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Abstract

The field trials are one of the most important phases of the SUIT project. It consisted in deploying two sites, conducted several measurements and test campaigns in the framework of the SUIT project. This report gives an overview of these trials, describing the various tests and the field work carried out so far.   It also reports all partners' components and contributions for these field trials.

Keyword list: Tests, measurement campaigns, field trials, integration, SUIT components.

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Filed trials report

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19th May 2008

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1 Introduction

This document is part of WP6 – Integration, performance evaluation and validation - and is related with Activity 6.3 -”Integration and test-bed/field trials”.

A laboratory work has been conducted before the field trials (described in document SUIT_438_WP6_D6.3_Test bed report”), integrating all SUIT components.

The field trial was run from 01 February 2008 to 15 of May 2008 in Aveiro City, Portugal. Two sites with DVBT-RCT and WiMAX base stations were deployed according to the SUIT project.

Tests and measurements were performed which included outdoor stationary reception, vehicular environment and verification of the system service.

The aim of this report is to present the procedures and the results of these field trials.

In this section, we outline the scope and the main objectives of the field trials. Section 2 describes the trials overview, with information about the sites location, system configuration and coverage prediction. After, in section 3, a short list with the main problems faced during the field work is outlined. The test campaigns, RF measurements, throughput performance are described in section 4. The section 5 contains detailed information about the partner’s contributions to the field trials. Finally, in section 6, conclusions are reported.

1.1 Scope

The scope of the filed trials is mainly to confirm the extensive range of the laboratory results and to investigate fully the overall performance of the SUIT system for various transmission modes and different field conditions.

In the field work, several measurement campaigns were conducted in the framework of the document SUIT_437_WP6_D6.1_Performance_metrics_definition.

Furthermore, trials are required to answer questions of levels of throughputs, service planning and coverage prediction and to investigate SUIT critical issues, like QoS and HO processes. Sufficient representative field data has to be acquired to improve the accuracy of the results.

Field trials were concluded with a big demonstration session for the market players (operators, broadcasters, regulators) and other people related with this subject.

1.2 Objective and aims

The basic main objectives of the field trials were:

- To assess the performance of the SUIT system under field conditions;
- Evaluate the accuracy of the computer RF coverage project;
- Investigate the WiMAX propagation, namely the multi-path effect ;
- Evaluate picture and sound quality;
- Collect feedback about the system from the market players;
- Test the advantages of SUIT algorithms namely the multiple description coding (MDC) scheme over WiMAX and DVB-T, the HO vertical (between WiMAX and DVB-T) and HO Horizontal (WiMAX / WiMAX and DVB-T / DVB-T);
- To demonstrate the advantage of combining DVB-T and WiMAX to ensure high capacity at high speed, 150 km/h;

- To evaluate the quality (QoS) of the communications for portable and high-speed devices.

2 Field trials overview

Before moving the equipment to the field, a test bed was conducted to verify the end-to-end chain and to assure that the work field risks were minimized.

The field trials were performed in Aveiro City in a urban environment area (city centre) and in an open field, closest to the city (A25 motorway). DVBT-RCT and WiMAX sites were installed at two defined locations – Departamento Electronica e Telecomunicações Building (IT) and Segurança Social Building (SS).

Each site had DVBT-RCT and WiMAX equipment, two UHF antennas (one for transmit and one for receive) and one WiMAX antenna to provide radio coverage within the trial area according to the previous coverage project. The head-end SUIT components were installed in Instituto Telecomunicações laboratory and the contents were delivered to the sites over a 5 GHZ unlicensed link with 100 Mbit/s of throughput.

To conduct the tests campaigns, a vehicle (Land Rover Defender) was equipped with DC/AC power converters, test equipment and antennas (for DVBT-RCT, one antenna for each transceiver since a duplexer is used).

Because of the mobile “nature”, vertical polarization antennas have been used in all sites and in the survey vehicle.

2.1 Field trials work plan

Given the complexity of the system, a detailed field trial plan was drawn. The main goal was guarantee that all the work should be performed systematically.

This guide has been followed during the field trials work. In the following lines, we can find a summary of this work plan.

- Design the coverage project. For this, a survey should be made in some potential sites in Aveiro city to collect relevant data. After, the simulations must be performed with the computer tool in order to get the requested coverage area.
- Collect all the details of the sites in order to prepare the necessary hardware. Prepare the hardware and install it on sites.
- Set up the both sites with the equipments. Perform the first tests.
- Conduct the stationary and mobile tests with only one site operating. The other should be powered off. First, we should test one of the platforms (for instance WiMAX) and as soon as we finished the tests in this platform, we move to the other, testing it. Finally, we should perform the tests with the both RF platforms operating. Make the necessary corrections.
- Test the HO process in WiMAX and DVBT-RCT.
- Carry out the necessary measurements campaigns.
- Refine the whole system with SUIT services, preparing it for the demo session.
- Conduct the Demonstration session.

2.2 Remote Control

As the sites are located away from the IT laboratory, a remote control system has been developed in order to guarantee total control of the sites remotely. An uPLC was installed in each site controlling an AC switch system. A software application was developed (Figure 1 – Remote control software) and was running in a PC on IT lab. With this tool, we were able to switch on and off all sites equipment. In addition, two laptops with XP system were placed in the sites and they were connected to the base stations through RS232 port and Ethernet port. Remote desktop was enabled in order to allow the lab computer and vehicular computer to connect remotely to these site computers. Windows Hyperterminal and Rucom applications were used to communicate with the base station equipment.

This solution made possible the remote control from the survey vehicle as well, as we could access the sites with the WiMAX upstream or over the RCT channel in DVBT (Figure 2). This flexibility proven to be very useful, granting a big efficiency and time spare in the field trials work.

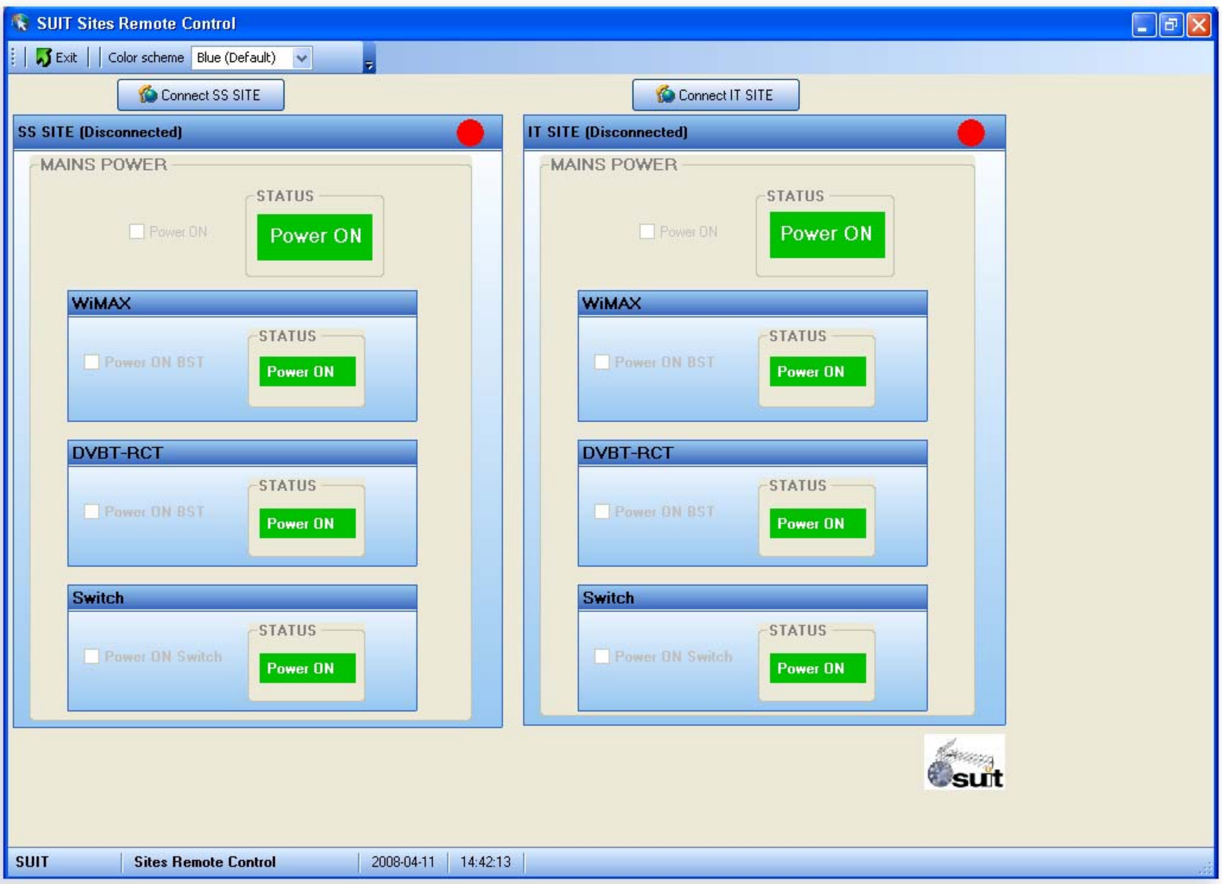


Figure 1 – Remote control software

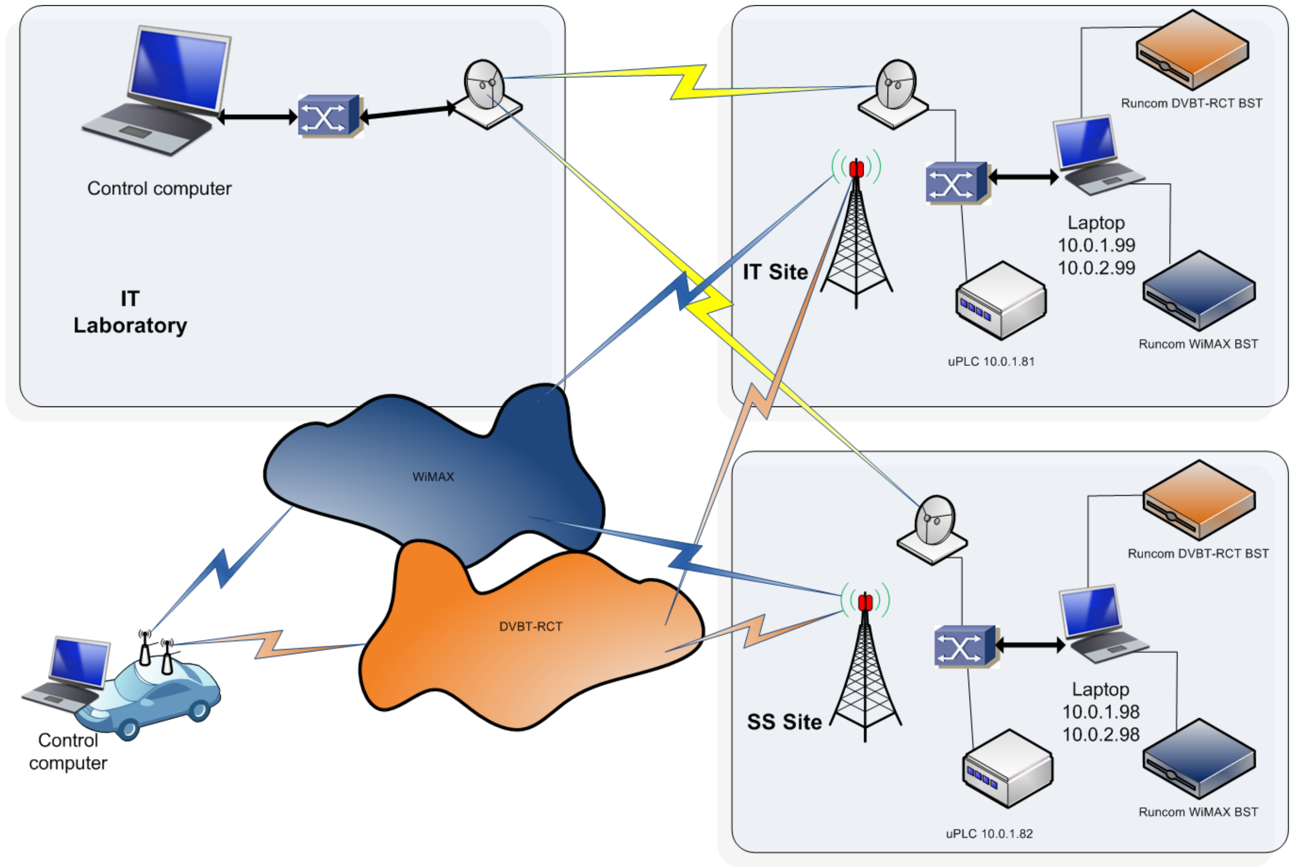


Figure 2 – Remote Control Lay-out

2.3 Sites location

One site was located in the highest building of the city (Segurança Social building) and we named it as SS Site with latitude 40°38'38.75"N and longitude 8°38'57.25"W. The other site was installed in one building closest to the IT building (IT Site) with latitude 40°38'1.49"N and longitude 8°39'35.23"W

These locations have been chosen according to the main goals of the field trials. They are the result of a compromise among some requirements: guarantee the coverage areas needed under SUIT demands, good conditions to install equipments, hardware and antennas, easy access so that facilitates get at the site in case of need.

The distance between the two sites is about 1,5 kilometres.

