived. Limited service tests may be planned to achieve particular goals and objectives such as obtaining relevant comparative data for difficult locations.

3.1.3.3 Capturing channel characteristics

Capturing channel characteristics has the specific meaning, for the purpose of this Report, to determine channel characterization and is accomplished by the detailed measurement of specific signal conditions at specific times and in specific locations using specific fixed and movable antennas. The detailed measurements of signal characteristics include effects of channel impairments such as level variations, impulse noise, in-band interference, and multipaths.

Although this classification is very useful for didactic explanation of the DTTB systems evaluation there are a lot of commonalities between the modes and a lot of time and resources can be spared by preparing a test plan which combines several of these testing procedures.

3.1.3.4 Receiving modes

This Report proposes five different receiving modes: fixed, portable, pedestrian, mobile and personal.

TABLE 2

Receiving modes

Modes	Outdoor	Indoor
Fixed	Fixed outdoor	Fixed Indoor
Low speed	Pedestrian	Portable
High speed	Mobile	Personal

0 Fixed reception is defined as reception by an immobile receiver and receive antennas. Typically, this includes a roof-top mounted antenna (outdoor) or a fixed-location indoor antenna.

1 Portable reception is defined as reception by a receiver that can be moved from place to place, that uses a self-contained receiving antenna, but that remains stationary during operation.

2 Pedestrian reception is defined as reception by a receiver that is moving at no more than 5 km/h (3.1 mph). Typically, this is a receiver that may be used while walking, or a hand-held receiver where occasional and frequent short movements occur.

3 Mobile reception is defined as reception by a receiver that is moving at greater than 5 km/h (3.1 mph). Typically, this is a receiver used in a vehicle moving faster than walking speed.

4 Personal reception is defined as reception by a receiver that is moving at lesser or greater than 5 km/h and the receiver uses a low-gain antenna used on hand-held devices. Typically, this is a hand-held receiver that may be used anywhere, including inside a moving vehicle.

3.1.4 Test signals

3.1.4.1 In-service measurements

In-service measurements will use the DTTB signal itself with no modifications or may use a repetitive video sequence with appropriate sound to enable evaluation of the programme stream errors. Care should be taken that the transport stream (TS) consists of a seamless loop that does not create a disturbance in the video or audio. The bit rate of this signal should nearly fill the available bit capacity of the channel to maximize the accuracy of the visual error probability. This signal excels in quick field error measurements when other, more accurate error measurement techniques are not available.

3.1.4.2 Out-of-service measurements

Out-of-service is defined as not available for regular programme viewing. For out-of-service measurements, the transmission/reception may use specially tailored test signals. These test signals must occupy the same spectrum and have the same average power as a DTTB signal, but may be tailored for specific out-of-service measurements such as channel characterization.

A common test signal is the PN23 sequence (pseudo noise of $2^{23} - 1$ random bits) injected into a DTTB modulator. The PN23 signal excels in measurements of pass band flatness, signal power, peak power probability, interference characteristics, and BER. Other PN sequences can be used with similar results (see Annex 4).

The test signal to assess channel response has different needs. The test signal repetition rate should be short enough to characterize time-varying channels, yet be long enough to cover the expected multipath. Anticipated multipath covers the range of –30 μs to +60 μs, dictating a sequence capable of measuring a range greater than 90 μs. In all of the three ITU-R recommended DTTB systems almost any TS is acceptable since the stream is convolved with an internal PN15 or PN16 generator. However, a known sequence is desirable for synchronized processing and a pure null packets sequence is recommended.

3.1.5 Antenna class and orientation

3.1.5.1 Antenna for coverage measurement

Any receive antenna used for coverage measurement must be calibrated with respect to a standard dipole mounted on a mast at the prescribed height above ground (9.1 m or 30 ft). Documentation for the antenna must be included in the test report. Antennas for coverage measurements are normally oriented towards the transmission tower, which means in the direction of maximum signal. For purposes other than coverage in some instances optional measurements may be made with the antenna oriented in other directions. Such measurements are also recorded with the orientation data field indicating the directions.

3.1.5.2 Antenna for service and channel characterization

Antennas for service and channel characterization measurements may be professional or consumer products as desired according to the goals and objectives of the field test plan. Such antennas typically will be employed in an “in-service” setting, and are often used only a few feet above the floor or ground and relatively close to people and nearby surrounding objects. Such antennas should be mounted in a manner that allows the testing personnel to easily and repeatedly point, tilt and position the antenna with accuracy and to record meaningful results from such movements. Antennas may be oriented in an optimal (maximum signal or most easily received signal) or non-optimal position (as might be used for a single setting but receiving signals from multiple directions). The inclusion, for different classes of services, of measurements to determine the criticality of the antenna orientation on the receivers’ capability to adequately decode the DTTB signal is recommended.

Antennas for service testing and channel characterization measurements include but are not limited to the following classes and orientation:

– Fixed outdoor measurement should be performed with an antenna at 9.1 m above ground. Orientation may be optimal or non-optimal and must be so indicated in the database.
– The fixed indoor antenna, associated with a fixed receiving installation, and used for service or channel characterization measurements is normally a consumer style antenna. It should be characterized for gain and pattern with respect to a dipole, and mounted about 1.5 m (5 ft) above the floor. This class of antenna may be used in an optimal or non-optimal orientation according to the field test plan and which must be indicated in the database. It should be noted that the antenna’s performance characteristics may markedly change in the indoor environment from measured values made in a controlled test environment.
– In case of portable receiving applications, the antenna used is normally a consumer style antenna that may be designed as non-directional (monopole) or directional (dipole or multiple element). It must be characterized for gain and pattern with respect to a dipole. Portable antennas are normally positioned about 1 m (3.3 ft) above the floor (ground) and may be oriented in an optimal or non-optimal position according to the field test plan and indicated in the database.
– An antenna, associated with pedestrian, can be considered to be of random directional characteristics with little or no gain. If possible, the antenna should be characterized for gain and pattern with respect to a dipole, and mounted about 1 m (3.3 ft) above the floor. Because of the relative insensitivity (gain) the orientation of the antennas used in pedestrian and personal applications is normally considered to be non-optimal (see Annexes 2 and 3).

– Antennas associated with mobile applications are normally considered to be non-directional (monopole or similar design) and mounted in fixed positions on vehicles in a manner to maximize their exposure to radio signals. Mobile antennas must be characterized for gain with respect to a dipole. The orientation of an antenna used in mobile applications is considered to be undefined (none or non-optimal) (see Annexes 2 and 3).
– The same as pedestrian, antennas associated with personal receiving mode, can be considered to be of random directional characteristics with little or no gain. If possible, the antenna should be characterized for gain and pattern with respect to a dipole, and mounted about 1 m (3.3 ft) above the floor. Because of the relative insensitivity (gain) the orientation of the antennas used in pedestrian and personal applications is normally considered to be non-optimal.

3.1.6 Test duration

Test duration is defined according to the receiving mode and encompass a wide range including seasonal (months or years), very long term (days or months), long term (minutes or hours), short term (seconds to minutes) and very short term (seconds to less than a second). See Annex 1: Test Summary Chart, Footnote No. 1.

3.1.6.1 Coverage measurements

Coverage measurements are normally conducted for short periods of time. Fixed position coverage measurements over long periods of time (hours, days, months, years) provide useful information about the effect of weather, seasons and day-night variations.

3.1.6.2 Service measurements

For service measurements, the test duration should be a minimum of 5 min. During that time single (averaged over the period) or multiple measurements may be made according to the field test plan.

3.1.6.3 Capturing channel characteristics

For capturing channel characteristics, the test duration can be any range that is suitable to both the field test plan and storage capability of the test equipment. Channel characteristics measurements are made for short durations (a minimum of 20 s) due to storage capacity.

3.1.7 Site conditions

A description of site conditions is essential for each location in which field test measurements are made. The test plan should include documentation of the location of each site with geographic coordinates to the nearest arc second (or better), address, surrounding area (photographs), nature of buildings including their construction, vegetation, weather conditions at time of test and, if possible, specific marking of the pavement or ground where the measurement was taken. It is also very important to detail specific environmental changes observed along the run and on each site of the cluster measurements.

3.1.8 Calibration measurements

Calibration measurements shall be made (beginning and end of each test day) of test system, as well as of the transmission system components, to determine that both systems are performing properly. A known test signal is typically used to simulate the expected unimpaired real-world signals and calibrate the test equipment. As a minimum set of measurements, the effectively transmitted DTTB signals must be checked as for its integrity, at predefined moments, but other components may also be routinely tested at the transmission site. It is advisable to use transmission monitors (receivers) at the transmission site, as a full time check of the integrity of the transmitted DTTB signals. For this purpose, the DTTB RF signal levels provided for these transmission monitors shall be adjusted slightly above threshold, to allow detection of small degradation of the transmitted DTTB signals.

3.1.9 Documentation of results

Results are documented in a manner such that the data may be efficiently processed and analysed at a later time. Part of the development of measurement methodology and specific test procedures includes the consideration of collecting and recording of data. That consideration must take into account how that data is to be used. Measurement data should be entered (recorded) into a database where the structure is designed for efficient interchange and analysis.

When designing a database and developing the specific measurement procedures, consideration should be given to the kinds of processing and analysis expected to be conducted and how the data might be used in comparison with other tests to be performed at later times and in other locations.

During a "pass/fail" test, an unimpaired signal must be received over a continuous length of time in order for the test reception to "pass". Typically this length of time will be at least 5 min. However, all data (measurements and site condition records) should be preserved even if the test reception is judged to "fail" or the data is not used in the initial analysis process.

Tabular database formats are the preferred form of data collection. The format should be compatible with mainstream database software and is to be described in detail in the test report.

Tester's measurement observations are often valuable in describing anomalies in test results and should be included in a comments column or as footnotes in the test report.

3.1.10 Test facility development

The detailed list of equipment for a coverage field test facility is recommended, although service measurement test plans may not need the full complement to accomplish their objectives. Important elements include the following:

– Block diagram. A block diagram showing the components of the measured signal path must be provided with the test report.
– Dynamic range of operational levels. The dynamic range and noise figure of the test facility and its components should be determined and documented.
– Antenna. Whatever antenna is employed for service measurements it must:
  – be an example of a typical antenna for that application,
  – be calibrated by the factory or on a range or anechoic chamber,
  – be routinely checked to determine that it is performing as predicted.
– Down-lead system and related components. The cables, amplifiers, filters, attenuators switches, combiners, splitters, and other devices that could affect the measured signal each must be documented and calibrated. When professional antennas are not employed care should be taken to minimize the voltage standing wave ratio effects through a careful selection of amplifiers and attenuators located as close to the antenna as possible.
– Receiver. The receiver used for the service measurements must be described in detail and should have supporting calibration documentation.
– Other measurement equipment. Other equipment used for service measurements that provide data for the test report must be documented and should have supporting documentation and test results.

A simplified set-up for both indoor and outdoor field tests is shown in Fig. 2.

This test set-up is most conveniently housed in a test vehicle. Usually the required test equipment will be mounted in a vehicle that has a retractable antenna mast that can be raised up to 10 m. Tests may also be carried out with an omnidirectional or low-gain antenna at 1.5 m height close to the test van if it is desired to evaluate the system performance for portable or pedestrian reception.

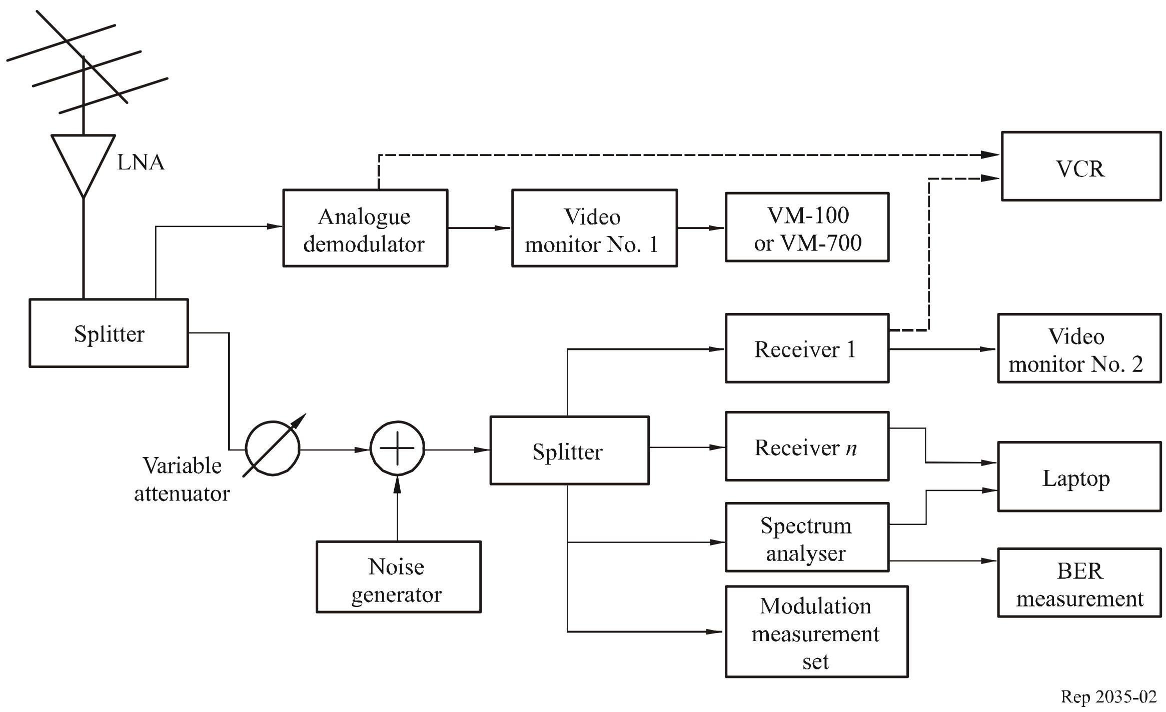
Equipment is selected and assembled according to test plan goals and objectives.

3.2 Coverage measurement procedures

Coverage measurements are made at a series of test sites. The following is a recommendation for establishment of procedures to be performed at each selected site. An important notice is that coverage measurements are based on the field measurement while the receivability test for fixed outdoor reception is based on BER measurements.

FIGURE 2

Equipment set-up for field tests



3.2.1 Measurement methodology

3.2.1.1 Description

Coverage measurements are based on the field strength of the digitally modulated television signal, which is measured with an instrument capable of indicating accurately the average amplitude of that signal.

The preferable way of collecting this information is to make an accurate and complete measurement exactly on the site location planned (for site selection see § 3.2.4) and to make additional measurements using a cluster or 30M run.

Cluster: For this purpose, the cluster is defined as one identifiable initial measurement point and at least four additional measurement points within a distance of the initial measurement point as specified in Fig. 3. Whenever possible the initial measurement point shall be the centre point.

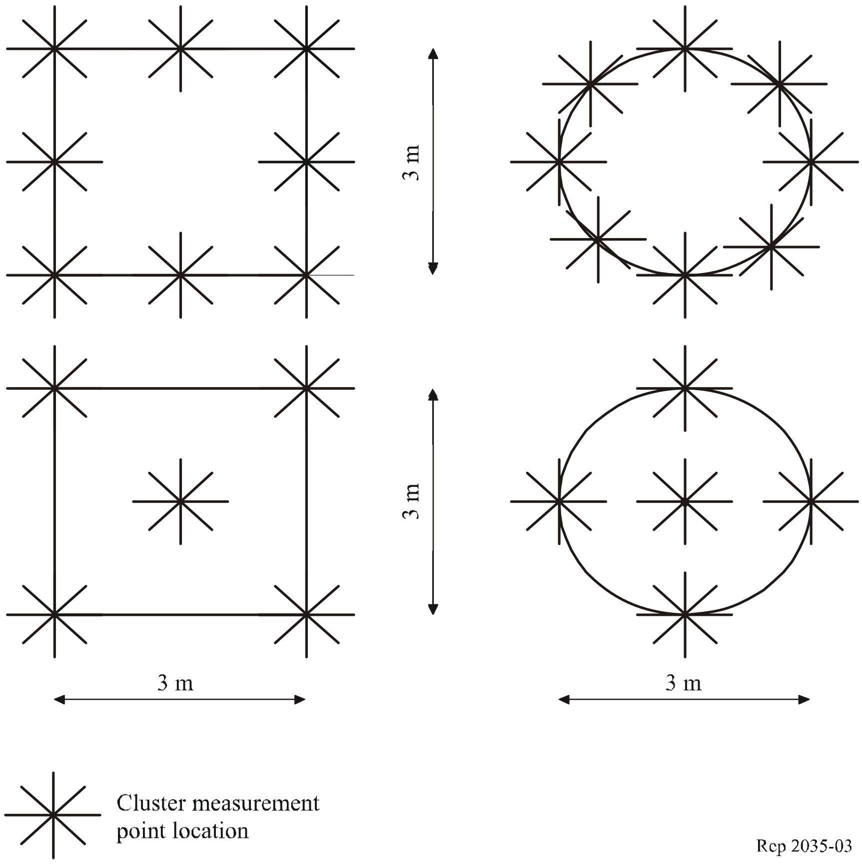
Typically, cluster measurements require a minimum of five evenly distributed measurement points to capture the complete measurement data set over an area of approximately nine square wavelengths. If multiple frequencies are to be measured at one location, the cluster measurement area should be defined as 9 m^2 (3 m per side). Suggested patterns would include those shown in Fig. 3.

Cluster measurements shall be applied when selected locations need to be further investigated.

30M run: If overhead obstacles preclude a cluster measurement, a 30M run may be made in lieu of the mobile run. The run is characterized by positioning the antenna at height of 9.1 m (30 ft) above ground level (AGL) and displacing the vehicle back and forth on a straight line of 30.5 m for each side (total of 61 m). The average field strength as well as the field value of a minimum of five fixed points within 61 m of the centre point of the mobile run values shall be recorded. Continuous data collection over the length of the run is desirable.

FIGURE 3

Cluster measurement point arrangements



Note that clusters and 30M runs are of interest at measurement points where the orientation of the receiving antenna yielding the strongest signal differs from that of a direct bearing to the transmitter. Under this scenario, field strength shall be read and recorded with the antenna oriented toward the transmitter and with the antenna oriented toward the strongest signal.

3.2.1.2 Antenna height

DTTB coverage (field strength) measurements are conducted at an antenna height of 9.1 m (30 ft) AGL.

3.2.1.3 Safety

The measurement platform, antenna, mast, and coaxial feed line represent potential safety hazards from electrical shock and/or falling objects. For this reason, it is imperative that the paramount criterion for measurement site selection is worker safety. Accordingly, all measurement sites must be free of overhead power lines, steeply sloped terrain, wet surfaces, high winds, thunderstorms, and other natural or man made obstructions or conditions which could threaten the safety of persons or property. The test plan should require that operators should be trained in proper safety procedures.

3.2.1.4 Geographical considerations

Coverage measurements are to be conducted at specific points along multiple radials and arcs. Radials shall extend from the transmitter location to the limit of predicted Grade B or noise-limited coverage. A minimum of eight, reasonably evenly-spaced, radials shall be measured. Measurement radials should be oriented so as to traverse representative terrain and population centres. These radials shall also include reception areas selected for service testing (see § 3.3) where practicable.

3.2.1.5 When to conduct field tests

When practical, coverage measurements should be timed such that seasonal and climatic propagation variations can be correlated to coincident service and channel characteristics measurements in a given reception area.

3.2.2 Field test facility equipment

The design of a field test facility can take two forms:

0 Mandatory, for which certain equipment is necessary to take the measurements.

1 Optional, that includes other measurement equipment used at the tester's discretion.

3.2.2.1 Mandatory

An instrumentation vehicle with telescoping mast that is capable of elevating a routable standard reference antenna to a height of 9.1 m AGL (30 ft) and transporting said elevated antenna a linear distance of 30.5 m (100 ft) in case the 30M run is desirable. Equipment includes the following:

0 Calibrated reference antenna(s), UHF and/or VHF.

1 Calibrated antenna balun (if required – depends upon reference antenna type in use) and antenna/coax impedance matching network.

2 Calibrated coaxial RF distribution system which may include a band pass filter, low noise amplifier, RF splitter (if multiple taps are used for simultaneous field strength measurements at different frequencies), and/or optional instrumentation devices.

3 Calibrated, average reading RF voltmeter(s) and system components with sufficient dynamic range, bandwidth, selectivity and sensitivity to measure DTTB field strength to predicted noise limited thresholds without introducing instrumentation bias or distortion to the measurement.

4 Differentially corrected GPS receiver.

5 Spectrum analyser for "best reception azimuth" antenna orientation indicator and for spectrum display image capture or recording. Some options are desired such as channel power, true RMS power detector and delay profile measurement. Instrument state

programming and measured data storage capabilities are other desired options, commonplace in modern equipment. Storage of the received DTTB signal spectrum may be used to ascertain the degree of multipath at each measurement site.

6 Digital television receivers.

7 Random noise generator.

3.2.2.2 Optional

Optional equipment includes the following:

0 Bit or segment error rate measurement set.

1 Other analysers, computers, printers, as desired.

2 Integrated data acquisition system to collect and store, on magnetic media, instrument state, measurement data and tester's comments.

3 Signal margin instrumentation – requires calibrated RF attenuator plus threshold detection hardware (vector analyser).

4 Optional receiving antenna(s) and polarization modes.

5 Camera to record test site and surrounds.

6 Vertical alignment adjusting equipment.

7 Angular register for antenna angle measurement.

8 Altimeter.

3.2.3 Measurement data set

Measurement data should include, but should not be restricted to, the following information:

3.2.3.1 Mandatory

0 Field strength (minimum, maximum, and median value) (dBμV/m).

1 System margin. Input RF signal shall be attenuated in a controlled manner until TOV is reached.

2 Distance and bearing to transmitting antenna location.

3 Ground elevation at measuring location (measured or calculated).

4 Date, time of day, topography, traffic and weather observations.

5 Azimuth orientation of receiving antenna for best reception and for maximum field strength (if different) with vertical angle of mast/antenna support structure.

6 A detailed equipment list specifying each antenna, measuring instrument, and system component, its manufacturer, type, serial number, rated accuracy and date of most recent calibration by either its manufacturer or a qualified calibration laboratory.

7 A detailed block diagram of the coverage survey system.

8 A detailed description of the procedure, date, time, and tabulated data for the pre-test field calibration check of each of the coverage survey system components conducted at the beginning of each measurement cycle.

3.2.3.2 Optional

0 C/N ratio at TOV for best reception and for maximum field strength. Random noise shall be added on a controlled manner. In the scope of field tests, the threshold of visibility is considered to be reached when trained observer is able to detect some kind of artefact on the image after TWO minutes of observation.

1 Spectrum analyser stored data of the DTTB receiver signal spectrum, for each antenna azimuth orientation. When practical, spectrum records of the measured signal should be made for each major measurement set and should include a narrow-band display (7 to 9 MHz) and a wideband display (for example 20 MHz) of the spectrum containing the desired signal and a signal slope display.

3.2.4 Statistical selection of sites

In order to obtain statistically significant results there must be enough data sample points measured to reflect the actual performance of the measured system. Practical considerations lead to a range of 30 to 100 sites, although reasonable statistical confidence intervals may require significantly more.

The number of measurement points in coverage area is a function of the following issues:

0 "Community": Minimum of eight reasonably evenly spaced radials. Measurement points are selected to begin at a distance of 3 km from the transmitter location and are to be repeated at intervals of 3 km to the maximum distance at which measurements are to be made, which is determined by a previous coverage prediction. Typically, at least 20% of all measurement points include cluster measurements or 30M (100 ft) runs.

1 Arcs: Arcs should be normally measured around the full 360° azimuth, except where terrain prohibits or when the transmitting antenna has a directional pattern. Individual selection of points should be made at a maximum of 20° spacing.

2 Individual location cluster measurements: Because coverage is determined by the statistical distribution of individual data point measurements, it is necessary to select individual location measurement sites at which multiple measurements can be conducted over a specified area. These measurements are referred to as "individual location cluster measurements". Typically, individual clusters are selected such that the elevated antenna may be accurately positioned at discrete intervals around the perimeter of an area of approximating 9 m^2 (see Fig. 3). A minimum of five, evenly spaced, measurement points is required.

3.2.5 Analysis considerations

Tabular database formats are the preferred form of data collection. The format should be compatible with mainstream database software and is to be described in detail in the test report.

Testers measurement observations are often valuable in describing anomalies in test results and should be included in a comments column or as footnotes in the test report.

Photographic (film or digital) records are important ways to explain a site condition in some detail. In addition to the surround area, photographs should be made of the test setup itself in relation to the surrounding environment.

Spectrum stored data provide insight into the condition of the signal that is measured as well as the spectrum in which the signal is located.

Coverage data should be used for pair-wise comparison of actual field strength versus calculated field strength.

3.3 Service measurement procedures

The following descriptions apply to all receiving modes (refer to § 3.1.3.4) except where noted. Certain measurement procedures may vary according to the selection of the receiving mode, in all cluster locations. When the 30M run is done, the measurement location selection cannot be at the "best" location. It should be done at an average location.

If coverage measurements are required at sites where service measurements are conducted, a set of cluster measurements must be conducted according to the procedures in § 3.2. If coverage and services measurements are made at the same location it is recommended that they be done at the same time.

3.3.1 Measurement methodology

The following general procedures outline a typical service measurement process.

3.3.1.1 Test duration

Observation duration and interval are selected to adequately capture the desired number of measurements. The test period must be representative of typical reception conditions and all data taken must be recorded. The test plan should set the duration of unimpaired reception which will be used as the pass/fail criteria. A five-minute period of unimpaired reception is the normal minimum test duration for failure decision.

Additionally to the normal observation period, the test may also include variable adjustable observation periods depending on the conditions to be tested, for example, one minute may be used to observe the effect of airplane flutter, or 20 min may be used to observe the effects of trees moving in the wind, or 10 min for moving traffic variations. When a test site is found to have special conditions, receiving signal monitoring period that is representative of the condition that should to be added to the normal observation period. In those cases, the degree of bias of such special measurement and the periodicity of the special conditions should be recorded.

3.3.1.2 Antenna class, height, orientation, and polarization

The antenna shall be selected and used according to the reception mode (fixed, portable, pedestrian, mobile and personal). Typically the selected antenna shall be representative of users' typical receiving antennas.

3.3.1.3 Functionality check

It is strongly recommended to perform field test with the same receivers used for laboratory tests. Evaluation of C/N ratio at TOV and static and dynamic multipath should be periodically and routinely checked to ensure proper operation.

3.3.1.4 Description

Service measurements are typically made in such a manner that they simulate real-world receiving situations. It is important to note, however that each kind of test has each particularities and procedure.

Fixed: Measurements of fixed reception are divided in outdoor and indoor measurements. Outdoor measurements follow exactly the same procedure as coverage measurements but neither clusters nor 30 m run are mandatory. For this test, the criticality of antenna orientation on the receiver capability to adequately decode the received DTTB signals shall be recorded. It is appropriate to measure the full azimuth range of antenna orientations that result in adequate operation of the DTTB receiver. A minimum of 100 sites is desirable for statistical confidence.

Indoor fixed reception shall be made in a minimum of 20% of the receiving sites with high signal strength and good outdoor reception. Measurements shall be done on the exact location used for current analogue reception placing the antenna at 1.5 m high. All measurements shall be recorded and the description of the place the measurements were taken shall be clearly stated.

Tests should include simulation of typical receiving conditions and shall include controlled movement of nearby persons and the operations of home apparatus such as a blender. It is important to document these critical variables in order to enable the consolidation of data from multiple test plans.

Portable: Typically the same sites tested for fixed indoor reception shall be used tested for portable reception. Important information to be recorded on portable receivability test is the site description and antenna pointing criticality. Tests should include simulation of typical receiving conditions and shall include controlled movement of nearby persons and the operations of home apparatus such as a blender. It is important to document these critical variables in order to enable the consolidation of data from multiple test plans.

Pedestrian: Typically the surrounding areas of the site used for indoor reception to be used for pedestrian reception with a minimum of 20 sites. It is important to keep the receiver on a position that simulate real-world receiving situations.

Mobile: For mobile reception it is necessary to select a route of at least 10 km. Each segment of the route, typically 1 km long, shall be described in terms of multipaths, analogue interference, traffic conditions and other obstructions. It is desirable to perform the channel characterization on selected segments of the route. Test should also include signal reacquisition in selected points of the route with speed higher than zero.

Personal: Typically the same route used for mobile reception should be used for personal reception tests. Note that the minimum route length of 10 km should be observed. The same antenna used for pedestrian reception should be used.

3.3.2 Field test facility

The list of test equipment is similar to the detailed list presented for coverage measurements of § 3.2.2. However, for testing indoor and portable receivability the test equipment should be moved to the user's house according to the test procedure.

