International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R BT.2247-1

(08/2012)

Field measurement and analysis of compatibility between DTTB and IMT

BT Series

Broadcasting service (television)

International Telecommunication Union

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Note: *This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2012

REPORT ITU-R BT.2247-1

Field measurement and analysis of compatibility between DTTB and IMT

(2011-2012)

Within many administrations consideration is being given to the entry of mobile services into the UHF band previously allocated primarily to terrestrial analogue and digital television services.

Entry of mobile services gives rise to assessment of compatibility of globally harmonized IMT applications and DTTB.

Regulatory agencies and broadcasting organizations have been seeking guidelines from ITU-R as the basis for spectrum planning to aid with the replanning of the bands previously allocated primarily to terrestrial analogue and digital television services.

Within many administrations the planning of digital terrestrial television services have been determined in the bands allocated to broadcasting based on clearly designed spectrum planning principles largely based upon protection of a minimum median field strength for all services.

Working Party 6A has been advised planning of mobile network deployments depend on mobile network operators.

Toward establishing a series of spectrum planning procedures for determining compatibility between broadcast service and mobile network planning, guidance is sought by broadcasting organizations on the level of interference within a geographic area.

At its September 2011 meeting, Working Party 6A received further contributions (Documents 6A/607, 6A/608) which have been added to the draft new Report.

This document provides a series of reports on field measurements and analysis of compatibility between broadcast service and mobile services within a geographic area.

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Chapter 1

Detailed results of field study of compatibility between DVB-T and UMTS

1 Introduction

This contribution describes a field study undertaken jointly by EBU and Free TV Australia in August 2008 making use of the existing UMTS (WCDMA) network in Australia in the 850 MHz band. The study aimed to carry out real tests of compatibility between DVB T reception on one side and UMTS base station and mobile terminal transmissions on the other side.

This study considered the potential impact on European and Australian DVB T receivers from UMTS base station and mobile terminal transmissions. It provides observations on the existing protection ratios of a panel of DTTB receivers assessed using the test method described in Recommendation ITU R BT.1368-7 (Annex 6, Test methods for protection ratio measurements for wanted digital terrestrial signals).

The location chosen for the survey was within the western suburbs of Sydney, given its undulating topography, likely symmetrical geographic UMTS cell size and likelihood of network presence. Measurements were also done in the city of Sydney and on the fringe of the city across Sydney harbour in North Sydney in order to consider the case of urban environment.

The objectives of the study were:

a) to assess the protection requirements between a UMTS transmission from a base station as an adjacent or image channel to the channel used for DVB T reception employing an external TV receive antenna (10 m a.g.l) or a portable receiving antenna (1.5 m a.g.l);

b) to assess the protection requirements between a UMTS transmission from a mobile terminal as an adjacent or image to the channel used for DVB T reception employing an external TV receive antenna (10 m a.g.l) or a portable indoor receiving antenna (1.5 m a.g.l).

Intended audiences of this study are Regulators, Telcos and Broadcasters. It provides information about the possible interference between the mobile service using UMTS and the Broadcasting service using DVB-T in the context of the use of adjacent channels. The report provides also indications about the possible measures to avoid or at least reduce sufficiently the risk of interference from UMTS into DVB-T. To be noted that one of these measures is related to the channel arrangements for IMT. The normal channel arrangements are to assign the uplink in the lower frequency allocation and the downlink in the upper frequency. In Europe, the ECC took a decision to reverse these channel arrangements.

2 Findings and proposals

Objective A − to assess the protection requirements between a UMTS transmission from a base station as an adjacent or image channel to the channel used for DVB-T reception employing an external TV receive antenna (10 m a.g.l) or a portable receiving antenna (1.5 m a.g.l).

Main outcome

The field measurements on real UMTS base stations operating in the UHF band have shown that levels as high as −14 dBm of UMTS signal can be received at the DTTB set-top boxes through the roof top antenna, from base stations transmitting at 40 W e.i.r.p. These levels approach the overloading threshold of the DTTB receiver. They were measured at distances representative of real situations between UMTS base stations and DVB-T receiving antennas. Furthermore, the concerned UMTS base stations use slant polarization which excludes the use of cross-polarization to mitigate the possible interference.

The measured levels and the compatibility tests made in this study show that the adjacent channel interference is a real issue that should be considered when implementing a mobile network in an area covered by an adjacent broadcasting channel. A set of measures is proposed here in order to ensure the protection of the broadcasting service from possible interference of UMTS base station.

General measures

− To reduce the out-of-band radiated signal spectrum of the base station. A possible target for compliance to reduce the out-of-band impact is at least the spectrum mask for sensitive cases as defined in the ETSI EN 300 744 V1.6.1 (2008-09) for the 8 MHz variant and AS4599 (Australian DTTB transmission standard) for the 7 MHz variant.

− To implement a guardband of 1 to 5 MHz between the wanted DVB-T channel and the mobile service channel from the base station. Such a guardband helps reduce the number of possible interference cases. However its implementation might have an impact on, i.e. offsetting, the channelling raster of the mobile service and would have to be taken into consideration as early as possible in the process of defining the planned channel raster for the mobile service.

Particular measures as interference mitigation techniques

− Use of cross-polarization between the mobile service signal and the broadcasting signal received in fixed reception mode.

− Reduction of the e.i.r.p. of the mobile service base station. The level of the required limitation depends on the wanted broadcasting signal characteristics to be protected and on the guardband implemented in the general measures (a higher guardband allows for less restriction on e.i.r.p.).

The measurements and the corresponding analysis in this study suggest the following order of magnitude: with a reduced level of out-of-band emissions, a 5 MHz guardband and cross-polarization, the e.i.r.p of the base station could be as high as 400 W (56 dBm) in the interior of the broadcasting coverage area (wanted level at receiver input of −60 dBm) but may have to be limited to 3 W (35 dBm) at the edge of the broadcasting coverage area.

For the image channel case, i.e. mobile service downlink channel being the image frequency of the broadcasting channel (that is N+9 or N+10 depending on the channel bandwidth), there is no effect of reducing the out-of-band emission level or of implementing a guardband. However, using cross-polarization and reducing the e.i.r.p. level improve the protection.

If there are still cases of interference in the adjacent or image channel to the broadcasting service, further mitigation techniques could be used to solve the remaining cases:

− Installing rejecting filters on the fixed broadcast reception installations which are subject to interference. When relevant, this helps to avoid the possible overload of the DVB-T receiver input or any wideband broadcast antenna amplifier used in the receiving installation.

− Increasing the power of DVB-T transmitters to increase the wanted field strength. Alternatively, installing additional in-fill DVB-T transmitter(s) to cover the area concerned.

With regard to the specific case of impact of the mobile service downlink on portable DVB-T reception, further investigations and tests would be needed.

Objective B – to assess the protection requirements between a UMTS transmission from a mobile terminal as an adjacent or image to the channel used for DVB-T reception employing an external TV receive antenna (10 m a.g.l) or a portable indoor receiving antenna (1.5 m a.g.l).

Main outcome

One major parameter in this configuration is the actual transmit power of the mobile phone. The measurements made with one real UMTS mobile phone and one HSDPA data card operating in the UHF band have shown that the mobile transmit power varies considerably depending on the network configuration (density of the base stations) and the location of the mobile device in the network coverage area. The levels measured in Sydney suburbs and in the City range from −11 to −48 dBm.

In a dense network of small base stations implemented in a suburban area, the mobile phone transmit power seems to be kept at a low average level as the link budget does not require high transmit power. It was observed during the measurement that when the downlink signal at one location is weakly received, the respective uplink signal is often bursty. It is believed that the TPC is activated under a weak downlink environment. When a data/voice call is first initiated, an extremely high impulsive uplink signal can be observed. The network is then endeavoured to manipulate the TPC in order to reduce the uplink signal as the call is established. However, intermittent bursts can still be observed throughout the call. As could be expected, the average transmit power of the mobile terminal is higher in an upload session than in a download session and it can almost reach the maximum transmit power (according to specifications, i.e. 21 dBm).

Interference on portable indoor DVB-T reception from real UMTS mobile phone with insufficient guardband has been shown and recorded on video[1].

From the observed interference conditions during testing, our preliminary finding is that, taking into account the protection of both fixed and portable indoor reception of DVB-T from the UMTS

[1] These videos are available upon request to EBU.

uplink, a guardband[2] of 7 MHz would be suitable if the wanted DVB-T signal is at −60 dBm or higher, in all the UMTS cell coverage area. If the DVB-T signal is lower, like near the edge of the coverage area, a guardband of up to 21 MHz would be required.

The use of reversed FDD duplex (uplink in the upper part and downlink in the lower part) in the band above 790 MHz is a good measure to ensure a sufficient separation between the highest broadcasting channel below 790 MHz and the lowest uplink channel in the band above 790 MHz band.

With regard to possible image channel interference, there might be cases of interference on some types of receivers when receiving low wanted signal levels. Installation of image channel rejection filters at the victim receiver side could be the ultimate solution to solve these possible cases of interference.

Where to consider these findings?

This analysis provides insights into one case of compatibility based upon the UMTS network design, base station architectural structures and cellular service characteristics in one country.

Entry of mobile services into the band above 790 MHz is an issue being considered within many administrations and the results of studies in other administrations could give rise to assessment of compatibility of globally harmonized UMTS applications and DVB-T. The collaborators of this study would encourage ITU-R to call for more studies on this topic so that the globally harmonized compatibility can be realized not only from the theoretical studies but from actual UMTS and DTTB deployments across the regions.

3 Methodology

3.1 Parameters considered for the downlink

Figure 1 shows the spectral configurations between the Telstra NextG downlink signal and the Hutchison[3] downlink signal as well as the DTT channels for both the European and the Australian channel rasters.

A number of parameters and outcomes to be considered in the downlink study are outlined as follows:

a) channel configurations of the wanted and unwanted signals:
   - for the European 8 MHz channel raster: adjacent channel interference and N+9[4] image channel interference;
   - for the Australian 7 MHz channel raster: adjacent channel and N+10[2] image channel interference;

b) DTT reception mode: fixed with roof top antenna and portable;

[2] Guardband: frequency separation between the upper edge of one service and the lower edge of another service to achieve frequency planning compatibility between these services.

[3] While Hutchison has the spectrum licence of 870-880 MHz band, to date its 3G network does not appear to operate in this band.

[4] Image channel interference usually occurs at frequency around 70 MHz to 74 MHz above the desired carrier, therefore it can be perceived at 9 channels (9 × 8 = 72 MHz) above carrier for 8 MHz channel raster whereas at 10 channels (10 × 7 = 70 MHz) above carrier for 7 MHz channel raster.

c) distance between the base station (BS) and the study location (SL). This determines the level of the interfering field strength;

d) input level (dBm) of the UMTS signal at the DTT receiver. It was verified that the measuring equipment allows for measuring the average power in the concerned UMTS channel;

e) input level (dBm) of the DTT signal at the DTT receiver;

f) interference on the DTT received signal (observe via displayed picture) based on Recommendation ITU-R BT.1368-6 Annex 6 for subjective failure point (SFP) method for protection ratio measurements[5].

3.2 Parameters considered for the uplink

Figure 2 shows the spectral configurations between the Telstra NextG uplink signal and the Hutchison[6] uplink signal as well as the DTT channels for both the European and the Australian channel rasters.