Figure 3 – Sites location map

2.4 System configuration

The field trials system mainly consisted of four parts: the head-end, the IT site, the SS site and the survey vehicle. On IT site and on SS site, the UHF antennas and the WiMAX antennas were equal. The transmission and reception (for RCT channel) UHF antenna is a panel with vertical polarization (Figure 6).

The WiMAX antenna was a 90º sector panel from Andrew with the pattern showed in Figure 7, vertical polarization with 2º electrical tilt.
As the output power of the BST was not enough to perform the required tests, we designed and build up, two TDD power amplifiers with 30 dB of gain (Figure 4).

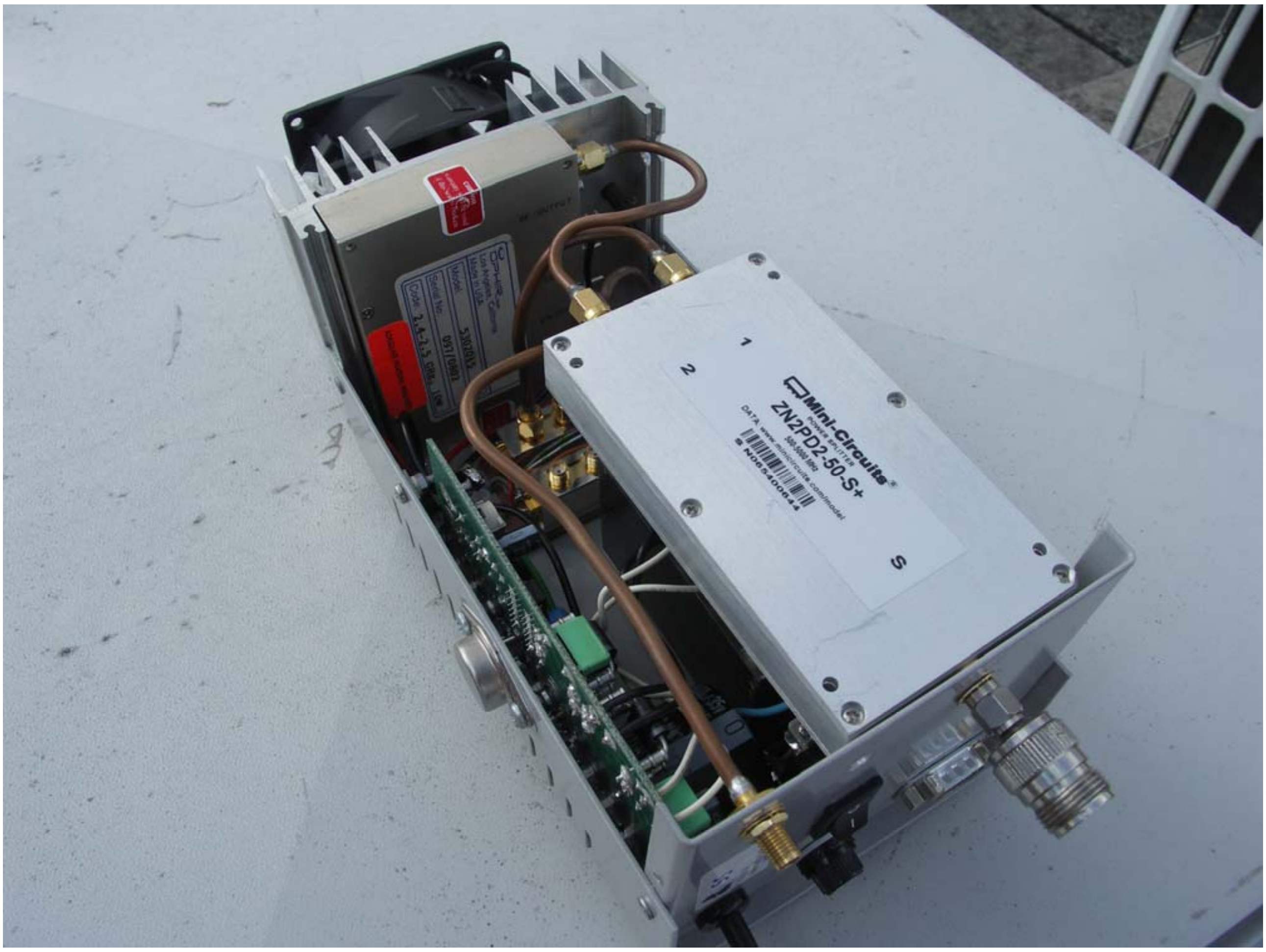


Figure 4 – WiMAX Power Amplifier

With these amplifiers, we were able to feed the antennas in both sites, with +30 dBm of power. The input range of the PA should be between -6 dBm and 0 dBm. According to the Runcom instructions, the WiMAX BST's output power should be around +15 dBm in order to guarantee the best performance. Because of it, and to prevent possible damages, we placed a 20 dB attenuator between the BST output and the PA input. The PA was assembled with one fast RF switch (to assure the TDD commutations) in the input and another fast RF switch (able to deal with 1 W of power) was inserted in the output. However, during the first test campaigns, these power RF switches have been damaged. We replaced them by two RF splitters.

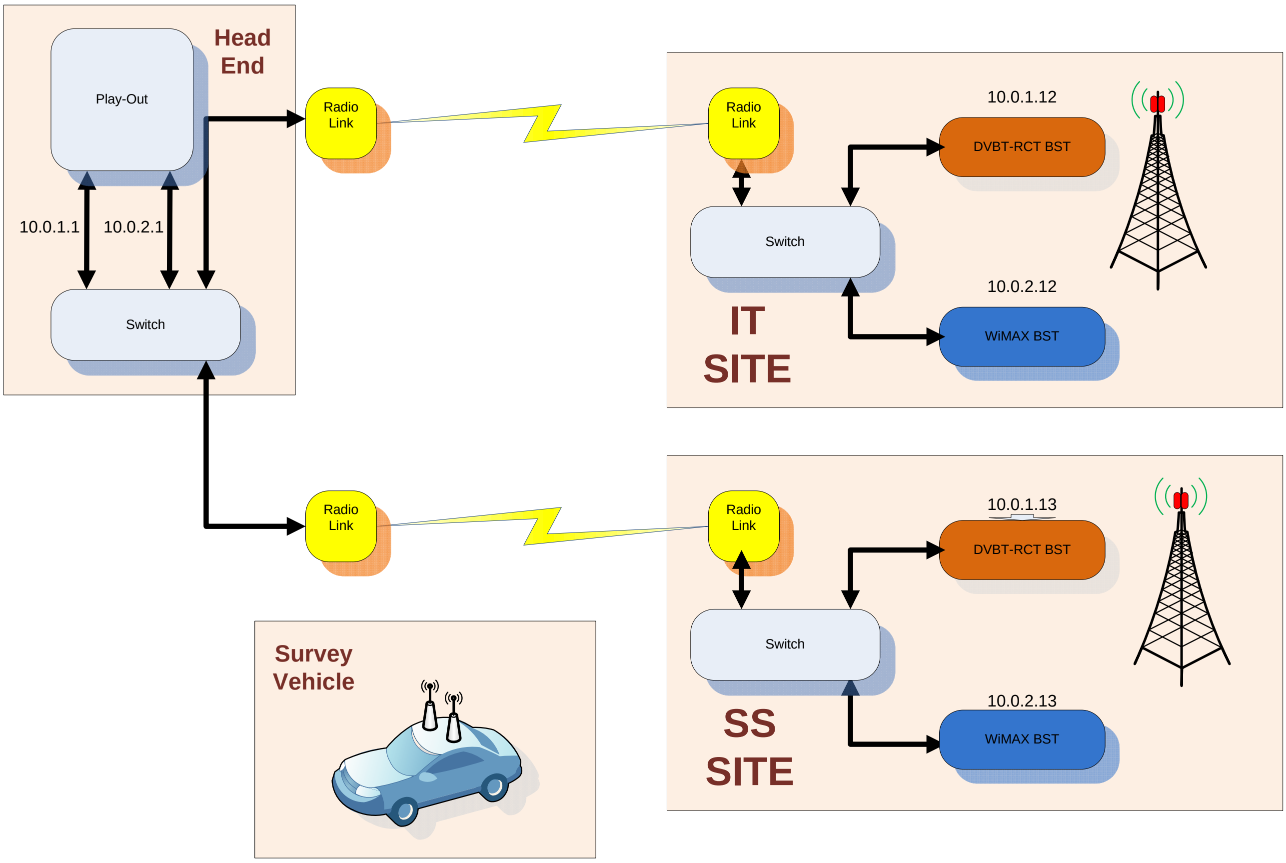


Figure 5 – Field trials overview

ELECTRICAL DATA	
ANTENNA TYPE	UTV-02
FREQUENCY RANGE	470 ÷ 860 MHz
IMPEDANCE	50 ohm
CONNECTOR	7/8" EIA
MAX POWER	2.5 kW
VSWR	≤ 1.1
POLARIZATION	Vertical
GAIN (referred to half wave dipole)	10.5 dB
HALF POWER BEAMWIDTH	E-Plane: ± 15° H-Plane: ± 32°
LIGHTNING PROTECTION	All Metal Parts DC Grounded

MECHANICAL DATA	
DIMENSIONS	757 x 457 x 178 mm
WEIGHT	12.5 kg
WIND SURFACE	0.34 m²
WIND LOAD	0,46 kN (wind speed 150 km/h)
MAX WIND VELOCITY	220 km/h Safety factor: 2
MATERIALS	Reflector (Stainless Steel) Internal Parts (Plated Brass and Copper) Radome (Fiberglass)
ICING PROTECTION	Full radome
RADOME COLOUR	Red - White - Green (standard)
MOUNTING	Directly on supporting mast or with special pipe clamps
PACKING	780 x 480 x 290 mm

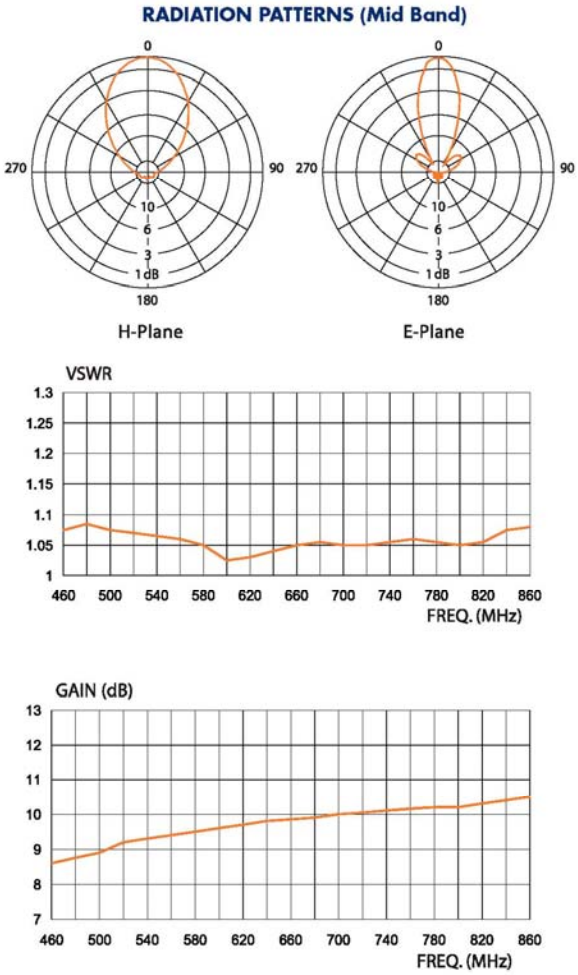


Figure 6 – UHF panel characteristics

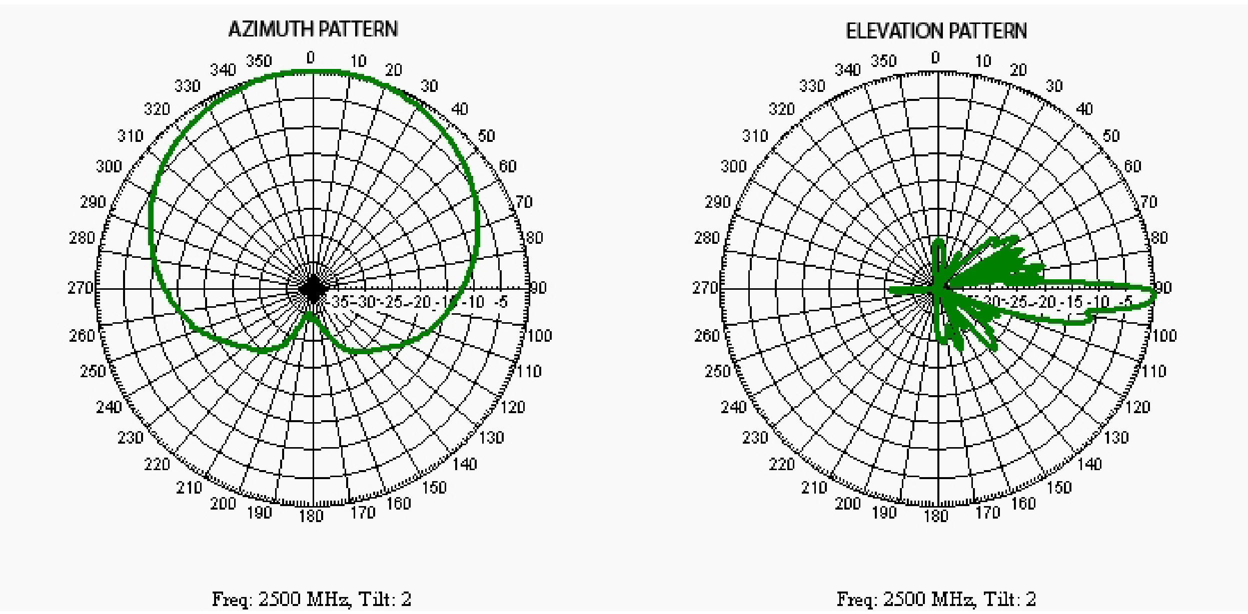


Figure 7 – WiMAX antenna patterns

Frequency (MHz) : 2300 - 2700
Polarization : Vertical
Gain (dBd/dBi) : 14.8/16.9
Azimuth BW (Deg.): 88
Elevation BW (Deg.): 5.7
Beam Tilt (Deg.): 2
USLS* (dB) : 18
Front-To-Back Ratio* (dB) : 34
VSWR : <1.5:1
PIM3 @ 2 x 20w (dBc) : -140
Max. Input Power (Watts) : 50
Impedance (Ohms) : 50
Lightning Protection : DC Ground

2.4.1 Survey vehicle

A survey vehicle was prepared for the field trials. A 2000 watts DC/AC converter was installed with electrical installation to allow AC equipments power connection. A customized table to accommodate all the test equipments, laptops and measure equipments replaced one of the back seats. On the roof of the car, was applied a metal structure to hold the antennas. (Figure 8)

Figure 8 – Survey vehicle

2.4.2 Head end

The head end was located in IT laboratory. There, we placed the SUIT Play out computer, the internet router, the SVC real-time encoder and the Ethernet switch.