3.3.3 Measurement data set

More than one set of measurements can be obtained during a service measurement. One is a mandatory or minimum set. Other measurements to enhance or describe a particular reception condition in more detail may be made as desired.

3.3.3.1 Mandatory

The mandatory set includes:

0 Field strength

1 Noise floor

2 Noise added until TOV is reached

3 *C*/*N* (to measure the increase of *C*/*N* with local impairments compared to laboratory result)

4 Calculated margin to threshold

5 BER or segment error rate (SER)

6 Delay profile

7 Equalizer tap values and energy

8 Detailed location of antenna

9 Antenna description, including its polarization

10 Antenna orientation

11 Calibration of measurement system

12 Site location details (geographical coordinates)

13 Time of day

14 Description of building in which, or around which measurements are made

15 Nature of area immediately surrounding the antenna.

3.3.3.2 Optional

Other measurement sets may include:

0 Site street address

1 Subjective audio and/or video impairments (directly observed or algorithm based)

2 Log of activity.

Spectrum analyser stored data of the DTTB receiver signal spectrum, for each antenna azimuth orientation when applicable. When practical, spectrum records of the measured signal should be made for each major measurement set and should include a narrow-band display (7 to 9 MHz) and a wideband display (for example 20 MHz) of the spectrum containing the desired signal and a signal slope display.

Describe in detail and record any other measurements made during the service measurements.

3.3.4 Statistical selection of sites

In order to obtain statistically significant results there must be enough data sample points measured to reflect the actual performance of the measured system. Practical considerations lead to a range of 20 to 100 sites, although reasonable statistical confidence intervals may require significantly more. Typically fixed outdoor measurements require 100 sites while the other service receivability tests a minimum of 20 sites.

Service measurements may include a bias towards one or more particular reception factors such as multipath, aircraft flutter or effects of building walls or trees. When site selection is biased in such a manner, rather than random, it must be noted as such in the test results and database.

It is recommended to note when and why measurements cannot be taken at a specific site. It is desirable to take measurements that capture data that show the non-uniformity ("burstiness") or uniformity of errors over time.

3.3.5 Analysis considerations

Site conditions and environment shall be recorded as a documentation of the environment of the measurement and, although the site condition is not a measure itself, it contains useful information for the analysis. Details of building construction as may be observed or are known are recorded. Whenever possible, a measurement may be repeated if the site condition indicates that the data may be suspect, and both results must be kept on the records.

Data should be reviewed at the point of measurement for accuracy and reasonableness, but not to the point of discarding data that may appear to be counterintuitive. Confirmation of reasonable data may be made through observations, notes, comparison to expected values, and additional non-mandatory measurements.

Specially for service measurements, photographic (film or digital) records are important ways to explain a site condition in some detail. In addition to the surround area, photographs should be made of the test setup itself in relation to the surrounding environment.

Spectrum display images provide insight into the condition of the signal that is measured as well as the spectrum in which the signal is located.

3.4 Capture of channel characteristics

The channel characteristics at a site describe the received signal condition. In addition to indicating parameters like received signal strength and the channel characteristics also describe other aspects of the received signal such as impulse response, and particularly multipath conditions as they change with time. A received signal at a particular location will be impacted by the particular location, its surroundings, objects (both man-made and natural) in the transmission path, interference, noise, and the receiving antenna (type, height, orientation).

The received signal generally includes components that took different paths from the transmitter to the receiver. This condition is commonly called "multipath". The principal or "main" component, normally defined as the strongest of the multipath components, may be the direct-path signal from the transmitter to the receiver if the path is unobstructed. However, depending on the location, one of the reflected signals could be the strongest.

The positions of the other signals are referenced to the main (the strongest) signal. Thus there would be signals arriving earlier than the main signal and after the main signal. These are called leading (pre-echoes) and lagging (post-echoes) because the signal leads or lags behind the main signal, respectively. Very rarely are these echoes static. Usually they vary continuously in amplitude and/or delay with time and the condition is consequently called dynamic multipath. If the strongest signal varies in amplitude such that another signal becomes stronger, then the reference for the time offset of the other reflections changes. This may appear to indicate that the distribution of the multipath in time has changed when actually only the relative amplitudes of the components varied.

In normal circumstances the receiving antenna characteristics and orientation will affect the degree of received multipath. Consequently, the impact of the choice of antenna and its orientation should be clearly understood when recording any signal for later analysis. There are several purposes for capturing channel characteristics at test sites:

– Create a set of statistics of occurrence of various forms and levels of degradation. Data to satisfy this purpose requires correlation with system performance field tests so that its significance to receiver performance can be assessed. In addition, the data recorded should allow cataloguing of characteristics (for example, ghost length or amplitude) for study of correlation among individual signal parameters.
– Provide records of challenging sites for testing new and improved DTTB designs. In this case as above, the data recorded should allow cataloguing of characteristics (for example, ghost length or amplitude) so that records of sites of particular interest can be retrieved. If data is taken specifically for use in receiver development, there should be some "standard normal" sites, some with average multipath, some with long pre- and/or post-echoes, some dynamic and some static. Because it is logical to test the DTTB sets for easy, moderate as well as tough sites, there should be criteria to classify sites for later selection for testing. Those criteria could be based on:
  – Static or dynamic nature of multipaths
  – Close-in (<1 μs), near (<5 μs), average (<20 μs), or far (>20 μs) multipaths for both pre-and post echoes
  – Strong (0 to –3 dB echo strength) and weak (< –3 dB echo strength) multipaths
  – Localized or spread multipaths

  Cataloguing by these criteria allows the designer to select relevant signals, and also allows selection of a range of signals for comparative testing of receivers.

– Recording of characteristics may be according to the specification of certain parameters as listed previously, or by recording of the RF environment, which allows both analysis and reproduction of the signal for input to receivers. The reproduction of a recorded signal for input to a receiver, however, is useful only for the particular transmission system recorded. This may or may not allow general analysis and reproduction of the signal conditions for an arbitrary system. Recording of generic signals, such as PN sequences, may be desirable for use in general characterization of the channel.

– Signals can be recorded or captured in the field:

 0 The DTTB RF signal can be recorded live for a minimum of 20 s and subsequently played back in the laboratory to test the receivers using this transmission standard.

 1 A special test or reference signal such as a pseudo-random sequence, is sampled (recorded) at specific intervals (a minimum of 20 s) and analysed off-line to determine the characteristics (impulse response) of a channel (multipath amplitude, delay and phase variation over time) for a particular location. Such information can be used later to program a channel simulator to reproduce the channel conditions. This channel simulator can be fed with a specific DTTB signal and used to evaluate the robustness of a transmission system to such channel conditions.

 2 Long-term testing may also be appropriate.

3.4.1 Methodology

The general procedure for this kind of test is to record the RF DTTB signal for a minimum of 20 s.

3.4.1.1 Capture of channel characteristics: direct method

An specific signal is transmitted from the transmission site and recorded at the receiving site for analysis. The transmitted signal may be the normal transmitted signal or may be a special out-of-service sequence. The captured RF sequence should be compared to the actual receiving characteristics for checking of consistency.

3.4.1.2 Capture of channel characteristics: DTTB RF signal method

0 VSB: The tap inferential method may be used if the direct method is not available. The equalizer tap values of a receiver are saved to allow characterization by calculating the multipath.

1 Coded orthogonal frequency division multiplex (COFDM) based systems: if the direct method is not available the delay profile can be recorded.

3.4.2 Field test facility

When designing the RF capture system, care must be taken so that the signal can be accurately reproduced at a later time. See § 3.1.10 and 3.2.2 for equipment selection guidelines.

Measurement data set

The measurement set is the collection of captured RF signals. Normally, other data such as those items listed in § 3.2.3 and 3.3.3 are also recorded.

3.4.3 Selection of sites

The location may be selected using the same criteria as when making service measurements, or locations may be biased towards specific impairments. When biased, locations may be selected based on an expectation of “easy”, “average” and/or “difficult” receiving conditions.

If biased, the type of bias needs to be explicitly noted in database. Some site selections may be made only for their expected future benefit to test improved receivers or systems.

Recording of signals should particularly be performed when the receiver under test fails to meet the acceptable performance criteria. This will enable analysis of the channel and may lead to an understanding of why the receiver cannot lock. Recording at a statistically significant sample of sites will also gather information as to whether the impairments present occur with high or low probability. This information can help in the manufacturer's decision on attacking the impairments via design improvements.

3.4.4 Analysis considerations

3.4.4.1 Channel characteristics

The captured signal provides data suitable for analysis to include at least echo length, phase, and amplitude (channel impulse response). Results can be analysed to determine the complexity of the impairments and which improvements are needed to acquire such a channel. The RF capturing device should output a data file convertible to the form used in common software simulation and analysis programs.

3.4.4.2 RF DTTB signal recordings

The recorded DTTB RF signals can be fed directly to receivers to evaluate the effects on design improvements or of adjustments on receivers' performance with the signals recorded under all the various selection criteria described previously. The signal can also be fed simultaneously to a number of receivers to compare their performance under exactly the same channel conditions.

3.5 Analogue broadcast television measurements

In some instances, DTTB field tests may incorporate tests of analogue television broadcast signals for comparison with the reception of DTTB signals. This kind of testing may be important to stations that wish to compare coverage and receivability of their analogue and DTTB facilities. While desirable on the surface, such comparisons should be made with extreme care because differences in frequency, power and location of different transmission facilities may have substantive effects on reception at a given location and with a given receive antenna orientation.

There are a number of reasons to test analogue against digital services. Different objectives will determine specific test plans and test facilities. Specifically:

– The most desirable approach is to make the analogue measurement on the same channel as the DTTB measurement. To do this the station must switch between DTTB and analogue. This may not be possible because the DTTB channel has different planning factors for interference than for analogue. Also, there is a difference between analogue and DTTB power when analogue replicates the area of DTTB. If the channel already has analogue on it then switching to DTTB is a simpler process. Two DTTB systems could be compared using a transmitting power for each system that will generate the same level of interference to adjacent or co-channel.

– Make the analogue measurements on the channel used by the same licensee as for the DTTB channel. For example, analogue channel 4 has been assigned channel 48 for DTTB. This is an easy measurement because both stations are on the air continuously and no switching is needed.

– Make the analogue measurements on the same band as DTTB and as close to the DTTB channel as practical. For example, a UHF analogue station on channel 20 is assigned channel 35 for DTTB but channel 32 is closer in frequency and operates from the same tower.

For DTTB, transmission or propagation impairments are not visible on the screen or heard in the sound until the impairments cause outages or loss of ability to decode or demodulate. Because of the powerful error correction techniques used the difference between error-free reception and “somewhat annoying” or ITU-R grade 3 is about only 1 dB. Therefore, to attempt to rate DTTB with impairment scale is extremely difficult. Instead, it is more useful to rate the DTTB reception based on measured BER or SER or on the number of impairment-caused “hits” on the screen or in the sound within a given period of time.

3.5.1 Methodology

For subjective measurements of an analogue signal, the Recommendation ITU-R BT.500 subjective impairment measurement scale must be employed in addition to standard objective measurements. This is a five-point scale:

– Impairments are imperceptible
– Perceptible but not annoying
– Somewhat annoying
– Annoying
– Very annoying.

The quality of programme material is not considered in the subjective measurement nor are transmission impairments such as differential phase and gain, video noise, audio noise and the like. Only those impairments that occur between the broadcast and the receiver antenna are to be considered.

Because each person has his/her own opinion about the levels of impairments it is recommended that at least three viewers with some experience average their subjective rating to arrive at a value to be recorded in the test results.

Subjective viewing is recommended at five picture heights from the screen in a moderately lighted environment. Select monitor size to adjust for constraint of environment.

3.5.2 Field test facility

In general, analogue testing can be conducted using the same test setup employed for DTTB with the exception of the receiver and some test equipment. The test facility development will be determined by the objective of the test, coverage or service. Both the received analogue and digital signals should follow the same or equivalent paths within the test facility.

3.5.3 Measurement data set

Mandatory measurements to be taken for analogue field tests include field strength (peak visual carrier), visual/aural ratio, video signal/noise ratio (weighted), subjective rating, and comments on the nature of impairment (noise, interference, multipath, aircraft flutter, other). It is desirable to make a high quality video/audio recording of the received signal at the same time the subjective rating is made.

It may also be considered that the subjective rating be made later, based on the recorded material, but this procedure requires a strict monitoring of the adequacy of the recorded material at the moment of recording.

3.5.4 Site selection

Sites selection should be consistent with sites selected in the coverage § 3.2 or service § 3.3 of this Report, depending upon test objectives.

3.5.5 Analysis considerations

Part of the measurement methodology and specific test procedures includes the consideration of collecting and recording of data and how that data is to be used. Measurement data should be entered (recorded) into a database that is specifically designed for efficient interchange and analysis. When designing a database and developing the specific measurement procedures, consideration should be given to the kinds of processing and analysis expected to be conducted and how the data might be used in comparison with reports from other tests performed at later times and in other locations.

If analogue measurements are made for comparison purposes, there must be sufficient dialogue or explanation given in the test report to establish the relationship of the analogue signals with respect to the DTTB signals.

3.6 Guidelines for comparative DTTB field tests

In addition to the arrangements for field trial of an individual system, special considerations are required for comparative trials. The insight gained from reviewing various field test data leads to some practical recommendations (Dos and Don'ts) to ensure that system comparative tests are reliable and fair, and results from different field trials can be compared on a common basis.

Do:

– Describe the methodology used in sufficient details together with the results.

– Describe in detail the environment of the field tests.

– Describe the desired service (indoor, outdoor, fixed, portable, mobile, etc.).

– Duplicate the conditions of the desired service as much as possible.

– Describe the necessary compromises which have been made.

– Limit the number of variables as much as possible (antenna height, orientation of antenna, season, modes of operation, …).

– Describe the type of receiver used (at the very least, disclose its generation) and present relevant performance data like laboratory results from random noise and multipath tests.

– Note if the receiver had its bandwidth adapted and what is the internal IF used, this can explain unexpected results due adjacent or taboos channels present at test location.

– Use the latest generation DTTB modems available.

– Carry tests at a sufficient number of sites to ensure that they are statistically representative.

– Clearly define the expected coverage area.

– Check the collected data continuously to ensure consistency.

– Be circumspect of bizarre or unexpected results and investigate further to find possible causes, especially, but not exclusively, for indoor sites, where impulsive noise from household appliances, etc. or tone interference, dynamic multipath from vehicular traffic or airplanes may come and go without warning.

– Find an appropriate calibration site and make daily visits to check for proper operation of the transmitter and of the receiving test setup equipment and DTTB receivers.

– Select sites that represent as much as possible typical users' reception conditions.

– Make a deliberate attempt to select sites incorporating a diversity of construction types and locations representative of expected typical users of the service in the respective markets.

– When comparing DTTB reception for different systems:

  – Perform the tests simultaneously in time to minimize channel variations.

– Use exactly the same site and receiving conditions (antenna position, location, and type of antenna, antenna height …). For example, during indoor tests, take pictures of the actual antenna position in the room.
– List possible limitations of the tests results and the test methodology (what you set out to test and not to test or what you could not test and why).
– Identify the possible cause(s) of reception failure whenever possible. A lot of insight can be gained from a careful analysis of failed and/or sensitive sites.

Do not:

– Eliminate sites without explanation.
– Change the test procedure unless mandatory.
– Use the best location found into the mobile runs or cluster to proceed with the service receivability test. It is fair to use the average location or perform the test in the best, worst and average location to represent the site.
– Inadvertently select sites that favour one system as compared to another.
– Try to test too many variables at once.

3.7 Field survey methodology for fixed measurement of digital television reception

3.7.1 Introduction

This section describes the procedure to capture fixed digital reception characteristics in a common format, such that different organizations may make measurements and subsequent analysis will enable benchmarking of digital coverage in a comparable manner. Some amendments to the document previously submitted are highlighted.

The focus of this methodology is to confirm DTTB coverage requirements. A key outcome of the process may lead to refinement of predictive algorithms to assist the future planning and better implementation of digital television services.

3.7.2 Pre-survey planning

The planning phase includes the collection of transmission data, predictive modelling, reference and measurement site selection:

1 Contact the local broadcasters to obtain actual transmission data. This will include actual power levels, frequency, antenna pattern information and modulation characteristics (modulation, guard interval, forward error correction). A checklist is provided in Appendix 1.

2 Apply a predictive field-strength computer model for the proposed survey area.

3 From the predictive model, establish reference sites with a clear propagation path to the transmission facility, preferably in the direction of the main lobe of the transmitting antenna. Establish up to three other similar sites (one in each quadrant from the transmitter), preferably in the direction of major lobes. Such measurement sites should be selected so that the propagation path is unobstructed and free from reflections, so that the propagation path exhibits as close as practicable free-space conditions.

4 The broadcaster would need to be contacted on the day of measurements to confirm broadcaster transmission parameters.

5 Using the predictive field-strength computer model, select where line-of-sight locations are identified that correspond to antenna lobe for the purpose of determining reference antenna sites. Select sites that correspond to antenna lobe maxima and nulls. These sites will be used for coverage at anticipated good sites and will check the transmitting antenna radiation pattern.

6 Select a range of measurement locations across the entire area expected to be covered and develop a plan indicating the route to be driven taking into account the sites selected in Steps 3 and 5. Pick specifically other points at edge of the line of sight coverage (points that are not line-of-sight) and in known problem areas. Any specific issues[1] to be looked for at each location should be noted in the plan. Measurement locations should be selected across the entire coverage/licence area. Most measurements should be made close to residences to reflect the actual reception environment.

Due to time and cost constraints only a statistically small number of measurements will be possible, hence, the goal in selecting measurement locations should be to identify areas where digital reception may be a problem to allow early identification of problems and solutions to be developed.

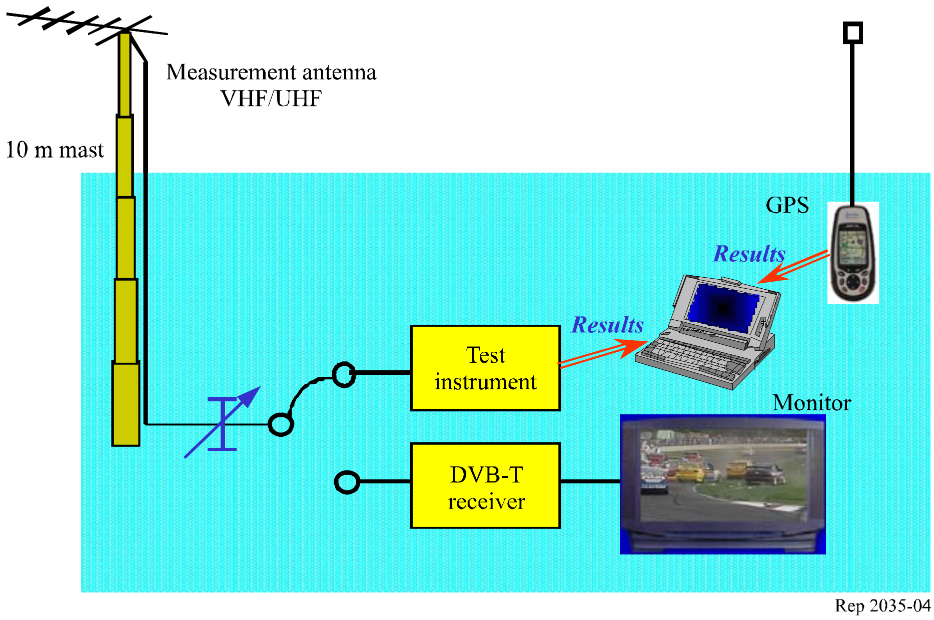
3.7.3 Measurement equipment

Measurements should be made with an antenna of known technical characteristics at the channels/frequencies to be measured. The survey measurement system should be of sufficient gain such that the overall gain/loss of the measurement system is as close as practicable to that of a DTTB test receiving system for a rural environment[2].

The equipment used will include, at a minimum:

– calibrated, adjustable dipole test antenna (VHF or UHF as appropriate);
– measurement antennas for the bands to be measured;
– calibrated test cable;
– signal strength measuring set with spectrum analyser function;
– digital decoder;
– picture monitor;
– field survey vehicle with 10 m telescopic mast and power supply system.

FIGURE 4
Survey measurement system



[1] For example, timing of signals in an SFN may be of particular interest.

[2] Refer: Appendix 3 of the ITU-R DTTB Handbook – Digital terrestrial television broadcasting in the VHF/UHF bands (Part 2 – Planning Part).

3.7.4 Measurement antennas

This methodology defines a convenient and practical survey system that delivers reliable and repeatable results. Such a system should be "representative of", but not necessarily replicate, domestic antenna installations. The recommended antenna parameters are contained in Appendix 3.

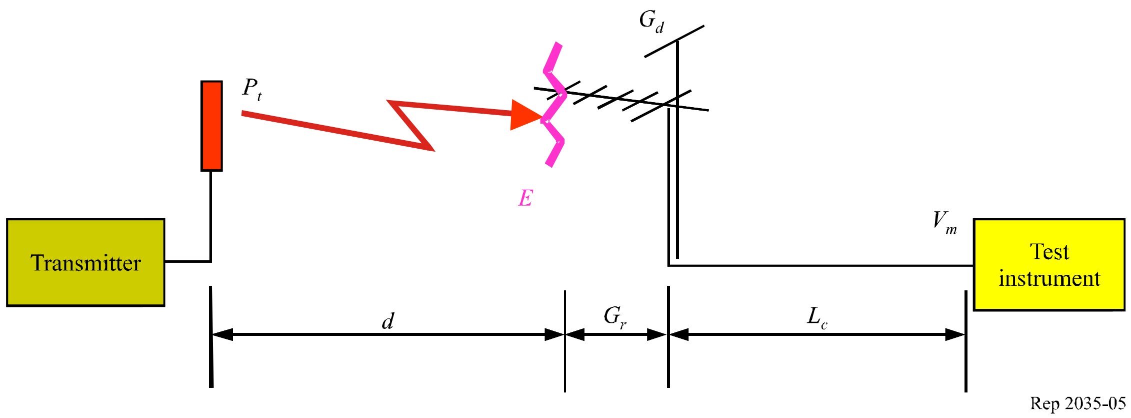
A UHF phased array "panel" type of antenna meets these objectives and permits assembly of a survey system that conforms with the "test receiving system" specification. Practical experience suggests that multi-element "yagi-style" antennas may not be optimum for UHF survey work in some areas because of their narrow beamwidths, and difficulty in achieving and maintaining correct orientation[3]. Yagi style may be more suitable in rural areas whereas the broader beam of a phased array means that the operator will have fewer problems with mast sway and overshoot on rotation in more cluttered environments. In a typical multipath situation the best signal is likely to occur at different orientations on different channels, which means, if a long-yagi style antenna is used, either compromising the performance across all channels or requiring multiple antennas to achieve acceptable results. By comparison, the use of a phased array with broader horizontal beam may deliver good performance across all channels from a single antenna.

For the DVB-T system, it is more important to maximize the total channel power received within the guard interval than it is to minimize the reception of multipath signals, so the value of narrow-beam antennas is reduced compared with the analogue case.

3.7.5 Calibration procedure

FIGURE 5

Reference measurement setup



The field strength, E, may be computed forward from the antenna data, tilt, etc.; with a known transmitter power (in effective radiated power, not effective isotropic radiated power) and measurement distance as follows:

$$E\ (\text{dB}(\mu\text{V/m})) = 10 \log (P_t)\ (\text{kW}) - 20 \log (d)\ (\text{km}) + 106.92 \quad (1)$$

[3] At this point of DTTB implementations in some countries there is anecdotal evidence, at least for the DVB-T system use of high-gain, narrow-beam antennas will not deliver optimum reception.

The field strength may be computed back from the receive antenna terminal voltage measurement (V_m), cable loss (L_c), receive antenna gain with respect to a dipole (G_{rd}) and carrier frequency (f), for a 75 Ω receive antenna impedance:

$$E \text{ (dB(μV/m))} = V_m \text{ (dBμV)} + L_c \text{ (dB)} + 20 \log (f) \text{ (MHz)} - G_{rd} \text{ (dBd)} - 33.68 \quad (2)$$

$$E \text{ (dB(μV/m))} = V_m \text{ (dBμV)} + L_c \text{ (dB)} + K \quad (2a)$$

where K (antenna factor) is given by 20 log (f) (MHz) – G_{rd} (dBd) – 33.68,

or if the antenna gain is in dBi:

$$E \text{ (dB(μV/m))} = V_m \text{ (dBμV)} + L_c \text{ (dB)} + K \quad (2b)$$

where K (antenna factor) is given by 20 log (f) (MHz) – G_{ri} (dBi) – 33.68 + 2.15.

This methodology offers dual calibration of the survey/measurement antenna with reference to the known transmit facility performance as well as to a dipole (being the basic reference), rather than using a dipole as the survey antenna.

At each reference site:

1 Call the transmission service provider to check the current transmitted power level.

2 Set up test dipole to the desired frequency of measurement (centre of digital channel) by adjusting the dipole lengths and shortening balun position according to the test antenna manufacturer's specification.

NOTE – For some calibrated dipoles this is "distance from centre point of dipole (cm) = 7 500/f (MHz for 1/4 wavelength dipole)".

3 Set up dipole on supplied non-metallic tripod at desired height. Alternatively, it may be desirable to mount the calibrated dipole on the 10 m mast to identify antenna characteristics at the reference fixed measurement AGL.

4 Connect to measurement set via calibrated measurement cable.

5 Measure the desired channel voltage V_{md} (dBμV).

6 Look up antenna factor from curves supplied by the test antenna manufacturer.

7 Calculate the field strength from the measured channel voltage, cable loss and the antenna factor specified by the antenna manufacturer or by using equations (2a) or (2b), as appropriate.

8 Set up the measurement antenna and connect to the measurement set using the calibrated measurement cable, and return the antenna to the exact position where the dipole was located.

9 Measure the terminal voltage[4] V_{mr} (dBμV). Determine the antenna correction factor (K) of the measurement antenna from the measured terminal voltage (V_{mr}), the cable loss (L_c) and the field strength recorded in Step 7 using equation (2a) or (2b), as appropriate.

10 Calculate the field strength anticipated from the transmitter using equation (1), and compare with the result in Step 7 above.

11 Resolve any anomalies between the results before proceeding to survey the area. As a guide, if results do not correlate within 3 dB, the provided transmitter e.r.p. should be queried and/or the calibration should be repeated.

[4] It is important that the measurement instrument indicates a terminal voltage derived from transmission power measured in the transmission bandwidth.

Repeat the procedure above for each broadcast transmission to be measured. Accurately note the vehicle position and antenna height at the time of the first calibration set of readings. Read and note levels of the channels under survey. Photograph the survey vehicle and the path towards the transmitter.

This can now be used as the reference set of readings. The survey vehicle should return to this location at times during the survey to reconfirm the system "health". If there is any doubt over the readings, returning to this location will be useful after repairs have been made to reconfirm all is as expected.

3.7.6 Measurement procedure

On arrival at each planned measurement location, the actual measurement location should be selected such that it is representative of viewing conditions of nearby residences (e.g. do not measure on an elevated roadway, but pull off the roadway into the township). In metropolitan areas note the typical height of existing television antennas used in that area and make measurements at that height, as well as at 10 m.

Also ensure that the measurement location is both safe for the vehicle survey operators and is not a road hazard to passing traffic. Take note of overhead power lines and overhanging trees and record in the comments field on the measurement recording sheets the terrain conditions and any obstructions for the purposes of later evaluation. The hazards of using a telescopic mast near power lines, and the dangers of driving away with the mast still elevated, are emphasized.

At each location, record the GPS references and note the geographic, climatic and environmental factors pertaining to the site as per the details in Appendix 2. If possible take one or more photos or video of the measurement location, as they may be helpful for later reference showing the measurement area including the survey vehicle. Photograph the path in the direction of the transmitters, and of typical receive antennas in use by local viewers, noting which service they appear to be watching.

Measure each broadcast transmission as follows:

1 Place the appropriate antenna securely on the mast and raise the mast so that the antenna is ten metres above ground level. Rotate, test and, if necessary, align the antenna to peak the signal on the test receiver; pass through the signal peak and back again to ensure you do not stop rotating the antenna on a side lobe[5]. If possible, occasionally check that the spectrum shape for each digital transmission is substantially flat and if necessary adjust the antenna pointing to achieve a reasonable shape compromise on all required channels.

2 If the measurement location and route is within a single frequency network (SFN), for measurement purposes, it may be necessary to use a highly directional antenna on a steerable platform when it is desired to be able to identify the contributions made by each individual transmitter in the SFN.

3 Record the measured voltage and, if possible spectrum shape for each required channel as well as for the complete group of transmissions.

4 Also record the BER, MER and, if possible, impulse response for each digital transmission as per Appendix 2.

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[5] It is good practice to note the spectrum shape and, in particular, any "dips" or slope across the transmission bandwidth. In setting up DVB-T receiving antennas for actual use, the spectrum shape is an important characteristic of the received DTTB signal.