A number of parameters and outcomes considered in the uplink study are outlined as follows:

a) channel configuration of the wanted and unwanted signals:
   – for the European 8 MHz channel raster: adjacent channel interference and N+9 image channel interference;
   – for the Australian 7 MHz channel raster: adjacent channel and N+10 image channel interference;

b) DTT reception mode: fixed with roof top antenna and portable indoor;

c) distance between the base station (BS) and the study location (SL). It was anticipated that TPC may work more effectively (higher dynamic range of the transmit signal variation) when the mobile phone is close to the edge of the cell coverage area;

d) mode of the mobile phone: on-call, file download and file upload;

e) distance between the mobile phone and the receiving antenna;

f) input level (dBm) of the UMTS signal at the DTT receiver. It was verified that the measuring equipment allowed for measuring the average power in the concerned UMTS channel;

g) input level (dBm) of the DTT signal at the DTT receiver;

h) interference on the DTT received signal (observe via displayed picture) based on Recommendation ITU-R BT.1368-6 Annex 6 for subjective failure point (SFP) method for protection ratio measurements[6].

3.3 Outdoor measurement procedures

This section outlines the necessary procedures to obtain the required measurements as illustrated in Fig. 3.

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[5] Recommendation ITU-R BT.1368-6 Annex 6 stated that "the subjective failure point method corresponds to the picture quality where no more than one error is visible in the picture for an average observation time of 20 seconds".

[6] While Hutchison has the spectrum licence of 825-835 MHz band, to date its 3G network does not appear to operate on this band.

3.3.1 Measurements for downlink study

Based on the outcome of an initial selection, the measurements at the selected locations for downlink study required the following procedures:

a) measure the UMTS channel power received with the 10 m mast and with co-polarization between the DTT receiving antenna and the UMTS BS antenna;

b) capture the signal and store it[7];

c) measure with cross-polarization (if practical), or refer to the antenna characteristics to evaluate the cross-polarization discrimination;

d) repeat steps a) and b) with portable antenna;

e) measure the field strength with a calibrated dipole antenna;

f) capture the signal and store it.

3.3.2 Measurements for uplink study

Based on the outcome of an initial selection, the measurements at the selected locations for uplink study required the following procedures:

a) ensure that the study location perceives reasonably low downlink signal in order to emulate a location at the fringe of coverage cell where TPC is most probably be required to enhance Quality of Service;

b) activate the UMTS handset and measure the UMTS channel power with portable indoor antenna that is located at 1.5 m above ground level and at a distance between 0 m and 2.5 m away from the mobile handset;

c) capture the signal and store it[7].

3.4 Indoor analysis procedures

With the availability of a signal analyser that is capable of digitizing the captured UMTS uplink/downlink signals and down-converting the respective signals to a nominated frequency for analyses, both downlink and uplink studies were conducted in a laboratory environment.

3.4.1 Analyses for downlink study − Frequency separation

The captured downlink signals would be regenerated at a relevant frequency for compatibility studies. The required procedures are as follows:

a) measure the total cable losses, x dB, in the configuration as illustrated in the indoor section of Fig. 3;

b) set the captured UMTS downlink signal at $-y$ dBm level such that the effective downlink level is $-(x+y) = M1$ dBm which is to be defined as a first typical level received from the base station on the basis of the outdoor measurements (see § 8.1.2);

c) set DTT signal at $-z$ dBm such that the effective DTT level is $-(x+z) = -80$ dBm, which may deem as the minimum required DTT signal perceived by any set-top boxes;

d) assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6;

e) if interference occurs as per step d), introduce an adequate guardband between UMTS and DTT by shifting the UMTS signal frequency such that the interference is completely mitigated;

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[7] With the availability of a signal analyser that is capable of digitizing the captured UMTS uplink/downlink signals.

f) further assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6 by residing UMTS signal frequency to image channel N+10 and N+9 for Australian and European set-top boxes, respectively;

g) repeat steps c) to f) with DTT effective level of −60 dBm;

h) repeat steps b) to g) with UMTS effective downlink signal at $M2$ dBm which is defined as a second typical level received from the base station on the basis of the outdoor measurements (see § 8.1.2).

3.4.2 Analyses for downlink study − Power restriction

The captured downlink signals would be regenerated at a relevant frequency for compatibility studies. The required procedures are as follows:

a) measure the total cable losses, x dB, in the configuration as illustrated in the indoor section of Fig. 3;

b) set DTT signal at $-y$ dBm such that the DTT effective level is $-(x+y) = -80$ dBm, which may deem as the minimum required DTT signal perceived by any set-top boxes;

c) assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6;

d) reduce UMTS downlink signal level, if interference occurs as per step c), until interference is completely mitigated;

e) repeat steps b) to d) with DTT effective level of −60 dBm;

f) repeat steps b) to e) with resided UMTS signal at:

- a frequency such that no guardband is used;
- centre frequencies of immediately adjacent TV channel (i.e. 1 MHz and 1.5 MHz guardband for Australian and European channel rasters);
- 5 MHz guardband;
- image channel N+10 and N+9 for Australian and European set-top boxes, respectively.

3.4.3 Analysis for uplink study − Frequency separation

The captured uplink signals were regenerated at a relevant frequency for compatibility studies. The procedures were as follows:

a) measure the total cable losses, x dB, in the configuration as illustrated in the indoor section of Fig. 3;

b) set the captured UMTS uplink signal at $-y$ dBm level such that the effective downlink level is $-(x+y) = M1$ dBm which is to be defined as a first typical level received from the terminal equipment on the basis of the outdoor and indoor measurements (see § 8.2.3);

c) set DTT signal at $-y$ dBm such that the DTT effective level is $-(x+y) = -80$ dBm, which may be deemed as the minimum required DTT signal perceived by any set-top boxes;

d) assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6;

e) if interference occurs as per step d), introduce an adequate guardband between UMTS and DTT by shifting the UMTS signal frequency such that the interference is completely mitigated;

f) further assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6 by shifting UMTS signal frequency to image channel N+10 and N+9 for Australian and European set-top boxes, respectively;

g) repeat steps c) to f) with DTT effective level of −60 dBm;

h) repeat steps b) to g) with UMTS effective uplink signals at other levels defined on the basis of the measurements of the uplink signal (see § 8.2.3).

3.4.4 Analysis for uplink study − Power restriction

The captured uplink signals were regenerated at a relevant frequency for compatibility studies. The procedures were as follows:

a) measure the total cable losses, x dB, in the configuration as illustrated in the indoor section of Fig. 3;

b) set DTT signal at $-y$ dBm such that the DTT effective level is $-(x+y) = -80$ dBm, which may be deemed as the minimum required DTT signal perceived by any set-top boxes;

c) assess picture quality according to Recommendation ITU-R BT.1368-6, Annex 6;

d) reduce UMTS uplink signal level, if interference occurs as per step c), until interference is completely mitigated;

e) repeat steps b) to d) with DTT effective level of −60 dBm;

f) repeat steps b) to e) with resided UMTS signal at:
   - a frequency such that no guardband is used;
   - centre frequencies of immediately adjacent TV channel (i.e. 1 MHz and 1.5 MHz guardband for Australian and European channel rasters);
   - 5 MHz guardband;
   - image channel N+10 and N+9 for Australian and European set-top boxes, respectively.