2.4.3 IT Site

There is a small room on the roof of this building, which has been used to install the equipment. Two masts with 4 meters high were placed on the roof to hold the antennas. All the connections have been made. First operational tests have been carried out.

Figure 9 – IT Site

2.4.3.1 DVB-T/RCT system components and configuration

This site was equipped with one DVBT-RCT BST (FDD system) from Runcom. One power amplifier (100 W) from Rhode & Swarchz was used to deliver the requested power. Two UHF antennas (one for transmission and other for reception) were installed on the masts pointing to A25 (40°37'53.30"N, 8°41'22.03"W). Low losses 50 ohms cables were used to connect the equipment to the antennas. A power pass-band filter tuned for channel 53, was inserted between the power amplifier and the transmission panel. Another pass-band filter for the 67 channel was inserted between the receiver UHF antenna and the BST RX input. The Runcom BST was configured to outputs 0 dBm (according to the UHF Power Amplifier input range, which is between -6 dBm and +6 dBm).

2.4.3.2 WiMAX system components and configuration

The Runcom WiMAX BST was connected to the 1W PA which is connected to the Andrew antenna with a low losses 2.5 GHZ cable. The BST was configured to deliver +15 dBm output power and to operate in 2540 MHZ. There was no mechanical vertical tilt applied to the antenna.

2.4.4 SS Site

In this location, there are no room available to install the equipment as we had in IT building. We took the option of placing a telecommunications shelter to accommodate all the equipment. The building has a big plane roof with excellent conditions to install the shelter. This shelter stayed closest to the masts in order to minimise the cable losses. The limit of the roof is protected with a metal railing that has been used to hold (with customized hardware) the two masts with 4 meters high. All the connections have been made. First operational tests have been carried out with success.

Figure 10 – SS Site

2.4.4.1 DVB-T/RCT system components and configuration

This site was equipped with one DVBT-RCT BST (FDD system) from Runcom. One power amplifier (100 W) from Rhode & Schwarz was used to deliver the requested power. Two UHF antennas (one for transmission and other for reception) were installed on the masts pointing to A25 (40°38'47.16"N, 8°39'8.27"W). Low losses 50 ohms cables were used to connect the equipment to the antennas. A power pass-band filter tuned for channel 43, was inserted between the power amplifier and the transmission panel. Another pass-band filter for the 59 channel was inserted between the receiver UHF antenna and the BST RX input. The Runcom BST was configured to outputs 0 dBm (according to the UHF Power Amplifier input range, which is between -6 dBm and +6 dBm). The PA was configured to deliver 20 watts of output power.

The UHF antennas had a vertical tilt of 4º.

2.4.4.2 WiMAX system components and configuration

The Runcom WiMAX BST was connected to the Andrew antenna with a low losses 2.5 GHZ cable. The BST was configured to deliver +19 dBm output power and to operate in 2520 MHZ. A Power Amplifier with 30 dB of gain was inserted between the BST and the antenna. There was a mechanical vertical tilt of 5º applied to the antenna.

2.4.5 Link's system

Two unlicensed 5 GHZ radio links (one between the IT building and the IT Site and the other between the IT building and the SS Site) were used to connect the Head end to the both sites.

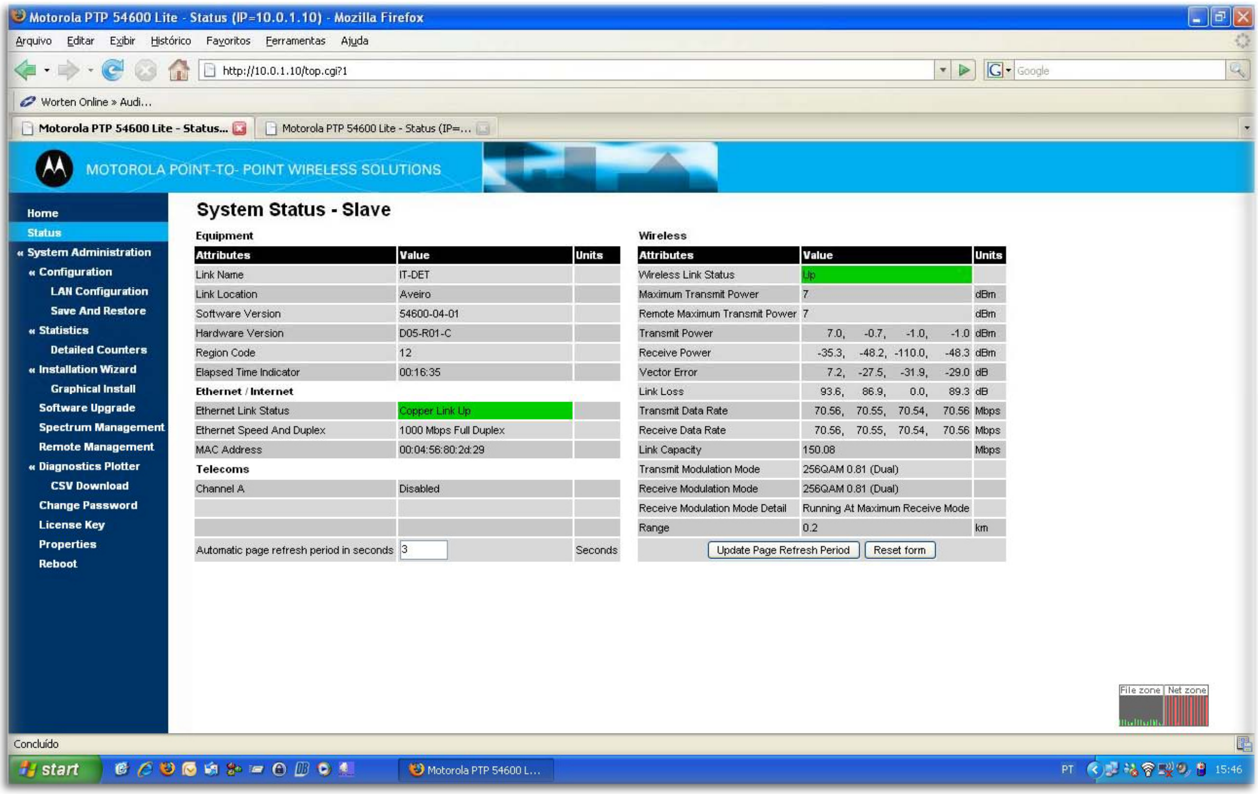


Figure 11 – Radio link configuration

2.5 RF Coverage prediction

Before set up of the two base stations, the field strengths from the DVB-T transmitters and from WiMAX BS have been predicted. For this coverage planning, a computer tool, named ICS Telecom, was used. With this software, a detailed coverage project was designed to serve the centre of the city and the high way A25 in order to guarantee the required conditions to perform the tests in the framework of SUIT_427_D1.5_Architecture_and_Reference_Scenarios.

The calculation to obtain the demanding overlap area was one of the most important works that has been done. Several simulations were performed in order to get a good balance between the best overlap area and the acceptable field strength inside the city centre under the SUIT requirements. This took into account that we were limited in conditions once we did not have professional telecommunications sites available in Aveiro to install the trial equipment.

In the following two items, some software outputs are showed.

Figure 12 – Intended coverage areas

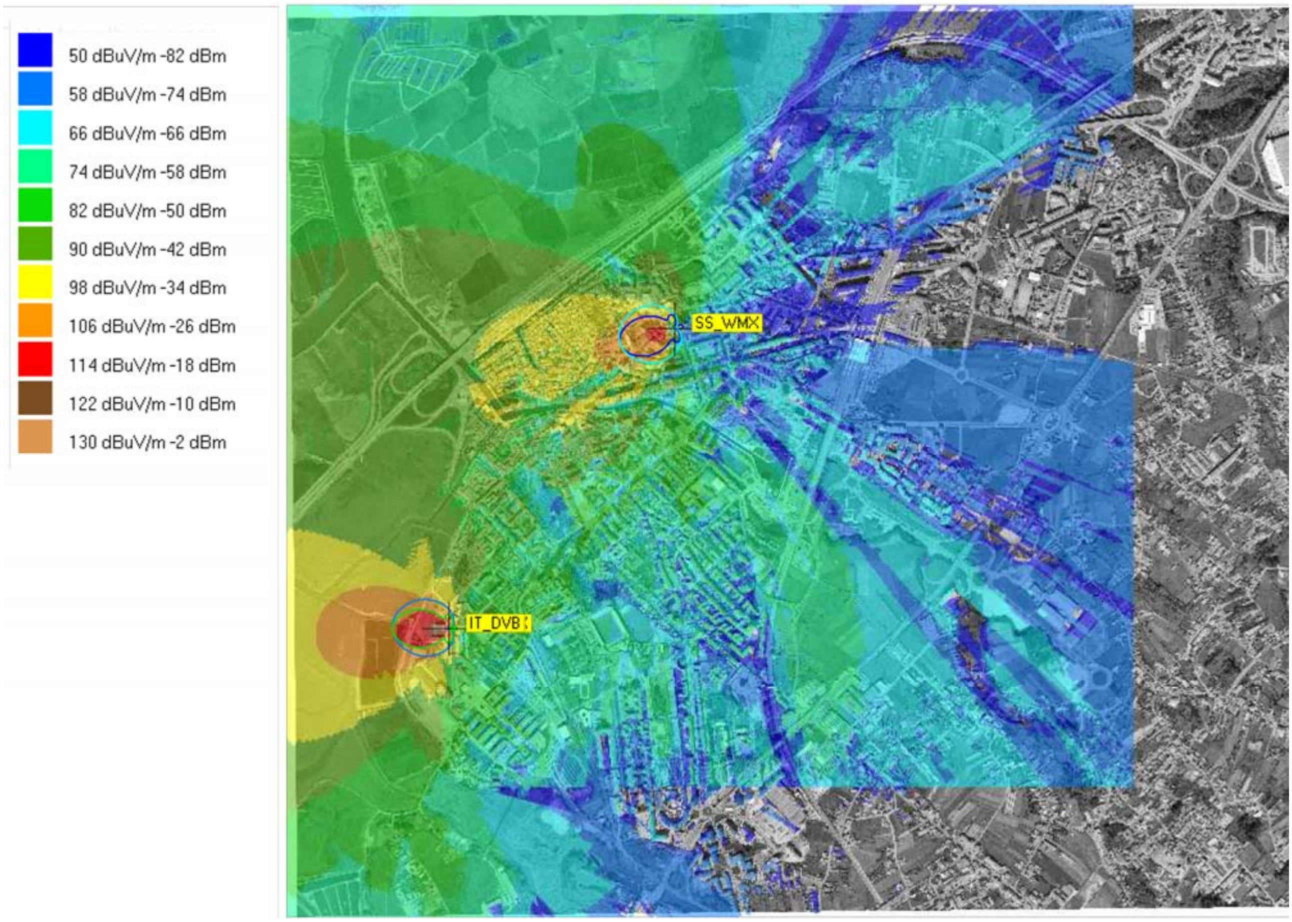
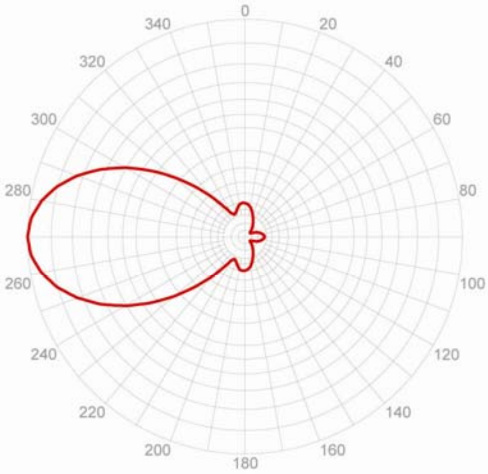
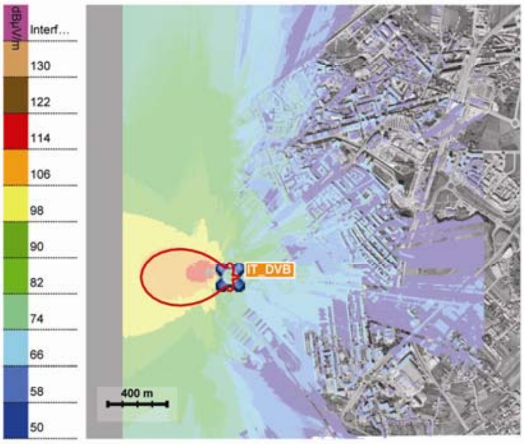


Figure 13 – Coverage prediction for both sites (DVBT and WiMAX)

2.5.1 DVB-T

ICS outputs for DVB-T coverage simulation.