5 If possible, assess impulse response and record comments if there are complex echoes that could make decoding more difficult, and if practicable, capture both the image of the impulse response, and the image of the MER across subcarriers.

NOTE 1– The results of the MER would be shown as an averaged value, with results shown in a diagram.

6 To determine available operating threshold, insert a variable attenuator between the antenna cable and the test receiver input. Increase the attenuation in small steps until the BER before Reed Solomon (RS) as measured by the test receiver is just less than 2×10^{-4} recording the amount of attenuation in dB[6, 7]. Assess results and re-measure if necessary.

NOTE 1 – BER is not suitable for mobile reception testing, as DVB-T was not designed for mobile. It should therefore only be tested in a fixed environment. For locations with low field strength, BER should be checked. However, BER should also be checked in areas of high field strength, as there could be impulse noise or other factors impairing reception. BER would be displayed before Viterbi and after Viterbi (limit 2×10^{-4}) with results shown in a diagram.

7 Whilst lowering the antenna, observe signal variations to determine if site is affected by ground reflections.

NOTE 1– As true free-space sites are rare, a small number of measurement sites are envisaged; and as many domestic antennas are mounted at less than 10 m, it is recommended that measurements are also done at other heights e.g. 7 and 5 m, to determine the contribution of multipath and other practical factors.

3.7.7 Site analysis

1 Before proceeding to the next measurement location, enter the results into a computer and assess the results.

2 From the GPS references, the bearing and distance to the transmitter may be calculated. Combined with transmitter data, this allows prediction of the field strength in free space. This figure should be noted to determine the total additional losses for the site. This may then be compared with the site characteristics to assess the accuracy of modelling parameters.

3 Choose a value from the DTTB signal quality scale[8] for the recordings at this site.

4 If any anomalies are noticed in this data analysis, services should be re-measured after moving a total distance within the typical physical constraints of roof antenna installations in the area (e.g. less than 20 m). Repeat measurements no more than three times. Doing a further measurement nearby should indicate whether the first result is affected by any location specific propagation affects.

5 The results should be examined for consistency and against the propagation model predictions. If no discrepancies are noted, the survey should proceed to the next planned measurement site.

6 If any anomalies are noticed in this data assessment:

a) check equipment and repeat measurements; or

b) in such cases, the possible causes for the anomalies need to be noted.

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[6] ETSI TR 101 290 V1.2.1 states that for quasi error free (QEF) operation after the RS decoder, a BER < 2×10^{-4} before the RS decoder is required.

[7] Noise injection is an alternative methodology that could be used to obtain thresholds (C/N).

[8] Refer: Document 6/115 (28 October 2004).

3.7.8 Propagation model site analysis

At the completion of the field survey for a particular region, the results should be statistically analysed to check against the propagation prediction model. This analysis may then include refinement of the model to minimize the difference between prediction and measured results.

3.8 Field survey methodology for nomadic measurement of digital television reception

3.8.1 Introduction

This section describes a procedure to capture the use of "drive and park" surveying which may offer a solution to the dilemma facing broadcasters and regulators of defining a method for DTTB coverage determination which could be less time-consuming than measurements taken at 10 m with a pump-up mast. An objective is to record digital reception characteristics in a common format, such that different organizations may make measurements and subsequent analysis will enable benchmarking of digital coverage in a comparable manner. Dependant upon the accuracy of the measurement technologies, this could also lead to the capture of larger amounts of data within a shorter time-frame.

A key outcome of the process is developed for the trial of an instrument which allows "drive and park" surveying. The key features of this field survey methodology are:

a) reference measurements are made at sites with a clear radio path at 10/7.5/5/2.5 m AGL to the transmission facility, preferably in the direction of the main lobe of the transmitting antenna;

b) a "drive and park" measurement technique is employed where measurements are undertaken using the new measurements technologies at predetermined sites at 1.5-2 m AGL. The measurement vehicle is driven predetermined distances on a selected route to capture a significant sample of measurement data at each site within the DTTB coverage location to determine fixed reception at each location on the route at 1.5-2 m.

A key outcome of the process may lead to the introduction of these technologies to assist the future planning and better implementation of digital television services.

It is anticipated that the survey data gathered by administrations would be submitted to Radiocommunication Study Group 3 to assist in the ongoing improvement in propagation prediction methods.

3.8.2 Pre-survey planning

The planning phase includes the collection of transmission data, predictive modelling, reference and measurement site selection.

1 Contact the local broadcasters to obtain actual transmission data. This will include actual power levels, frequency, antenna pattern information and modulation characteristics (modulation, guard interval, forward error correction). A checklist is provided in Appendix 1.

2 Apply a predictive field-strength computer model for the proposed survey area.

3 From the predictive model, establish reference sites with a clear propagation path to the transmission facility, preferably in the direction of the main lobe of the transmitting antenna. Establish up to three other similar sites (one in each quadrant from the transmitter), preferably in the direction of major lobes. Such measurement sites should be selected so that the propagation path is unobstructed and free from reflections, so that the propagation path exhibits as close as practicable free-space conditions.

4 The broadcaster would need to be contacted on the day of measurements to confirm broadcaster transmission parameters.

5 Using the predictive field-strength computer model, select where line of site locations are identified that correspond to antenna lobe, etc., for the purpose of determining reference antenna sites. Select sites that correspond to antenna lobe maxima and nulls. These sites will be used for coverage at anticipated good sites and will check the transmitting antenna radiation pattern.

6 Select a range of measurement locations across the entire area expected to be covered and develop a plan indicating the route to be driven taking into account the sites selected in Steps 3 and 5. Pick specifically other points at edge of the line-of-sight coverage (points that are not line-of-sight) and in known problem areas. Any specific issues[9] to be looked for at each location should be noted in the plan. Measurement locations should be selected across the entire coverage/licence area. Most measurements should be made close to residences to reflect the actual reception environment. Due to time and cost constraints only a statistically small number of measurements will be possible, hence, the goal in selecting measurement locations should be to identify areas where digital reception may be a problem to allow early identification of problems and solutions to be developed.

3.8.3 Measurement equipment

Measurements should be made with an antenna of known technical characteristics at the channels/frequencies to be measured. The survey measurement system should be of sufficient gain, such that the overall gain/loss is as close as practicable to that of a DTTB test receiving system for a rural environment[10].

The equipment used will include at a minimum:

– calibrated, adjustable dipole test antenna (VHF or UHF as appropriate);

– measurement antennas for the bands to be measured;

– calibrated test cable;

– signal strength measuring set with spectrum analyser function;

– digital decoder;

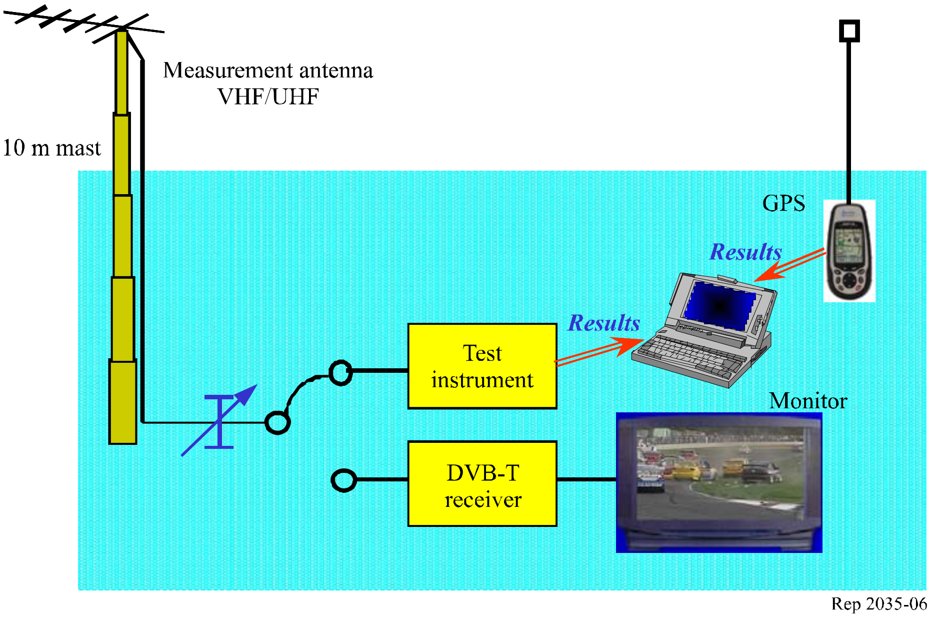
– picture monitor;

– field survey vehicle with 10 m telescopic mast and power supply system.

[9] For example timing of signals in an SFN may be of particular interest.

[10] See Appendix 3.

FIGURE 6
Survey measurement system



3.8.4 Measurement antennas

This methodology defines a convenient and practical survey system that delivers reliable and repeatable results. Such a system should be "representative of", but not necessarily replicate, domestic antenna installations. The recommended antenna parameters are contained in Appendix 3.

A UHF phased array "panel" type of antenna meets these objectives and permits assembly of a survey system that conforms with the "test receiving system" specification. Practical experience suggests that multi-element "yagi-style" antennas may not be optimum for UHF survey work in some areas because of their narrow beamwidths and difficulty in achieving and maintaining correct orientation[11]. Yagi style may be more suitable in rural areas, whereas the broader beam of a phased array means that the operator will have fewer problems with mast sway and overshoot on rotation in more cluttered environments. In a typical multipath situation, the best signal is likely to occur at different orientations on different channels which means, if a long-yagi style antenna is used, either compromising the performance across all channels or requiring multiple antennas to achieve acceptable results. By comparison, the use of a phased array with broader horizontal beam may deliver good performance across all channels from a single antenna.

For the DVB-T system, it is more important to maximize the total channel power received within the guard interval than it is to minimize the reception of multipath signals so the value of narrow-beam antennas is reduced compared with the analogue case.

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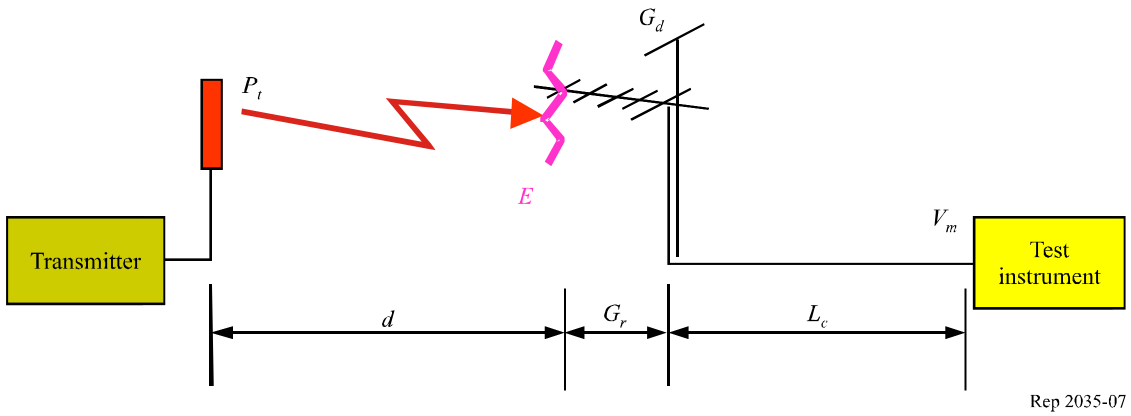
[11] At this point of DTTB implementations there is anecdotal evidence, at least for the DVB-T system use of high-gain, that narrow-beam antennas will not deliver optimum reception.

3.8.5 Calibration procedure

FIGURE 7
Reference measurement setup



The field strength, E, may be computed forward from the antenna data, tilt etc; with a known transmitter power (in effective radiated power, not effective isotropic radiated power) and measurement distance as follows:

$$E\ (\text{dB}(\mu\text{V/m})) = 10 \log (P_t)(\text{kW}) - 20 \log (d)\ (\text{km}) + 106.92 \tag{1}$$

The field strength may be computed back from the receive antenna terminal voltage measurement (V_m), cable loss (L_c), receive antenna gain with respect to a dipole (G_{rd}) and carrier frequency (f), for a 75 Ω receive antenna impedance:

$$E\ (\text{dB}(\mu\text{V/m})) = V_m\ (\text{dB}\mu\text{V}) + L_c\ (\text{dB}) + 20 \log (f)\ (\text{MHz}) - G_{rd}\ (\text{dBd}) - 33.68 \tag{2}$$

$$E\ (\text{dB}(\mu\text{V/m})) = V_m\ (\text{dB}\mu\text{V}) + L_c\ (\text{dB}) + K \tag{2a}$$

where K (antenna factor) is given by 20 log (f) (MHz) – G_{rd} (dBd) – 33.68,

or if the antenna gain is in dBi:

$$E\ (\text{dB}(\mu\text{V/m})) = V_m\ (\text{dB}\mu\text{V}) + L_c\ (\text{dB}) + K \tag{2b}$$

where K (antenna factor) is given by 20 log (f) (MHz) – G_{ri} (dBi) – 33.68 + 2.15.

This methodology offers dual calibration of the survey/measurement antenna with reference to the known transmit facility performance as well as to a dipole (being the basic reference), rather than using a dipole as the survey antenna.

At each reference site:

1 Call the transmission service provider to check the current transmitted power level.

2 Set up test dipole to the desired frequency of measurement (centre of digital channel) by adjusting the dipole lengths and shorting balun position according to the test antenna manufacturer's specification.

NOTE – For some calibrated dipoles this is "distance from centre point of dipole (cm) = 7 500/f (MHz for 1/4 wavelength dipole)".

3 Set up dipole on supplied non-metallic tripod at desired height. Alternatively, it may be desirable to mount the calibrated dipole on a free-standing fibreglass pole of 3 m to identify antenna characteristics at the reference fixed measurement AGL.

4 Replace dipole with measurement antenna[12] and repeat the reading.

5 Move vehicle to calibration location and repeat measurement with measurement antenna aligned to face towards the transmitter.

6 Connect to measurement set via calibrated measurement cable.

7 Measure the desired channel voltage V_{md} (dBμV).

8 Look up antenna factor from curves supplied by the test antenna manufacturer.

9 Calculate the field strength from the measured channel voltage, cable loss and the antenna factor specified by the antenna manufacturer or by using equations (2a) or (2b), as appropriate.

10 Set up the measurement antenna and connect to the measurement set using the calibrated measurement cable, and return the antenna to the exact position where the dipole was located.

11 Measure the terminal voltage[13] V_{mr} in dBμV. Determine the antenna correction factor (K) of the measurement antenna from the measured terminal voltage (V_{mr}), the cable loss (L_c) and the field strength recorded in Step 7 using equation (2a) or (2b), as appropriate.

12 Calculate the field strength anticipated from the transmitter using equation (1), and compare with the result in Step 7 above.

13 Resolve any anomalies between the results before proceeding to survey the area. As a guide, if results do not correlate within 3 dB, the provided transmitter e.r.p. should be queried and/or the calibration should be repeated.

Repeat the procedure above for each broadcast transmission to be measured. Accurately note the vehicle position and antenna height at the time of the first calibration set of readings. Read and note levels of the channels under survey. Photograph the survey vehicle and the path towards the transmitter.

This can now be used as the reference set of readings. The survey vehicle should return to this location at times during the survey to reconfirm the system "health". If there is any doubt over the readings, returning to this location will be useful after repairs have been made to re-confirm all is as expected.

3.8.6 Measurement procedure

On arrival at each planned measurement location, the actual measurement location should be selected such that it is representative of viewing conditions of nearby residences (e.g. do not measure on an elevated roadway, but pull off the roadway into the township). In metropolitan areas note the typical height of existing television antennas used in that area.

Also ensure that the measurement location is both safe for the vehicle survey operators and is not a road hazard to passing traffic. Take note of overhead power lines and overhanging trees, and record in the comments field on the measurement recording sheets the terrain conditions and any obstructions for the purposes of later evaluation. The hazards of using a telescopic mast near power lines, and the dangers of driving away with the mast still elevated, are emphasized.

At each measurement point whether during a drive test or at a static location on the route of the drive test, record the GPS reference. Note the geographic, climatic and environmental factors

[12] To be further clarified re omnidirectional antennas and SFNs.

[13] It is important that the measurement instrument indicates a terminal voltage derived from transmission power measured in the transmission bandwidth.

pertaining to the route as per the details in Appendix 2. If possible, photos or a video of the measurement location may be helpful for later reference.

Measure each broadcast transmission as follows:

1 Test and, if necessary, align the antenna to peak the signal on the test receiver; pass through the signal peak and back again to ensure you do not stop rotating the antenna on a side lobe[14]. If possible, occasionally check that the spectrum shape for each digital transmission is substantially flat, and if necessary adjust the antenna pointing to achieve a reasonable shape compromise on all required channels.

2 If the measurement location and route is within a single frequency network (SFN) it may be necessary, for measurement purposes, to use a highly directional antenna when it is desired to be able to identify the contributions made by each individual transmitter in the SFN.

3 Record the measured voltage and, if possible, spectrum shape for each required transmission.

4 Also record the BER, MER and, if possible, impulse response for each digital transmission as per Appendix 2.

5 If possible, assess impulse response and record comments if there are complex echoes that could make decoding more difficult, and if practicable, capture both the image of the impulse response and the image of the MER across sub-carriers.

NOTE 1 – The results of the MER would be shown as an averaged value, with results shown in a diagram.

6 MER is used for drive-by reception testing, as DVB-T was not designed for mobile.

7 If the antenna is height-adjustable and measuring at a static location, lower the antenna and observe signal variations to determine if the site is affected by ground reflections.

3.8.7 Site analysis

1 The results should be assessed for consistency and against the propagation model predictions. If no discrepancies are noted, the survey should proceed to the next planned measurement site.

2 If any anomalies are noticed in this data assessment,

a) check equipment and repeat measurements; or

b) if static measurements were made, choose different locations.

3.8.8 Propagation model site analysis

At the completion of the field survey for a particular region, the results should be statistically analysed to check against the propagation prediction model. This analysis may then include refinement of the model to minimize the difference between prediction and measured results.

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[14] It is good practice to note the spectrum shape and in particular any “dips” or slope across the transmission bandwidth. In setting up DVB-T receiving antenna's for actual use the spectrum shape is an important characteristic of the received DTTB signal.

4 Representative equipment and costs

The equipment required for laboratory tests and filed trials of the ITU-R DTTB systems A, B, and C are listed in § 4.1.1 to 4.1.4 together with some representative costs based upon previous tests. All costs are provided in Canadian dollars.

4.1 Equipment and facility costs

4.1.1 Laboratory test facilities

Item	Cost (1000 Canadian $)(1)
Digital modulator (Systems A, B and C)	60 each
Channel simulator	85
Spectrum analyser	35
Random noise generator	10
Filters	5
Analogue modulator (PAL or SECAM or NTSC)	10
Miscellaneous test equipment	30
TOTAL	355

(1) These estimates are based upon the use of professional grade equipment available in the 2001/2002 time frame; the currency exchange rates in mid-September 2002 were approximately 1$ Canadian = ~ 0.7 $US = ~ 0.7 Euros.

4.1.2 Transmission facilities

This cost estimate assumes that an existing transmitter building, an existing antenna tower as well as an existing antenna can be shared.

Item	Cost (1000 Canadian $)
Combiner	60
Transmission lines	10
RF equipment (DTTB Exciter, 2 500 W Tx, dummy load, etc.)	325
Transport stream player	40
Installation material	2
Racks, monitoring equipment, etc.	12
Installation (transmitter, combiner, racks, etc.)	15
Building integration	100
Engineering (planning, commissioning, maintenance)	15
Miscellaneous (travel, shipping, etc.)	10
DTTB encoder (HD and SD capable) – Real time video compression	100
Additional filter for adjacent channel operation	20
One year operating costs (maintenance, power, training, etc.)	70
TOTAL	779

4.1.3 Field test facilities

Item	Cost (1000 Canadian $)
Test van (with AC generator and 10 m antenna mast)	100
Professional DTTB receivers (Systems A, B and C)(1)	5
Antennas	5
Coverage prediction software (i.e. CRC-COV)	55
Vector analyser	60
TOTAL	235

(1) These estimates are for the type of professional receiver used in field trials, and are not related to the prices of receivers or STBs mass-produced for the domestic market.

4.1.4 Summary of equipment and facility costs

Item	Cost (1000 Canadian $)
Laboratory test facilities	355
Transmission facilities	779
Field test facilities	235
TOTAL	1 369

5 System descriptions

5.1 ITU-R DTTB System A – The ATSC 8-VSB system

The ATSC Digital Television Standard was developed by the Advanced Television Systems Committee in the United States of America.

The ATSC system was designed to transmit high-quality video and audio (high definition television (HDTV)) and ancillary data over a single 6 MHz channel. The system was developed for terrestrial broadcasting. It can reliably deliver 19.4 Mbit/s of data throughput in a 6 MHz terrestrial channel.

For terrestrial broadcasting, the system was designed to allow the allocation of an additional digital transmitter for each existing analogue transmitter with comparable coverage, and minimum disturbance to the existing analogue service in terms of both area and population coverage. This capability is met and even exceeded as the RF transmission characteristics of the system are carefully chosen to cope with an analogue environment.

Various picture qualities can be achieved with 18 video formats (SD or HD, progressive or interlaced, as well as different frame rates). There is a great potential for databased services utilizing the opportunistic data transmission capability of the system. The system can accommodate fixed (and possibly portable) reception.

The system is quite efficient and capable of operating under various conditions, i.e. clear channel availability or, as implemented in the United States of America, constrained to fit 1 600 additional channel allocations into an already crowded spectrum, and reception with roof-top or portable antennae.

The system is designed to withstand many types of interference: existing analogue TV services, white noise, impulse noise, phase noise, continuous wave and passive reflections (multipath). The system is also designed to offer spectrum efficiency and ease of frequency planning.

The system uses a single carrier modulation scheme, eight-level Vestigial-SideBand (8-VSB) modulation. It is designed for single transmitter (multi-frequency network (MFN)) implementation. However, on-channel repeater and gap-filler operation are viable.

Although the system was developed and tested with 6 MHz channels, it can be scaled to any channel bandwidths (6, 7, or 8 MHz) with corresponding scaling in the data capacity.

5.2 ITU-R DTTB System B – The DVB-T COFDM system

The DVB-T system was developed by an European consortium of public and private sector organizations – the Digital Video Broadcasting Project.

The DVB-T specification is part of a family of specifications also covering satellite (DVB-S) and cable (DVB-C) operations. This family allows for digital video and digital audio distribution as well as transport of forthcoming multimedia services.

For terrestrial broadcasting, the system was designed to operate within the existing UHF spectrum allocated to analogue PAL and SECAM television transmissions. Although the system was developed for 8 MHz channels, it can be scaled to any channel bandwidth (8, 7, or 6 MHz) with corresponding scaling in the data capacity. The net bit rate available in 8 MHz channel ranges between 4.98 and 31.67 Mbit/s, depending on the choice of channel coding parameters, modulation types, and guard interval duration.

The system was essentially designed with built-in flexibility, in order to be able to adapt to all types of channel. It is capable of coping not only with Gaussian channels, but also with Ricean and Rayleigh channels. It can withstand high-level (up to 0 dB) long delay static and dynamic multipath distortion. The system is robust to interference from delayed signals, either echoes resulting from terrain or building reflections, or signals from distant transmitters in an SFN arrangement.

The system features a number of selectable parameters that accommodate a large range of *C*/*N*s and channel behaviours. It allows fixed, portable, or mobile reception, with a consequential trade-off in the usable bit rate. This range of parameters allows the broadcasters to select a mode appropriate to the application foreseen. For instance, a moderately robust mode (with a correspondingly lower data rate) is needed to ensure reliable portable reception with a simple set-top antenna. A less robust mode with a higher data rate could be used where the service planning uses frequency-interleaved channels. The less robust modes with the highest payloads can be used for fixed reception and if a clear channel is available for digital TV broadcasting.

The system uses a large number of carriers per channel modulated in parallel via an FFT process (fast Fourier transform), a method referred to as OFDM. It has two operational modes: a “2k mode” which uses a 2k FFT; and an “8k mode” which requires an 8k FFT. The system makes provisions for selection between different levels of QAM modulation and different inner code rates and also allows two-level hierarchical channel coding and modulation. Moreover, a guard interval with selectable width separates the transmitted symbols, which allows the system to support different network configurations, such as large area SFNs and single transmitter operation. The “2k mode” is suitable for single transmitter operation and for small SFN networks with limited distance between transmitters. The “8k mode” can be used both for single transmitter operation and for small and large SFN networks.

5.3 ITU-R DTTB System C – The ISDB-T BST-OFDM system

The ISDB-T system was developed by the Association of Radio Industries and Businesses (ARIB) in Japan.

ISDB (integrated services digital broadcasting) is a new type of broadcasting intended to provide audio, video and multimedia services. The system was developed for terrestrial (ISDB-T) and satellite (ISDB-S) broadcasting. It systematically integrates various kinds of digital contents, each of which may include multiprogramme video from low definition television (LDTV) to HDTV, multiprogramme audio, graphics, text, etc.

Since the concept of ISDB covers a variety of services, the system has to meet a wide range of requirements that may differ from one service to another. For example, a large transmission capacity is required for HDTV service, while a high service availability (or transmission reliability) is required for data services such as the delivery of a "key" for conditional access, downloading of software, and so on. To integrate different service requirements, the transmission system provides a range of modulation and error protection schemes, which can be selected and combined flexibly in order to meet each requirement of these integrated services.

For terrestrial broadcasting, the system has been designed to have enough flexibility to deliver digital television and sound programmes and offer multimedia services in which various types of digital information such as video, audio, text and computer programs will be integrated. It also aims at providing stable reception through compact, light and inexpensive mobile receivers in addition to integrated receivers typically used in homes.

The system uses a modulation method referred to as band segmented transmission (BST) OFDM, which consists of a set of common basic frequency blocks called BST-Segments. Each segment has a bandwidth corresponding to 1/14th of the terrestrial television channel spacing (6, 7, or 8 MHz depending on the region). For example, in a 6 MHz channel, one segment occupies 6/14 MHz = 428.6 kHz spectrum, seven segments occupy $6 \times 7/14$ MHz = 3 MHz.

In addition to the properties of OFDM reviewed in the previous section, BST-OFDM provides hierarchical transmission capabilities by using different carrier modulation schemes and coding rates of the inner code on different BST-segments. Each data segment can have its own error protection scheme (coding rates of inner code, depth of the time interleaving) and type of modulation (QPSK, DQPSK, 16-QAM or 64-QAM). Each segment can then meet different service requirements. A number of segments may be combined flexibly to provide a wideband service (e.g. HDTV). By transmitting OFDM segment groups with different transmission parameters, hierarchical transmission is achieved. Up to three service layers (three different segment groups) can be provided in one terrestrial channel. Partial reception of services contained in the transmission channel can be obtained using a narrow-band receiver that has a bandwidth as low as one OFDM segment.

Thirteen OFDM spectrum segments are active within one terrestrial television channel. The useful bandwidth is $BW_{TV} \times 13/14$, corresponding to 5.57 MHz for a BW_{TV} = 6 MHz channel, 6.50 MHz for a 7 MHz channel, and 7.43 MHz for an 8 MHz channel.

The system was developed and tested with 6 MHz channels but it can be scaled to any channel bandwidth with corresponding variations in the data capacity. The net bit rate for one 428.6 kHz segment in a 6 MHz channel ranges between 280.85 and 1 787.28 kbit/s. The data throughput for a 5.57 MHz DTTB channel ranges between 3.65 and 23.23 Mbit/s.

The system was designed to provide fixed, portable or mobile reception at different data rates and robustness. It is also designed for SFN operation.