FIGURE 1

UMTS downlink channels

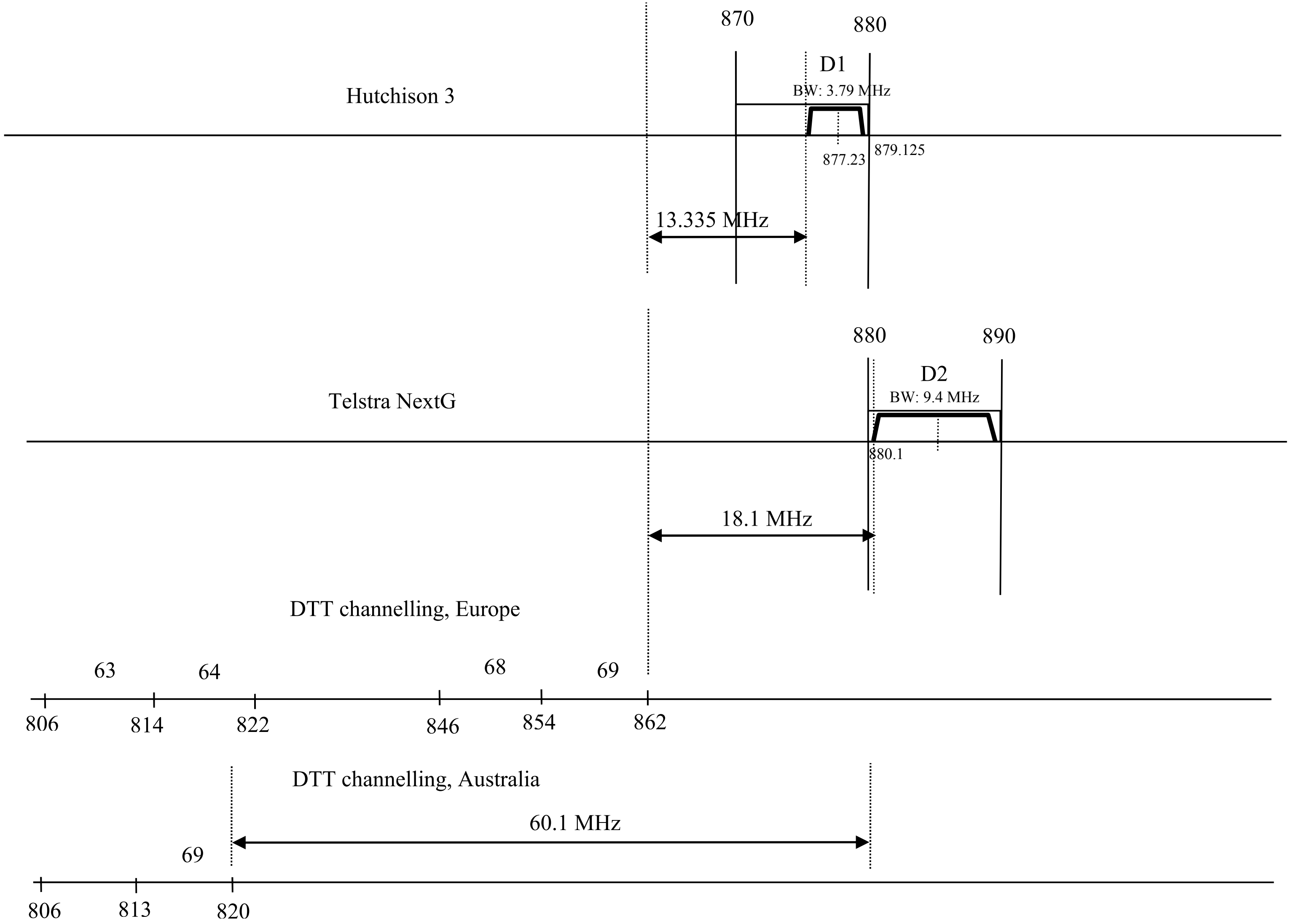


FIGURE 2

UMTS uplink channels

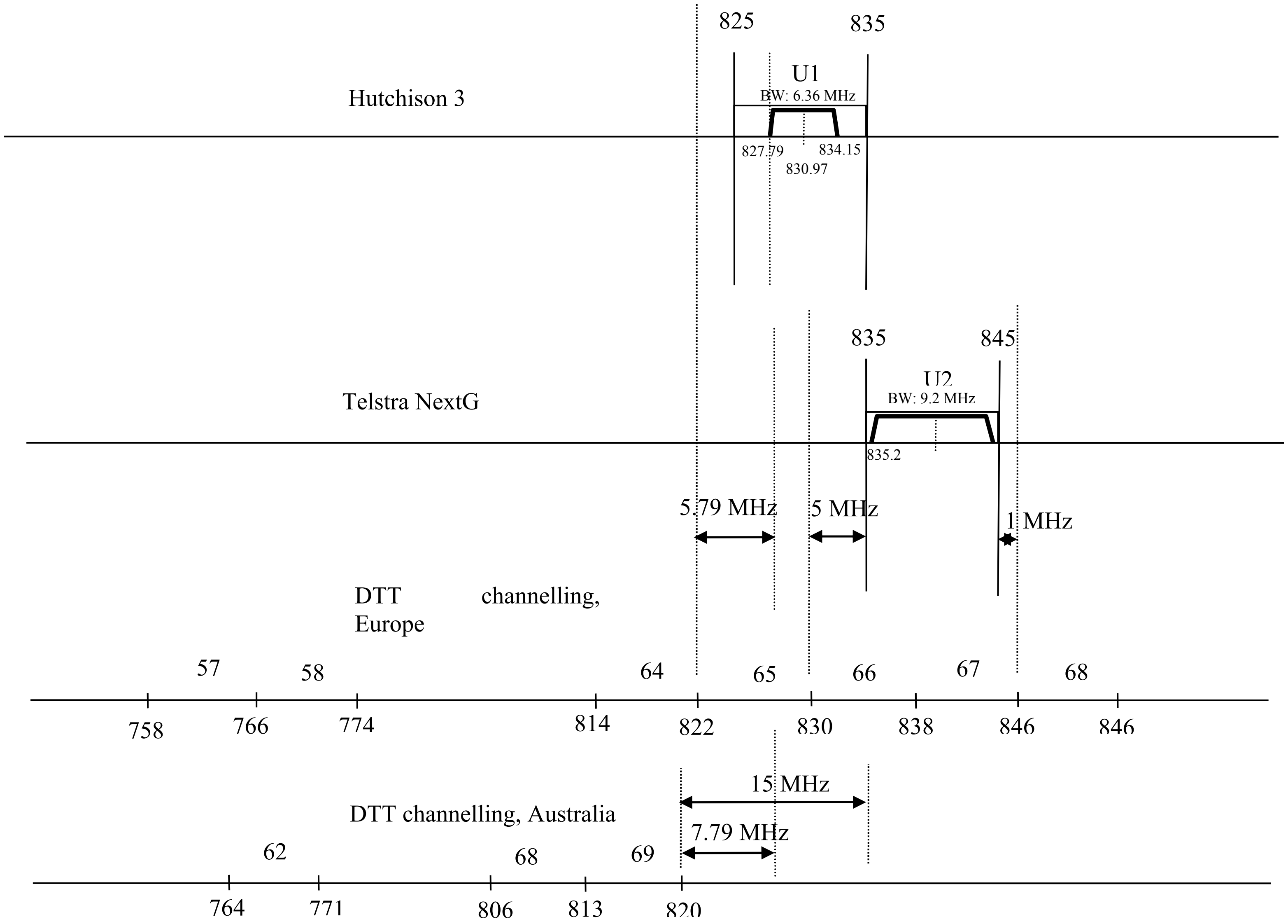
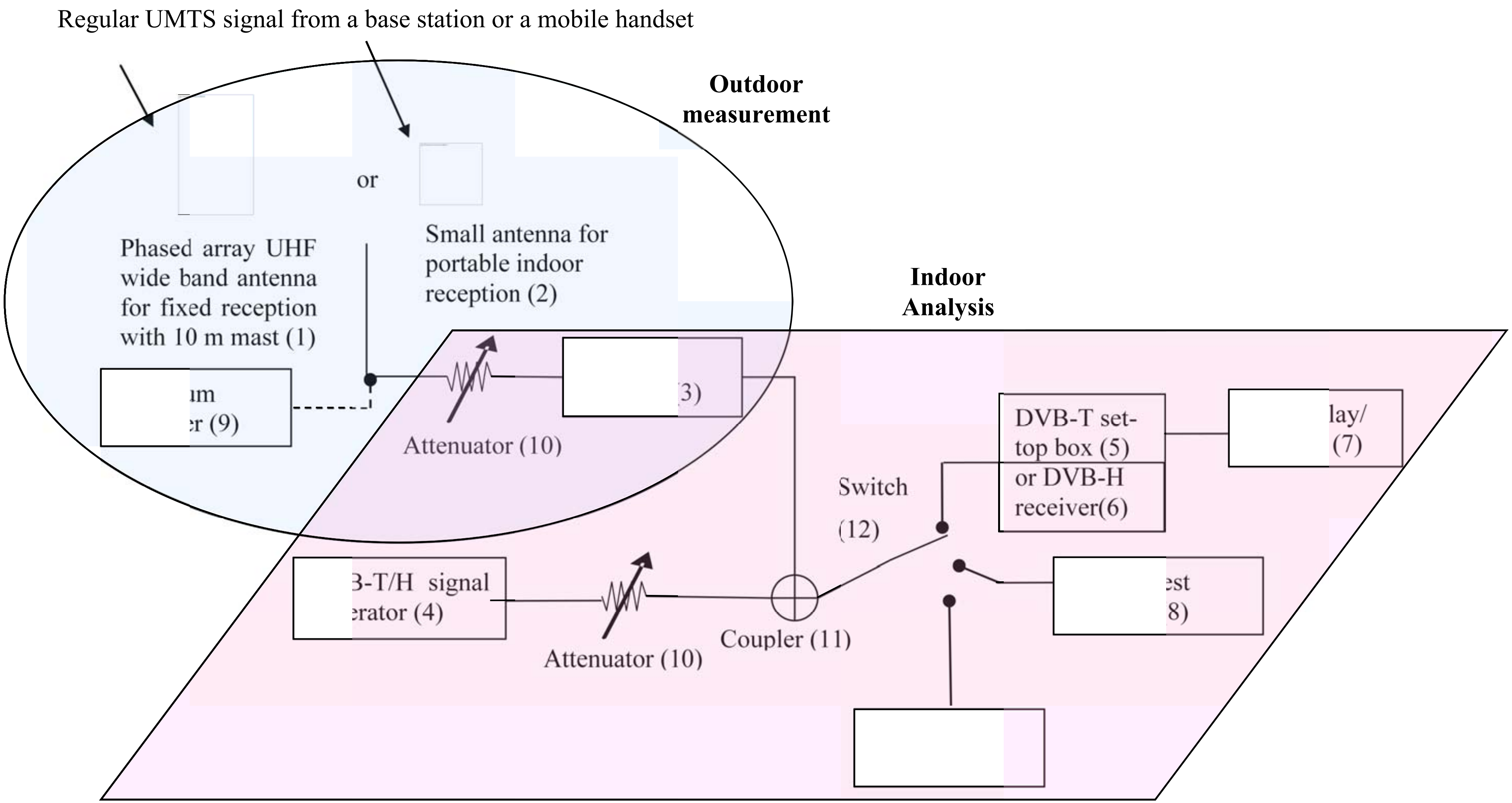


FIGURE 3

Illustration of the measurement procedures



4 Site selection and characteristics

Australia is one of the countries as of today that makes use of the 850 MHz band by one of its UMTS/3G providers, namely Telstra. This provides an implemented UMTS network to perform testing of compatibility between UMTS and DVB-T services that operate, spectrally and/or geographically, in close proximity.

A number of locations in the Sydney metropolitan were selected for this study to cover different granularity of a large population environments. This includes:

a) location within the western suburb of Sydney (see Annex 1) which has an undulating topography that is similar to some typical European low rise suburban area and within adequately good UMTS coverage, i.e.:
   - Mill Place, St Clair (33 47 24.3 S/150 47 37.2 E)
   - Fuller Place, St Clair (33 47 28.6 S/150 48 07.2 E)
   - Japura Place, St Clair (33 47 31.4 S/150 48 17.0 E)
   - Augusta Place, St Clair (33 47 34.8 S/150 48 21.7 E)
   - Mark Leece Sporting Complex, St Clair (33 47 31.5 S/150 47 22.4 E)
   - Gosse Court, St Clair (33 47 31.0 S/150 47 24.0 E)
   - Shepherd Street, Colyton (33 47 22.5 S/150 48 24.5 E)
   - Potter Field, Colyton (33 47 08.2 S/150 47 18.9 E)

b) location within Sydney CBD that emulates a busy city compacted with large number of UMTS base stations located at rooftop of skyscrapers serving a large number of concurrent users, i.e.
   - Margaret Street, Sydney (33 51 52.9 S/151 12 25.4 E)
   - Loftus Street, Sydney (33 51 46.5 S/151 12 36.9 E)
   - Martin Place, Sydney (33 52 06.6 S/151 12 30.4 E)

c) location within high rise residential area in Sydney/North Sydney that emulates the fringe area of a busy CBD but well within good UMTS coverage, i.e.
   - The Rock, Sydney (33 51 14.9 S/151 12 30.2 E)
   - Blue’s Point, North Sydney (33 50 56.9 S/151 12 15.2 E)
   - Miller Street, North Sydney (33 47 24.3 S/150 47 37.2 E)

d) potential residential/commercial location which receives very weak UMTS downlink signal, i.e.
   - Avenue Road, Mosman (33 49 54.7 S/151 14 15.2 E).

It is important to note that the sites outlined above were chosen to observe the signal level or channel power of UMTS uplink/downlink. Only a few among them were selected for the capturing of UMTS uplink or downlink signal.

5 Pre-trial spectrum plot analysis

Based on an initial investigation, the selected study locations were characterized for different tasks outlined as follows:

a) Observation of uplink/downlink signal levels − A quick snapshot of the spectrum chart as picked up by a portable Yagi antenna to observe the signal level of the downlink channels. Separate snapshots were taken when a phone/data call was established via an UMTS mobile handset to observe the signal level of the uplink channels. Sites required for this task are:
   - Margaret Street, Sydney (33 51 52.9 S/151 12 25.4 E)
   - Loftus Street, Sydney (33 51 46.5 S/151 12 36.9 E)
   - Martin Place, Sydney (33 52 06.6 S/151 12 30.4 E)
   - The Rock, Sydney (33 51 14.9 S/151 12 30.2 E)
   - Blue’s Point, North Sydney (33 50 56.9 S/151 12 15.2 E)
   - Miller Street, North Sydney (33 47 24.3 S/150 47 37.2 E)

b) Capture of downlink signals − A wideband UHF phased array antenna mounted at 10 m mast of a field survey vehicle was positioned such that the maximum signal strength from the nearest UMTS base station could be observed via a spectrum analyser. The downlink signal and its spurious emissions were captured and recorded into digitized form for further analysis. Sites selected for this task are:
   - Gosse Court, St Clair (33 47 31.0 S/150 47 24.0 E)
   - Shepherd Street, Colyton (33 47 22.5 S/150 48 24.5 E)
   - Potter Field, Colyton (33 47 08.2 S/150 47 18.9 E)

c) Capture of Uplink Signals − A portable indoor UHF Yagi antenna was positioned in close proximity to an UMTS mobile handset when a voice/data call was established such that the maximum signal strength from the handset could be observed via a spectrum analyser. The uplink signal and its spurious emissions were captured and recorded into digitized form for further analysis. Sites required for this task are:
   - Mill Place, St Clair (33 47 24.3 S/150 47 37.2 E)
   - Avenue Road, Mosman (33 49 54.7 S/151 14 15.2 E)

The plots presented in the following indicate some samples of uplink and/or downlink signal levels as perceived in the selected study locations.