Call sign	IT_DVB
Address	IT_DVB
Info1	*
Info2	F3E
User	*
Status	Unknown
Date	20080517
Network ID	*
Type	C
Link	LS
Group	ICS
Call Number	0
Nominal power	20.0000000 Watts
Tx losses (additional)	0.00 dB
Radiated power	204.65862 Watts
Power mode	fixed
X or Longitude	-8.39576 (4DMD)
Y or Latitude	40.38010 (4DMD)
Z	22.0 m
Call sign	IT_DVB
Address	IT_DVB
X or Longitude	-8.39576 (4DMD)
Y or Latitude	40.38010 (4DMD)
Z	22.0 m
Antenna height	1.4 meters
General Frequency	730.00000 MHz
Tx bandwidth	8000.00 kHz
Rx bandwidth	8000.00 kHz
Radiated power	204.65862 Watts

Figure 14 – DVB-T coverage IT site

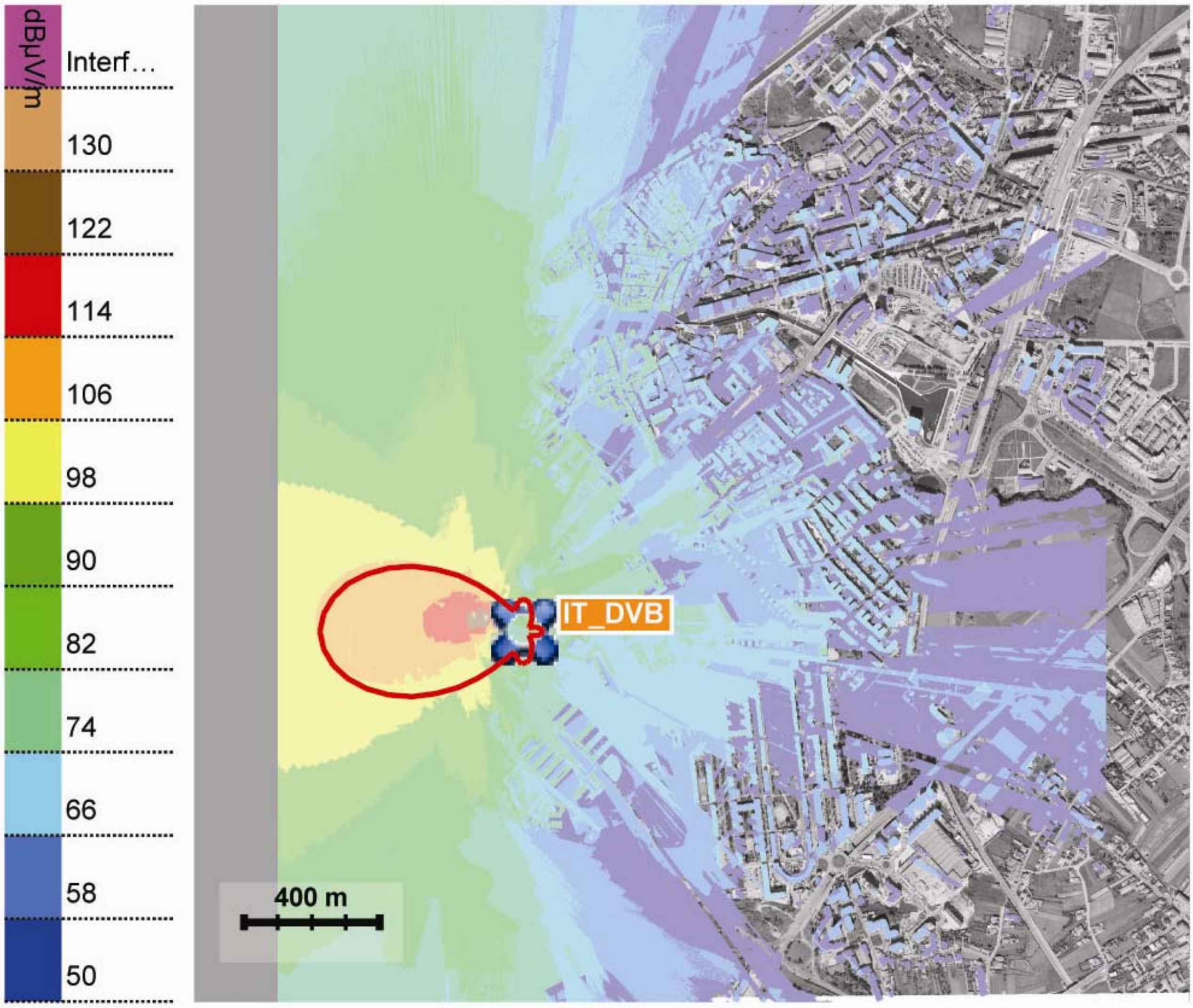
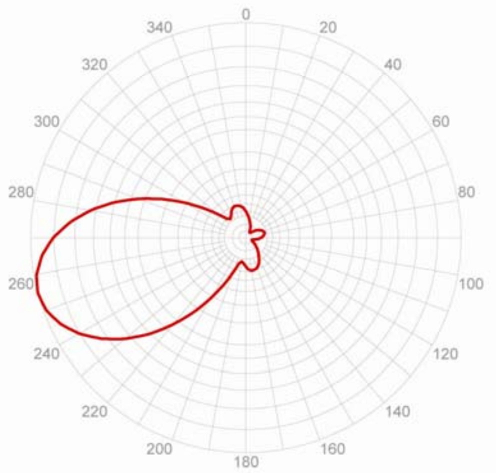
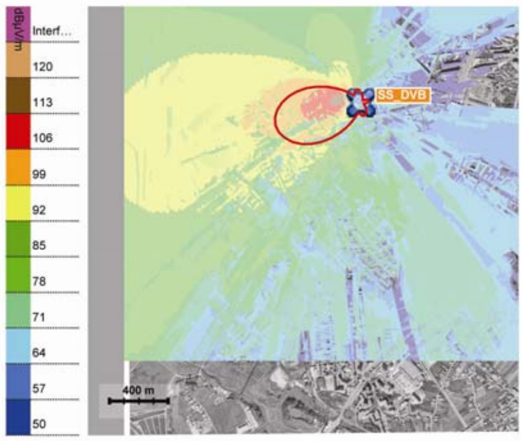


Figure 15 – DVBT coverage map IT site





Call sign	SS_DVB
Address	SS_DVB
Info1	*
Info2	F3E
User	*
Status	Unknown
Date	20080516
Network ID	*
Type	C
Link	LS
Group	ICS
Call Number	0
Nominal power	9.0000000 Watts
Tx losses (additional)	0.00 dB
Radiated power	87.95134 Watts
Power mode	fixed
X or Longitude	-8.38944 (4DMD)
Y or Latitude	40.38647 (4DMD)
Z	59.0 m
Call sign	SS_DVB
Address	SS_DVB
X or Longitude	-8.38944 (4DMD)
Y or Latitude	40.38647 (4DMD)
Z	59.0 m
Antenna height	1.4 meters
General Frequency	650.00000 MHz
Tx bandwidth	8000.00 kHz
Rx bandwidth	8000.00 kHz
Radiated power	87.95134 Watts

Figure 16 – DVB-T coverage SS site

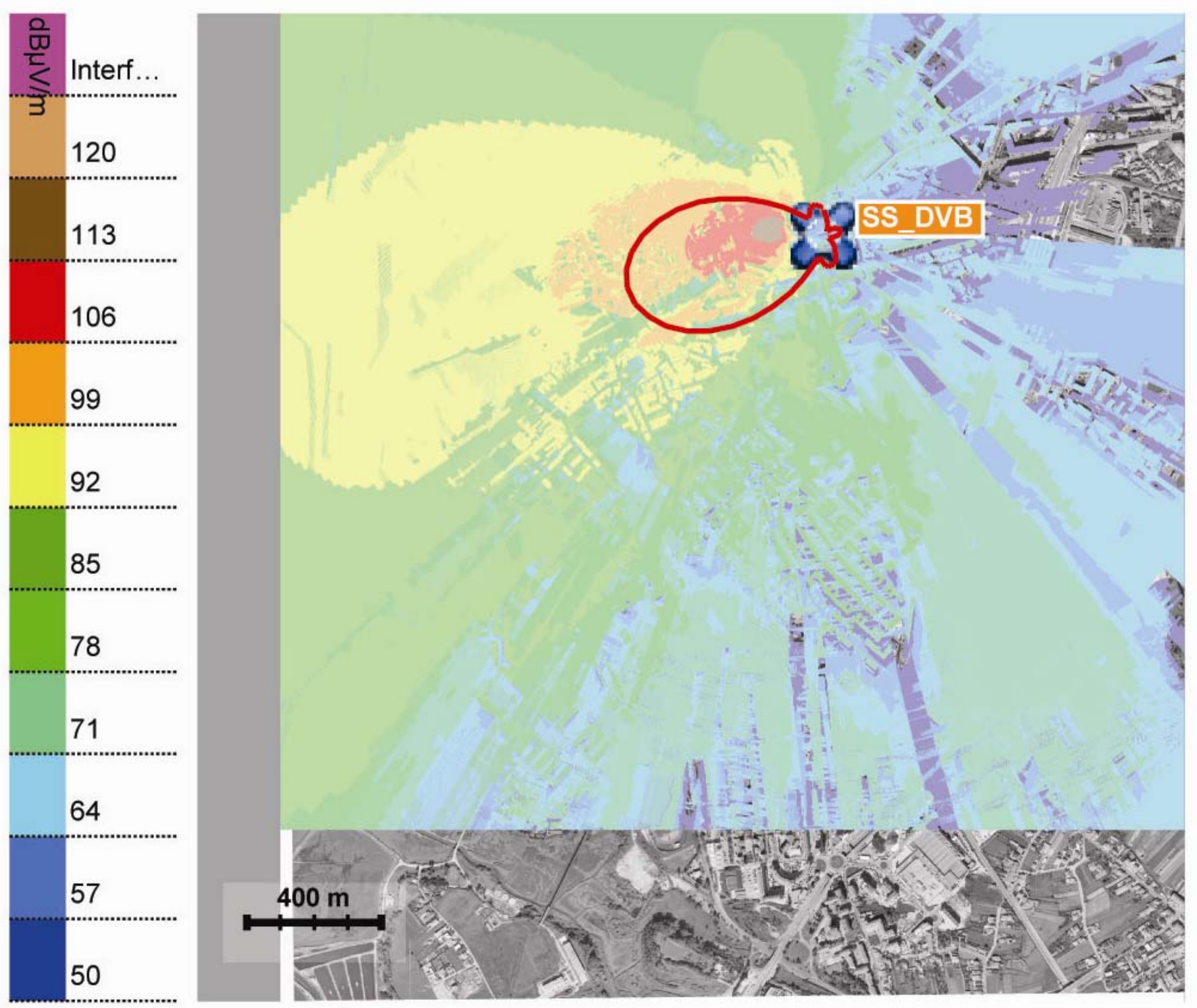
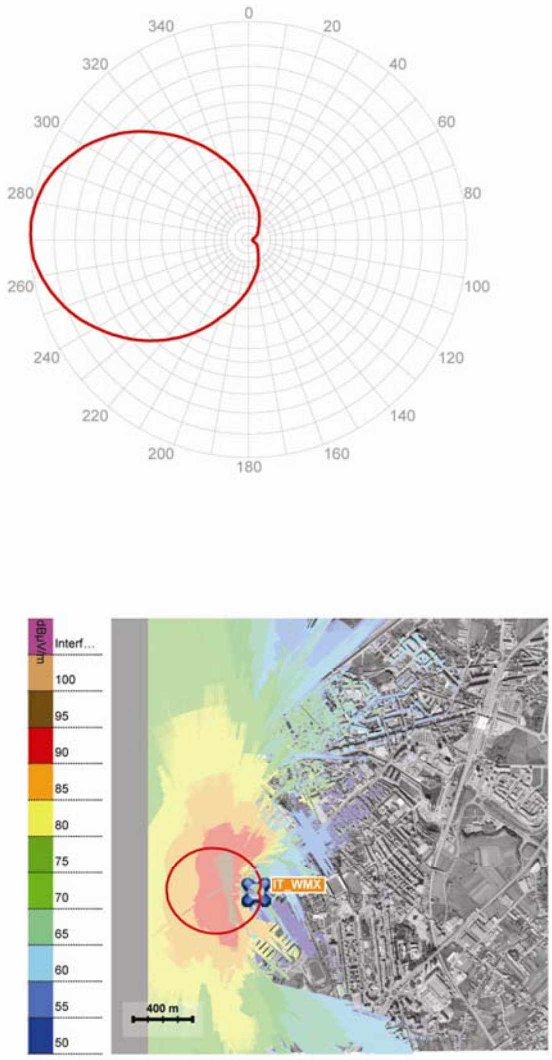


Figure 17 – DVBT coverage map IT site

2.5.2 Wimax

Software outputs for WiMAX coverage simulation.