Annex 1

Field test summary chart

Test purpose or type	Primary information (* indicates principle information sought)	Receiving mode(1)	Site selection	Test duration(2)	Antenna class and height	Antenna orientation	Test conditions (environment and measurement)
Coverage (coverage model verification)	Field strength verify the predicted coverage: received signal level impulse noise RF interference	Outdoor: cluster (100 ft run) (multiple points) (azimuth angle)	Typical from 30 to 100, higher number is statically better. Location over radial, arc or grids	Short term(3)	Outdoor, 10 m; calibrated directional with gain	Toward transmission tower	Weather Measurements on: arcs, radials, grids, clusters RF interference Time variability
Service (receivability)	Demodulated and decoded signal statistics how well can the signal be received? * Impairments: impulse noise RF interference Signal level variations Multipath measurements – include but not limited to: signal strength noise floor error rate noise-added threshold equalizer taps tested (system) calibration information location antenna direction pilot level, if any No site selection is based on impairments	Fixed	Typical from 30 to 100, higher number is statically better. Location over radial, arc or grids	Seasonal Very long term Long term Short term Very short term	Outdoor, 10 m AGL; directional with gain	Optimal(4) Non-optimal(5)	Weather Impairments(6) Nearby objects in motion(7): neighbouring far
			At least 20% of sites with good (high signal level) outdoor reception	Seasonal Very long term Long term Short term Very short term	Indoor, 1.5 m above floor level (AFL): directional with some gain reference dipole(8)	Optimal Non-optimal	Weather Impairments(6) Nearby objects in motion: near neighbouring far
		Portable	At least 20% of sites with good (high signal level) outdoor reception	Long term Short term Very short term	Indoor, 1 m AFL: monopole directional	Optimal Non-optimal	Weather Impairments Nearby objects in motion: near neighbouring far
		Pedestrian: < 5 km/h < 3.11 mph	At least 20% of sites with good (high signal level) outdoor reception	Short term Very short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects in motion: near neighbouring far Receiver in motion

Field test summary chart (*end*)

Test purpose or type	Primary information (* indicates principle information sought)	Receiving mode(1)	Site selection	Test duration(2)	Antenna class and height	Antenna orientation	Test conditions (environment and measurement)
		Mobile: 5 km/h > 3.11 mph		Short term Very short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects per route segment
		Personal: 5 km/h > 3.11 mph	At least one route with a minimum of 10 km (6.2 miles)	Short term Very short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects per route segment
Channel characteristics	Multipath:* amplitude phase delay quantity number and dispersion doppler Field strength Impulse noise Other information as desired: RF interference; e.g., adjacent and taboo decoded signal statistics signal level variations Site selections may be biased as required; e.g. impairments	Fixed	If done together with service receivability, record the failing and difficult reception sites (i.e. degraded *C*/*N*)	Seasonal Very long term Long term Short term	Outdoor, 10 m AGL: directional with gain Indoor, 1.5 m AFL: directional with some gain	Optimal Non-optimal	Weather Impairments Nearby objects in motion: near neighbouring far
		Portable	If done together with service receivability, record the failing and difficult reception sites	Seasonal Very long term Long term Short term	Indoor, 1 m AFL: monopole directional	Optimal Non-optimal	
		Pedestrian		Short term Very short term	Non-directional, 1.5 m AFL: monopole	Optimal Non-optimal	Impairments Nearby objects in motion: near neighbouring far Receiver in motion
		Personal	If done together with service receivability, record the failing and difficult reception route segments	Short term Very short term	Non-directional, 1.5 m AFL: monopole	Optimal Non-optimal	
		Mobile		Short term Very short term	Non-directional, 1.5 m AFL: monopole	Optimal Non-optimal	

Notes relating to Annex 1:

(1) Fixed: Permanently located, orientable, or non-orientable
Portable: Moveable, stationary during use
Pedestrian: In motion during use; < 5 km/h using low gain antennas
Mobile: In motion during use; > 5 km/h
Personal: In motion during use; > 5 km/h using low gain antennas

(2) Test duration (includes both observation period and observation interval)
Seasonal: Months/year (snow)
Very long term: Days/months (weather)
Long term: Min/h (programme length)
Short term Seconds (announcement length/data)
Very short term: < Seconds (data)

(3) Long term analysis: Coverage may also be measured on a long-term basis to obtain time variability

(4) Antenna oriented for best reception for each channel tested

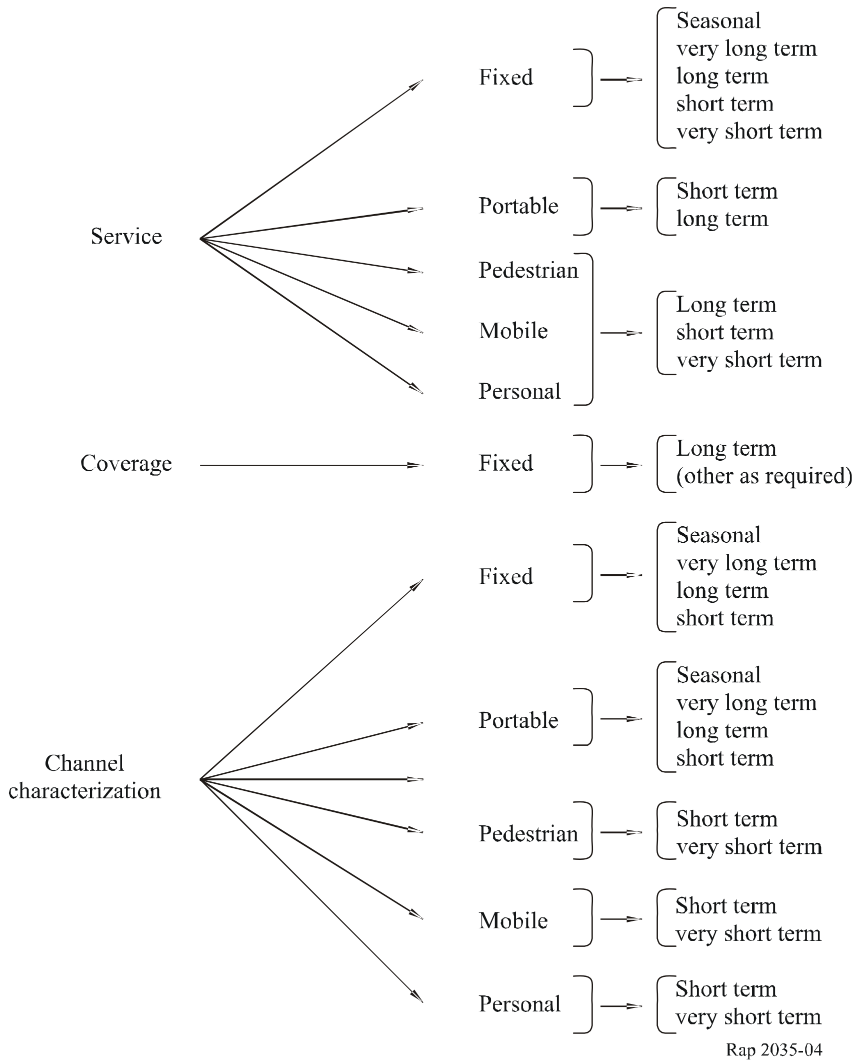
(5) Antenna oriented for averaged "best" reception among all channels to be received

(6) Typical impairments: Street lights, transformers, dimmers, auto ignition
Interference, multipath, signal level variations

(7) Near: Within a few wavelengths (e.g., people)
Neighbouring: A few wavelengths to 200 ft (e.g., vehicles)
Far: More than 200 ft (e.g., airplanes)

(8) A calibrated reference dipole may also be used for indoor measurements.

Test types, receiving modes, and test durations



Annex 2

Minimum DTTB comparative field test summary chart

Test purpose or type	Primary information	Receiving mode	Site selection	Test duration	Antenna class and height	Antenna orientation	Test conditions (environment and measurement)
Service (receivability)	Demodulated and decoded signal statistics how well can the signal be received? Impairments: impulse noise RF interference Signal level variations Multipath measurements – include but not limited to: signal strength noise floor error rate noise-added threshold tested (system) Calibration: information location antenna direction No site selection is based on impairments. ATSC specifics: equalizer taps pilot level, if any COFDM specifics: delay profile	Fixed outdoor	At least 100 sites located over radials, arcs or grids	Long term Short term	Outdoor, 10 m AGL: directional with gain	Optimal Non-optimal	Weather Impairments Nearby objects in motion: neighbouring far
		Fixed indoor	At least 20% of sites with good (high signal level) outdoor reception	Long term Short term	Indoor, 1.5 m AFL: directional with some gain. Reference dipole[(1)]	Optimal Non-optimal	Weather Impairments Nearby objects in motion: near neighbouring far
		Portable	At least 20% of sites with good (high signal level) outdoor reception	Short term	Indoor, 1 m AFL: monopole directional	Optimal Non-optimal	Weather Impairments Nearby objects in motion: near neighbouring far
		Pedestrian: < 5 km/h < 3.11 mph	At least 20% of sites with good (high signal level) outdoor reception	Short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects in motion: near neighbouring far Receiver in motion
		Mobile: 5 km/h > 3.11 mph	At least one route with a minimum of 10 km (6.2 miles)	Short term Very short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects per route segment
		Personal	At least one route with a minimum of 10 km (6.2 miles)	Short term Very short term	Non-directional, 1.5 m AFL: monopole	Not specified	Weather Impairments Nearby objects per route segment

(1) Reference dipole: A calibrated reference dipole may also be used for indoor measurements.
Observation: some of these reception modes may be suppressed, according to each country's needs.

Annex 3

PN test sequences

Many PN sequences are used for various applications. The following are some that are in use today:

$2^{11} - 1$ (2 047) per ITU-T Recommendation O.152

$2^{15} - 1$ (32 767) per ITU-T Recommendation O.151

$2^{23} - 1$ (8 388 607) per ITU-T Recommendation O.151

Annex 4

Multipath ensembles

Many multipath ensembles are used by different laboratories. Some of the ensembles used for static multipath simulation are the following:

Name	Description	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6
UK short delay	Delay (µs)	0	0.05	0.4	1.45	2.3	2.8
	Attenuation (dB)	2.8	0	3.8	0.1	2.6	1.3
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0
UK long delay	Delay (µs)	0	5	14	35	54	75
	Attenuation (dB)	0	9	22	25	27	28
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0
DVB-T (portable reception)	Delay (µs)	0.5	1.95	3.25	2.75	0.45	0.85
	Attenuation (dB)	0	0.1	0.6	1.3	1.4	1.9
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	336	9	175	127	340	36
CRC	Delay (µs)	0	–1.8	0.15	1.8	5.7	35
	Attenuation (dB)	0	11	11	1	Variable	9
	Frequency (Hz)	0	0	0	0	5	0
	Phase (degrees)	0	125	80	45	0	90
Brazil A	Delay (µs)	0	0.15	2.22	3.05	5.86	5.93
	Attenuation (dB)	0	13.8	16.2	14.9	13.6	16.4
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0
Brazil B	Delay (µs)	0	0.3	3.5	4.4	9.5	12.7
	Attenuation (dB)	0	12	4	7	15	22
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0
Brazil C	Delay (µs)	0	0.089	0.419	1.506	2.322	2.799
	Attenuation (dB)	2.8	0	3.8	0.1	2.5	1.3
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0

Name	Description	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6
Brazil D	Delay (µs)	0.15	0.63	2.22	3.05	5.86	5.93
	Attenuation (dB)	0.1	3.8	2.6	1.3	0	2.8
	Frequency (Hz)	0	0	0	0	0	0
	Phase (degrees)	0	0	0	0	0	0
Brazil E	Delay (µs)	0	1	2	–	–	–
	Attenuation (dB)	0	0	0	–	–	–
	Frequency (Hz)	0	0	0	–	–	–
	Phase (degrees)	0	0	0	–	–	–

The most common fading model for used in mobile reception simulation is the GSM channel applied to typical urban areas, reproduced below:

Name	Description	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6
Typical urban GSM	Delay (µs)	0	0.2	0.5	1.7	2.3	5.0
	Attenuation (dB)	13	10	12	16	18	20
	Fading	Rayleigh					

Annex 5

Laboratory test results

This Annex is a compilation of the results obtained strictly according to the guidelines of this Report, aiming to be an updated characterization of the commercially available DTTB receivers. The set of results made available through this Report comprise the results obtained along year 2000 and year 2004.

Tests were performed within the agreement signed by the ABERT/SET Digital Television Group and the Mackenzie Presbyterian University in Brazil.

ABERT/SET is a technical study group on digital television, which comprises ABERT (Brazilian Association of Television and Radio Broadcasters) and SET (Brazilian Society of Television Engineering) and has the participation of engineers from all the networks in Brazil and members from the industry and research centres. Mackenzie University, which has also participated in the test concluded on April 2000, hosted the experiments.

Test results are identified according to the year they were performed. Results of year 2000 were kept for purposes of comparison but they do not represent current status of DTTB receiver technology.

It is to be noted that the presented results relates to 6 MHz channel bandwidth. For 7 MHz and 8 MHz countries the useful bit rate is higher and should be calculated accordingly. As the length of the guard interval is also of relevance for the multipath performance analysis, the detailed parameter set for DVB-T is provided in Table 3 for clarification.

TABLE 3

Duration of the guard interval for DVB-T – 6 MHz

Mode	8k mode				2k mode			
Guard interval (GI)	1/4	1/8	1/16	1/32	1/4	1/8	1/16	1/32
Duration of guard interval Δ	298.7 µs	149.3 µs	74.7 µs	37.3 µs	74.7 µs	37.3 µs	18.7 µs	9.3 µs
Symbol duration $T_S = \Delta + T_U$	1 493 µs	1 344 µs	1 269 µs	1 232 µs	373 µs	336 µs	317 µs	308 µs

1 Experiment 2.1: Random noise impairment

1.1 ATSC test results

Modulation		8VSB
Forward error correction (FEC)		2/3
Bit rate (Mbit/s)		**19.4**
Carrier-to-noise threshold (dB)	RX1 2004	15.2
	RX2 2004	15.4
	RX3 2004	15.2
	ZEN 2000	14.7
	ZEN2 2000	15.4
	RXA 2000	15.1
	RXS 2000	14.8
	RXU 2000	16.1

1.2 DVB-T test results

Modulation		64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM	64-QAM
Carrier number		8k	8k	8k	8k	8k	2k	8k	8k
FEC		3/4	3/4	2/3	1/2	1/2	3/4	3/4	2/3
GI		1/16	1/8	1/16	1/16	1/16	1/16	1/32	1/32
Bit rate (Mbit/s)		**19.7**	**18.7**	**17.6**	**8.8**	**4.4**	**19.7**	**20.4**	**18.1**
Carrier-to-noise threshold (dB)	RX1 2004	19.5		17.4	10.6	4.7	–	–	–
	RX2 2004	17.8		17.3	8.8	3.0	–	–	–
	RX3 2004	17.7		16.2	8.2	4.0	–	–	–
	RX4 2004	19.0		18.1	–	–	–	–	–
	NDS 2000	19.0	18.8	–	–	–	19.0	–	–
	RXK 2000	19.2	–	–	–	–	19.2	19.0	18.5
	RXL 2000	–	–	–	–	–	–	–	18.4
	RXM 2000	–	–	–	–	–	–	19.2	17.0
	RXN 2000	20.0	–	–	–	–	20.0	–	–

Modulation		64-QAM	64-QAM	64-QAM	64-QAM
Carrier number		8k	8k	8k	8k
FEC		3/4	1/2	3/4	1/2
GI		1/16	1/16	1/16	1/16
α =		1	1	2	2
Priority		LP	HP	LP	HP
Bit rate (Mbit/s)		**13.2**	**4.4**	**13.2**	**4.4**
C/*N* ratio (dB)	RX1 2004	20.4	11.3	25.1	8.0
	RX5 2004	19.0	6.8	23.7	5.3

1.3 ISDB-T test results

Modulation		64-QAM	64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM	64-QAM
Carrier number		8k	8k	4k	8k	8k	8k	4k	2k	8k
FEC		3/4	3/4	3/4	2/3	1/2	1/2	3/4	3/4	3/4
GI		1/16	1/8	1/8	1/16	1/16	1/16	1/16	1/16	1/32
Time interleaver (s)		0.2	0.2	0.2	0.2	0.4	0.4	0.1	0.1	0.2
Bit rate (Mbit/s)		**19.3**	**18.3**	**18.3**	**17.2**	**8.6/0.66**	**4.3/0.33**	**19.3**	**19.3**	**19.9**
Carrier-to-noise threshold (dB)	RX1 2004	19.5	19.3	19.3	17.7	9.7	3.8	–	–	–
	RX2 2004	18.9	18.5	18.4	17.4	8.7	3.9	–	–	–
	PART 2004	–	–	–	–	11.9	3.2	–	–	–
	NEC 2000	18.6	–	–	–	–	–	18.6	18.6	18.7
	RXJ 2000	–	–	–	–	–	–	19.2	–	–

2 Experiment 2.2: Input RF signal dynamic range

Tests performed comprised minimum signal level.

2.1 ATSC test results

Modulation		8VSB
FEC		2/3
Bit rate (Mbit/s)		**19.4**
Minimum signal level (dBm)	RX1 2004	–77.8
	RX2 2004	–79.5
	RX3 2004	–72.7
	ZEN 2000	–81.4
	ZEN2 2000	–80.5
	RXA 2000	–82.4
	RXS 2000	–81.4

2.2 DVB-T test results

Modulation		64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM
Carrier number		8k	8k	8k	8k	2k	8k
FEC		3/4	2/3	1/2	1/2	3/4	2/3
GI		1/16	1/16	1/16	1/16	1/16	1/32
Bit rate(Mbit/s)		**19.7**	**17.6**	**8.8**	**4.4**	**19.7**	**18.1**
Minimun signal level (dBm)	RX1 2004	–78.2	–79.7	–86.5	–92.2	–	–
	RX2 2004	–78.4	–79.2	–87.0	–91.6	–	–
	RX3 2004	–76.7	–79.9	–86.7	–92.9	–	–
	RX4 2004	–75.8	–77.1	–82.3	–	–	–
	RX5 2004	–78.2	–	–83.8	–89.6	–	–
	NDS 2000	–	–	–	–	–80.8	–
	RXK 2000	–	–	–	–	–70.7	–71.1
	RXL 2000	–	–	–	–	–	–81.5
	RXM 2000	–	–	–	–	–	–81.4
	RXN 2000	–	–	–	–	–76.1	–

Modulation		64-QAM	64-QAM	64-QAM	64-QAM	64-QAM	64-QAM
Carrier number		8k	8k	8k	8k	8k	8k
FEC		3/4	1/2	3/4	1/2	3/4	1/2
GI		1/16	1/16	1/16	1/16	1/16	1/16
α =		1	1	2	2	4	4
Priority		LP	HP	LP	HP	LP	HP
Bit rate (Mbit/s)		**13.2**	**4.4**	**13.2**	**4.4**	**13.2**	**4.4**
Minimun signal level (dBm)	RX1 2004	–76.4	–84.8	–71.2	–89.2	–70.3	–89.0
	RX5 2004	–77.7	–86.3	–71.6	–89.5	–	–90.6

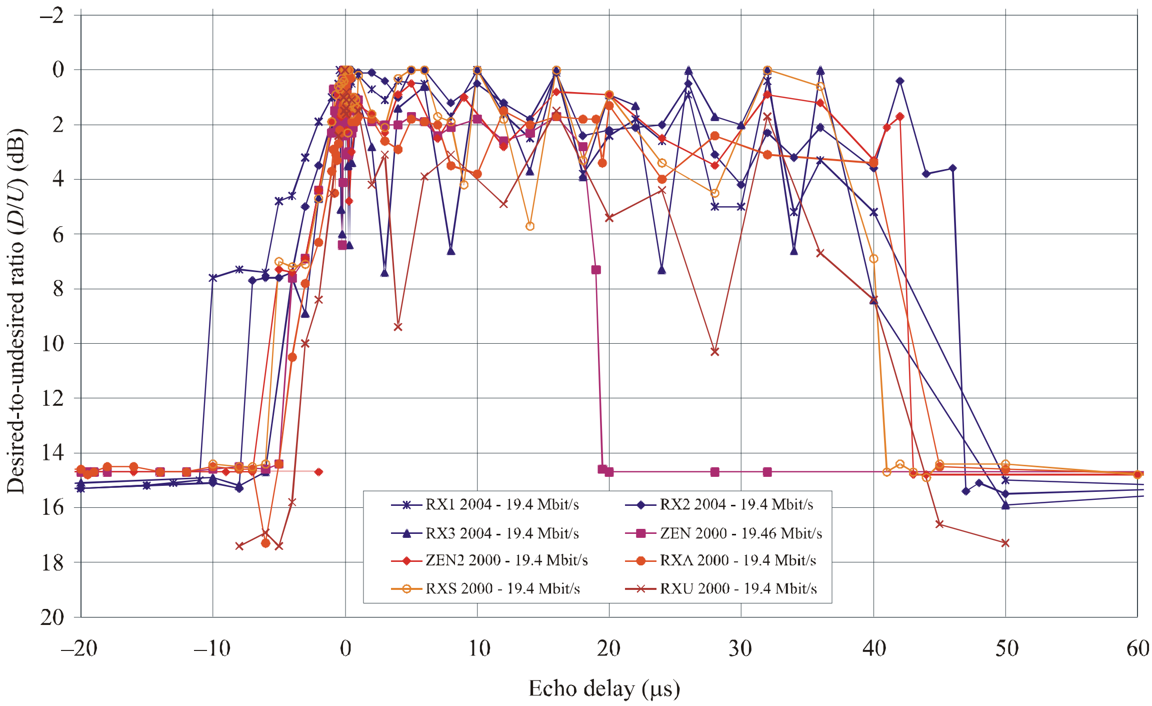
2.3 ISDB-T test results

Modulation		64-QAM	64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM
Carrier number		8k	8k	4k	8k	8k	8k	4k	4k
FEC		3/4	3/4	3/4	2/3	1/2	1/2	3/4	3/4
GI		1/16	1/8	1/8	1/16	1/16	1/16	1/16	1/16
Time interleaver (s)		0.2	0.2	0.2	0.2	0.4	0.4	0.2	0.1
Bit rate(Mbit/s)		**19.3**	**18.3**	**18.3**	**17.2**	**8.6**	**4.3**	**19.3**	**19.3**
Minimun signal level (dBm)	RX1 2004	–76.8	–76.7	–77.1	–79.2	–86.8	–93.1	–	–
	RX2 2004	–76.8	–77.5	–76.9	–79.2	–87.4	–92.4	–	–
	NEC 2000	–	–	–	–	–	–	–78.6	–
	RXJ 2000	–	–	–	–	–	–	–	–81.4

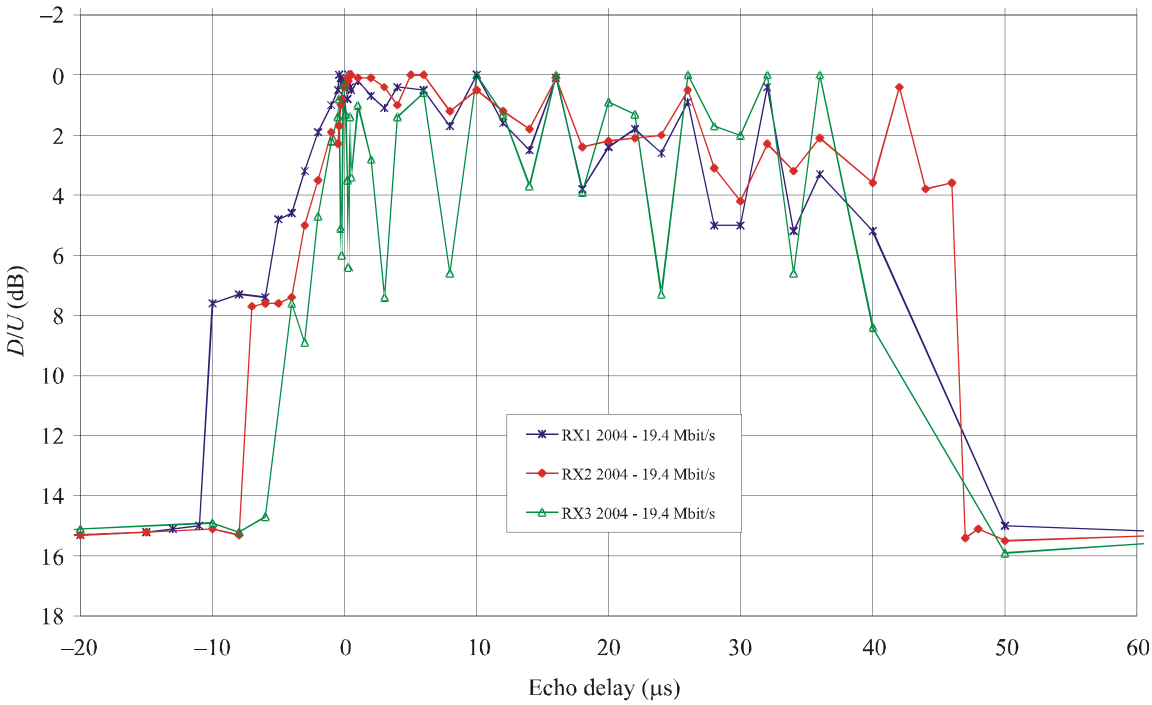
3 Experiment 2.3: Static multipath interference

3.1 Multipath interference (echo or ghosting) without interfering noise

3.1.1 ATSC test results

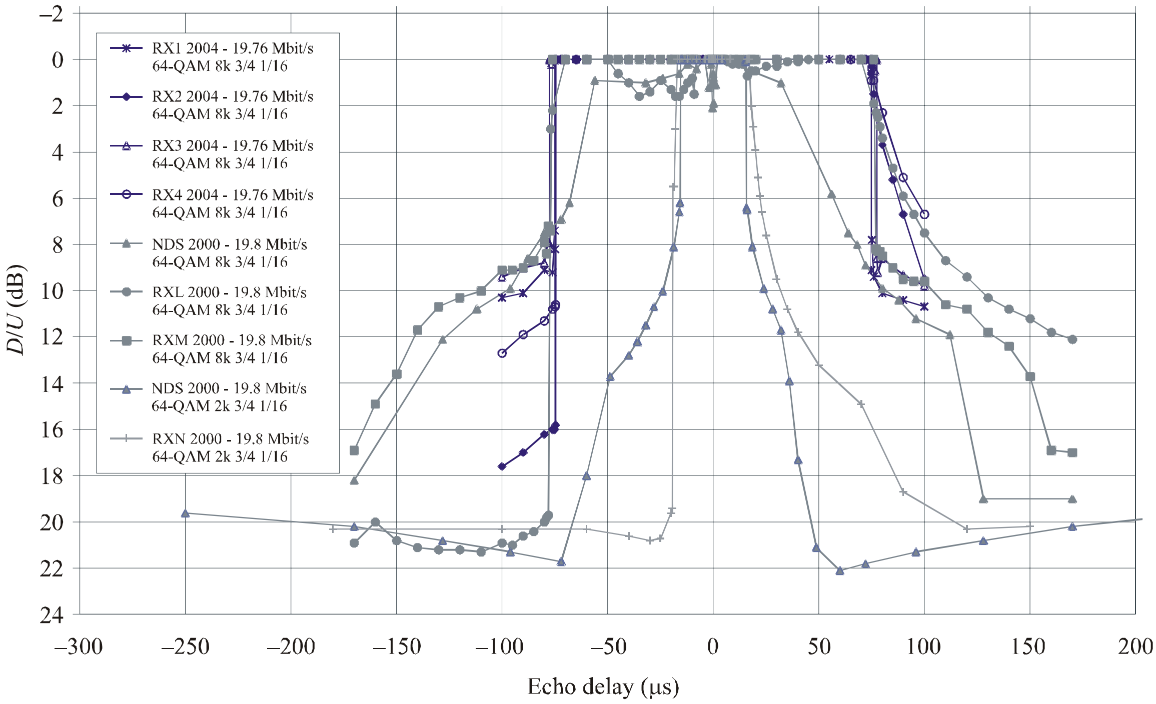


Rep 2035-05



Rep 2035-06

3.1.2 DVB-T test results



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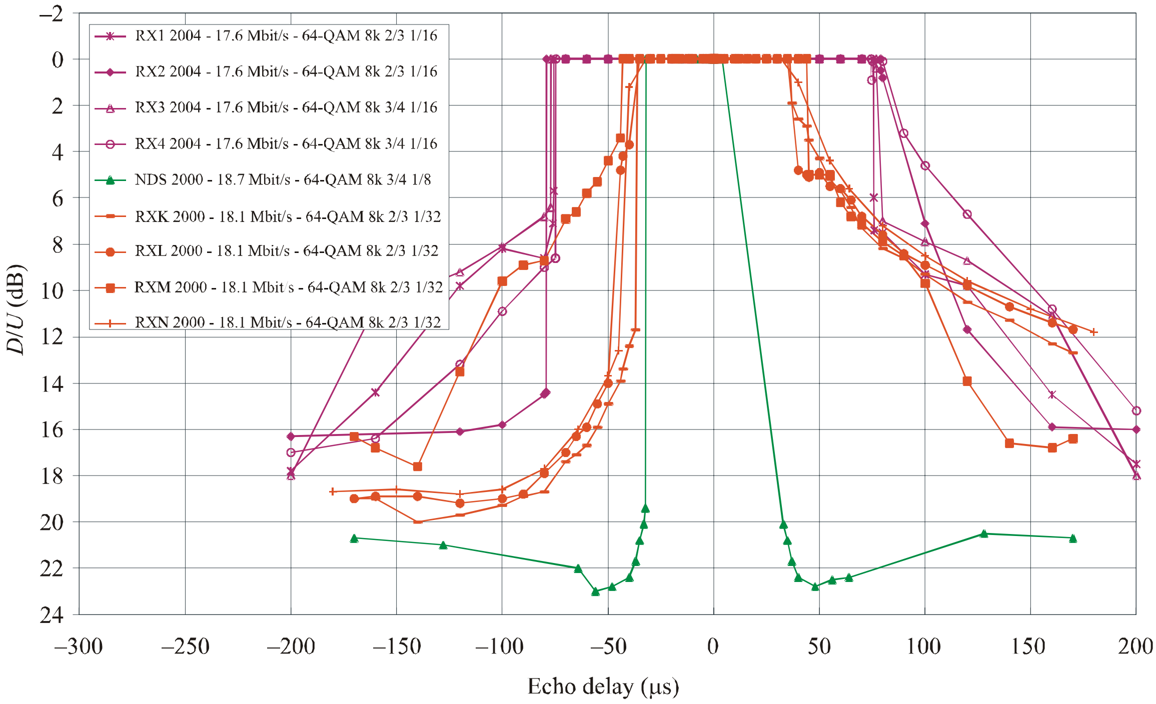