FIGURE 4

Spectrum chart at Margaret Street (picked up via portable Yagi antenna)

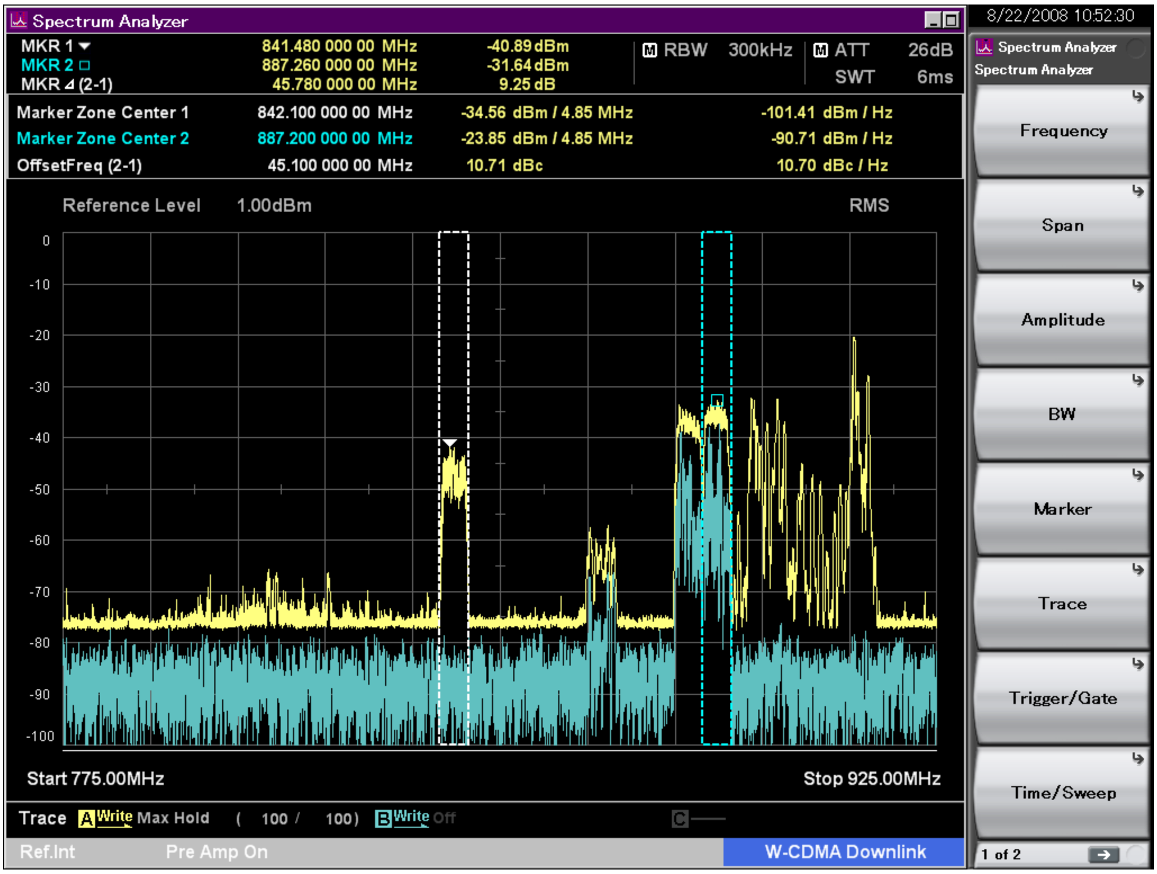


Figure 4 indicates the UMTS uplink and downlink signal levels measured at Margaret Street within Sydney CBD with a portable UHF Yagi antenna. Two downlink channels, centred at 882.2 MHz and 887.2 MHz, were observed at levels approximately −23.8 dBm. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −34.5 dBm. It is also noted that a number of GSM signals at levels equal to or higher than the UMTS signals were observed at frequencies above 890 MHz.

FIGURE 5

Spectrum chart at Loftus Street (picked up via portable Yagi antenna)

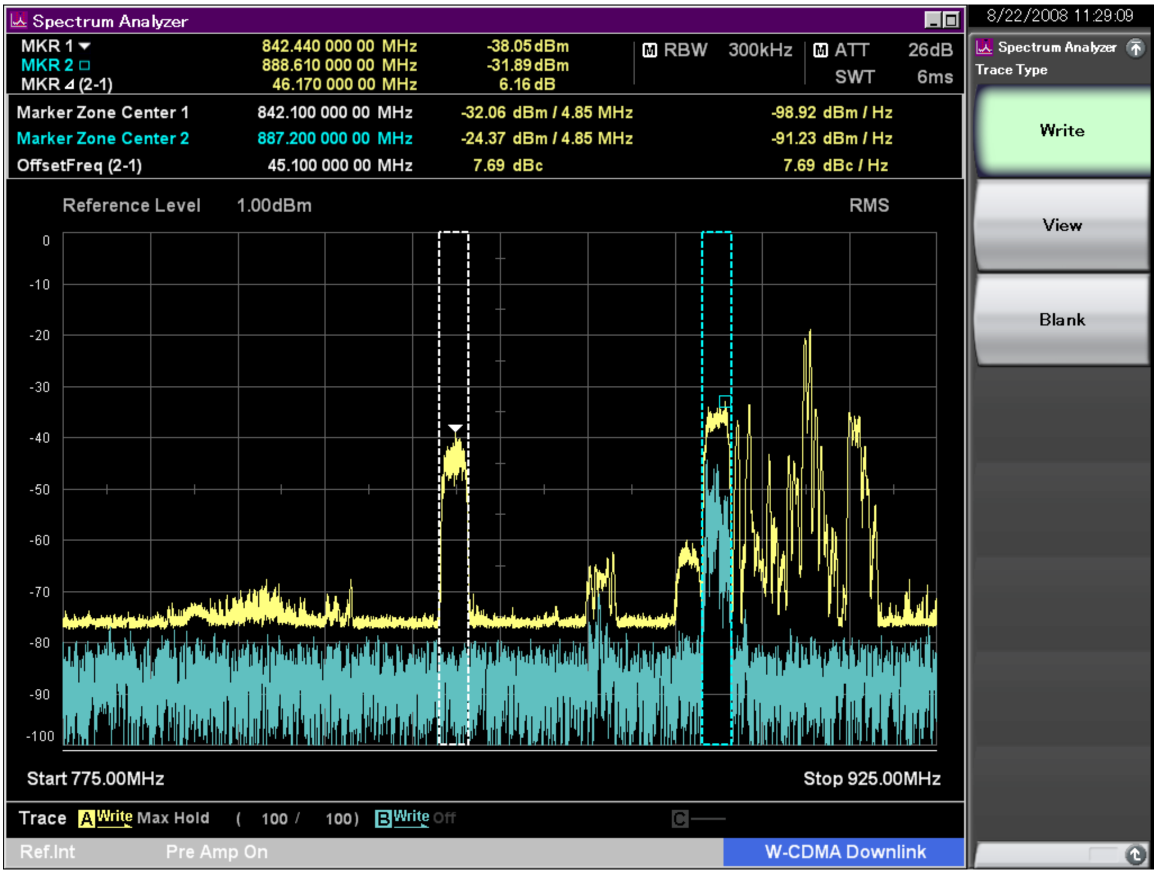


Figure 5 indicates the UMTS uplink and downlink signal levels measured at Loftus Street within Sydney CBD (in close proximity to the Australia Stock Exchange) with a portable UHF Yagi antenna. Two downlink channels, centred at 882.2 MHz and 887.2 MHz, were observed with one at level approximately −24.4 dBm whereas the other was significantly lower at −54 dBm. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −32 dBm. It is also noted that a number of GSM signals at levels equal to or higher than the UMTS signals were observed at frequencies above 890 MHz.

FIGURE 6

Spectrum chart at Martin Place (picked up via portable Yagi antenna)

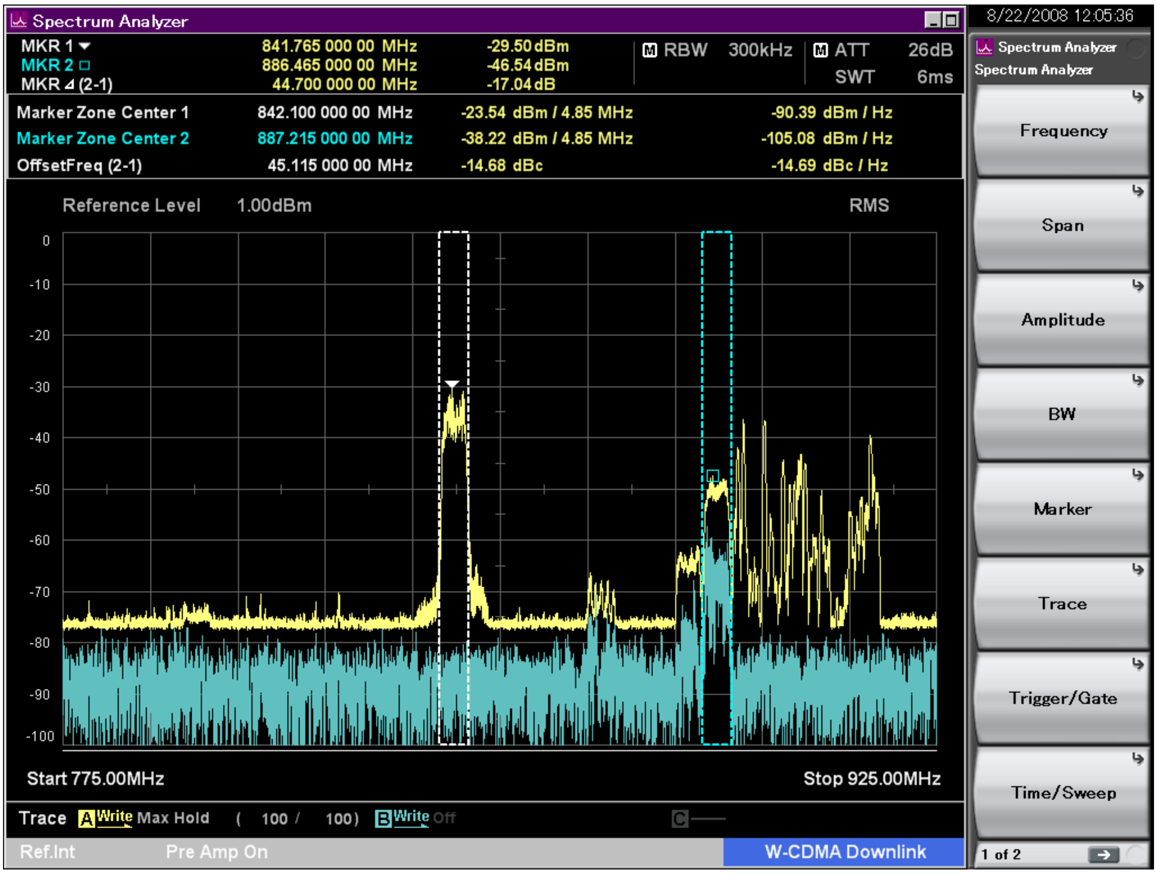


Figure 6 indicates the UMTS uplink and downlink signal levels measured at Martin Place within Sydney CBD (crowded with pedestrians) with a portable UHF Yagi antenna. Two downlink channels, centred at 882.2 MHz and 887.2 MHz, were observed with one at level approximately −38.2 dBm whereas the other was slightly lower at −55 dBm. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −23.5 dBm. It is noted that the uplink signal comprised some spurious emissions which was not observed at other Sydney CBD locations, e.g. Margaret Street and Loftus Street. It is also noted that a number of GSM signals at levels equal to or higher than the UMTS downlink signals were observed at frequencies above 890 MHz.