Call sign	IT_WMX
Address	IT_WMX
Info1	*
Info2	F3E
User	*
Status	Unknown
Date	20080516
Network ID	*
Type	C
Link	LS
Group	ICS
Call Number	0
Nominal power	0.1000000 Watts
Tx losses (additional)	0.00 dB
Radiated power	1.51356 Watts
Power mode	fixed
X or Longitude	-8.39576 (4DMD)
Y or Latitude	40.38010 (4DMD)
Z	22.0 m
Call sign	IT_WMX
Address	IT_WMX
X or Longitude	-8.39576 (4DMD)
Y or Latitude	40.38010 (4DMD)
Z	22.0 m
Antenna height	2.0 meters
General Frequency	2515.00000 MHz
Tx bandwidth	5000.00 kHz
Rx bandwidth	5000.00 kHz
Radiated power	1.51356 Watts

Figure 18 – WiMAX coverage parameters IT site

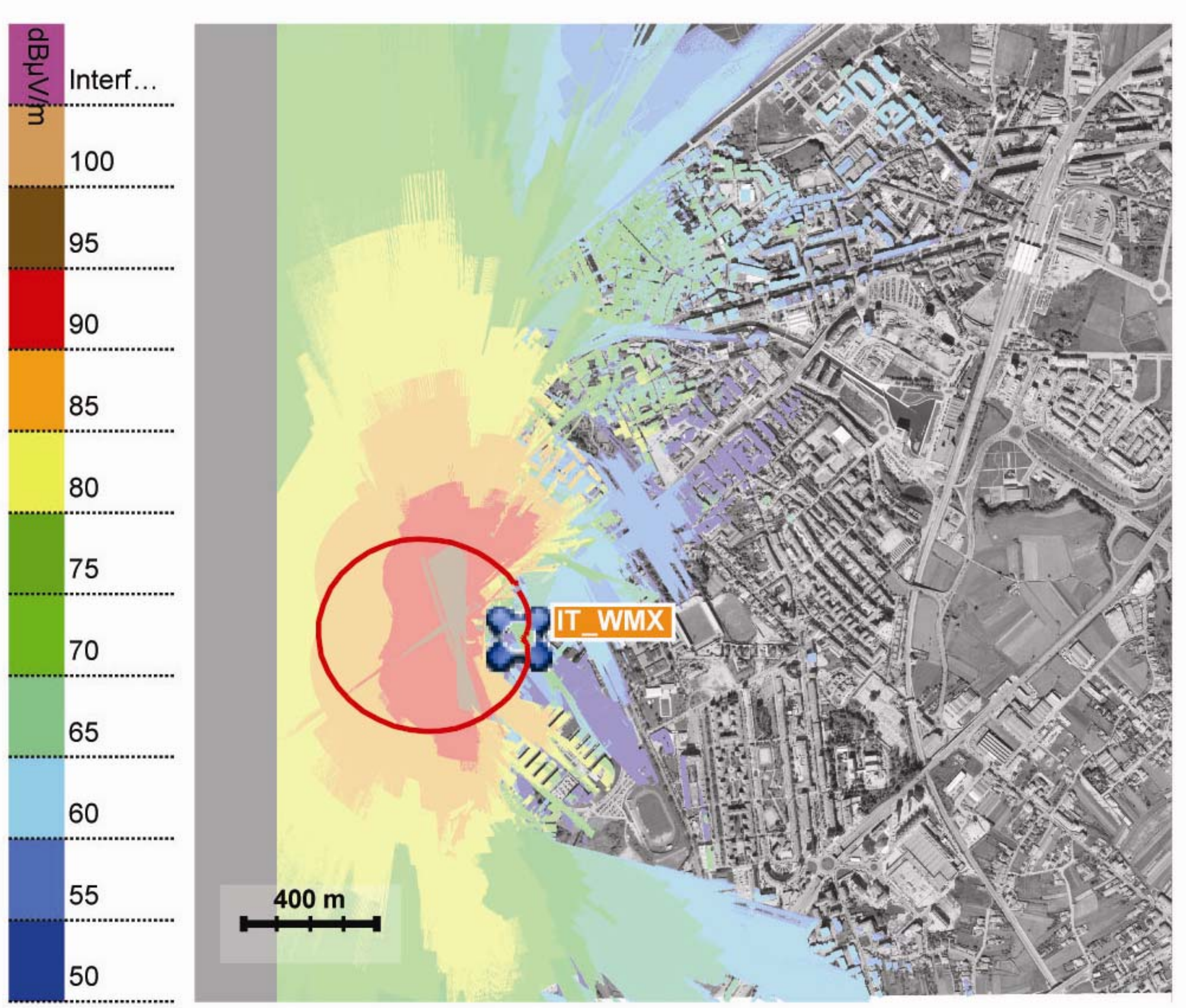
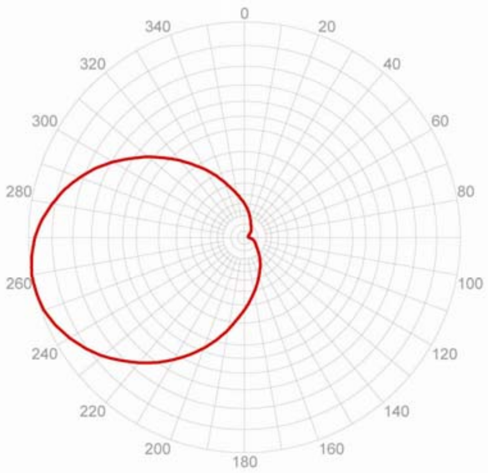


Figure 19 – WiMAX coverage map SS site



Call sign	SS_WMX
Address	SS_WMX
Info1	*
Info2	F3E
User	*
Status	Unknown
Date	20080516
Network ID	*
Type	C
Link	LS
Group	ICS
Call Number	0
Nominal power	0.7943282 Watts
Tx losses (additional)	15.00 dB
Radiated power	0.38019 Watts
Power mode	fixed
X or Longitude	-8.38944 (4DMD)
Y or Latitude	40.38647 (4DMD)
Z	59.0 m
Call sign	SS_WMX
Address	SS_WMX
X or Longitude	-8.38944 (4DMD)
Y or Latitude	40.38647 (4DMD)
Z	59.0 m
Antenna height	2.0 meters
General Frequency	2535.00000 MHz
Tx bandwidth	5000.00 kHz
Rx bandwidth	5000.00 kHz
Radiated power	0.38019 Watts

Figure 20 – WiMAX coverage parameters SS site

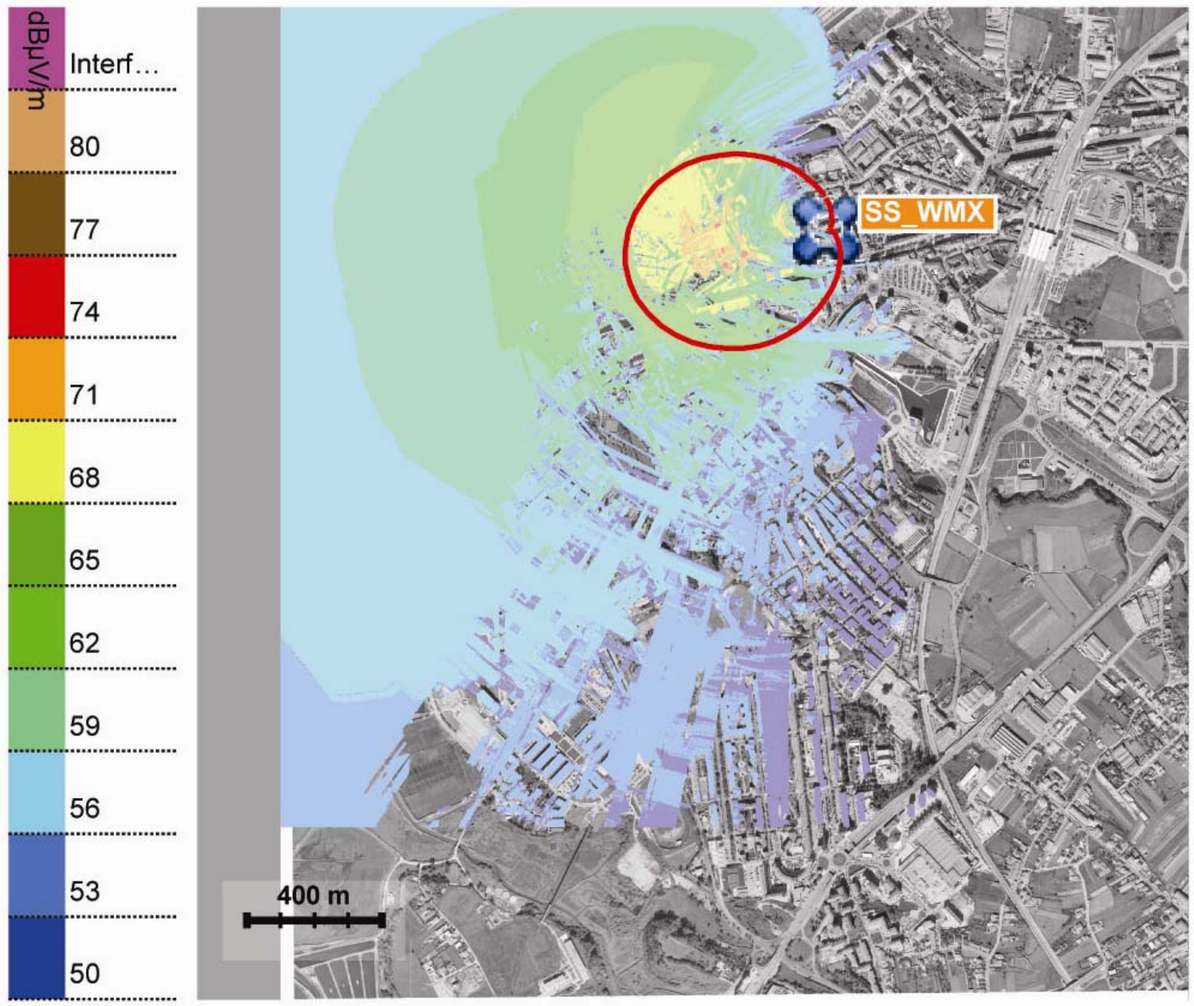


Figure 21 – WiMAX coverage map SS site

3 Major field trials problems faced

Field trials work is always risky. It is expectable facing technological problems. In this project, we have experienced several and very difficult troubles. Some of them were more serious and complex than the others. However, all of them have conditioned the evolution of the field trials work. Overcoming the troubles was in most of the times, challenging and difficult but had also contributed for increasing our knowledge about the SUIT system implementation constraints. As the register of the problems is very extensive, report all of them could be a boring process. Because of it, a short list of the more relevant problems has been elaborated and this is outlined in the following lines.

- Low level of the field strength received in WiMAX from the IT site. During the first tests, and after some tests campaigns, we detected that the WiMAX coverage of the IT site was not as predicted. Some procedures have been carried out to determine the source of the problem. We measured, with a power meter, the real power delivered by the Runcom BST. The power was good. After, we measured the transmitting cable. It had about 6 db of attenuation which, is very high. We decided replace the cables (in IT and SS site) by others with fewer losses. Consequently, the WiMAX field strength rose to the value that should be.

- When performing the tests to understand the performance of the RF platforms, we realized that, most of the time, the CPE's got easily crashed. Runcom updated the CPE's firmware, and the problem seemed been solved. At least, the number of crashes has reduced drastically, which allow us to move forward in test campaigns.

- During the first tests to prepare the throughput measurement campaigns, we detected that, the Down Link bitrate achieved in different modulation schemes in DVBT-RCT, was not accordingly the table delivered by Runcom (tests performed with Iperf application). Several verifications have been made in DVBT-RCT base stations configuration parameters. After few days of intense work, we have realized that when we changed the modulation, a parameter named "AirPortMir" changed automatically. This parameter is related with the maximum throughput in DL and limits the throughput. We took the decision of changing the parameter value increasing its value, and with this, we fixed this issue.

- The first SS site WiMAX tests revealed that, in most of the places under the coverage area, the CINR did go upper than 20 dB, which was a big problem, as we could not achieve decent DL throughput with this figures. We thought that the problem was related, in some way, with the multi-path effect, once most of the measures were taken in centre of the city. Moreover, the symptom was not constant. Sometimes we got more than 20 dB of CINR. In our first attempts to test the HO process, we verify this problem again. The other RF figures read were good, namely the RSSI, but the CINR did not rose, even in open space (various detailed and systematic measures were undertaken in some areas out of the city). These measures showed that the problem should be other than the multi-path effect. Could be a BST problem. A methodic work to detect the problem was conducted for several days. As we did not have the same problem in IT site, we replace the IT WiMAX BST by the SS BST. The problem disappeared which means that the problem was not related with the BST. Backing to the SS site, we operated the two BST alternatively and both performed well (we got, in open areas, about 32 dB CINR and DL throughputs of 8,6 Mbit/s in unicast). When we placed everything at the original state, we realized that the problem has appeared again. More and exhaustive tests have been conducted and finally we discovered that we had a problem in the GPS receiver (not easy to detect once no alarm was lighting in receiver front panel). The PPS signal and the 10 Mhz were not good and this was triggering the problem. It seems that the signals were provoking distortion in DL modulation, which affected the CINR values.