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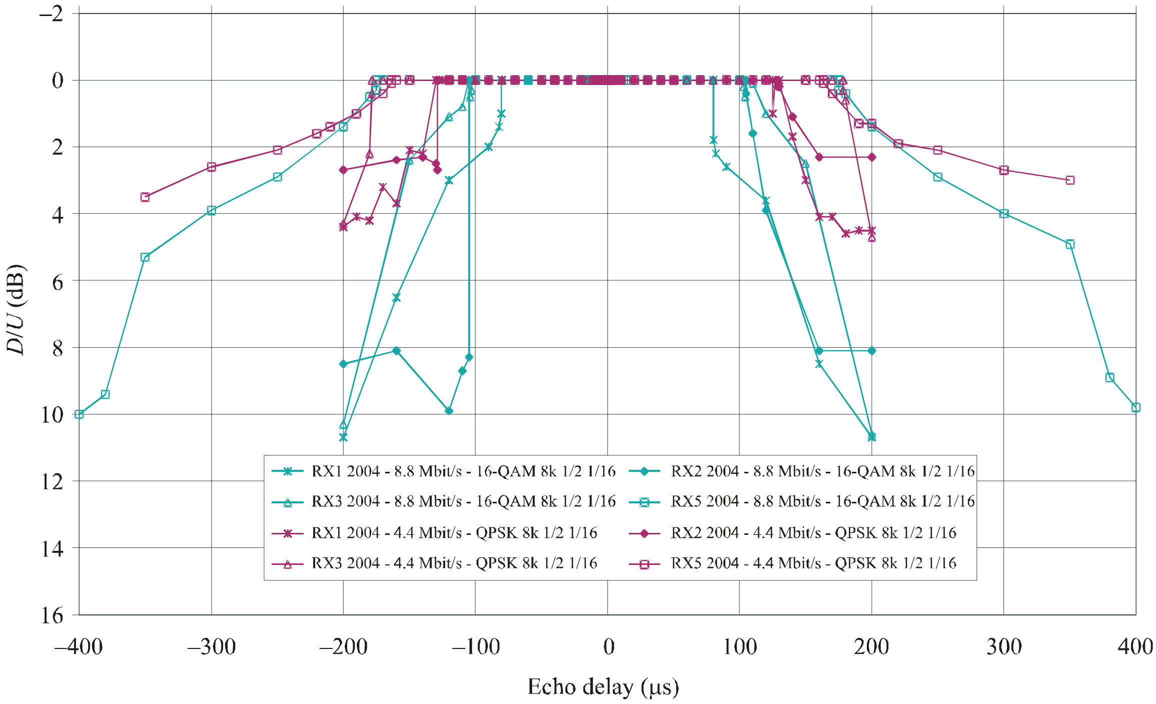

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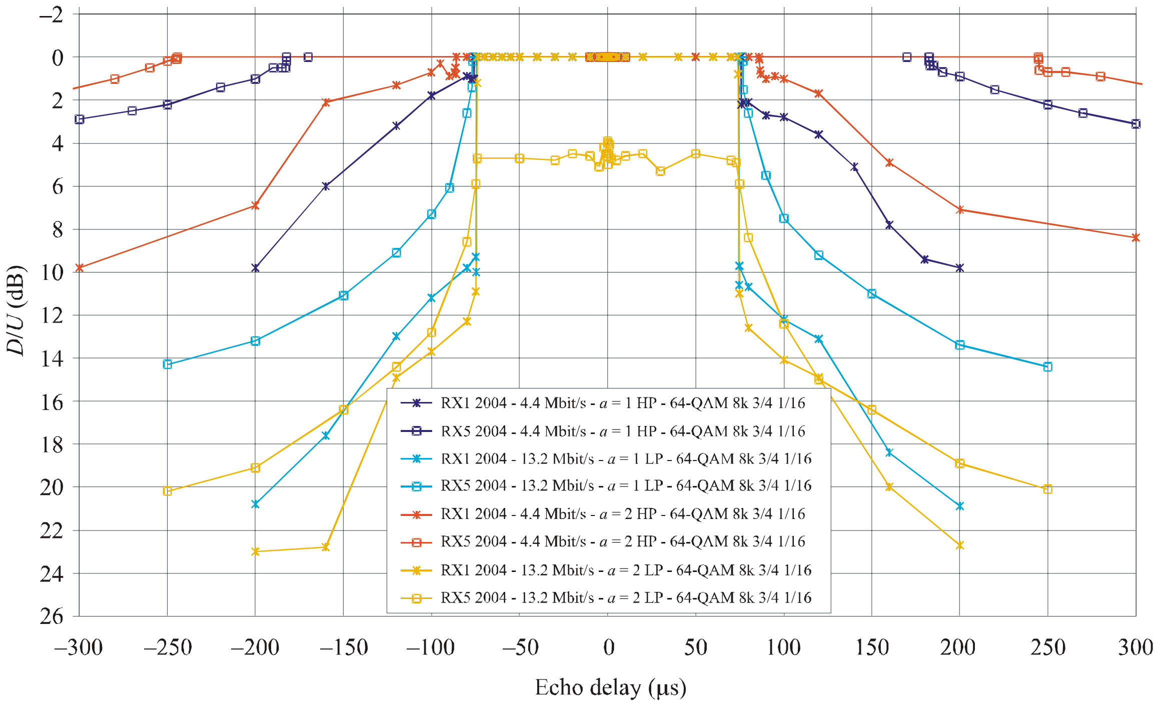
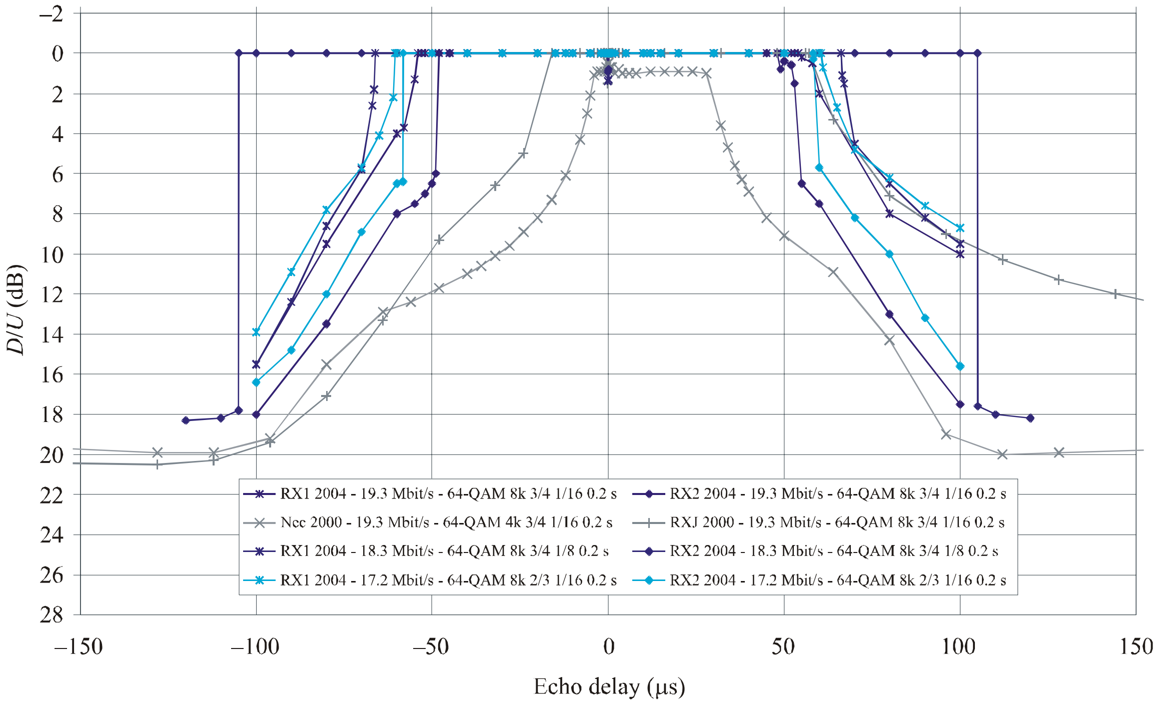


Rep 2035-10

3.1.3 ISDB-T test results



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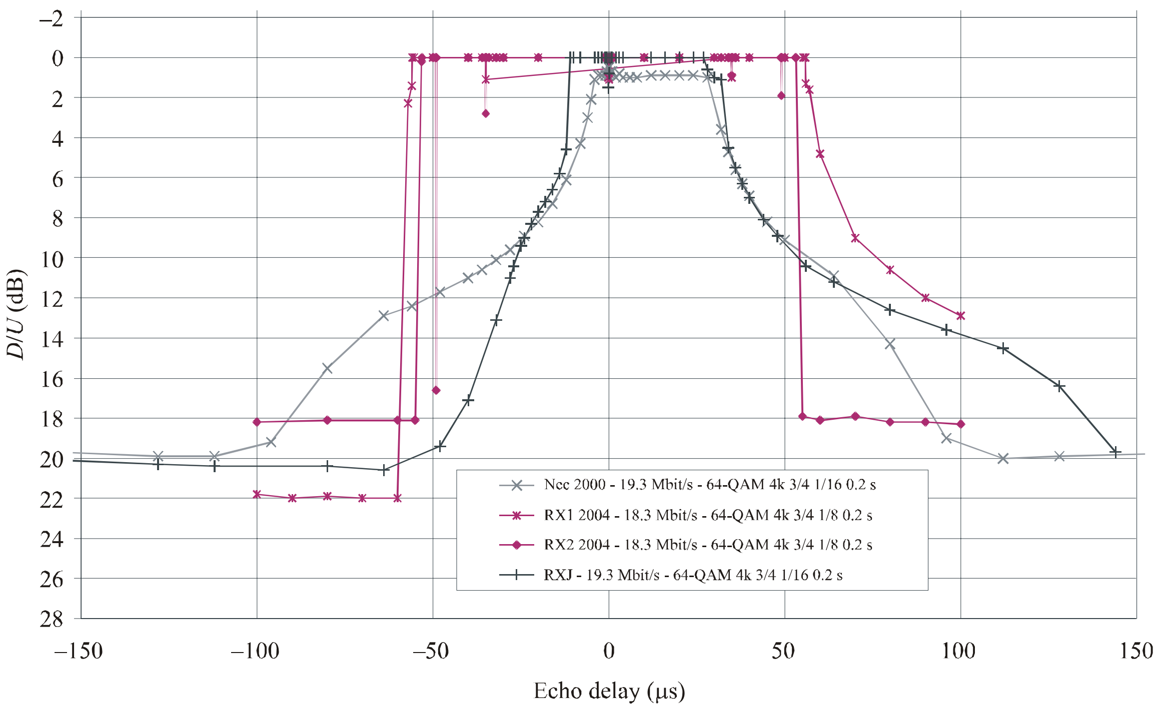

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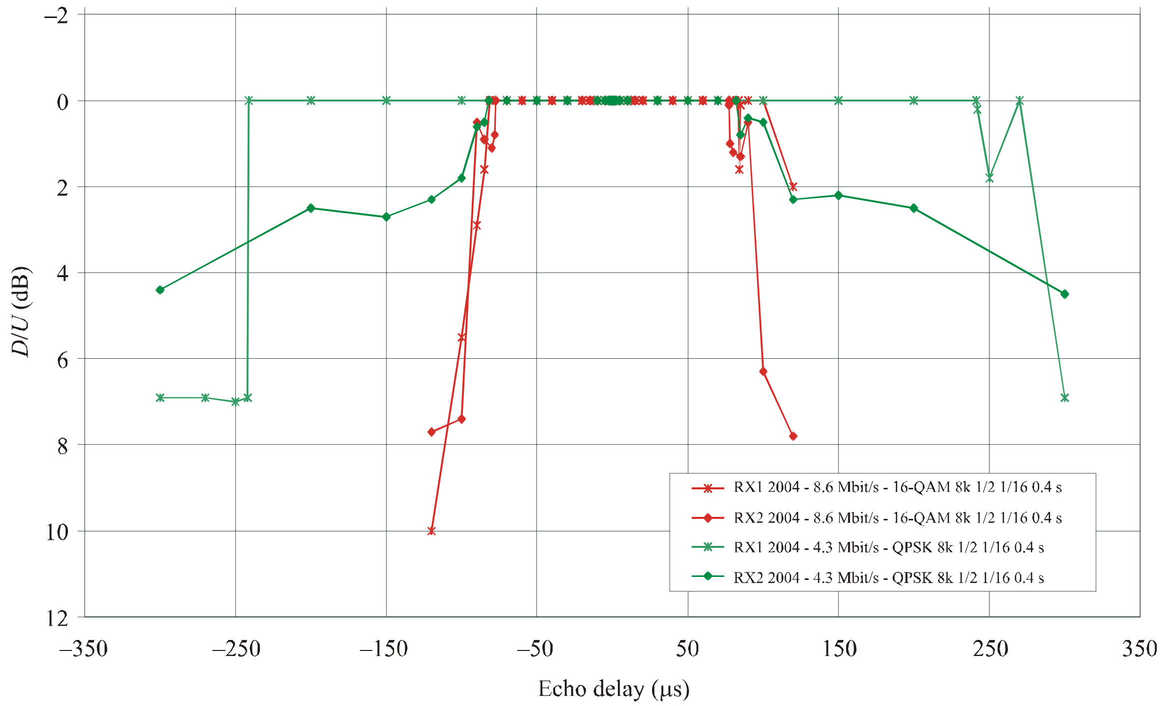
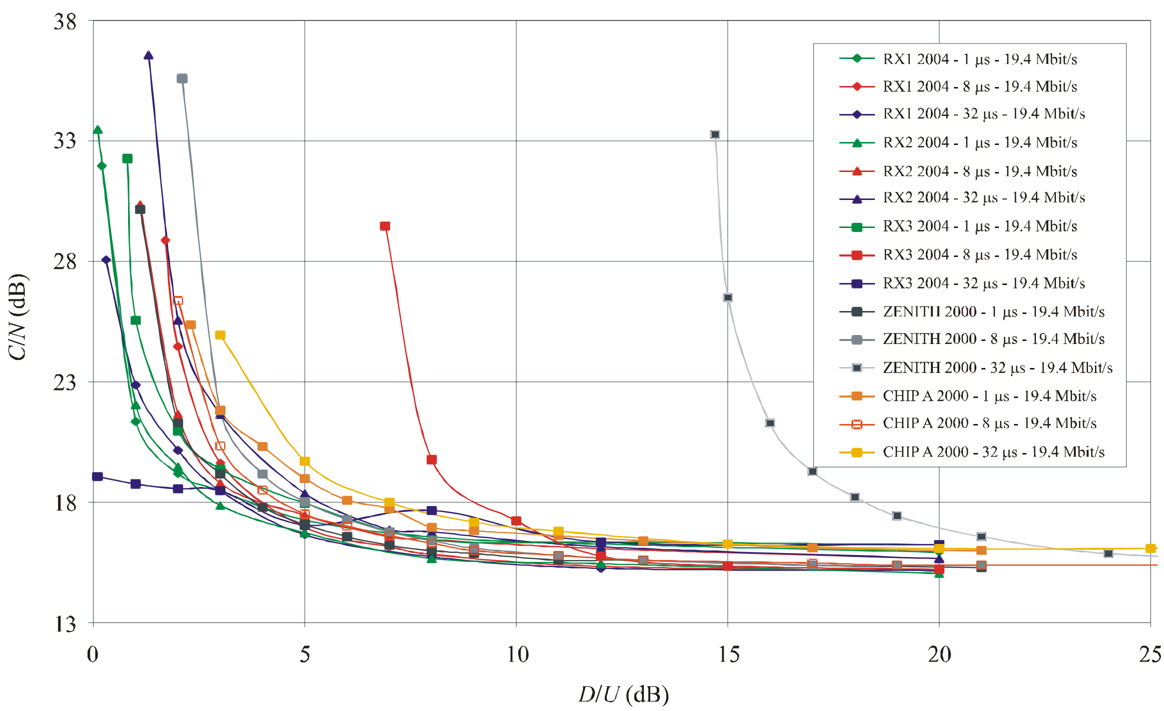


Rep 2035-13

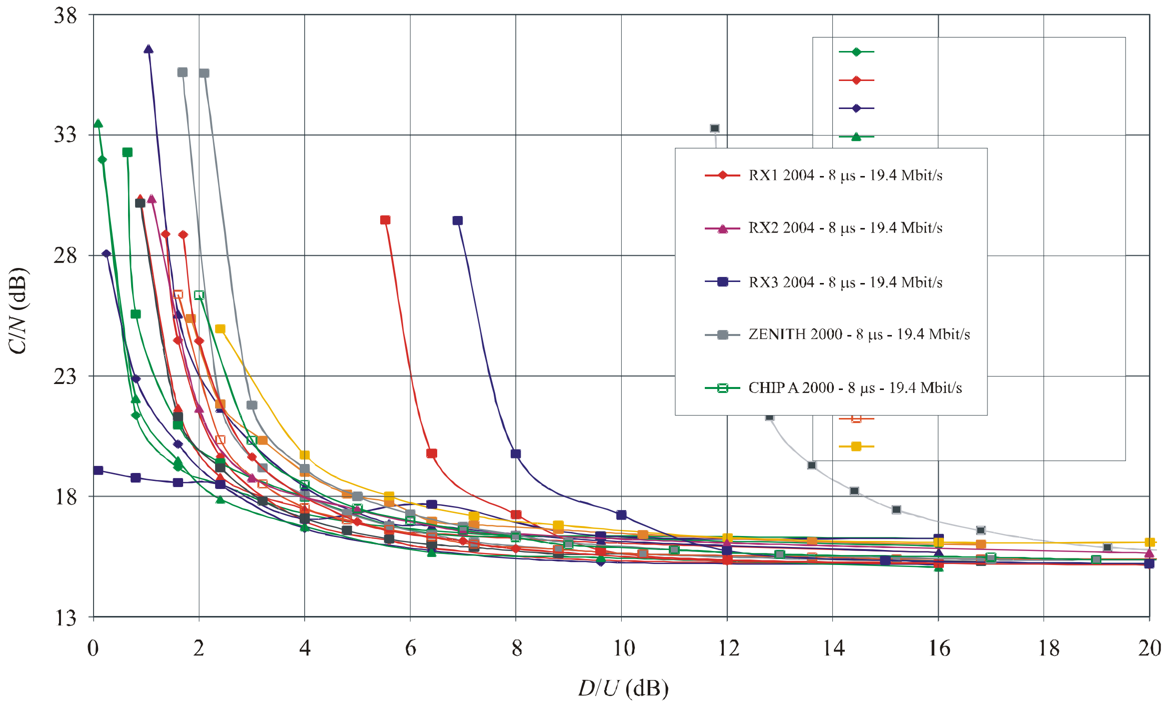
3.2 Multipath interference (echo or ghosting) with interfering noise

Only post-echo results were included in this Report.