FIGURE 7

Spectrum chart at The Rock (picked up via phased array antenna at 2.5 m height)

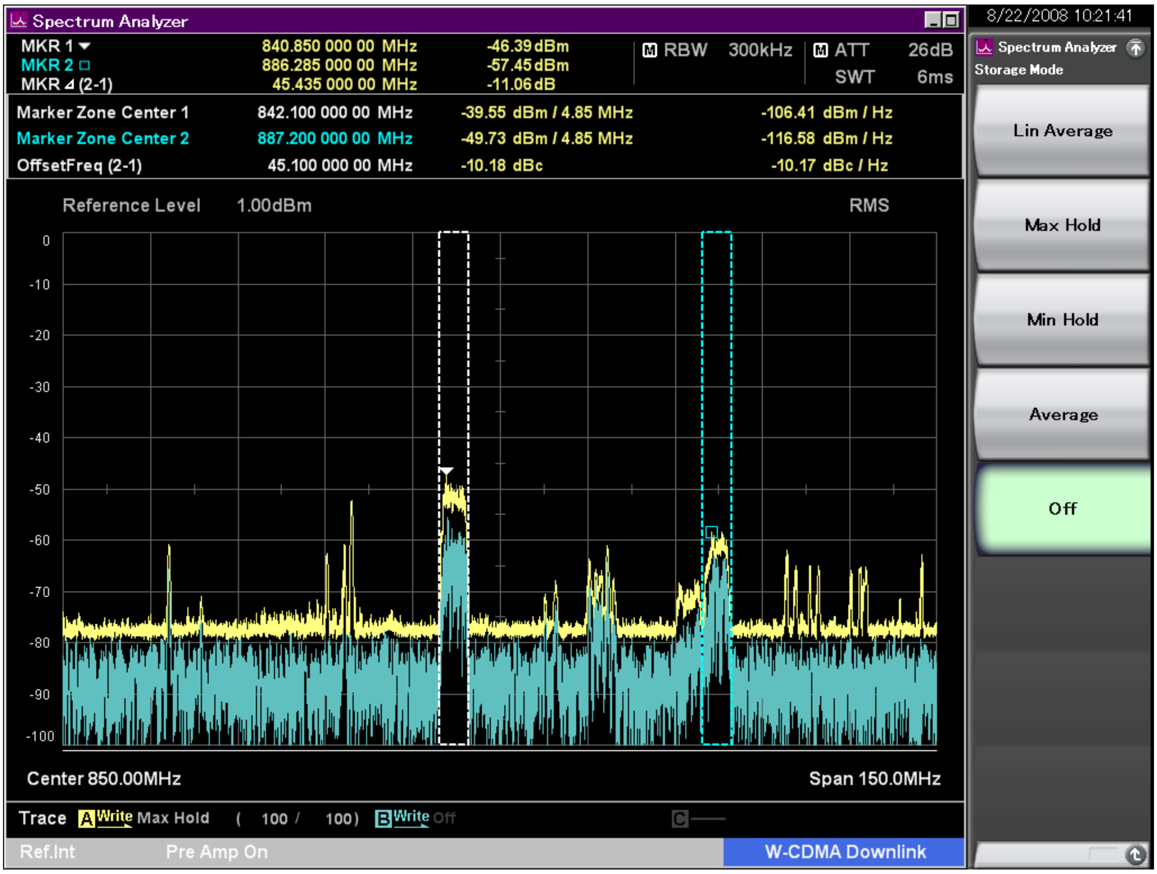


Figure 7 indicates the UMTS uplink and downlink signal levels measured at The Rock (at the fringe of Sydney CBD) with a phased array antenna at 2.5 m height above ground level. Two downlink channels, centred at 882.2 MHz and 887.2 MHz, were observed at levels approximately −60 dBm and −49.7 dBm, respectively. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −39.5 dBm. It is noted that this location only perceived a small number of weak GSM signals at frequencies above 890 MHz.

FIGURE 8

Spectrum chart at Blue's Point (picked up via portable Yagi antenna)

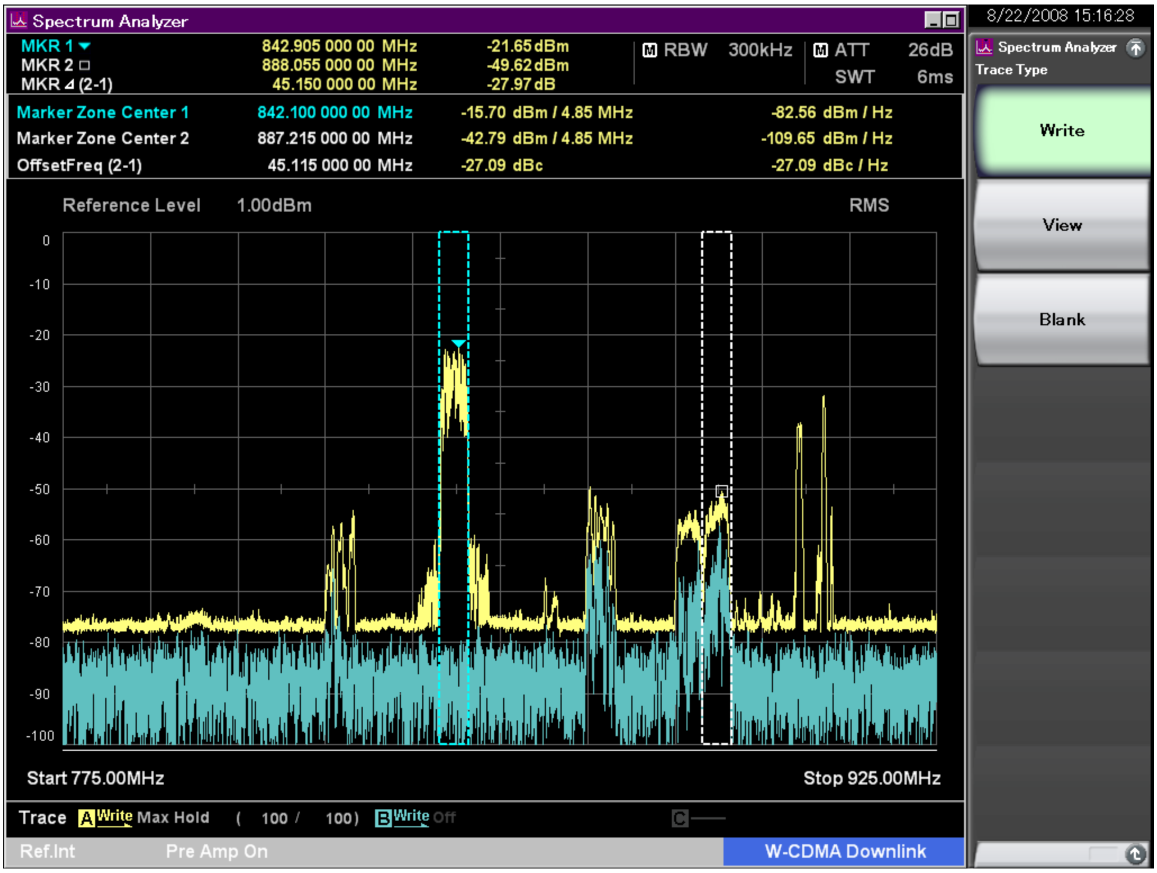


Figure 8 indicates the UMTS uplink and downlink signal levels measured at Blue's Point Reserve with a portable UHF Yagi antenna. Two downlink channels, centred at 882.2 MHz and 887.2 MHz, were observed at levels approximately −43 dBm. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −15.7 dBm. It is noted that the uplink signal comprised some spurious emissions which were not observed at Sydney CBD locations, e.g. Margaret Street and Loftus Street. It is also noted that very few GSM signals at frequencies above 890 MHz were observed and they were at levels much higher than the UMTS downlink signals.

FIGURE 9

Spectrum chart at Miller Street (picked up via portable Yagi antenna)

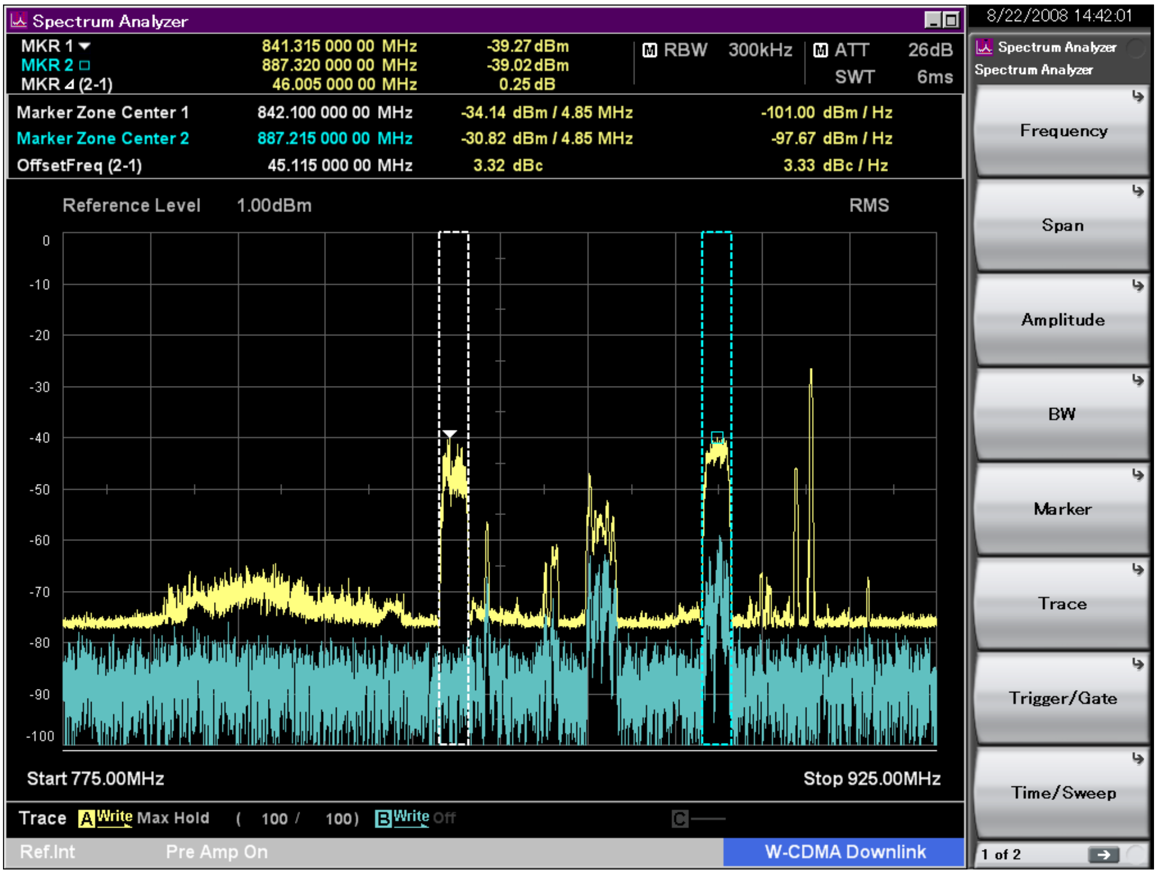


Figure 9 indicates the UMTS uplink and downlink signal levels measured at Miller Street (residential area in North Sydney) with a portable UHF Yagi antenna. One downlink channel centred at 887.2 MHz was observed at level approximately −30.8 dBm. The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −34.5 dBm. It is noted that frequencies around 790 MHz to 820 MHz were filled up with very weak signals. These signals were analogue TV transmissions at channel 66 (Manly/Mosman TEN service at 792-799 MHz) and possible wireless microphones and/or land mobiles. It is also noted that very few GSM signals at frequencies above 890 MHz were observed and some were at levels equal to or higher than the UMTS downlink signals.