4 Trial campaigns

With the sites in operation at a stable stage, a large amount of tests (in stationary and mobile environment) have been performed according to the trial campaigns plan.

Using the vehicle, several measurements campaigns have been conducted for 3 moths and a half and 2200 kilometres covered, within the coverage areas collecting data for later evaluation.

Figure 22 – Field trial measurements

4.1 RF Coverage measurements

A programme of work was undertaken to compare the field strengths measures with the computer predicted values in order to achieve reliable planning parameters for both DVB-T services and WiMAX services according to the SUIT demands.

To measure DVB-T field levels, equipment from Audemat-Aztec was used.

To measure WiMAX RF levels we intended to use one tool from Rhode & Schwarz named Romes, but unfortunately, and despite our efforts, we did not receive the tool so far.

4.1.1 DVB-T

A summarized detail of the field strengths is outlined in this item. The results will be reported and analysed in the deliverable SUIT_WP6.5 – Analysis of Results. Several measurement campaigns, in different routes over the coverage area, have been conducted (Figure 23)

Figure 23 – DVB-T field level measurement campaign

4.1.2 Wimax

We have not so far received the tool to measure the WiMAX field strength. Because of it, the measures have not been performed.

4.2 SUIT performance test

According to the document SUIT_437_WP6_D6.1_Performance_metrics_definition, several measurements have been done. The data will be processed and analysed in the deliverable SUIT_WP6.5 – Analysis of the results.

4.2.1 Measurement profiles configuration

We have defined in the work plan a few profiles that have been used during the measurements campaigns. Here we outline, in detail, those profiles.

4.2.1.1 Fixed measurement profile

In this test profile we used the IT Site to transmit and received the traffic over RF channels. The data streams were sent and received in the IT laboratory. SUIT play-out, Iperf and Wireshark tools, SUIT terminal were used to perform the tests and measurements.

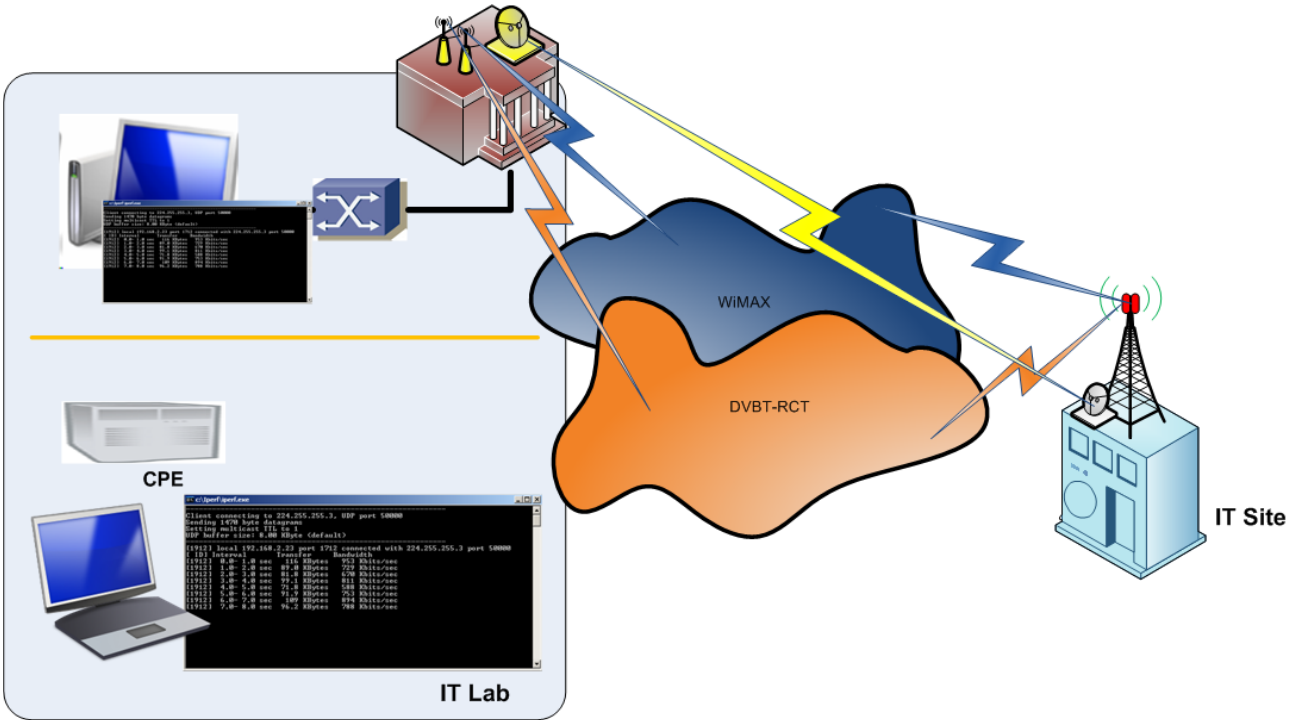


Figure 24 – Fixed measurement profile

4.2.1.2 Fixed and Stationary measurement profile

This is the same as the fixed profile, but with the car stopped in front of IT Site. The vehicle carried on the measurement equipment, namely, WiMAX and DVBT-RCT mobile CPE's and laptops with Iperf, Wireshark and SUIT terminal. The data streams were sent and received in the IT laboratory and in the equipment installed in the survey vehicle. SUIT play-out, Iperf and Wireshark tools, SUIT terminal were used to perform the tests and measurements.

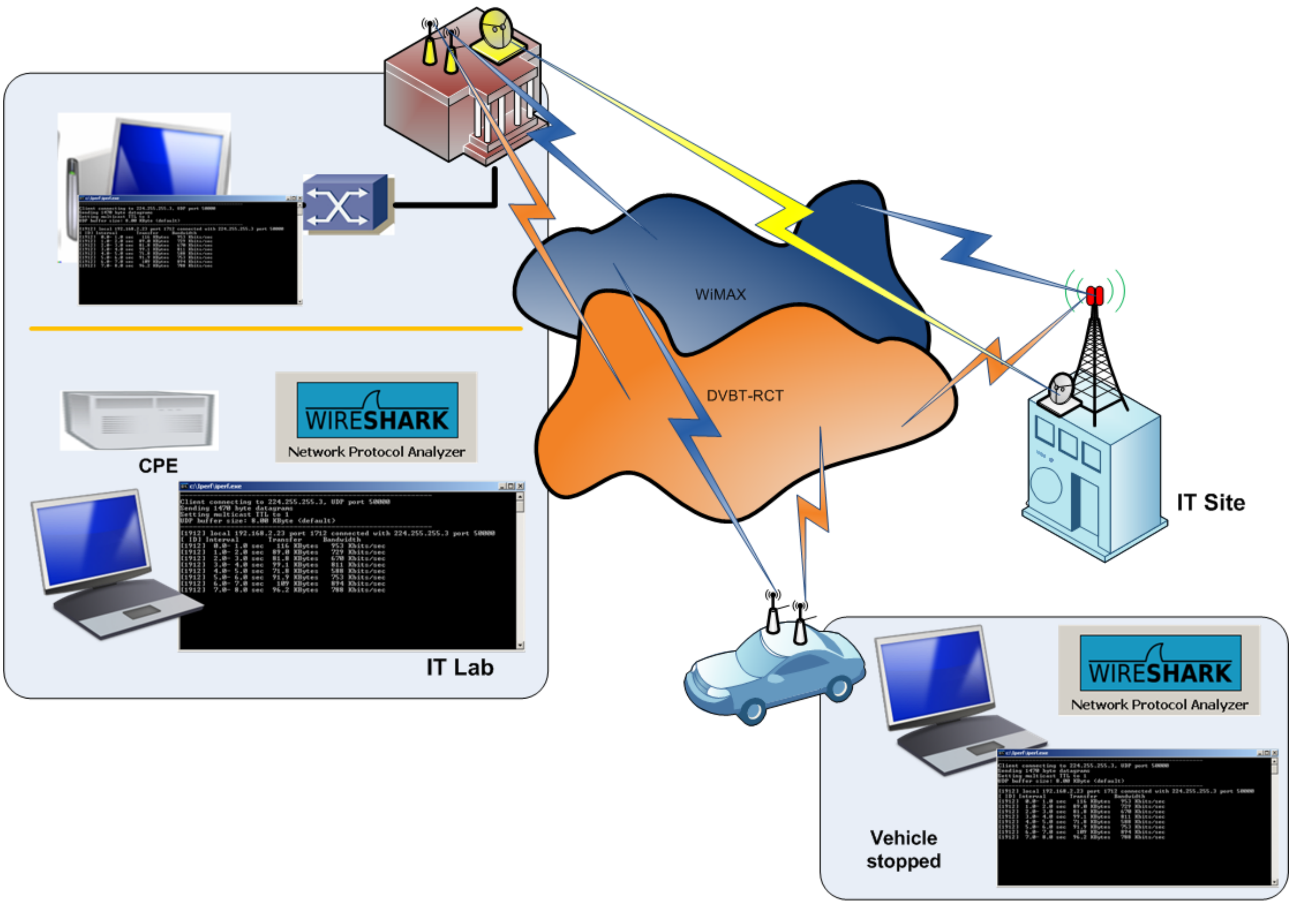


Figure 25 – Fixed and stationary measurement profile

4.2.1.3 Mobile measurement profile

This is the same as the fixed and stationary profile, but the car was moving. In this test configuration the vehicle transports laptops, CPE's and DVBT measurement equipment from Audemat.

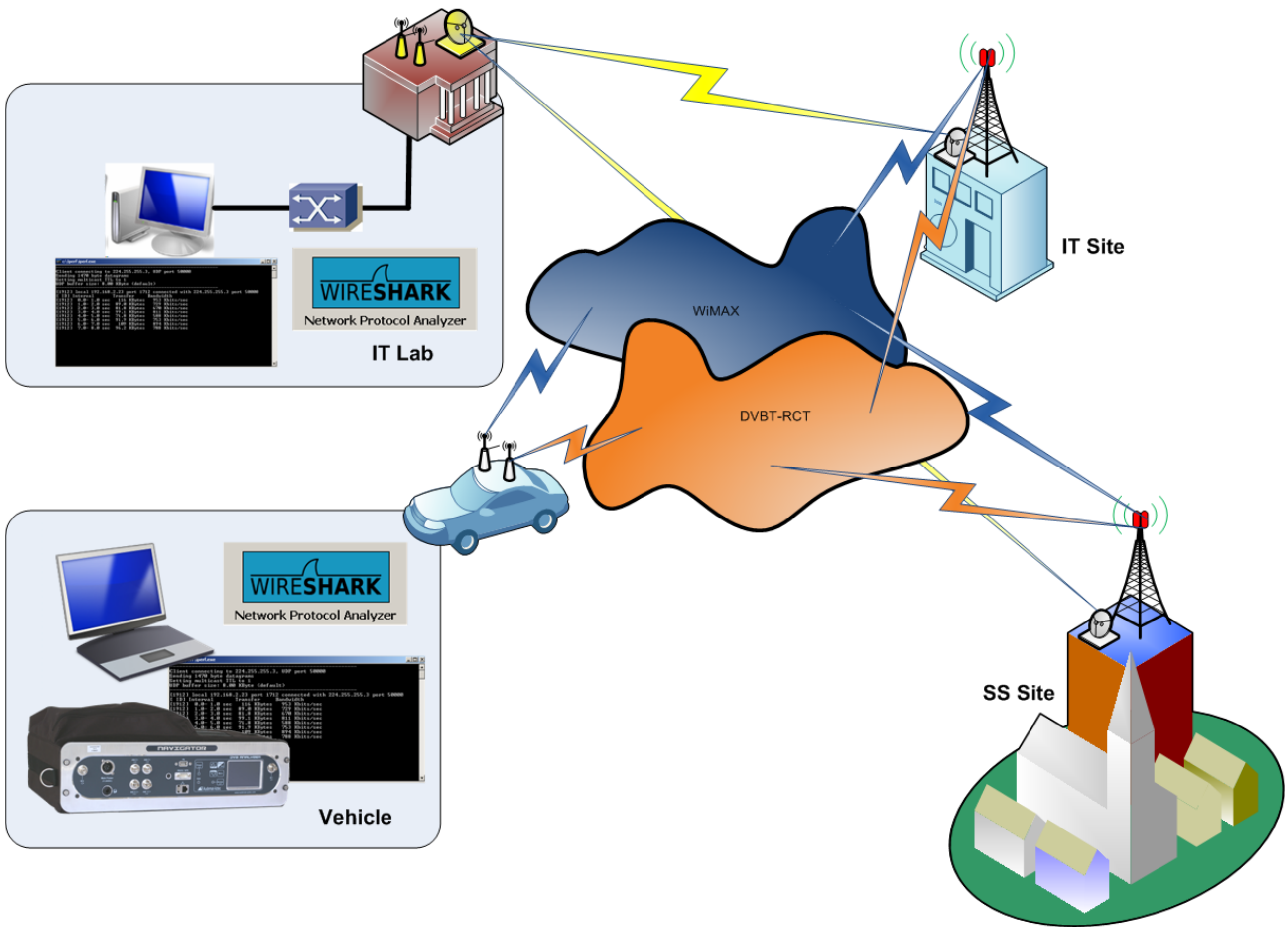


Figure 26 – Mobile profile

4.2.2 Throughput performance test

To measure the throughput performance we have used the Iperf application and Wireshark. Multicast data streams were sent over the DVBT-RCT chain (Down Link) and over WiMAX network (Down Link). The traffic is from both platforms in fixed reception and mobile reception. In WiMAX we measured as well the Down Link with unicast traffic. The throughput over the Up Stream in DVBT-RCT and over the Up Link in WiMAX, were measured with unicast traffic. We defined the SUIT Network as the chain from the WiMAX and DVBT-RCT Ethernet boards in the Play-out PC and the Ethernet boards in the WiMAX and DVBT-RCT CPE's (Figure 27).