3.2.1 ATSC test results

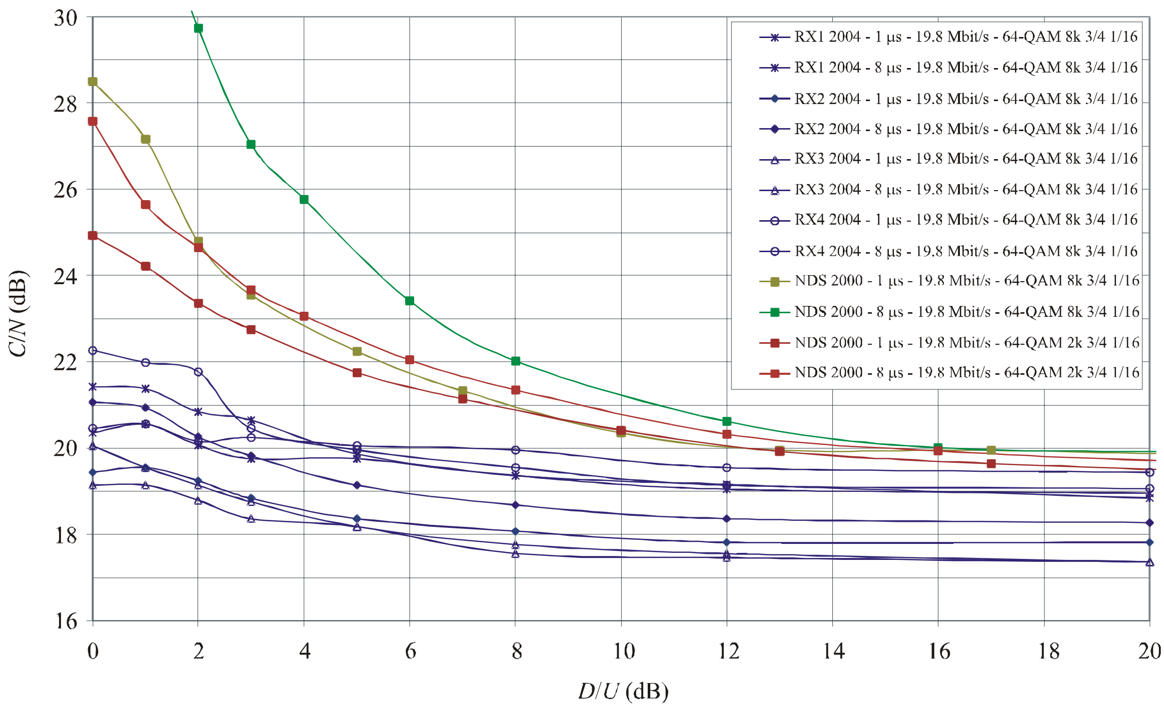


Rep 2035-14

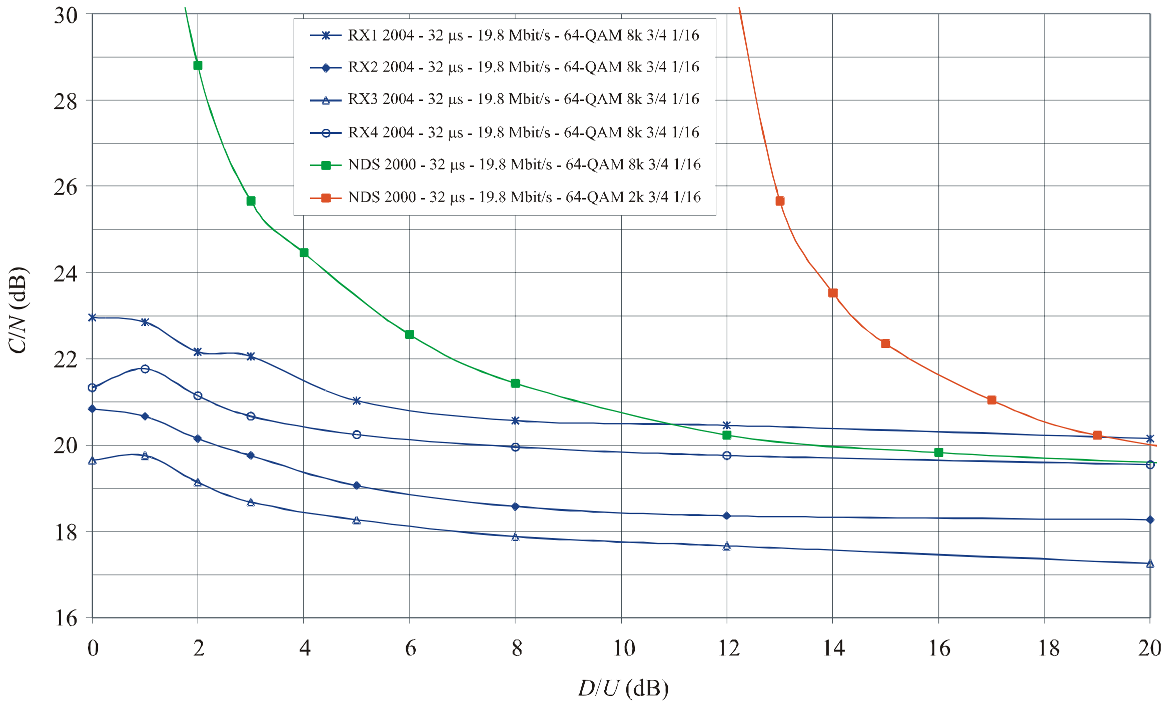


Rep 2035-15

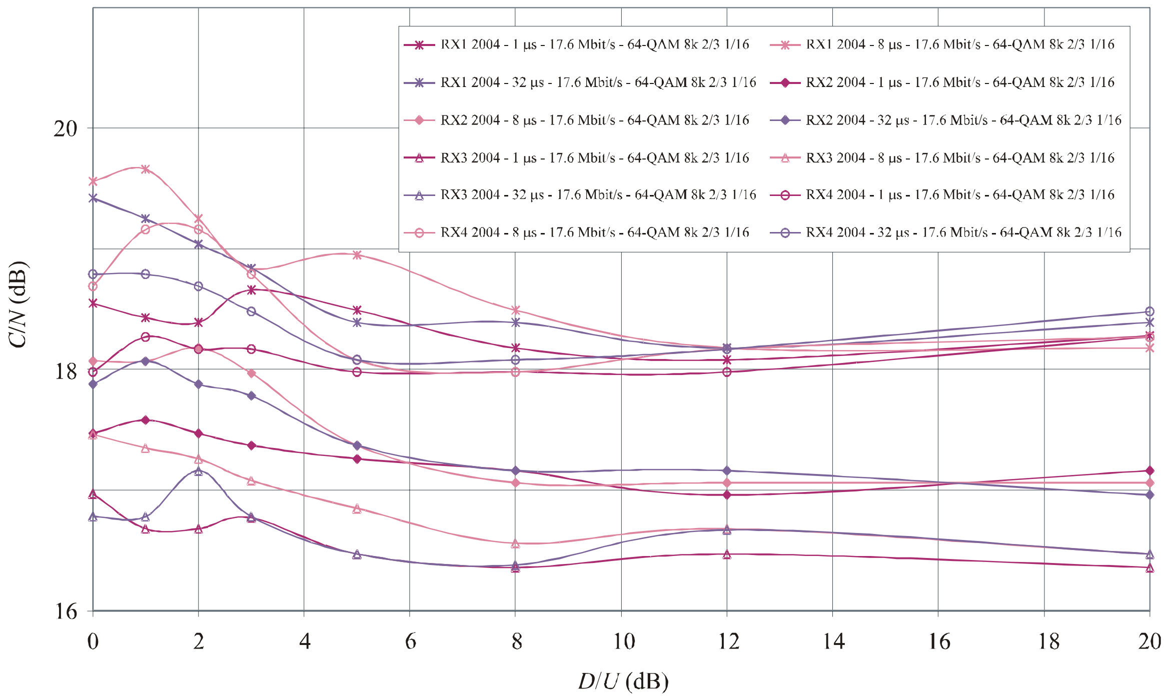
3.2.2 DVB-T test results



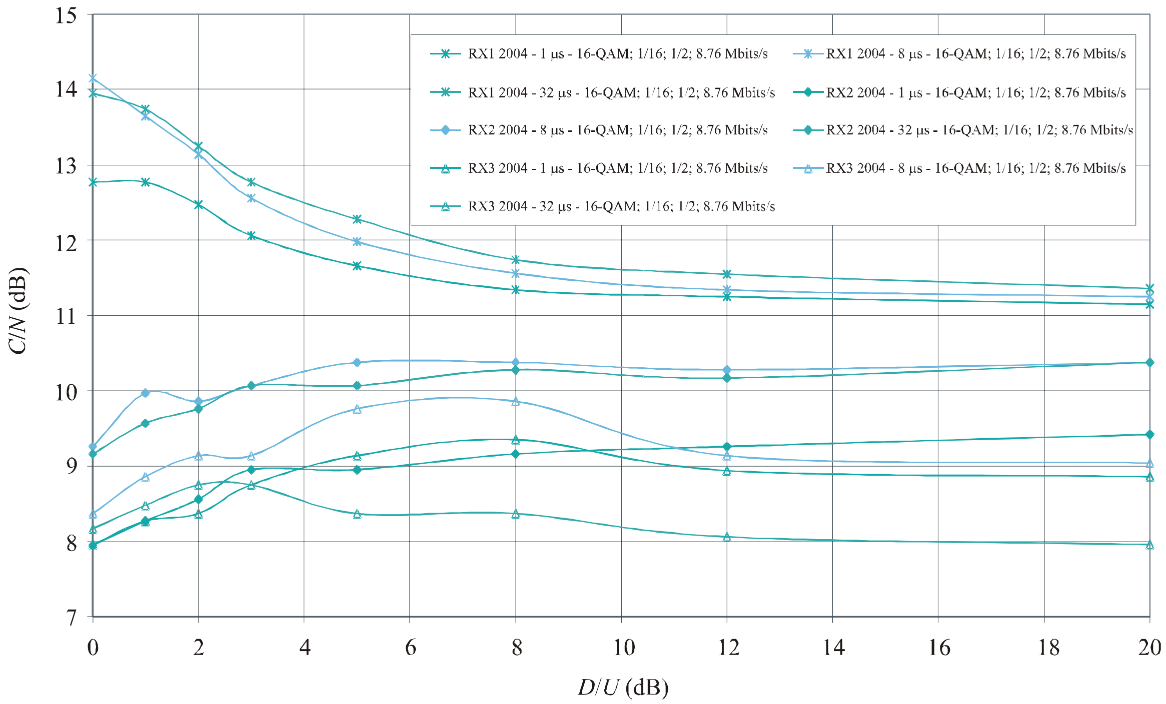
Rep 2035-16



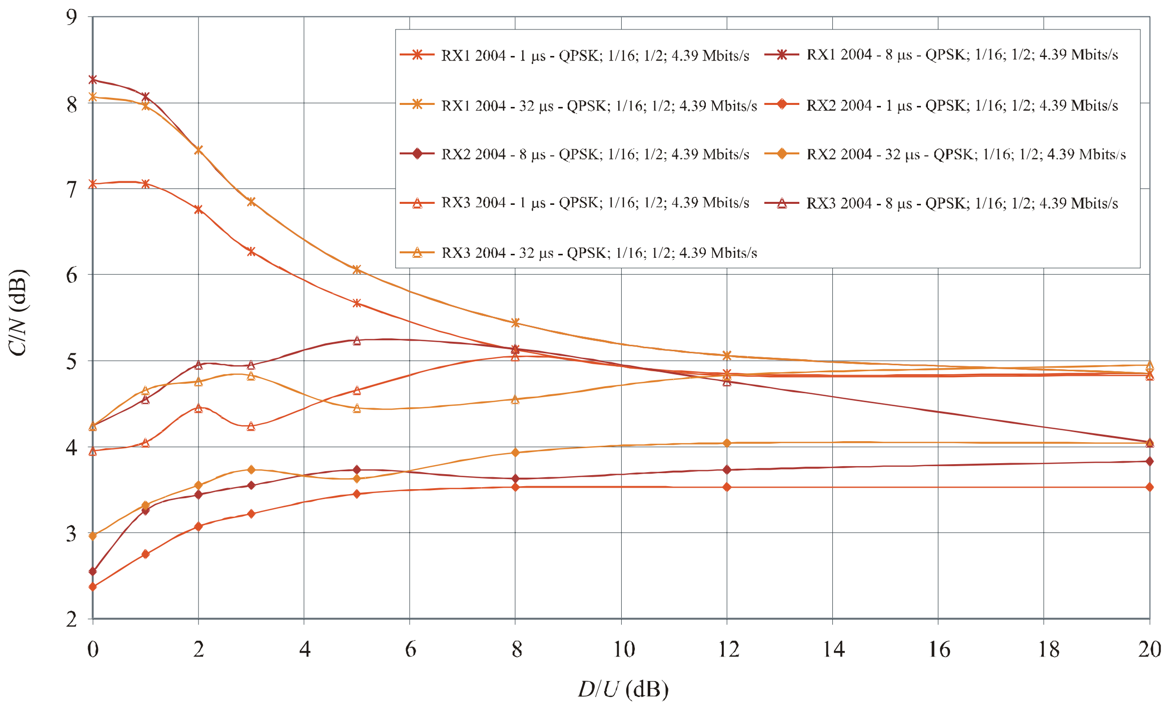
Rep 2035-17



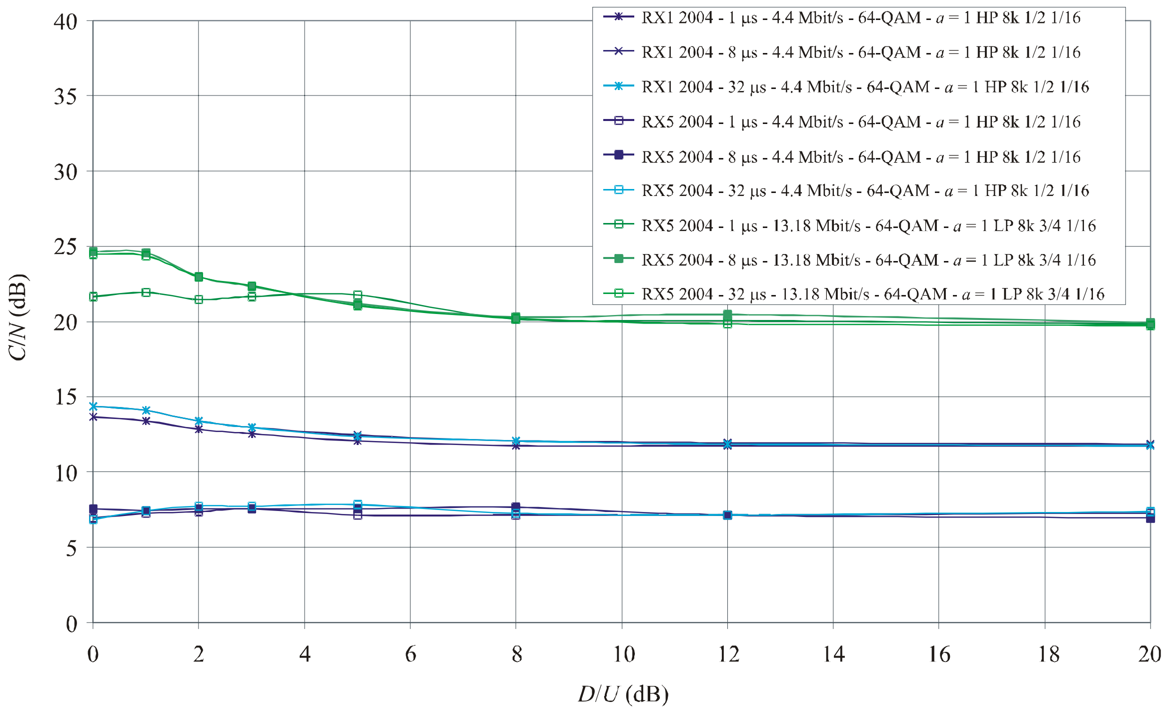
Rep 2035-18



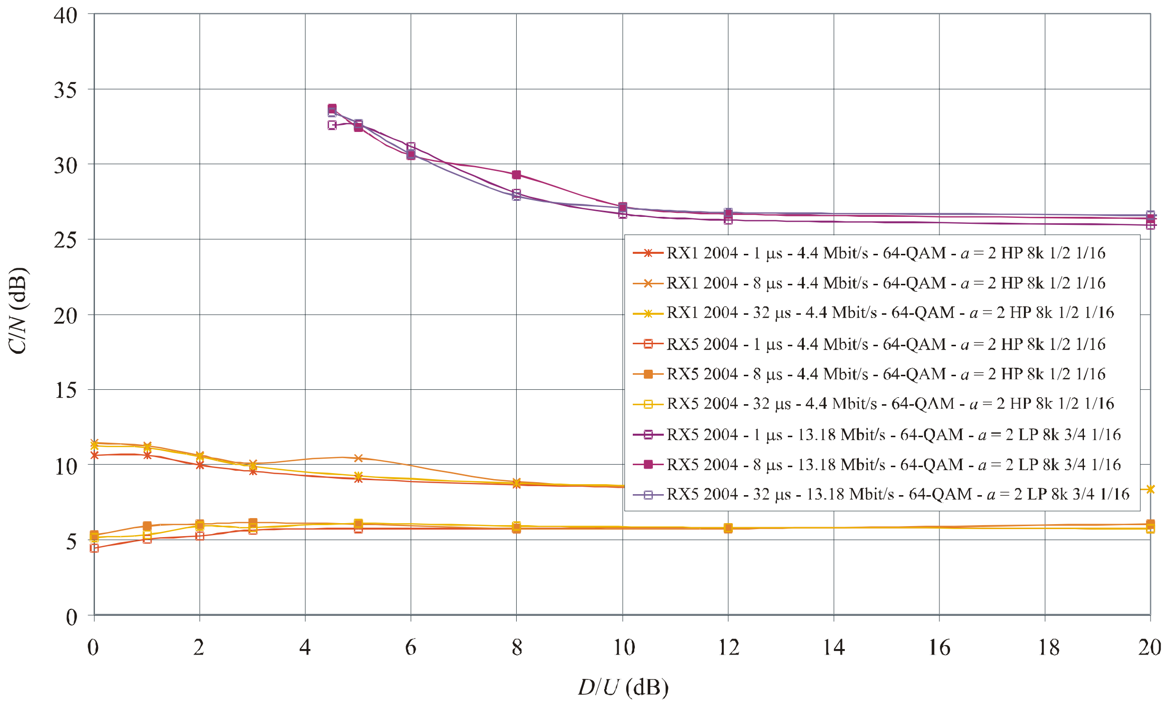
Rep 2035-19



Rep 2035-20

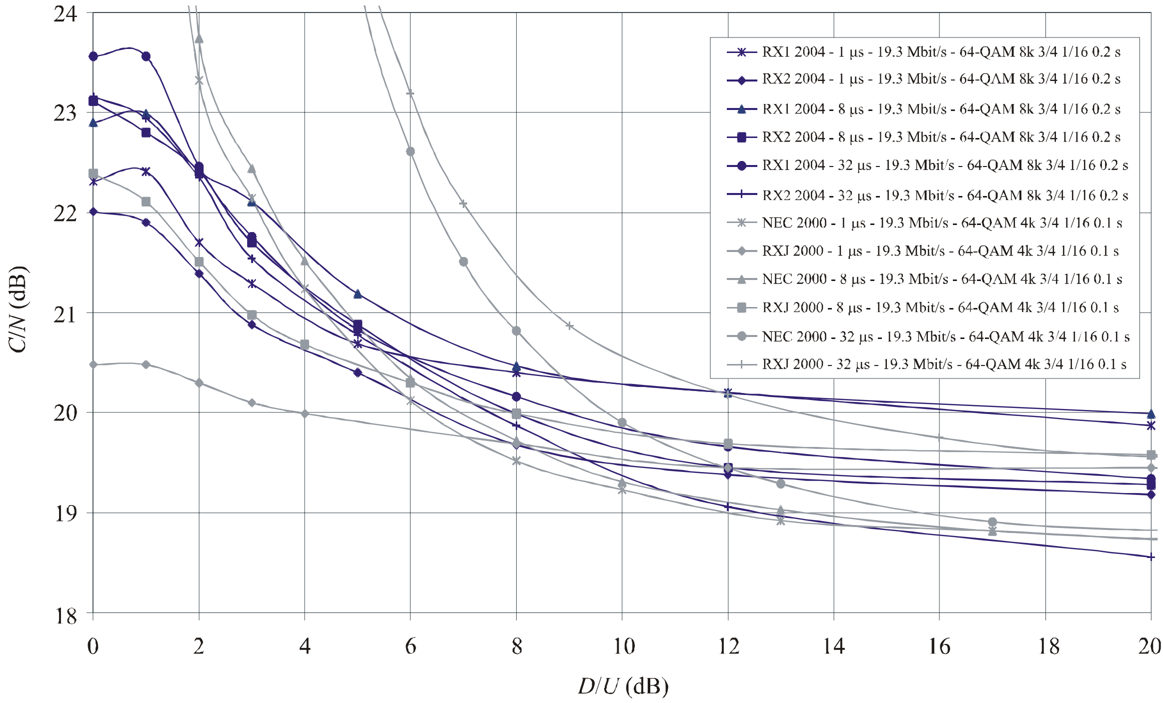


Rep 2035-21

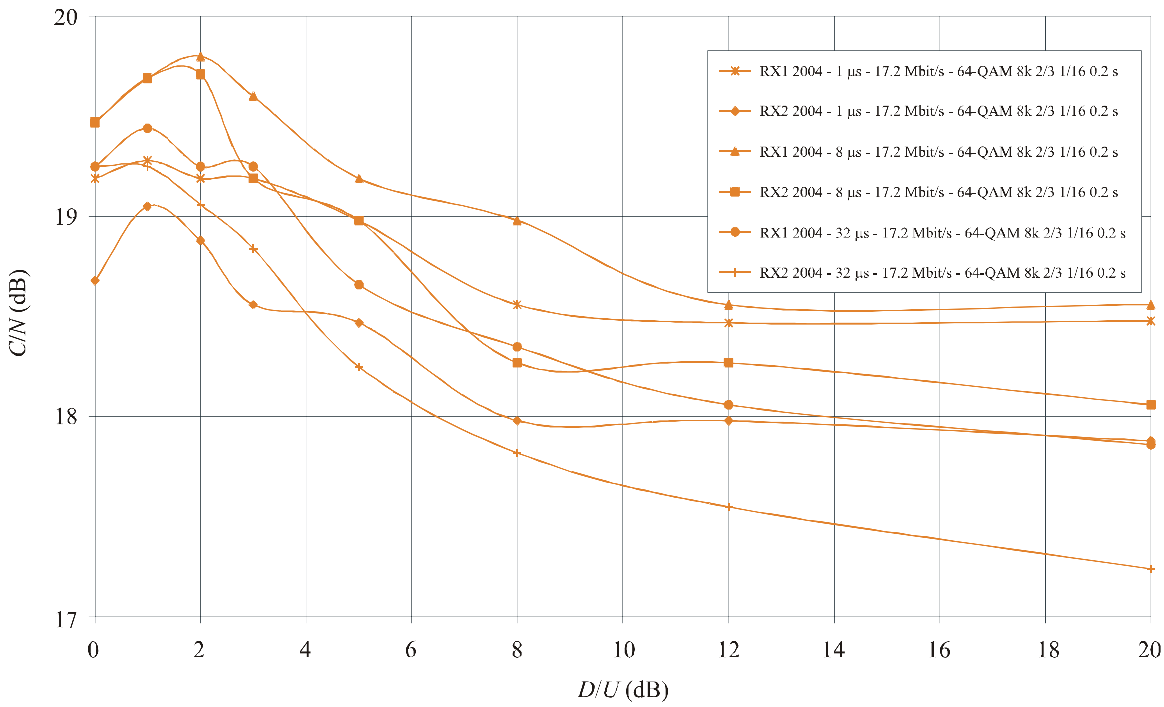


Rep 2035-22

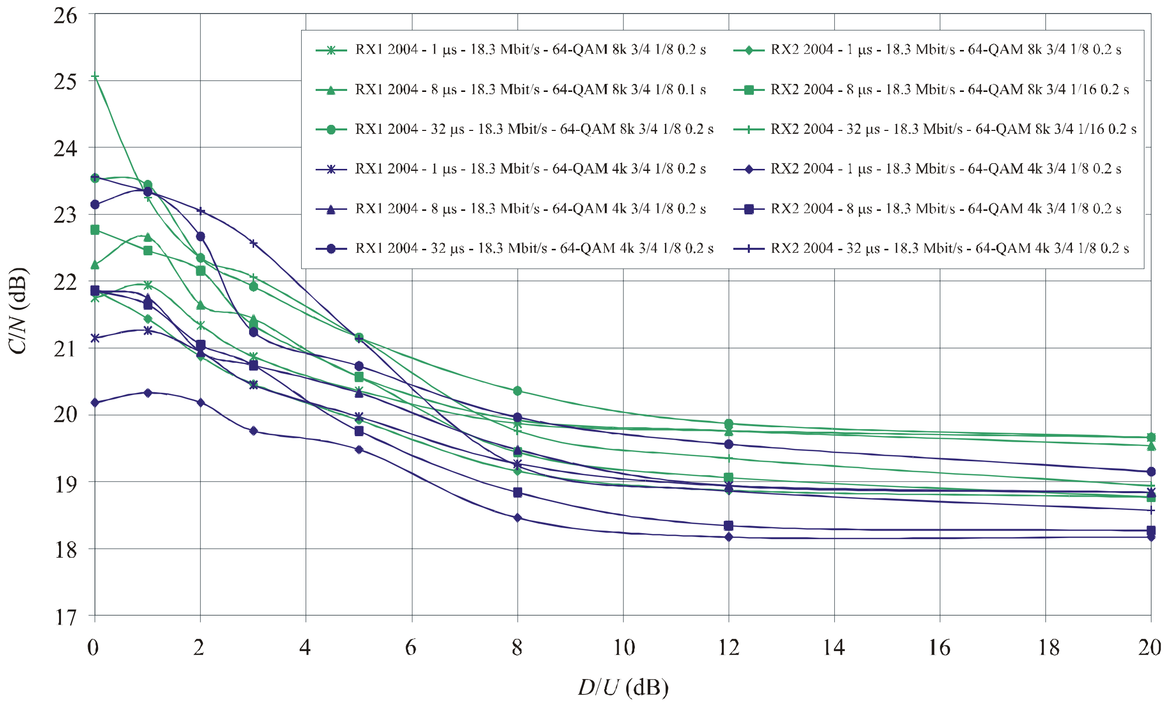
3.2.3 ISDB-T test results



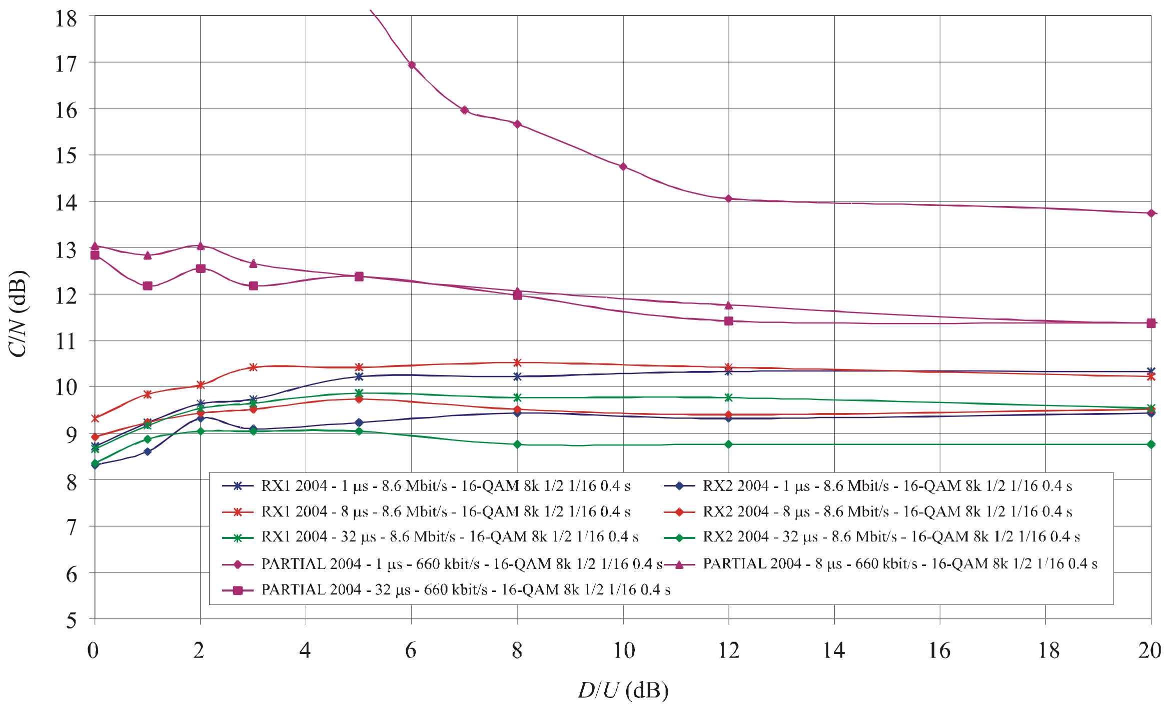
Rep 2035-23



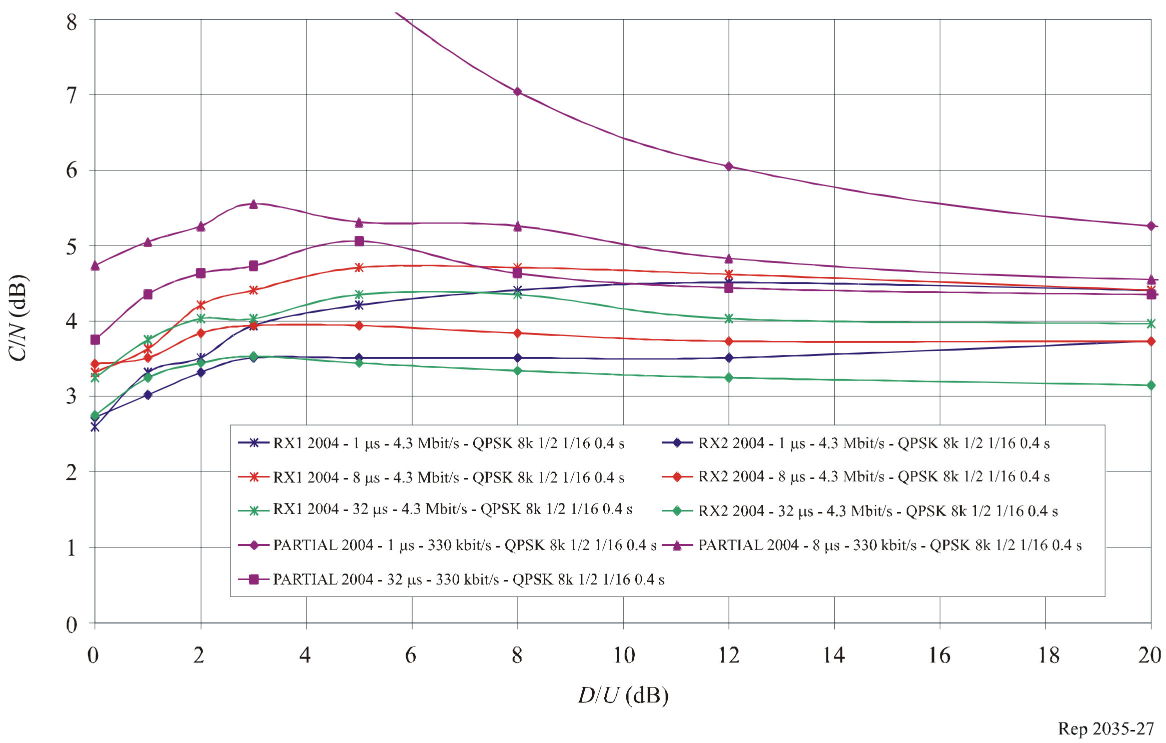
Rep 2035-24



Rep 2035-25



Rep 2035-26



NOTE 1 – The results for partial reception of ISDB-T interfered by a post-echo of 1 µs were measured under a condition that deep attenuation affected the desired portion of the spectrum. Therefore, the results presented on the above graphs are "worst-case" results. Since great variation in performance is to be expected in this reception mode, test results under different phases shall be provided.

3.3 Multipath interference of ensembles

3.3.1 ATSC test results

NF: Do not function.

Modulation			8VSB		
FEC			2/3		
Bit rate (Mbit/s)			**19.4**		
C/*N* ratio (dB)			*C*/*N* ratio		
BRAZIL A	RX1 2004	18.1	BRAZIL D	RX1 2004	NF
	RX2 2004	18.4		RX2 2004	NF
	RX3 2004	18.8		RX3 2004	NF
	ZEN 2000	16.1		ZEN 2000	NF
	ZEN2 2000	17.1		ZEN2 2000	NF
	RXA 2000	17.1		RXA 2000	NF
	RXS 2000	16.8		RXS 2000	NF
	RXU 2000	17.6		RXU 2000	NF
BRAZIL B	RX1 2004	NF	BRAZIL E	RX1 2004	17.8
	RX2 2004	NF		RX2 2004	19.3
	RX3 2004	NF		RX3 2004	NF
	ZEN 2000	NF		ZEN 2000	NF
	ZEN2 2000	NF		ZEN2 2000	NF
	RXA 2000	27.9		RXA 2000	NF
	RXS 2000	NF		RXS 2000	NF
	RXU 2000	NF		RXU 2000	NF
BRAZIL C	RX1 2004	NF			
	RX2 2004	NF			
	RX3 2004	NF			
	ZEN2 2000	NF			
	RXA 2000	NF			
	RXS 2000	NF			
	RXU 2000	NF			

Modulation				8VSB	
FEC				2/3	
Bit rate (Mbit/s)				**19.4**	
C/*N* ratio (dB)		*C*/*N*	VAR	*C*/*N*	VAR
CRC 1	RX1 2004	NF	0	33.3	6.2
	RX2 2004	NF	0	23.9	8
	RX3 2004	NF	0	NF	50
CRC 2	RX1 2004	NF	0	34.9	10.5
	RX2 2004	NF	0	27.8	11
	RX3 2004	NF	0	NF	50
CRC 3	RX1 2004	NF	0	NF	50
	RX2 2004	NF	0	NF	50
	RX3 2004	NF	0	NF	50
CRC 4	RX1 2004	NF	0	NF	50
	RX2 2004	NF	0	NF	50
	RX3 2004	NF	0	NF	50
UK SHORT DELAY	RX1 2004	NF			
	RX2 2004	NF			
	RX3 2004	NF			
UK LONG DELAY	RX1 2004	18.2			
	RX2 2004	18.8			
	RX3 2004	18.2			

3.3.2 DVB-T test results

Modulation		64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM
Carrier number		8k	8k	8k	8k	8k	2k	8K
FEC		3/4	3/4	2/3	1/2	1/2	3/4	2/3
GI		1/16	1/8	1/16	1/16	1/16	1/16	1/32
Rate (Mbit/s)		**19.8**	**18.7**	**17.6**	**8.8**	**4.4**	**19.3**	**19.3**
BRAZIL A	RX1 2004	22.7	23.2	20.4	12.8	6.5	–	–
	RX2 2004	20.7	20.4	18.4	10.4	4.5	–	–
	RX3 2004	20.0	19.8	17.7	10.5	5.8	–	–
	RX4 2004	21.7	21.6	19.0	*	*	–	–
	NDS 2000	20.3	–	–	–	–	19.7	–
	RXK 2000	–	–	–	–	–	–	20.5
	RXL 2000	–	–	–	–	–	–	19.7
	RXM 2000	–	–	–	–	–	–	18.8
	RXN 2000	–	–	–	–	–	20.9	19.1
BRAZIL B	RX1 2004	24.6	24.8	22.3	15.7	9.2	–	–
	RX2 2004	22.8	22.4	20.3	11.3	7.8	–	–
	RX3 2004	22.2	22.1	19.5	11.4	6.5	–	–
	RX4 2004	23.5	25.5	21.0	*	*	–	–
	NDS 2000	NF	–	–	–	–	23.2	–
	RXK 2000	–	–	–	–	–	–	26.3
	RXL 2000	22.8	–	–	–	–	–	22.1
	RXM 2000	23.5	–	–	–	–	–	20.8
	RXN 2000	–	–	–	–	–	24.6	22.1
BRAZIL C	RX1 2004	22.6	23.0	20.1	13.7	8.6	–	–
	RX2 2004	21.2	21.1	19.2	10.7	5.4	–	–
	RX3 2004	22.1	20.7	18.3	10.8	6.6	–	–
	RX4 2004	21.9	22.0	19.6	*	*	–	–
	NDS 2000	–	–	–	–	–	–	21.3
	RXK 2000	–	–	–	–	–	–	22.0
	RXL 2000	–	–	–	–	–	–	20.4
BRAZIL D	RX1 2004	24.8	24.6	21.7	15.1	10.4	–	–
	RX2 2004	22.5	22.6	20.2	10.9	5.7	–	–
	RX3 2004	22.2	22.2	19.8	10.6	7.2	–	–
	RX4 2004	23.4	24.2	20.7	*	*	–	–
	NDS 2000	NF	–	–	–	–	23.0	
	RXK 2000	–	–	–	–	–	–	24.5
	RXL 2000	–	–	–	–	–	–	22.6
	RXM 2000	–	–	–	–	–	–	20.6
	RXN 2000	–	–	–	–	–	25.0	22.5