FIGURE 10

Spectrum chart at Gosse Court (picked up via a phased array antenna at 10 m height)

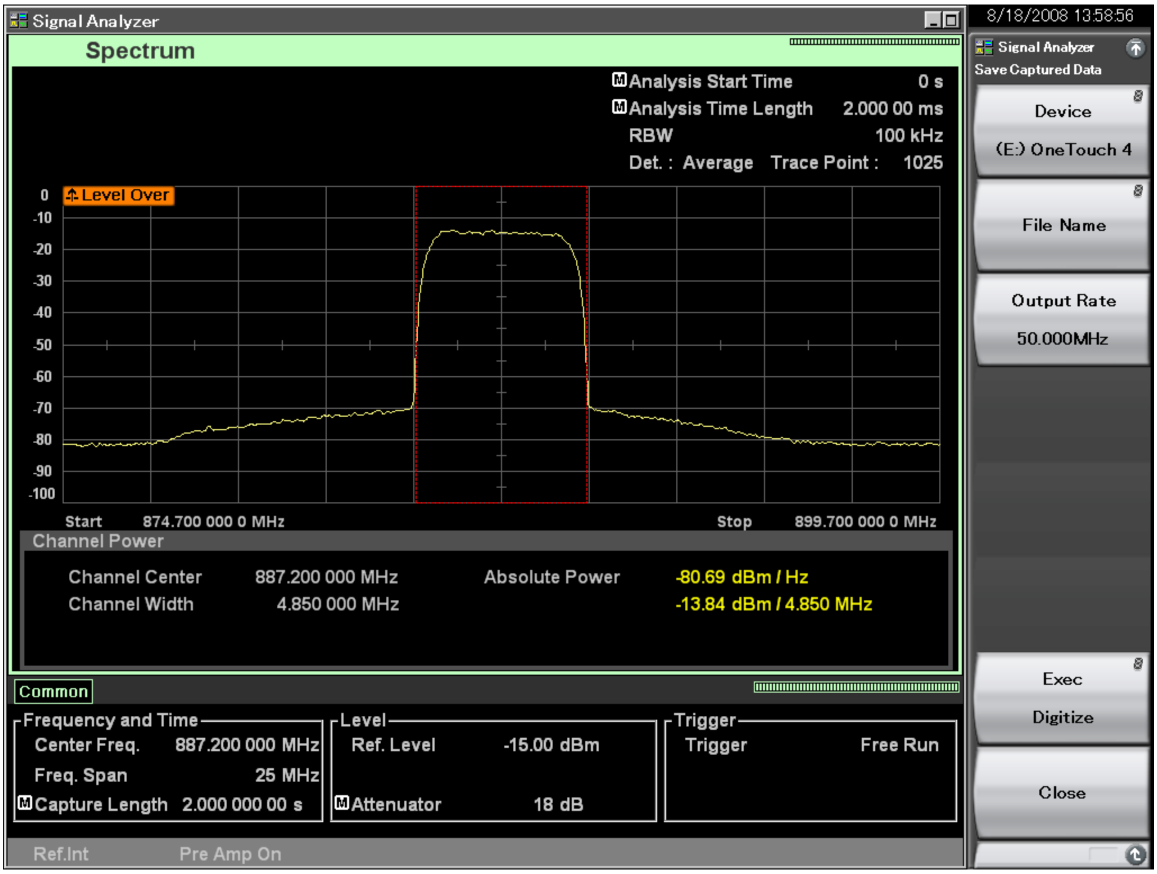


Figure 10 indicates the UMTS downlink signal received at Gosse Court with a UHF phased array antenna mounted on 10 m mast. The signal level was measured at a level approximately −13.8 dBm.

FIGURE 11

Spectrum chart at Shepherd Street (picked up via a phased array antenna at 10 m height)

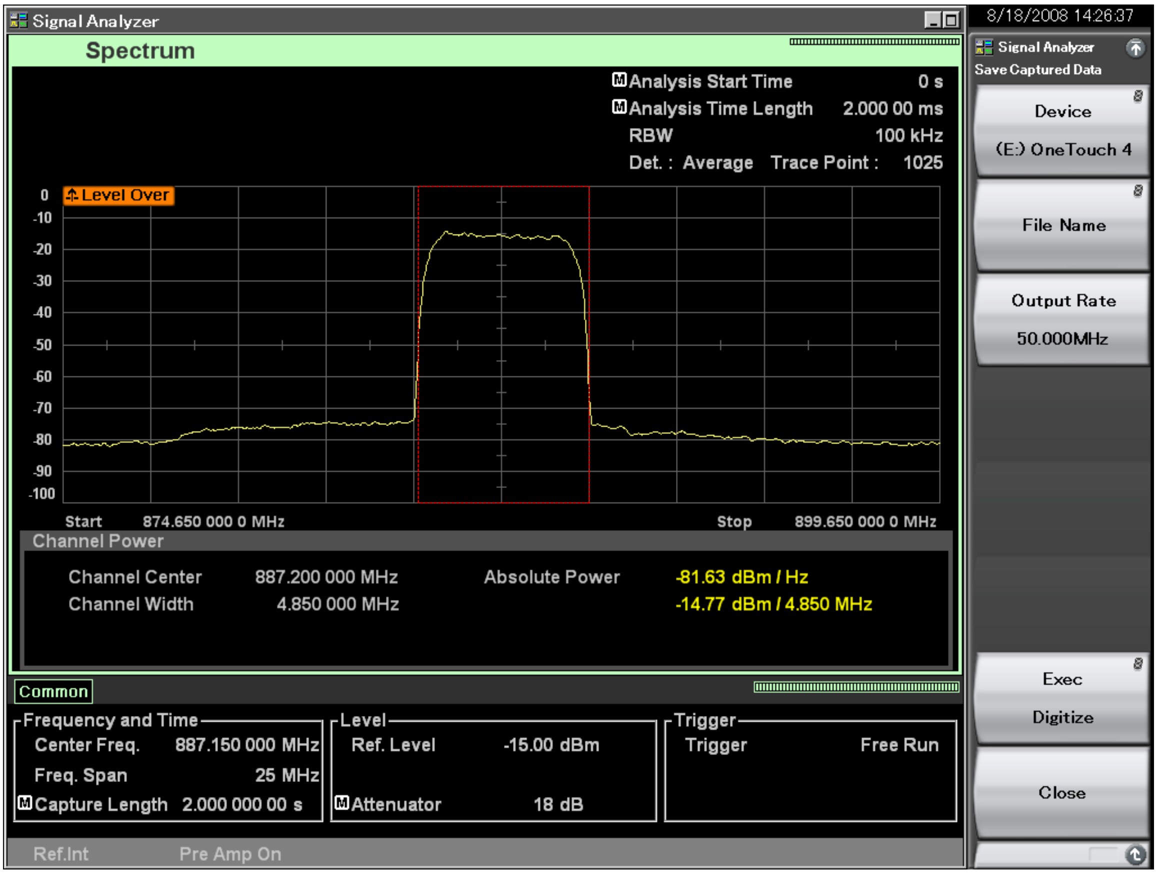


Figure 11 indicates the UMTS downlink signal received at Shepherd Street with a UHF phased array antenna mounted on 10 m mast. The signal level was measured at a level approximately −14.8 dBm.

FIGURE 12

Spectrum chart at Potter Field (picked up via a phased array antenna at 10 m height)

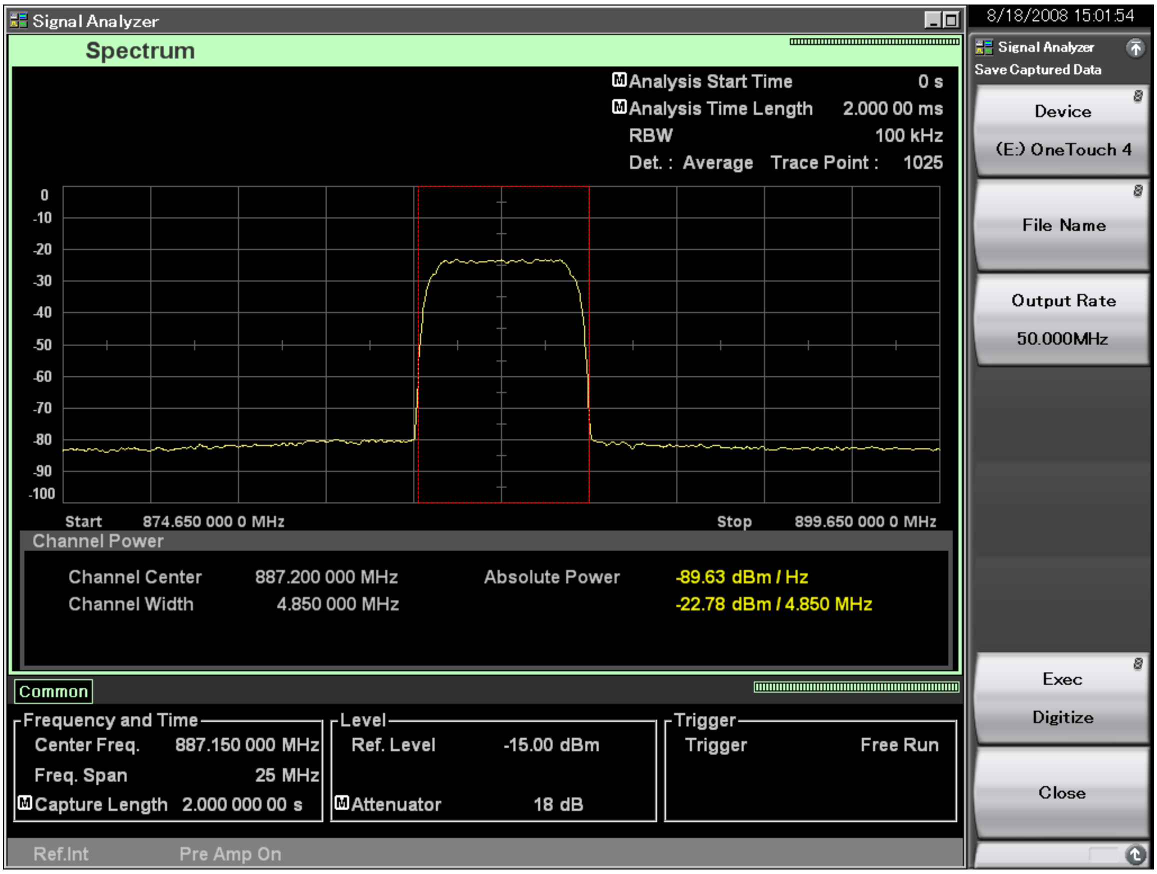


Figure 12 indicates the UMTS downlink signal received at Potter Field with a UHF phased array antenna mounted on 10 m mast. The signal level was measured at a level approximately −22.8 dBm.

FIGURE 13

Spectrum chart at St Clair (picked up via external rooftop antenna)

Figure 13 indicates the spectrum scan of frequencies from 545 MHz to 895 MHz at St Clair via an external rooftop antenna. The UMTS downlink signal level was measured at a level approximately −35.4 dBm. It is noted that the antenna was capable of picking up a number of television broadcasts from 547 MHz to 792 MHz, including services from Sydney (Artarmon) and Illawarra (Knights Hill).