In the following sections we outline the procedures to carry out such measures.

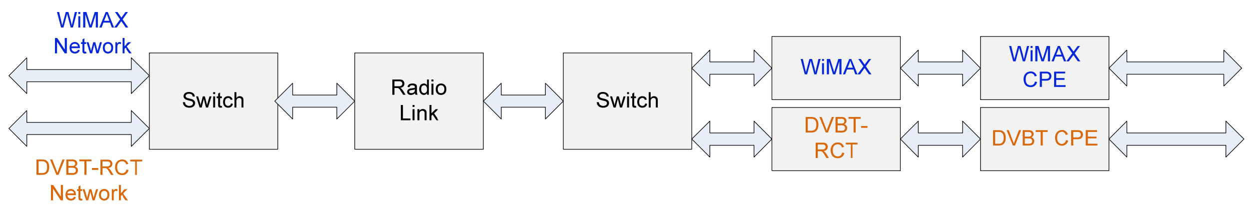


Figure 27 – SUIT Network

4.2.2.1 Fixed reception under different modulation schemes

In this test, we sent an Iperf sequence over the DVBT-RCT and over WiMAX chain, changing the modulation on IT Base Stations. We measured in the IT laboratory the maximum throughput achieved in each modulation scheme.

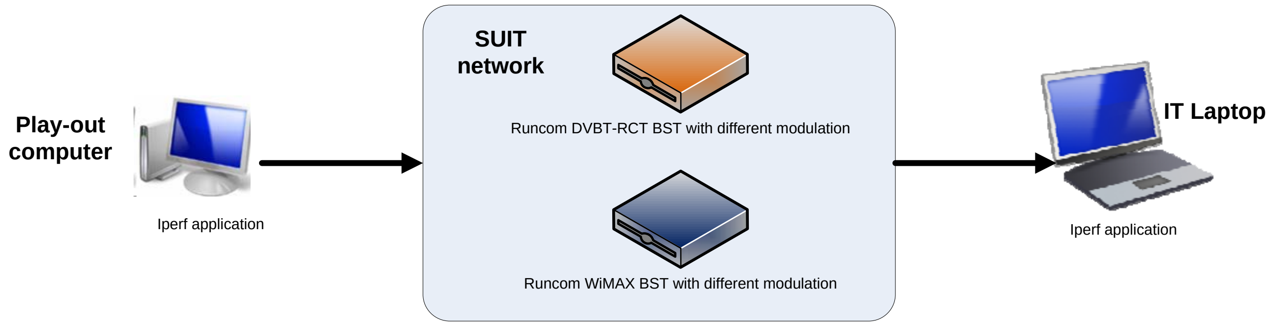


Figure 28 – Throughput under different modulation

The following tables shows the figures achieved for DVBT-RCT downlink with two different receivers.

4.2.3 Reliability test

To confirm the reliability of the SUIT network, some intensive tests have been carried out. These tests consisted in sending video streams through the entire chain and verify the stability of the system. Several scenarios were tested.

4.2.3.1 Fixed reliability tests

Wimax and DVBRCT CPE's were located in IT lab (Building Profile)
Wimax and DVBRCT BST's were located in IT building.
Two descriptions in IP multicast video have been transmitted from the play-out computer to the CPE's over the RF chain.

Figure 29 – Fixed reliability

4.2.3.2 Mobile reliability tests without HO

Wimax and DVBRCT Special mobile CPE designed for SUIT were placed in the car.
The test was performed only with the IT site operating.
The survey vehicle drove in A25 highway in front of IT building and in a distance up to 3 km.

Two HD video services have been transmitted from the play-out computer over the SUIT network to the mobile SUIT terminal.

Figure 30 – Mobile reliability

4.2.3.3 Point to Multi Point reliability tests without HO

The aim of this test was to show two CPE's operated simultaneously in point to multi point configuration. One of the CPE was the building profile CPE (as described in Fixed reliability tests) and the other CPE was the mobile (as described in Mobile reliability tests).
Both CPE's (the fixed and the mobile) were operated receiving from IT building BST's the two video descriptions simultaneously which, have been transmitted from the play-out computer.

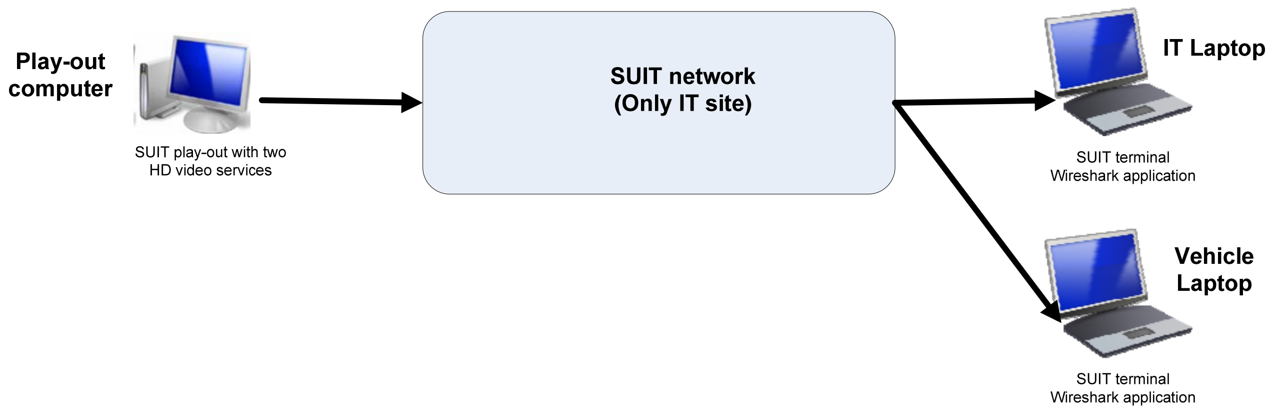


Figure 31 – Point to multipoint tests

4.2.3.4 Stationary and mobile reliability tests with SS site

The BST's at SS site have been powered up (IT site was powered off) and tests performed in front of this site.
The same two video descriptions have been transmitted from the play-out computer.

Figure 32 – SS site reliability tests

4.2.4 Play-out performance measurements

We loaded the Play-out computer with the maximum of services and connected two laptops one on each Ethernet port (WiMAX and DVBT-RCT). With the Wireshark we captured the packets sent by the play-out through the two ports.

4.2.5 Network performance measurements

In this section, we conducted some network tests in IT laboratory (fixed) and in the vehicle on high way and in the centre of the city. We performed the tests choosing the maximum acceptable throughput in each platform, to deliver the SUIT services. In those conditions, we measured some important values to evaluate, the performance of the network, in the DL and in the Up Link in both, WiMAX and DVBT-RCT. To conduct these performance tests we have used the Iperf tool and Wireshark.

4.2.5.1 Network Jitter

He have sent an Iperf sequence in DL and in UP link and measured the Jitter for the target throughput with the Wireshark (Figure 33). We performed tests in stationary mode, mobile in high way and mobile in centre of the city.

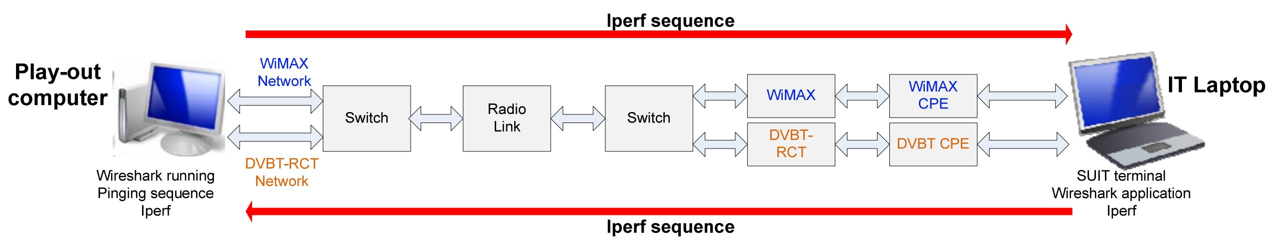


Figure 33 – Jitter and packet losses tests

4.2.5.2 Network packet losses

We followed the same test procedures as for Network Jitter measurements (Figure 33).

4.2.5.3 Network delay

To measure the network delay we performed the following tests. We launched the Wireshark application in the Play-out computer and in the laptop connected to the CPE at the end of the chain. After, we started a pinging sequence from the play-out computer to the laptop. We read the

Wireshark ping request time on Play-out computer (PO_RT), the ping request on CPE laptop (CPE_RT), the ping reply time on CPE laptop (CPE_RpT) and the ping reply time on the Play-out computer (PO_RpT). We measured the network delay for WiMAX and for DVBT-RCT sending the ping sequence over one network first and moved to the other afterwards (Figure 34).

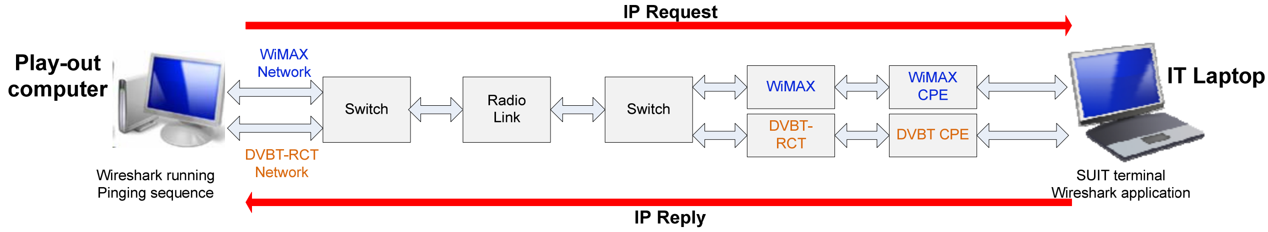


Figure 34 – Delay test

The delay time of the network (DT) is calculated as follows:
DT = (PO_RpT – (CPE_RpT- CPE_RT) – PO_RT)/2

4.2.6 Gateway performance measurements

To verify the performance of the Gateway we performed three tests. From the play-out computer, we sent an ip multicast video sequence. In the first test we replaced the network elements by cables (Figure 35). After, we sent the sequence over the network (Figure 36). In both tests, we received the video on the SUIT terminal after the Gateway (Figure 36) and analyzed the traffic with the Wireshark. Finally, to evaluate the combiner, we performed a simple test disconnecting the DVBT-RCT cable.

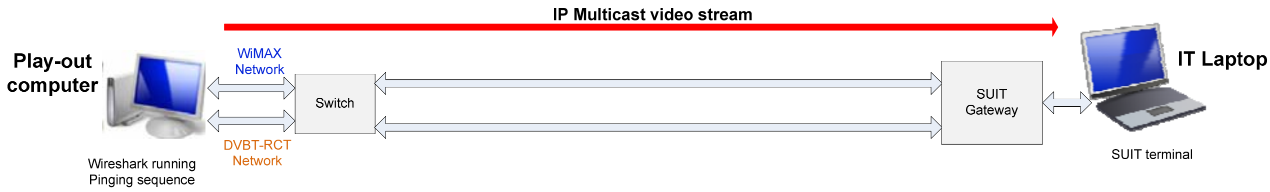


Figure 35 – Gateway test with cables

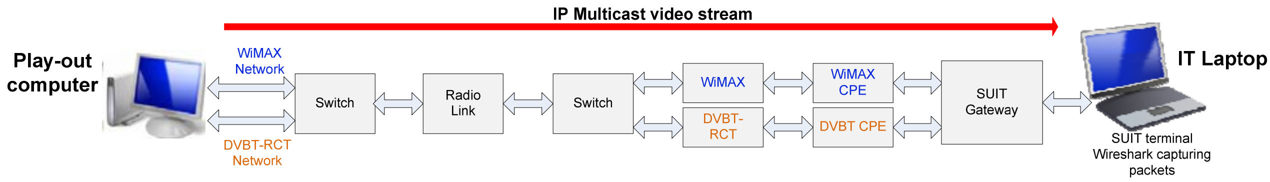


Figure 36 – Gateway test over the network

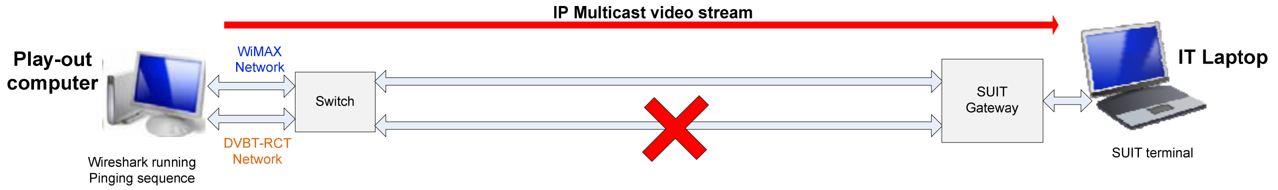


Figure 37 – Gateway combiner test

4.2.7 Terminal performance measurements

In these tests, we intended to analyze the pair encoder/decoder of the video. We have an original HD YUV video stream and we coded it in SCV H.264 with the Vitec encoder. We sent this video H.264 sequence to the SUIT terminal. We decode the video sequence with the SUIT terminal and store it in a file. We converted the H.264 SVC into YUV format. Then, we used an application developed within SUIT project, to compare the original file with this new YUV file. We got the SSIM and APSNR results that allow us validate the video quality (Figure 38).