		64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM
BRAZIL E	RX1 2004	32.3	31.3	26.0	20.0	14.3	–	–
	RX2 2004	27.5	27.2	24.4	14.1	4.8	–	–
	RX3 2004	27.2	26.9	23.3	13.7	5.8	–	–
	RX4 2004	29.1	29.6	25.6	*	*	–	–
	NDS 2000	NF	–	–	–	–	32.4	–
	RXK 2000	–	–	–	–	–	–	30.4
	RXL 2000	28.8	–	–	–	–	–	27.7
	RXM 2000	29.5	–	–	–	–	–	24.5
	RXN 2000	–	–	–	–	–	NF	24.9
CRC 1	RX1 2004	24.3	24.6	21.3	15.0	8.2	–	–
	RX2 2004	22.9	23.6	20.6	11.2	5.3	–	–
	RX3 2004	25.1	25.7	21.6	11.6	6.3	–	–
	RX4 2004	23.1	23.6	20.9	*	*	–	–
CRC 2	RX1 2004	24.1	24.6	20.9	14.6	8.1	–	–
	RX2 2004	22.5	22.9	19.9	11.3	4.9	–	–
	RX3 2004	24.8	24.1	21.4	11.5	6.0	–	–
	RX4 2004	22.6	23.0	20.2	*	*	–	–
CRC 3	RX1 2004	23.8	23.9	20.9	14.4	7.7	–	–
	RX2 2004	22.0	22.7	19.8	11.0	4.8	–	–
	RX3 2004	23.7	23.6	20.5	10.9	5.8	–	–
	RX4 2004	22.3	22.5	20.3	*	*	–	–
CRC 4	RX1 2004	24.7	23.9	21.4	14.5	8.2	–	–
	RX2 2004	22.3	23.0	20.0	11.2	5.2	–	–
	RX3 2004	24.2	24.6	21.7	11.2	6.5	–	–
	RX4 2004	22.6	23.0	20.3	*	*	–	–
UK SHORT DELAY	RX1 2004	23.2	23.4	21.0	14.4	9.6	–	–
	RX2 2004	21.8	21.7	19.7	11.0	5.4	–	–
	RX3 2004	21.2	21.2	18.9	11.5	6.7	–	–
	RX4 2004	22.6	22.9	20.2	*	*	–	–
UK LONG DELAY	RX1 2004	22.7	22.2	20.0	12.7	6.3	–	–
	RX2 2004	20.5	20.2	18.2	10.2	4.4	–	–
	RX3 2004	20.1	20.1	17.6	10.3	6.0	–	–
	RX4 2004	21.1	21.5	19.0	*	*	–	–

Modulation		64-QAM	64-QAM	64-QAM	64-QAM
α =		1 HP	1 LP	2 HP	2 LP
Carrier number		8k	8k	8k	8k
FEC		1/2	3/4	1/2	3/4
GI		1/16	1/16	1/16	1/16
Rate (Mbit/s)		**4.3**	**13.18**	**4.3**	**13.18**
BRAZIL A	RX1 2004	–	–	9.2	27.0
	RX5 2004	8.3	22.1	8.2	NF
BRAZIL B	RX1 2004	–	–	11.8	29.4
	RX5 2004	8.9	25.9	9.6	NF
BRAZIL C	RX1 2004	–	–	11.8	25.5
	RX5 2004	10.3	23.0	8.8	NF
BRAZIL D	RX1 2004	–	–	11.7	28.5
	RX5 2004	9.5	24.4	9.3	NF
BRAZIL E	RX1 2004	–	–	16.9	29.0
	RX5 2004	12.4	NF	11.5	NF
CRC 1	RX1 2004	–	–	13.3	28.2
	RX5 2004	9.9	25.2	8.0	NF
CRC 2	RX1 2004	–	–	12.5	27.5
	RX5 2004	9.8	24.4	9.3	NF
CRC 3	RX1 2004	–	–	11.7	26.7
	RX5 2004	9.5	23.7	8.8	NF
CRC 4	RX1 2004	–	–	11.1	29.7
	RX5 2004	9.5	24.2	8.7	NF
UK SHORT DELAY	RX1 2004	–	–	11.2	30.1
	RX5 2004	9.8	23.5	11.0	NF
UK LONG DELAY	RX1 2004	–	–	9.4	24.9
	RX5 2004	8.4	24.5	6.5	NF

3.3.3 ISDB-T test results

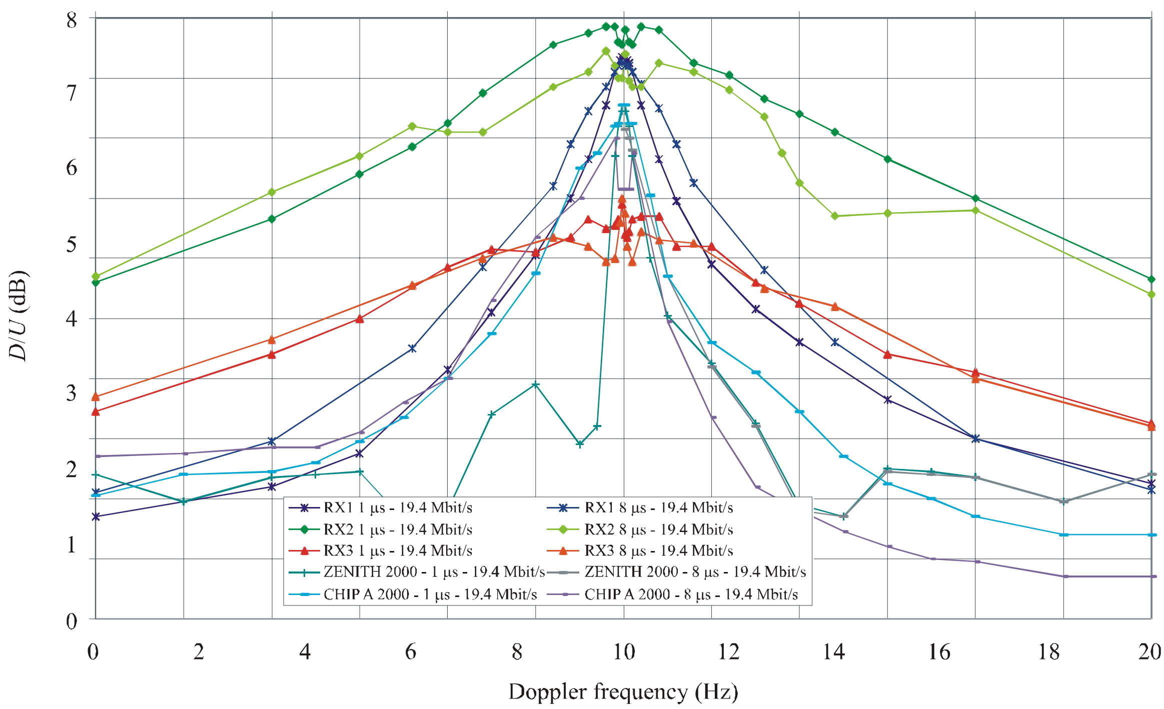
Modulation		64-QAM	64-QAM	64-QAM	64-QAM	16-QAM	QPSK	64-QAM	64-QAM	64-QAM
Carrier number		8k	8k	4k	8k	8k	8k	4k	2k	8k
FEC		3/4	3/4	3/4	2/3	1/2	1/2	3/4	3/4	3/4
GI		1/16	1/8	1/8	1/16	1/16	1/16	1/16	1/16	1/32
Time interleaver (sec)		0.2	0.2	0.2	0.2	0.4	0.4	0.1	0.1	0.2
Rate (Mbit/s)		**19.3**	**18.3**	**18.3**	**17.2**	**8.6**	**4.3**	**19.3**	**19.3**	**19.3**
BRAZIL A	RX1 2004	22.6	22.6	21.5	20.3	11.2	5.5	–	–	–
	RX2 2004	22.1	21.9	20.9	19.7	10.4	4.6	–	–	–
	PART 2004	–	–	–	–	11.2	3.5	–	–	–
	NEC 2000	20.6	–	–	–	–	–	20.3	20.5	20.5
	RXJ 2000	–	–	–	–	–	–	19.9	–	19.1
BRAZIL B	RX1 2004	25.6	25.9	24.3	22.1	12.0	7.3	–	–	–
	RX2 2004	25.1	25.7	23.3	22.0	11.6	6.0	–	–	–
	PART 2004	–	–	–	–	14.9	6.9	–	–	–
	NEC 2000	24.7	–	–	–	–	–	24.4	24.6	24.4
	RXJ 2000	–	–	–	–	–	–	22.1	–	19.7
BRAZIL C	RX1 2004	22.8	22.9	22.0	20.5	11.6	5.7	–	–	–
	RX2 2004	23.0	23.0	22.0	20.3	11.0	5.2	–	–	–
	PART 2004	–	–	–	–	12.1	4.8	–	–	–
	NEC 2000	24.4	–	–	–	–	–	24.3	24.6	24.2
	RXJ 2000	–	–	–	–	–	–	21.5	–	19.1
BRAZIL D	RX1 2004	25.1	25.0	22.3	22.0	12.0	6.7	–	–	–
	RX2 2004	24.8	24.7	22.1	21.7	11.4	6.3	–	–	–
	PART 2004	–	–	–	–	NG	18.0	–	–	–
	NEC 2000	25.8	–	–	–	–	–	25.3	Not OK	25.7
	RXJ 2000	–	–	–	–	–	–	22.0	–	19.9
BRAZIL E	RX1 2004	30.5	31.0	28.4	26.7	14.1	8.8	–	–	–
	RX2 2004	31.7	31.9	29.0	27.3	13.7	8.6	–	–	–
	PART 2004	–	–	–	–	0.0	NG	–	–	–
	NEC 2000	Not OK	–	–	–	–	–	Not OK	Not OK	Not OK
	RXJ 2000	–	–	–	–	–	–	30.2	–	23.3
CRC 1	RX1 2004	24.2	23.7	24.8	21.1	12.0	5.9	–	–	–
	RX2 2004	23.4	23.1	24.3	20.5	11.0	5.5	–	–	–
	PART 2004	–	–	–	–	15.9	6.1	–	–	–
CRC 2	RX1 2004	24.1	23.6	24.8	21.2	12.1	6.1	–	–	–
	RX2 2004	23.5	23.3	24.4	20.4	11.4	5.6	–	–	–
	PART 2004	–	–	–	–	15.3	5.4	–	–	–
CRC 3	RX1 2004	24.7	24.6	24.9	21.3	12.2	6.5	–	–	–
	RX2 2004	23.9	24.0	24.6	20.9	11.2	5.9	–	–	–
	PART 2004	–	–	–	–	15.1	5.3	–	–	–
CRC 4	RX1 2004	25.9	24.9	24.7	21.8	12.3	6.6	–	–	–
	RX2 2004	25.6	25.3	24.2	22.0	11.5	6.0	–	–	–
	PART 2004	–	–	–	–	14.7	5.2	–	–	–
UK SHORT DELAY	RX1 2004	24.3	24.0	22.3	22.0	12.0	6.4	–	–	–
	RX2 2004	23.6	23.6	21.8	21.2	11.4	5.9	–	–	–
	PART 2004	–	–	–	–	11.9	4.5	–	–	–
UK LONG DELAY	RX1 2004	22.7	22.7	21.0	20.3	11.2	5.6	–	–	–
	RX2 2004	21.9	21.7	22.0	20.0	10.4	4.9	–	–	–
	PART 2004	–	–	–	–	12.7	4.5	–	–	–

4 Experiment 2.4: Dynamic multipath interference

4.1 Multipath interference caused by moving objects

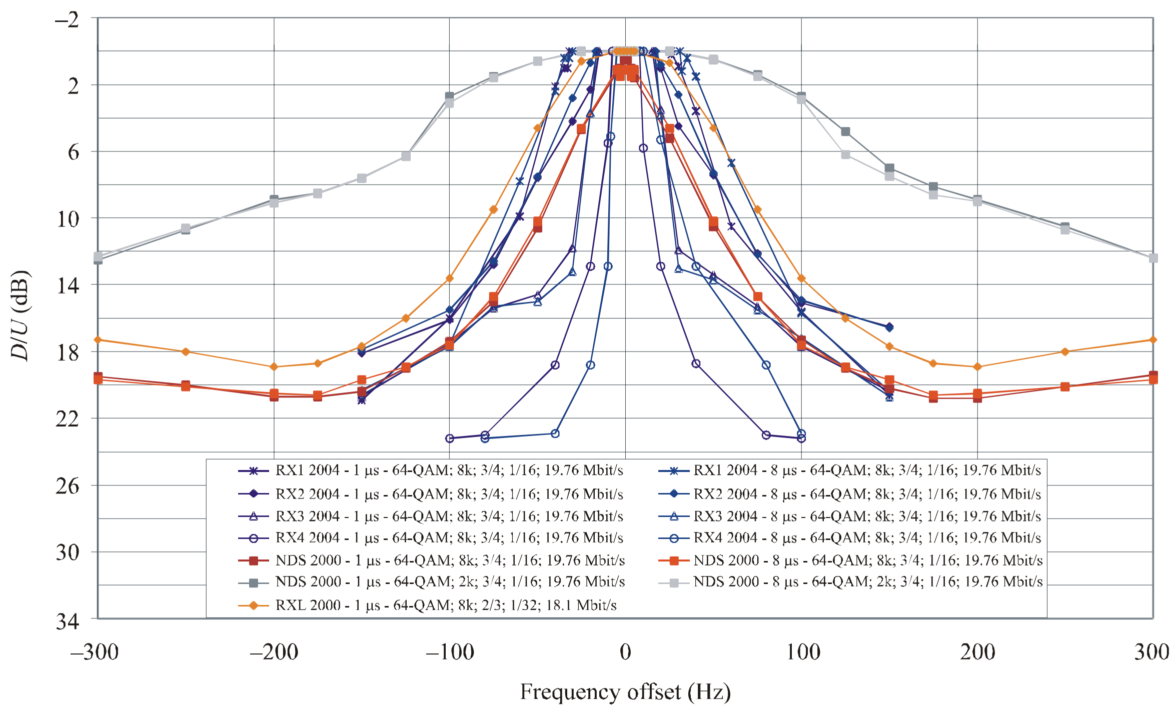
Only post-echo results were included in this Report.