FIGURE 14

Spectrum chart at Avenue Road (picked up via portable Yagi antenna)

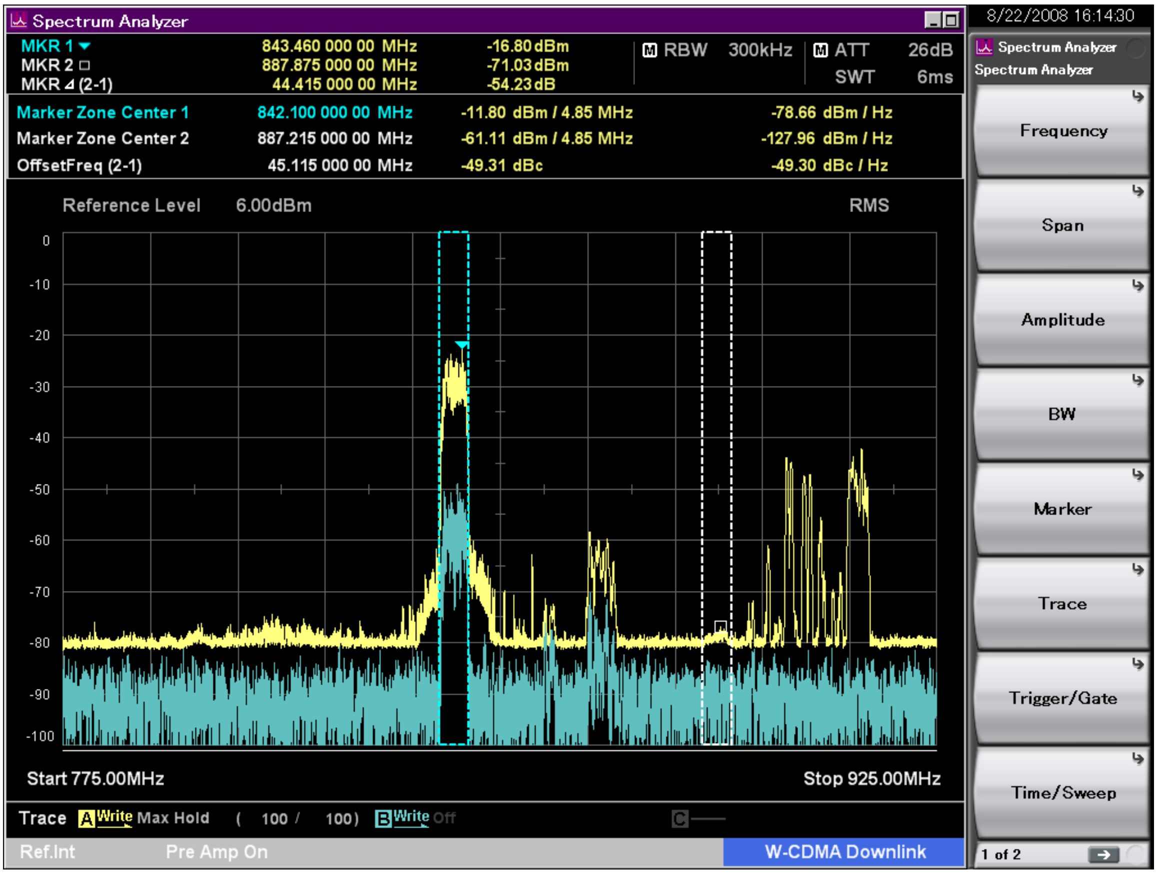


Figure 14 indicates the UMTS uplink and downlink signal levels measured indoor at Avenue Road Mosman with a portable UHF Yagi antenna. One downlink channel centred at 887.2 MHz was observed at a very low level of −61 dBm (almost approaching the noise floor). The uplink signal, when the mobile broadband card was in operation, was measured at a level approximately −11.8 dBm. It is noted that the uplink signal comprised some spurious emissions which were much higher than the UMTS downlink signal itself. It is also noted that a number of GSM signals at frequencies above 890 MHz were observed and they were at levels much higher than the UMTS downlink signals.

6 UMTS uplink/downlink signal characteristics

The UMTS networks in Australia, as of today, are operating in 850 MHz, 1 800 MHz and 2 200 MHz bands. Among them, this study is focusing on the WCDMA system implemented in 850 MHz band occupying frequency ranges of 835-845 MHz and 880-890 MHz for uplink and downlink, respectively. This frequency arrangement is categorized as UMTS Terrestrial Radio Access Frequency Division Duplex (UTRA/FDD) Band V with a recommended transmit/receive frequency separation of 45 MHz as specified in the 3GPP specification.

6.1 Downlink signals

Two 5 MHz downlink channels constitute the 10 MHz spectrum between 880-890 MHz with the respective carrier frequencies at 882.5 MHz and 887.5 MHz, as per the 3GPP specification.

Spectrum scan results indicated that majority areas of Sydney receive only one downlink channel of bandwidth approximately 4.85 MHz at centre frequency of approximately 887.2 MHz. Sydney CBD is the only exception where at this location UMTS utilizes both downlink channels most probably due to the rise in noise levels and to meet the demand of a higher capacity of admitted users in the CBD network. It is noted that the centre frequencies of the lower and upper uplink channels are offset by approximately −0.3 MHz to 882.2 MHz and 887.2 MHz, respectively, when compared to the 3GPP specification.

An initial investigation was conducted on a number of UMTS base stations with easy access to measure signal level at clear line of sight (LoS). Table 1 outlined the parameters for the three selected base stations and the respective measurements at the study locations. Figures 15, 16 and 17 illustrated the set-up of each measurement. It is noted that a wideband UHF TV antenna is chosen for this study which was mounted on the 10 m mast of the field survey vehicle.

TABLE 1

Technical parameters for targeted base stations

		Shepherd Street	Gosse Court	Potter Field
Base station (BS)	Lat	33 47 25.1 S	33 47 31.8 S	33 47 12.3 S
	Long	150 48 24.9 E	150 47 21.6 E	150 47 15 E
ACMA site id		9007685	133747	133561
Licensed nominal transmission power*	e.i.r.p.*	501 W	40.6 W	39.5 W
Licensed carrier frequencies	Rx	840 MHz	839.8 MHz	839.8 MHz
	Tx	885 MHz	884.8 MHz	884.8 MHz
Bandwidth	Rx	9.9 MHz	9.2 MHz	9.2 MHz
	Tx	9.9 MHz	9.4 MHz	9.4 MHz
Transmitting antenna height		20 m	16 m	22.5 m
Azimuth degrees		20 120° 270°	60 150° 290°	90 220° 335°
Polarization		Slant/Cross	Slant/Cross	Slant/Cross
Downlink frequency		887.2 MHz	887.2 MHz	887.2 MHz
Downlink bandwidth		4.85 MHz	4.85 MHz	4.85 MHz

* e.i.r.p. levels as provided by the ACMA database. It was not possible to check the actual transmitting power.

FIGURE 15

Downlink measurement at Shepherd Street

FIGURE 16

Downlink measurement at Gosse Court

FIGURE 17

Downlink measurement at Potter Field

6.2 Uplink signals

Two 5 MHz uplink channels constitute the 10 MHz spectrum between 835-845 MHz with the respective carrier frequencies at 837.5 MHz and 842.5 MHz, as per the 3GPP specification. It is also stated in the 3GPP specification that the nominal maximum output power from a user equipment (UE), e.g. mobile handset or mobile broadband card, shall not exceed +24 dBm (+1/–3 dB) and +21 dBm (+2/–2 dB) for Power Classes 3 and 4 equipment, respectively.

Spectrum scan results indicated that majority areas of Sydney perceive only one uplink channel of bandwidth approximately 4.85 MHz at centre frequency of approximately 842.2 MHz. Sydney CBD is the only exception where at this location UMTS utilizes both uplink channels most probably due to the rise in noise levels and to meet the demand of a higher capacity of admitted users in the CBD network. It is noted that the centre frequencies of the lower and upper uplink channels are offset by approximately –0.3 MHz to 837.2 MHz and 842.2 MHz, respectively, when compared to the 3GPP specification.

Several measurements were made at different locations in Sydney CBD and North Sydney using the mobile terminal as transmitter and the signal level was measured using a Yagi antenna. See Figs 18 and 19 illustrating examples of these measurements.

FIGURE 18

Outdoor measurement of uplink and downlink signals received with a portable antenna (Example 1)

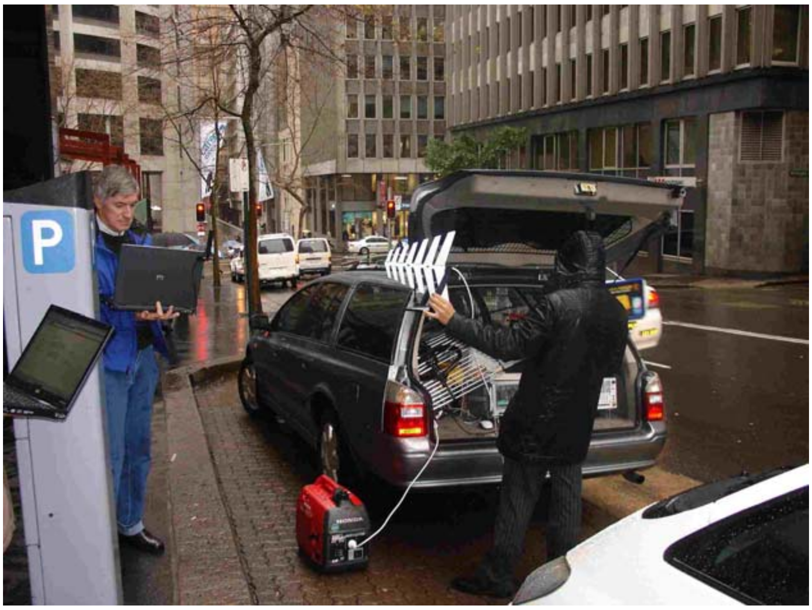


FIGURE 19

Outdoor measurement of uplink and downlink signals received with a portable antenna (Example 2)

6.2.1 User equipment uplink measurement at 13A Mill Place, St Clair

The user equipment (UE) selected for this measurement included a mobile handset and a mobile broadband card (HSDPA Turbo G-series card, with an optional external antenna). By establishing a voice/data call, a constant uplink signal was received. The uplink signal generated by the selected UE, which was located at some constant distance (0 m to 2.5 m) away from the fixed receive (Rx) antenna, was measured by a spectrum analyser. The measurement configuration with a calibrated dipole as Rx is shown in Fig. 20. A similar arrangement was repeated with a portable indoor Yagi antenna.

The channel power of the uplink signals generated at various distances away from different fixed Rx is tabulated in Table 2. It is noted that the mobile broadband card has an antenna socket for optional connection to an external antenna. This enabled a direct measurement of its output power by directly connecting the spectrum analyser to the mobile broadband card through the antenna socket.

FIGURE 20

UE uplink measurement configuration (indoor)

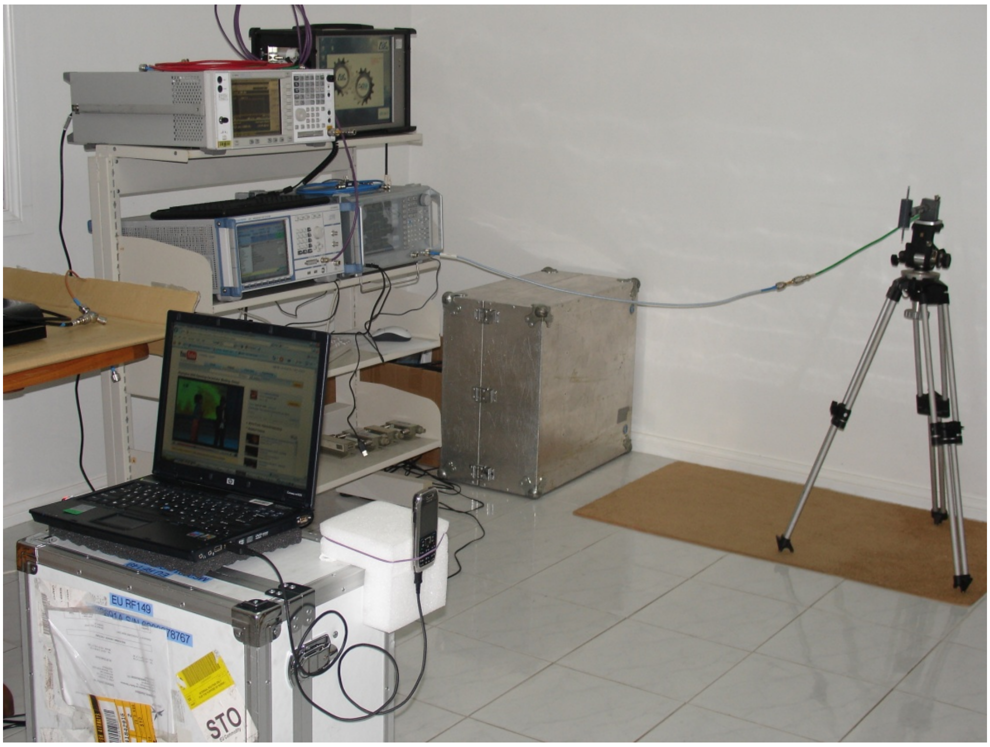


TABLE 2

Uplink signals generated from UE at St Clair

Tx/Rx	Distance between UE and Rx antenna (m)	Channel power (dBm)
Mobile handset/YAGI	0	−23
	0.5	−42
	1.0	−51
	1.5	−47
	2.0	−51
	2.5	−54
Mobile handset/calibrated DIPOLE	0	−26
	0.5	−47
	1.0	−54
	1.5	−52
	2.0	−55
	2.5	−58
Broadband card/YAGI	0.5	−32
	1.5	−50
	2.5	−54
Broadband card with external antenna/YAGI	0.5	−34
	1.5	−45
	2.5	−49
Broadband card/direct input	0	−5

6.2.2 UE uplink measurement at 44 Avenue Road, Mosman

The UE selected for this measurement similarly also includes a mobile handset and a mobile broadband card (HSDPA Turbo G-series card, with an optional external antenna). The uplink signal generated by the selected UE, which was located at some constant distance (0 m to 2.5 m) away from the portable indoor Yagi antenna, was measured by a spectrum analyser.