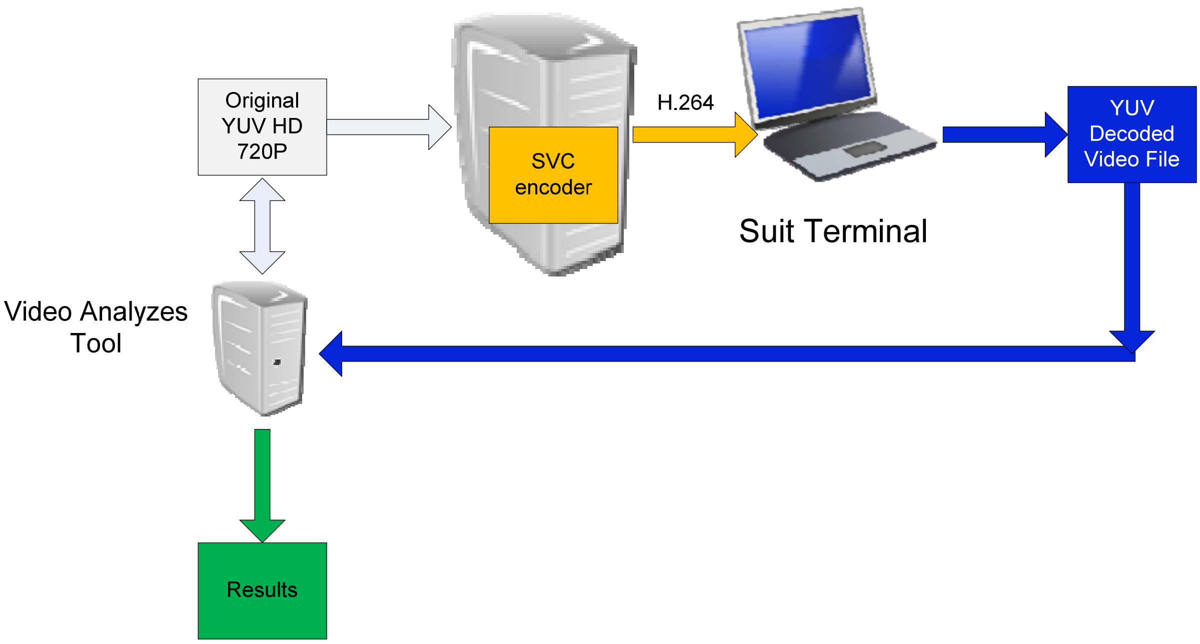


Figure 38 – Terminal test

4.2.8 HO performance measurements

In order to test the HO process in the field, we drove the vehicle over the overlap coverage area. During the Hand over process we were visualizing the output of the monitoring software running in the CPE's. Simultaneously, we sent Iperf sequences in ip multicast over the network to measure the losses on HO moment.

4.2.8.1 WiMAX HO conditions

Overlap area is been defined according to the following:

- In the overlap area both WiMAX BST's (serving and target) should have signals with CINR figures according to the scan and preference thresholds configured in the CPE.

- As an example, if the scan threshold is 15dB and the preference threshold is –200 (2dB) the CPE will start to make the scanning if the CINR from the serving BST would be 15dB and if at this point the CINR from the target BST is 17dB (15+2) the CPE will make the HO.
- In order to prevent “ping pong” phenomena or oscillating the CPE has 4dB hysthersis. This prevent from the CPE fast transition back to the serving BST unless there is 4dB+2dB=6dB difference from the current CINR.
- The figure below shows the overlap area. It is important that serving CINR at this point would be maximum as the scan threshold figure has been defined and the target CINR would be above the serving CINR as the preference threshold configured it.
- HO transition time is not longer than 150msec. By this time the target BST is received all data needed from the serving BST so there is no packet loss.

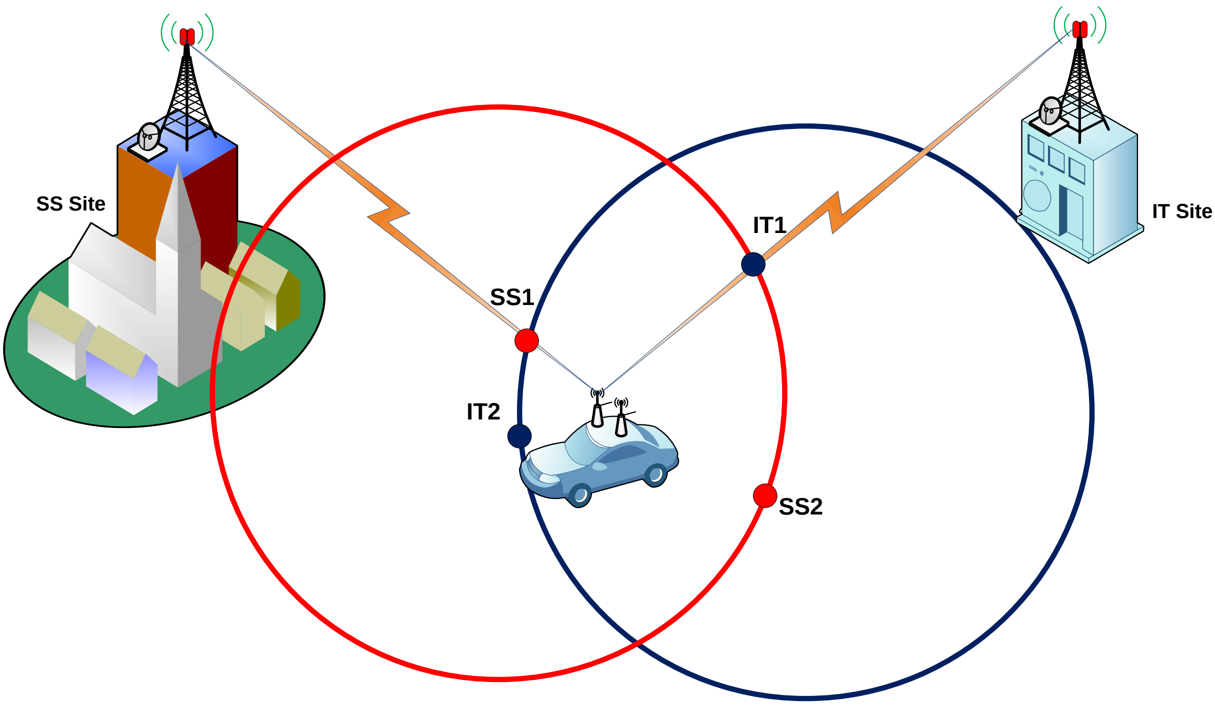


Figure 39 – HO scenario

4.2.8.2 DVBT-RCT HO conditions

In the contrary to WiMAX in DVBT-RCT the mobile CPE is composed by two DVBT-RCT mobile transceivers. Only one transceiver is transferring data to/from the BST at the time. Each transceiver is operating in its pair of frequencies so in this case two pairs of frequencies are needed.

Overlap area is been defined according to the following:

- In the overlap area both DVBRCT BST’s (serving and target) should have signals with RSSI (DL gain) of –75dBm
- HO scanning process is starting when DL gain from the serving BST is decreased below –75dBm.

- HO transition will occur when the DL gain from the target BST would be higher than –69dBm.

5 Partners' Contributions

5.1 – IT

5.1.1 - Contributions

The main contributions of IT to the field trials are:

1. HD Video Camera
2. Building profile (with Wavecom)
3. Terminal (with Vitec, UPM and MCT)
4. One WLAN and another STB.
5. Two DVB-T power amplifiers
6. Real Time MDC-3
7. MDC-3 Combiner
8. One GPS
9. One power attenuator
10. One variable attenuator
11. Several low power attenuators

5.2 - IBBT

5.2.1 - Contributions

The main contributions of IBBT to the field trials are:

1. Non-real time MDC-2 (CGS)
2. An Integrated Extractor (MDC-1+MDC-2 for CGS)

5.3 - URL

5.3.1 - Contributions

The main contributions of URL to the field trials are:

1. Playout

5.4 - UniS

5.4.1 - Contributions

The main contributions of UniS to the field trials are:

1. Audio SVC Codec
2. Audio MDC Codec

5.5 - Vitec

5.5.1 Contributions

The main contributions of VITEC to the field trials are:

1. One SDTV real-time MPEG-4 SVC video encoder, including an MPEG-4 AAC audio encoder
2. One HDTV real-time MPEG-4 SVC video encoder, including an MPEG-4 AAC audio encoder
3. Integration of MDC1 post-processing for SVC bitstreams in the SDTV and HDTV real-time encoders
4. An A/V RTP streaming server embedded in the SDTV and HDTV real-time encoders
5. An RTP receiver and a real-time HDTV SVC bitstream decoding and rendering library to be included in the SUIT terminal

5.6 – RUNCOM

5.6.1 - Contributions

The main contributions of RUNCOM to the field trials are:

1. Two DVB-T/RCT Exciters
2. Two WiMAX BST's
3. Two DVB-RCT CPE's
4. Three WiMAX CPE's
5. One mobile CPE (consist of two DVBRCT transceivers and one Wimax transceiver).

   Runcom has included a separate box consist of the Suit Gateway and Hub.
6. Two UHF omni antennas for the vehicle.

5.7 – IRT

5.7.1 - Contributions

The main contributions of IRT to the field trials are:

1. SD&S Server software
2. ENG System

5.8 – UPM

5.8.1 - Contributions

The main contributions of UPM to the field trials are:

1. Gateway
2. Terminal (with IT, Vitec and MCT)

5.9 - Wavecom

5.9.1 - Contributions

The main contributions of Wavecom to the field trials are:

1. Providing two RadioLinks
2. Providing three Gateways
3. Three Switches with VLAN features
4. One Router with traffic shaping features
5. Building profiles (with IT)
6. One variable attenuator
7. Several low power attenuators

5.10 - MCT

5.10.1 – Contributions

The main contributions of MCT to the field trials are:

1. Two WiMAX Power Amplifier with TDD control
2. Four Filters for UHF
3. One GPS receiver
4. Four WiMAX filters
5. Terminal (with IT, Vitec and UPM)
6. Four UHF antenna panels
7. Two WiMAX 2,5 Ghz antenna panels
8. Masts and hardware to hold antennas and equipments in sites
9. One shelter for SS site

6 Conclusions

For over 3 months and half, several people from some of the SUIT partners, have worked hard, setting up the system, testing it, solving problems, measuring and refining it. Tied deadlines and complex problems have pushed us to the limit in a big struggle against time. Fortunately, high levels of motivation, strong commitment with the SUIT main goals, perseverance and deep engagement of the people directly involved in the field work, have granted the desired ending, putting the system in place.

It should be stressed that, we spent lots of the field trials time, solving SUIT components intrinsic issues, which brought us additional time management problems.

The field trials have proven the complexity of the SUIT system. Operating two different RF platforms at the same time and in the same trial is not, for sure, an easy task. We have to add to this, two base stations that are prototypes and one of the platforms that is not mature (WiMAX 802.16e). This combination increases dramatically the risk of fail. However, we must say that we have achieved good results.

We overcome, with more or less difficulties, the big challenges we have faced. Perform the tests systematically granted us more efficiency solving all trouble. For example, we took 1 month to identify that one GPS equipment connected to SS BST was not compatible to be used in RUNCOM WiMAX BST. We took 3 weeks to find out that the frequency 650MHz cannot be used in the downlink. This problem apparently has been solved today by exchanging the frequencies assigned to SS DVB-RCT system. No doubt, SUIT provided us a huge amount of knowledge.

The tests carried out so far, the measurements performed and the extensive quantity of acquired data will be enough to validate the SUIT concept, confirmed the advantages of the SUIT innovations, namely the multiple descriptions, network convergence, scalable video coding and HDTV at high speed. See deliverable 6.5 for results.

7 Acronyms

AP	Access Point
BER	Bit Error Rate
BPF	Band Pass Filter
BST	Base Station
C/N	Carrier to noise ratio
CGS	Coarse Grain SNR Scalability
CIR	Committed Information rate
CPE	Customer Premises Equipment
DV	Digital Video
DVB	Digital Video Broadcasting
DVB-RCT	DVB Return Channel Terrestrial
DVB-T/H	DVB Terrestrial/ Handheld
EDCA	enhanced distributed channel access
ENG	Electronic news gathering
FGS	Fine Grain SNR Scalability
GPS	Global Position System
GW	Gateway
HO	Handover
HD	High Definition
IP	Internet Protocol
Kpbs	kilobit per second
Mbps	Megabit per second
MER	Modulation Error Ratio
MIR	Maximum Information Rate
PA	Power Amplifier
QoS	Quality of Service
RF	Radio Frequency
RL	Radio Link
RTP	Real-Time Transport Protocol
RS	Reed-Solomon
TDD	Time Division Duplex
TS	MPEG-2 Transport Stream
UHF	Ultra High Frequency
SD	Standard definition
STB	Set top box

SVC	Scalable Video Coding