4.1.1 ATSC test results

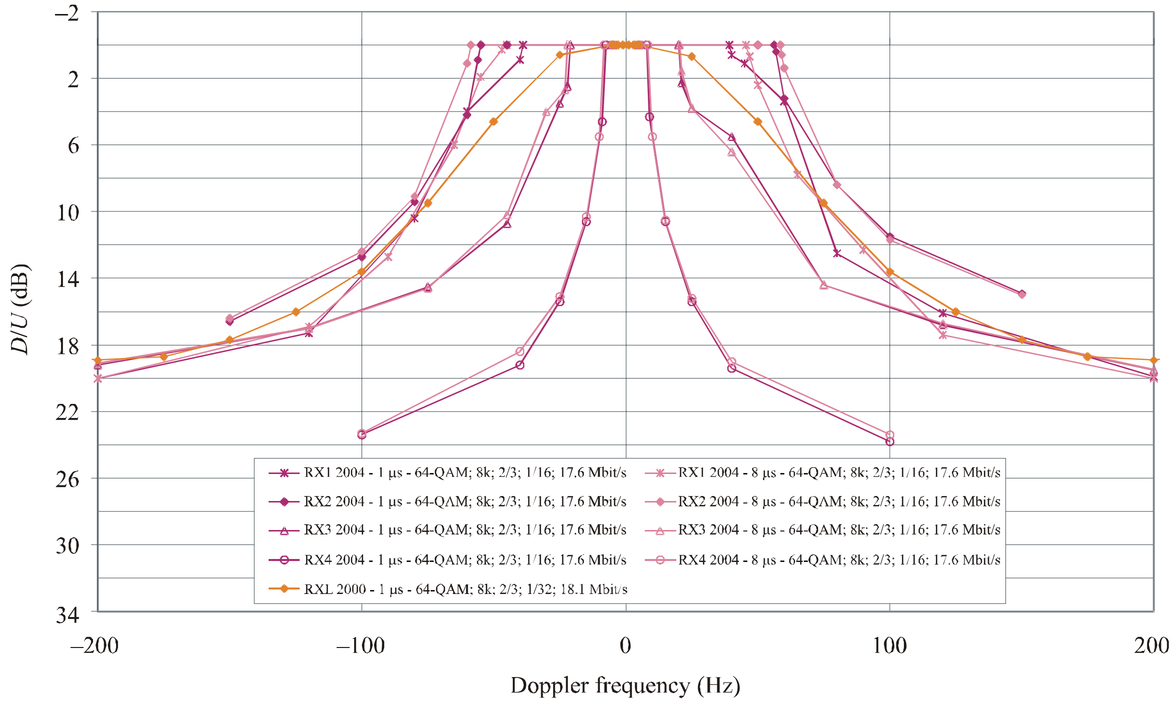


Rep 2035-28

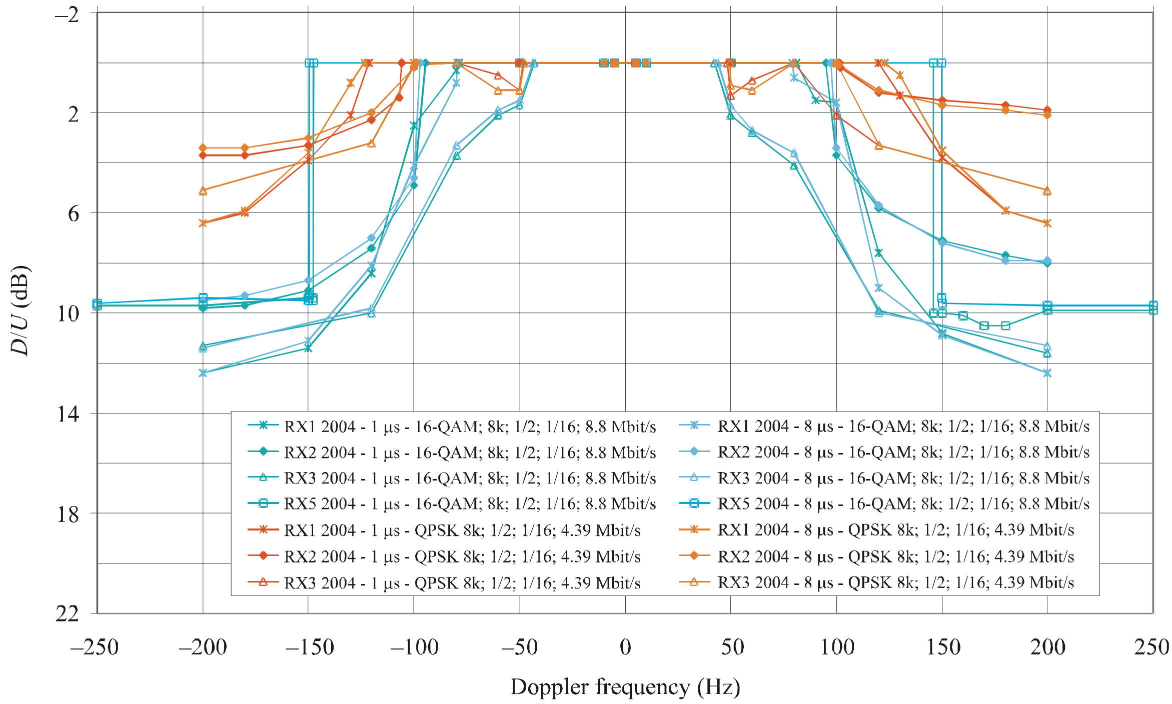
4.1.2 DVB-T test results



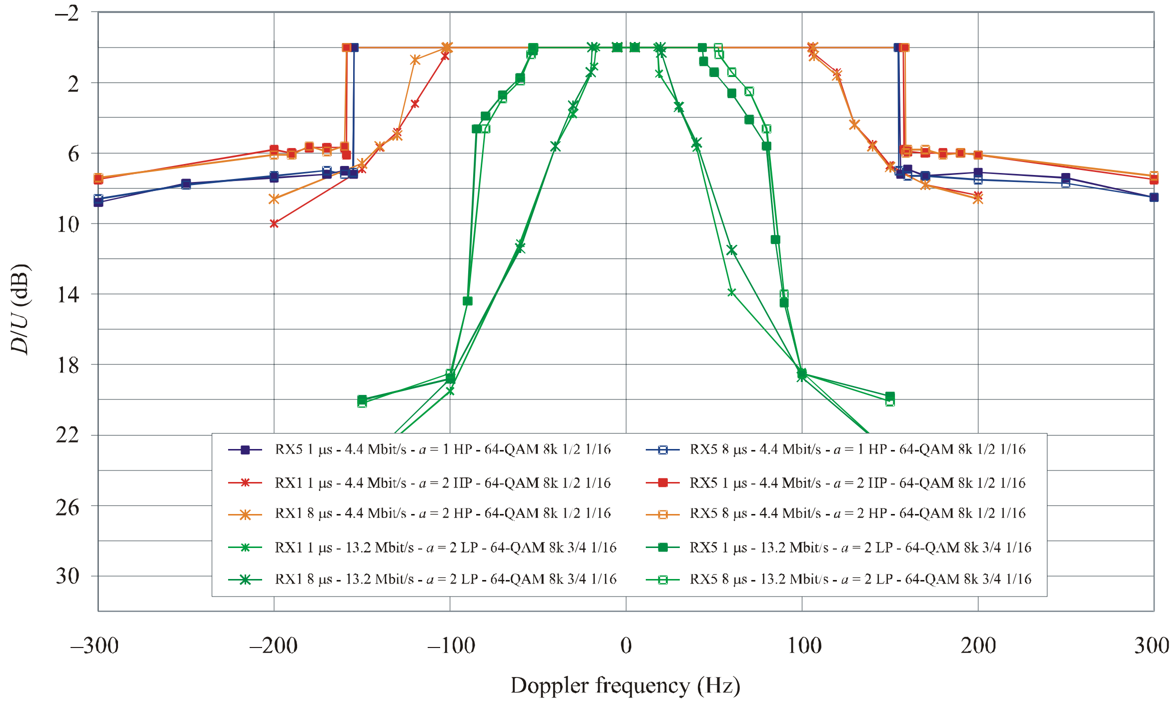
Rep 2035-29



Rep 2035-30

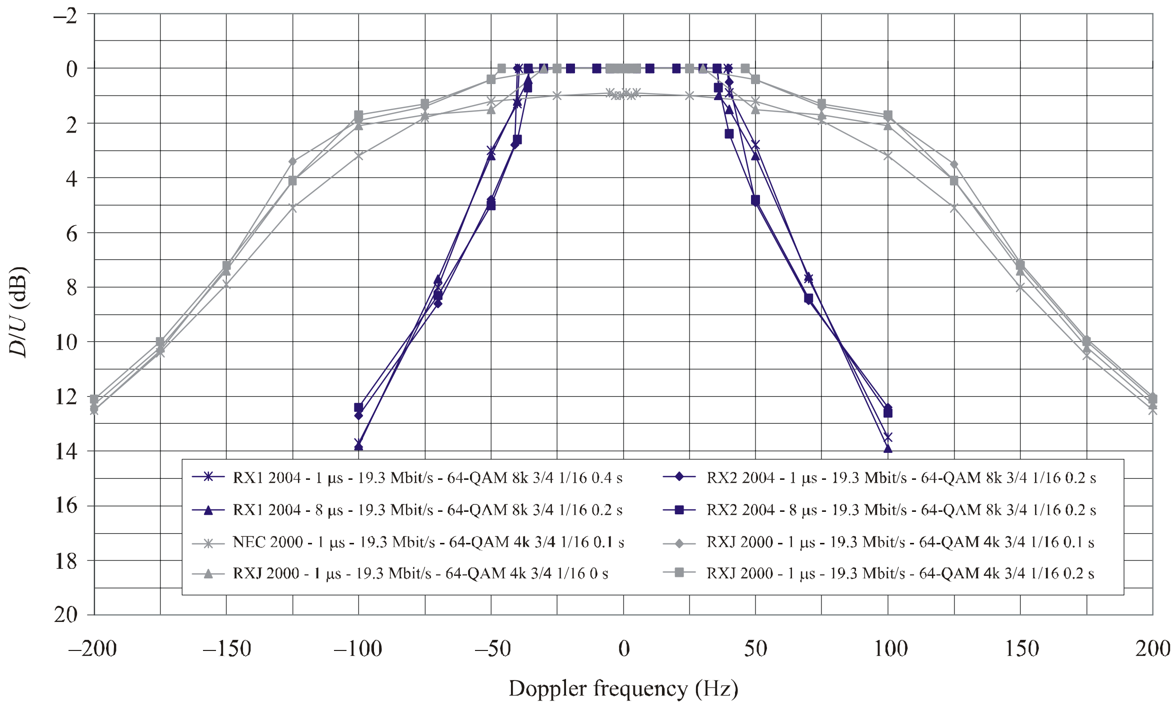


Rep 2035-31

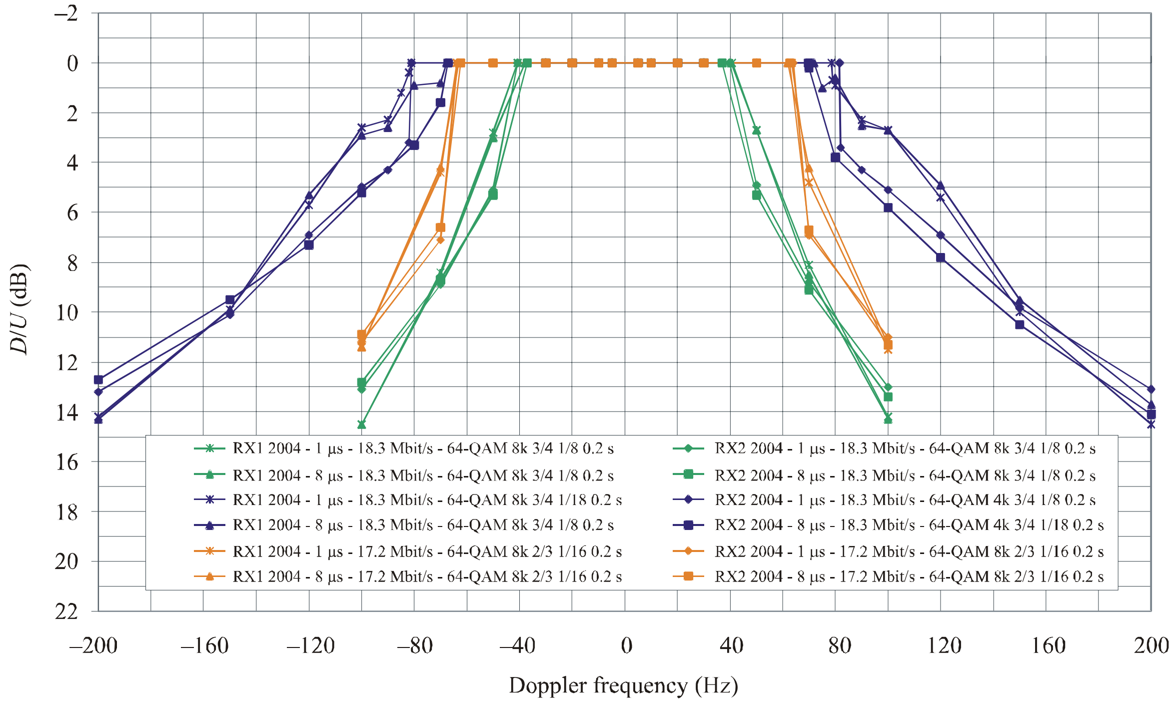


Rep 2035-32

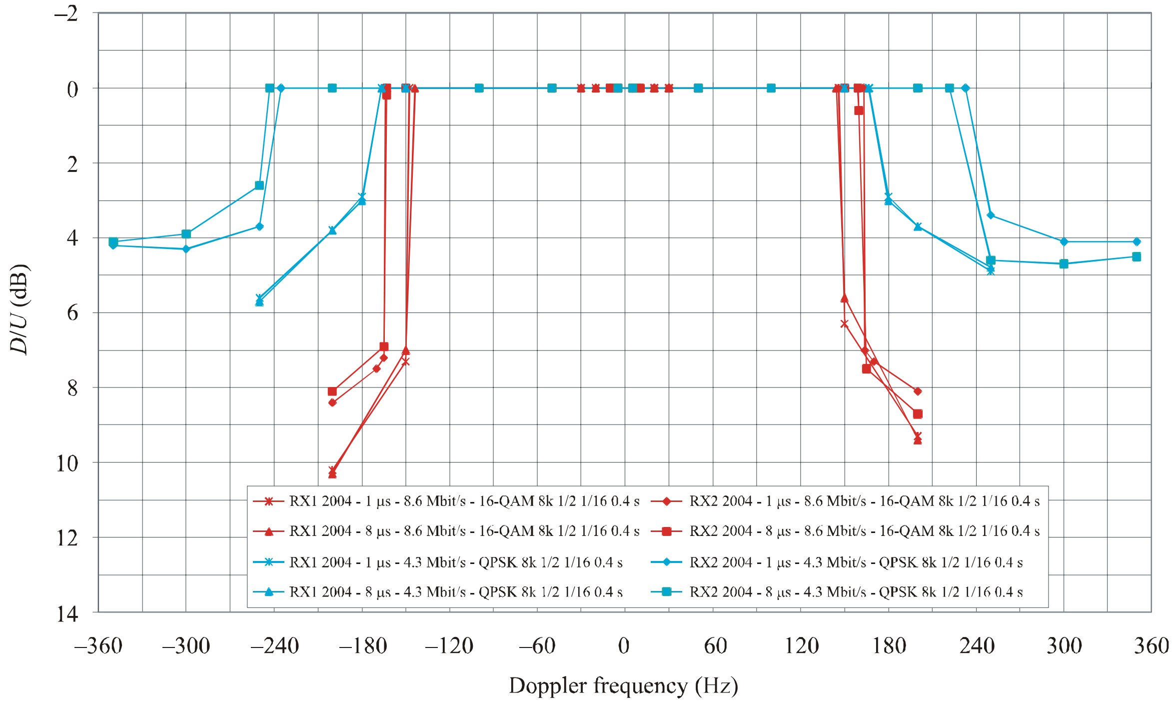
4.1.3 ISDB-T test results



Rep 2035-33



Rep 2035-34



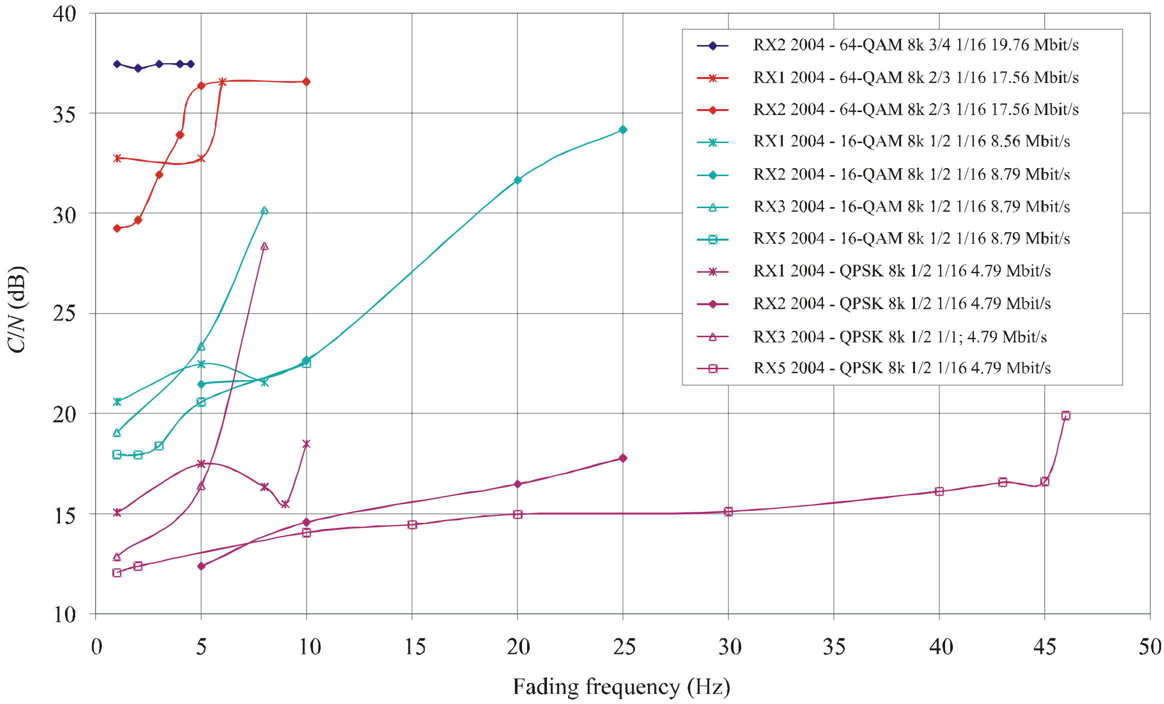
Rep 2035-35

4.2 Mobile reception

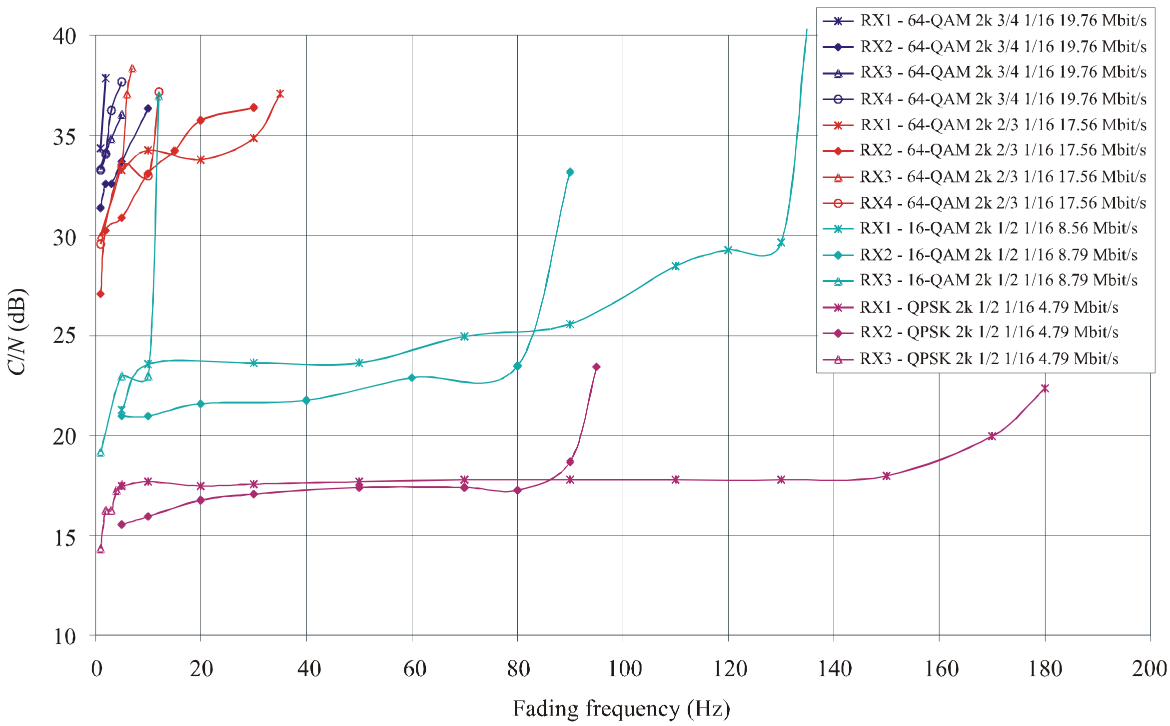
4.2.1 ATSC test results

ATSC receivers did not function on the mobile test channel.

4.2.2 DVB-T test results

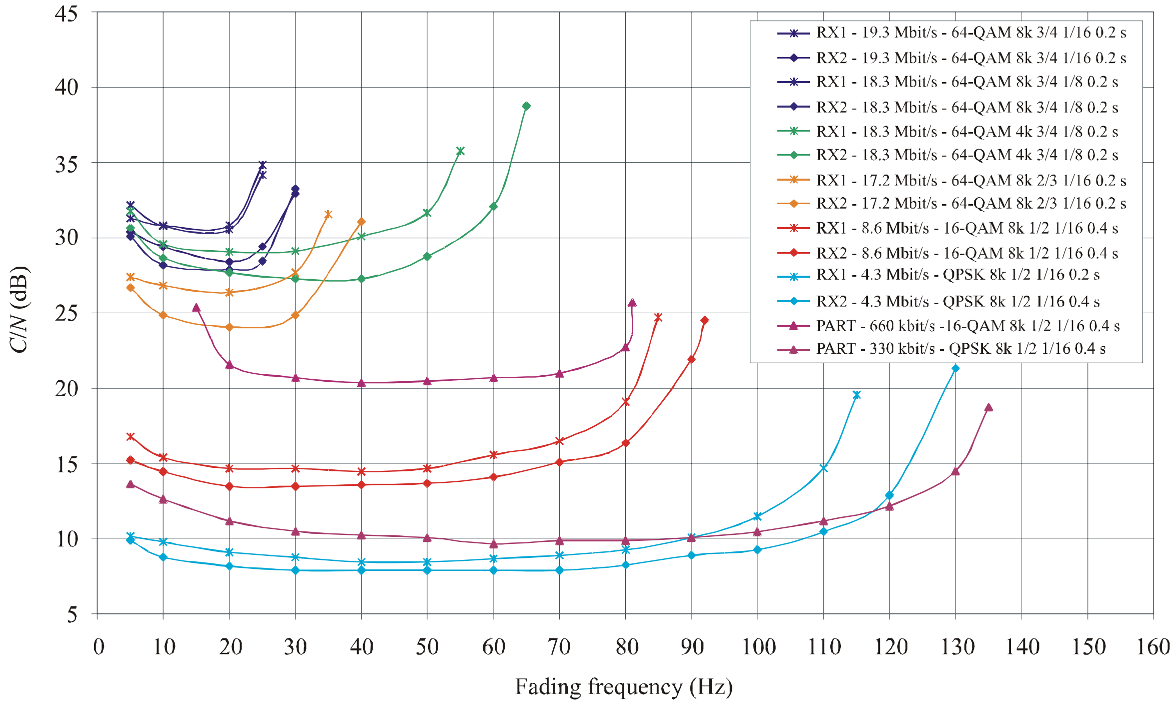


Rep 2035-36



Rep 2035-37

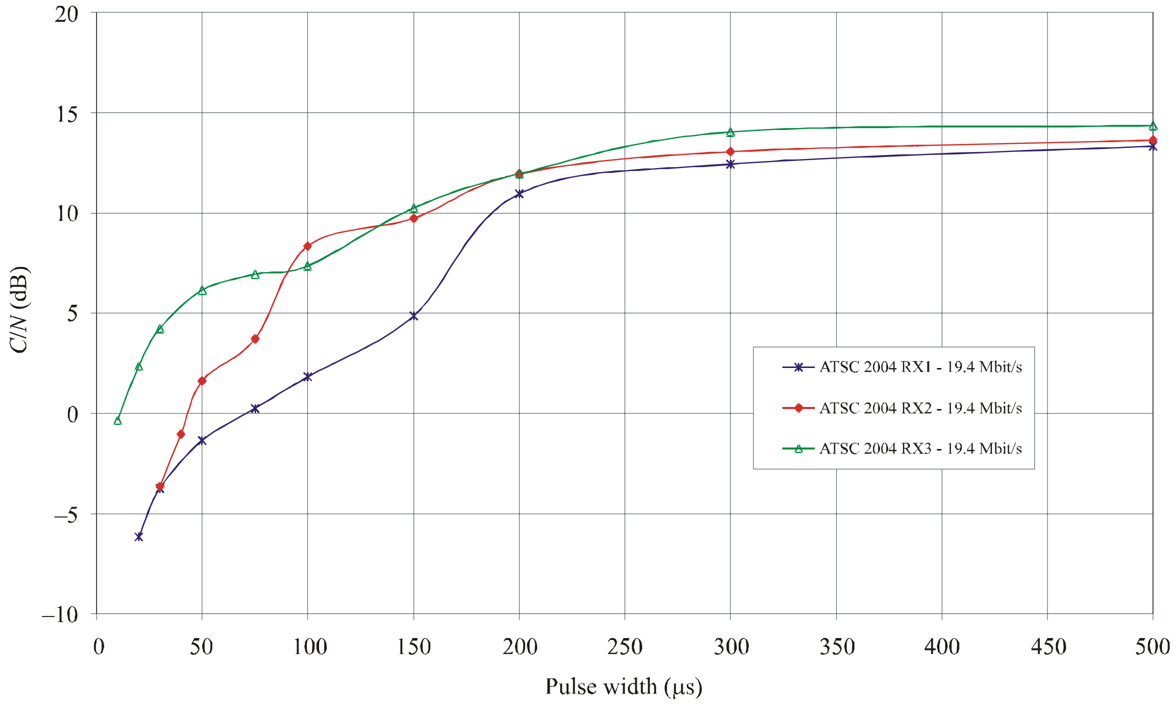
4.2.3 ISDB-T test results



Rep 2035-38

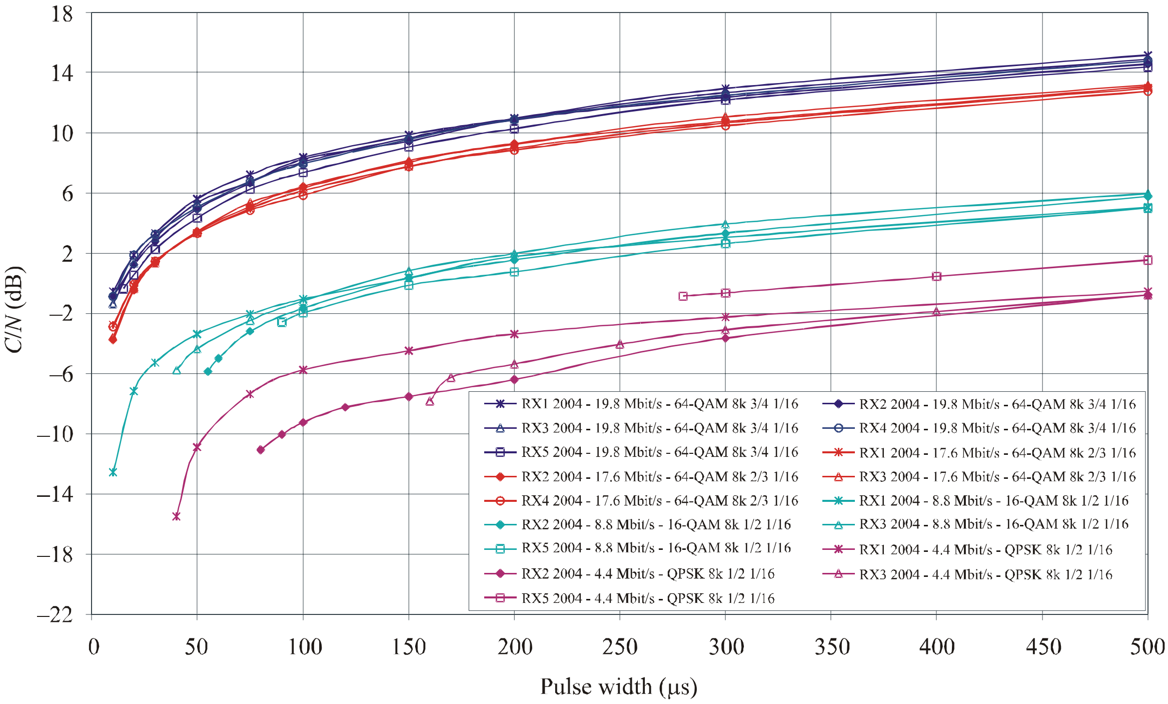
5 Experiment 2.7: Impulse noise

5.1 ATSC test results

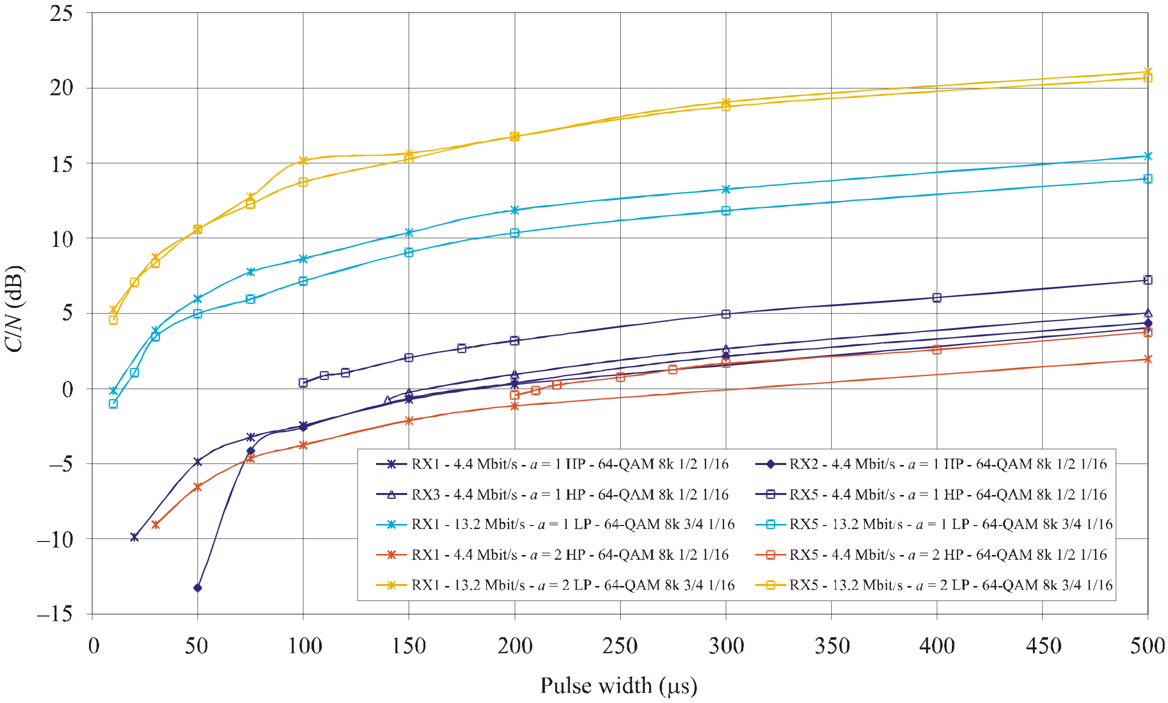


Rep 2035-39

5.2 DVB-T test results

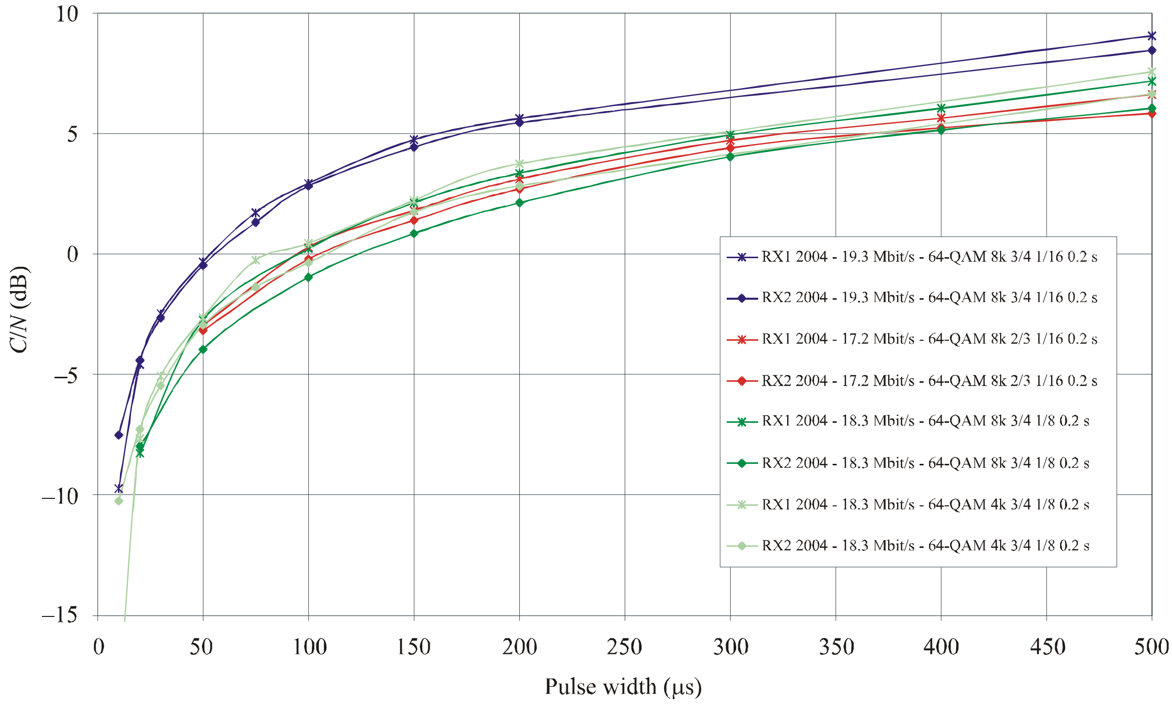


Rep 2035-40

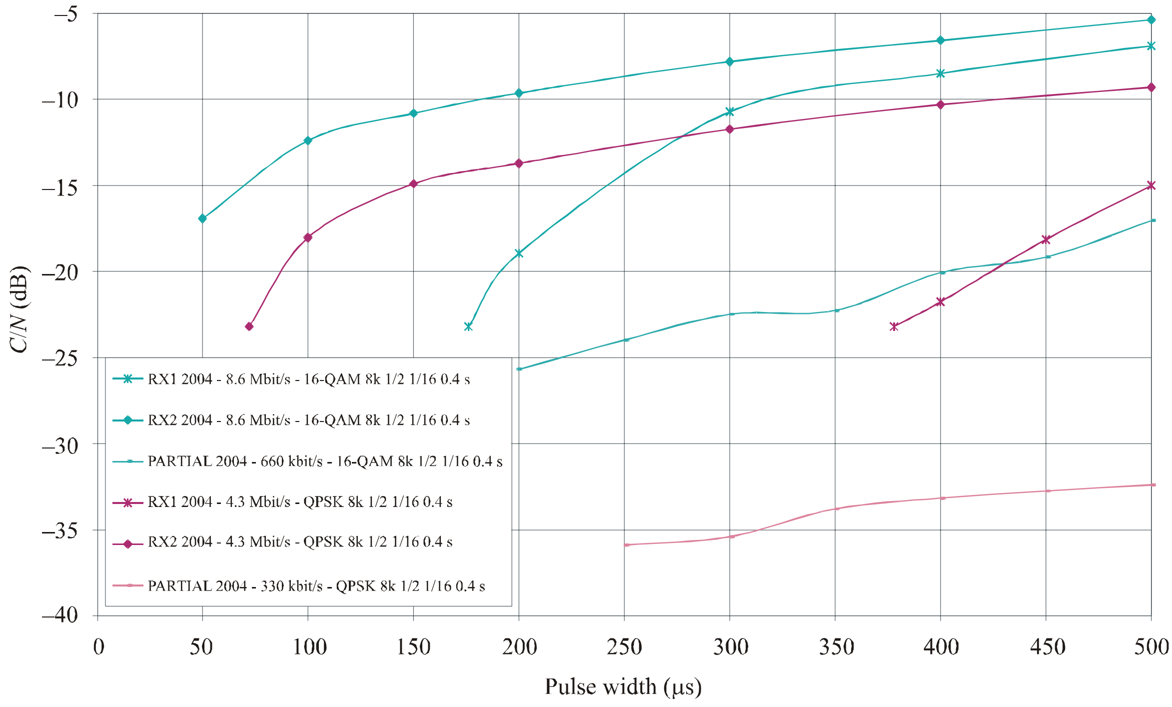


Rep 2035-41

5.3 ISDB-T test results



Rep 2035-42



Rep 2035-43

Appendix 1

Test transmission characteristics

TRANSMISSION SITE			Service A	Service B	Service N
Date of measurement					
Location description					
GPS reference	Datum (e.g. WGS84)				
	Zone				
	Northing/latitude				
	Easting/longitude				
	Height (antenna centre)	m ASL			
BROADCAST SERVICES			**Service A**	**Service B**	**Service N**
Transmission characteristics	Call sign				
	Centre frequency	MHz			
	Licensed maximum ERP	kW			
	System gain	dB			
	Antenna type				
	Operating transmitter power	kW			
	Tx MER				
	Polarization (**H**orizontal / **V**ertical)	H V			
	Radiation pattern	Omni/Directional			
	HRP plot (every 10º)				
	VRP plot				
	Beam tilt	deg			
	Modulation	QPSK 16-QAM 64-QAM			
	Code rate	1/2 2/3 3/4 5/6 7/8			
	Guard interval	1/32 1/16 1/8 1/4			
	Transmission mode	2K/8K			
	Bit rate				

Note, cells shaded ▬ indicate parameters that must be checked with the broadcaster during the field survey.

Appendix 2

DTTB site measurement data profile

1 Reception site data

RECEPTION SITE DATA		Requirement	Site A	Site B	Site C
Date of measurement					
Location description					
Local government area					
Site category	Reference/LOS/ measurement	R LOS M			
GPS reference	Datum (e.g. WGS84)				
	Zone				
	Northing/latitude				
	Easting/longitude				
	Height	m ASL			
Direction from Transmitter	Bearing	degrees			
	Distance	km			
Environment	Urban/Suburban/Rural	U S R			
Geography	Coastal/Flat/Hilly/ Undulating/Mountainous	C F H U M			
Signal obstruction	Foliage[15]/Hills/ Mountains/Low Rise/High Rise/Power Lines/Other/None	F H M LR HR PL O N			
Signal path	Line Of Sight/Over Water/Over Vehicle Traffic/Other	LOS OW VT O -			
Electrical noise sources	Note any observations				
Household viewing habits	Antenna	describe			
	Type	describe			
	Height	m above ground			
	Pointing	describe			
Weather conditions	Weather	describe			
	Temperature	deg C			
	Humidity	%			

[15] Note any foliage within close proximity of the receiving antenna and the path of the transmitted signal.

REFERENCE TESTING EQUIPMENT				
Reference antenna model				
Height	m			
Passive antenna gain	dBd			
Antenna correction factor	dB			
Feeder and distribution losses	dB			
Test receiver model				

2 Television broadcasting service data

BROADCAST SERVICES			Service A	Service B	Service N
Service	Frequency				
Reception characteristics	Impulse response	Level			
		Timing			
	Multipath	variable			
		static			
	Antenna height setting	m			
	Measured voltage	dBμV			
	COFDM spectrum slope/dips	dB			
	BER before Viterbi (CBER)				
	BER post Viterbi (VBER)				
	BER post Reed-Solomon				
	MER	dB			
	Carrier to noise	dB			
	Threshold attenuation	dB			
	Digital signal quality assessment	1-5			

Appendix 3

Recommended reference testing equipment[16]

Type	Description
DTTB test receiver	Test receiver for precision DTTB measurements
DTTB receiver demodulator	Receiver demodulator for high precision DTTB measurements
VHF antenna	VHF channels 6-12, Yagi antenna 10 elements, forward gain 8-11 dB. Front to back ratio 20 dB Gain slope across any 7 MHz channel < 1 dB, impedance 75 Ω, VSWR > 1.6:1 Half power beamwidth < 35º
UHF antenna	UHF channels 28-69, fringe antenna phased array antenna, forward gain 10-13.5 dB. Front to back ratio >20 dB Gain slope across any 7 MHz channel < 1 dB Impedance 75 ohms, VSWR > 1.6:1 Half power beamwidth < 35º
Reference dipole	Telescopic (tunable) dipole or appropriate broadband antenna (e.g. bi-conical or log-periodic antenna) for which calibrated antenna factors traceable to national standards are available
Cable types	Twin shielded RG214 (50 Ω) or alternatively quad shield RG6 (75 Ω) or RG223 are lighter when using with an antenna on a tall mast

16 Refer: ITU-R DTTB Handbook – Digital terrestrial television broadcasting in the VHF/UHF bands (Part 2 - Planning Part) – http://www.itu.int/publ/R-HDB-39/en.

Appendix 4

DTTB coverage field study flow chart

Identify area and sites within the area to be surveyed

Notify broadcasters

- identify area and sites to be surveyed
- seek local knowledge on sites.

Apply predictive model from DTTB coverage data collection

- identify ‘matches’ from data collection for sites within survey area
- identify profile of sites not available from within the data collection

Identify “calibration or reference” sites (at least 4)

Establish calibration procedure for survey

- between survey vehicle and transmission site(s)
- verification of transmission parameters with broadcaster, e.g. transmitter location, EIRP, MER.

Establish procedure for survey

- include GPS references for all measurements
- use reference antenna and receiver
- take measurements at antenna height of 10 m AGL

Antenna calibration

- measure field strength (dBμV)
- record spectrum shape
- measure MER, *C*/*N*, BER
- measure/calculate impulse response (if possible), particularly within SFNs
- at metropolitan sites repeat measurements at typical height of installed antennas at/or near measurement site

Visual observations (where applicable or required)

- photograph antenna type surveyed in area
- note height of installed antennas at/or near measurement site

Analysis of survey data

- calculate resultant field strength (measured FS – correction factors + cable loss)
- calculate free space path loss from transmitter to site
- apply “digital signal quality” scale to measured field strength

Establish predictive model for selected site

- define site type – urban, suburban, rural, topography,
- record impulse response/interference/multi-path margin
- record time/location availability margin
- record antenna height allowance
- define resultant field strength
- add to DTTB coverage model data collection.