The measurement results are tabulated in Table 3. It is noted that the downlink signal at 44 Avenue Road, Mosman was significantly lower than other studied locations. Therefore, the UE was relying on the Transmit Power Control (TPC) to tune up the output power in order to maintain constant level of Quality of Service (QoS). The tabulated results, particularly the direct input measurement of +15.5 dBm, intuitively suggested that the mobile broadband card was capable of generating an output power that is reasonably close to the nominal maximum output power level as stated in the 3GPP specification.

TABLE 3

Uplink signals generated from UE at Mosman − Part 1 − August 2008

Tx/Rx	Distance between UE and Rx antenna (m)	Channel power (dBm)
Mobile handset/YAGI	0.5	−21.2
	1.0	−15.3
	2.5	−20.6
Broadband card with external antenna/YAGI	0.5	−11.8
	1.0	−16.5
	2.5	−25.8
Broadband card/direct input	0	+15.5

Interference on portable indoor DVB-T reception from real UMTS mobile phone with insufficient guardband has been shown and recorded on video[8]. Figures 21 and 22 show captured frames of one of the videos.

FIGURE 21

Captures of a recorded video showing interference on portable indoor DVB-T reception from real UMTS mobile phone with insufficient guard (7 MHz DVB-T signal centred at 830.5 MHz and 4.6 MHz UMTS uplink signal centred at 842.1 MHz, i.e. guardband of 5.8 MHz) − First Frame

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[8] These videos are available upon request to EBU.

FIGURE 22

Captures of a recorded video showing interference on portable indoor DVB-T reception from real UMTS mobile phone with insufficient guard (7 MHz DVB-T signal centred at 830.5 MHz and 4.6 MHz UMTS uplink signal centred at 842.1 MHz, i.e. guardband of 5.8 MHz) − Picture block artefacts and loss of signal observed

Additional measurements carried out in January 2009

The objective was to take similar measurements as the preceding (0.5 m, 1 m, 1.5 m, 2 m and 2.5 m and direct input, between indoor TV receive antenna and UMTS mobile terminal at height 1.5 m above ground level) with the difference that the UMTS mobile terminal is constantly uploading data to ensure establishment of uplink. For comparison and verification purpose, same measurements were also conducted when the UMTS mobile terminal is constantly downloading data.

The results are shown in Table 4.

TABLE 4

Uplink signals generated from UE at Mosman − Part 2 − January 2009

Tx/Rx	Distance between UE and Rx antenna (m)	Channel power during upload session (in average mode) (dBm)	Channel power during download session (in average mode) (dBm)
Broadband card with external antenna/Yagi	0.5	−22.02	−25.98
	1	−22.17	−29.70
	1.5	−24.41	−30.10
	2	−21.24	−24.24
	2.5	−20.42	−30.57
Broadband card without external antenna/Yagi	0.5	−17.79	−23.86
	1	−23.38	−29.58
	1.5	−26.19	−27.41
	2	−32.38	−37.18
	2.5	−31.14	−32.81
Broadband card/direct input	0	+20.46	+19.50

These additional measurements show mainly two things:

1) the transmit power of the mobile terminal is higher in an upload session than in a download session;

2) the mobile terminal almost reaches the maximum transmit power (according to the specifications, i.e. 21 dBm).

7 Set-top box sensitivity testing

A series of tests were performed on a number of selected Australian and European set-top boxes (STB), which also included a USB stick receiver, to determine the sensitivity of each receiver and its susceptibility to interference caused by other signals transmitting at adjacent and image channels.

The conducted tests are described as follows:

– Sensitivity: Each receiver was fed with a DVB-T wanted signal level at one particular carrier frequency and the level was decreased. The threshold level immediately before the first picture break up was observed and recorded.

– Adjacent channel: Each receiver was fed with fixed DVB-T wanted signal levels (−40 dBm/−60 dBm) and mixed with an interferer DVB-T signal. The interferer signal was operating at the immediate upper and lower adjacent channel of the wanted signal. The interferer signal level was increased in constant steps. When the first picture break up was observed, the interferer level was recorded.

– Image channel: Each receiver was fed with fixed DVB-T wanted signal levels (−40 dBm/−60 dBm) and mixed with an interferer DVB-T signal. The interferer signal was operating at 9/10/11 channels above the wanted signal. The interferer signal level was increased in constant steps. When the first picture break up was observed, the interferer level was recorded.

All results are tabulated in the following tables:

Tables 5 and 8 outline the sensitivity of the Australian and European STBs, respectively, whereas Tables 6 and 9 show the achievable protection ratio of the respective STBs. The achievable protection ratios of the majority tested STBs are highlighted in red as they did not meet the expected protection ratios for adjacent and image channels, which are commonly defined at −30 dB and −40 dB, respectively. Given that Australian broadcasters also provide DVB-T services via VHF Band III spectrum, similar sensitivity and adjacent channel tests were conducted on Australian STBs in VHF Band III frequencies. The respective results are tabulated in Table 7.

TABLE 5

Sensitivity of Australian STBs operating in 7 MHz channel raster

		Wanted signal			**Interference signal**				
Model	**Sensiti-vity (dBm)**	**Freq. (MHz)**	**Ch.**	**Signal level (dBm)**	**Adjacent interferer (n+1) (dBm)**	**Adjacent interferer (n-1) (dBm)**	**Image interferer (n+9) (dBm)**	**Image interferer (n+10) (dBm)**	**Image interferer (n+11) (dBm)**
STB1-7 MHz	−84.8	704.5	53	−40	−13.7	−16.5	1.1	−4.0	−0.8
				−60	−31.8	−34.2	−11.8	−24.8	−21.3
STB2-7 MHz	−83.1	704.5	53	−40	−11.5	−14.4	5.6	−1.7	3.1
				−60	−32.0	−35.2	−12.0	−22.0	−17.2
STB3-7 MHz	−81.2	704.5	53	−40	−13.2	−12.7	0.9	−7.3	−3.3
				−60	−29.5	−27.5	−11.9	−26.5	−23.2
STB7-7 MHz (USB)	−81.3	704.5	53	−40	−19.6	−20.1	−14.6	−13.3	−12.2
				−60	−34.4	−28.5	−19.1	−21.0	−20.7

TABLE 6

Australian STBs achievable protection ratios

Model	Signal level (dBm)	Carrier/interference: Adjacent interferer (n+1) (dB)	Adjacent interferer (n-1) (dB)	Image interferer (n+9) (dB)	Image interferer (n+10) (dB)	Image interferer (n+11) (dB)
STB1-7 MHz	−40	−26.3	−23.5	−41.1	−36.0	−39.2
	−60	−28.2	−25.8	−48.2	−35.2	−38.7
STB2-7 MHz	−40	−28.5	−25.6	−45.6	−38.3	−43.1
	−60	−28.0	−24.8	−48.0	−38.0	−42.8
STB3-7 MHz	−40	−26.8	−27.3	−40.9	−32.7	−36.7
	−60	−30.5	−32.5	−48.1	−33.5	−36.8
STB7-7 MHz (USB)	−40	−20.4	−19.9	−25.4	−26.7	−27.8
	−60	−25.6	−31.5	−40.9	−39.0	−39.3

TABLE 7

Sensitivity and achievable protection ratios of Australian STBs operating in VHF band III

		Wanted signal			Interference signal		Carrier/Interference	
Model	Sensitivity (dBm)	Freq. (MHz)	Ch.	Signal level (dBm)	Adjacent interferer (n+1) (dBm)	Adjacent interferer (n-1) (dBm)	Adjacent interferer (n+1) (dB)	Adjacent interferer (n-1) (dB)
STB1-7 MHz	−69.1	198.5	9	−40	−9.7	−12.2	−30.3	−27.8
				−60	−26.2	−26.9	−33.8	−33.1
STB2-7 MHz	−73.1	198.5	9	−40	−15.0	−15.0	−25.0	−25.0
				−60	−33.2	−35.2	−26.8	−24.8
STB3-7 MHz	−81.7	198.5	9	−40	−9.7	−8.1	−30.3	−31.9
				−60	−29.6	−29.0	−30.4	−31.0

TABLE 8

Sensitivity of European STBs operating in 8 MHz channel raster

Model	Sensiti-vity (dBm)	Wanted signal Freq. (MHz)	Wanted signal Ch.	Wanted signal Signal level (dBm)	Interference signal Adjacent interferer (n+1) (dBm)	Interference signal Adjacent interferer (n-1) (dBm)	Interference signal Image interferer (n+9) (dBm)
STB6-8 MHz	−83.0	786	60	−40	−7.9	−11.2	6.2
				−60	−27.5	−30.9	−12.8
STB8-8 MHz	−81.2	786	60	−40	−8.9	−8.8	8.7
				−60	−26.2	−32.2	−12.7
STB5-8 MHz	−81.5	786	60	−40	−9.5	−11.6	−4.6
				−60	−23.2	−29.0	−22.5
STB9-8 MHz	−81.8	786	60	−40	−12.0	−11.0	−10.9
				−60	−25.8	−30.1	−15.5
STB4-8 MHz	−81.6	786	60	−40	−11.1	−12.6	−7.7
				−60	−23.2	−26.3	−24.1
STB10-8 MHz	−81.1	786	60	−40	−11.1	−8.3	−8.5
				−60	−23.7	−23.7	−14.4
STB11-8 MHz (USB)	−81.3	786	60	−40	−17.3	−17.5	−12.3
				−60	−33.8	−34.9	−15.7

TABLE 9

European STBs achievable protection ratios

Model	Signal level (dBm)	Carrier/interference: Adjacent interferer (n+1) (dB)	Carrier/interference: Adjacent interferer (n-1) (dB)	Carrier/interference: Image interferer (n+9) (dB)
STB6-8 MHz	−40 −60	−32.1 −32.5	−28.8 −29.1	−46.2 −47.2
STB8-8 MHz	−40 −60	−31.1 −33.8	−31.2 −27.8	−48.7 −47.3
STB5-8 MHz	−40 −60	−30.5 −36.8	−28.4 −31.0	−35.4 −37.5
STB9-8 MHz	−40 −60	−28.0 −34.2	−29.0 −29.9	−29.1 −44.5
STB4-8 MHz	−40 −60	−28.9 −36.8	−27.4 −33.7	−32.3 −35.9
STB10-8 MHz	−40 −60	−28.9 −36.3	−31.7 −36.3	−31.5 −45.6
STB11-8 MHz (USB)	−40 −60	−22.7 −26.2	−22.5 −25.1	−27.7 −44.3

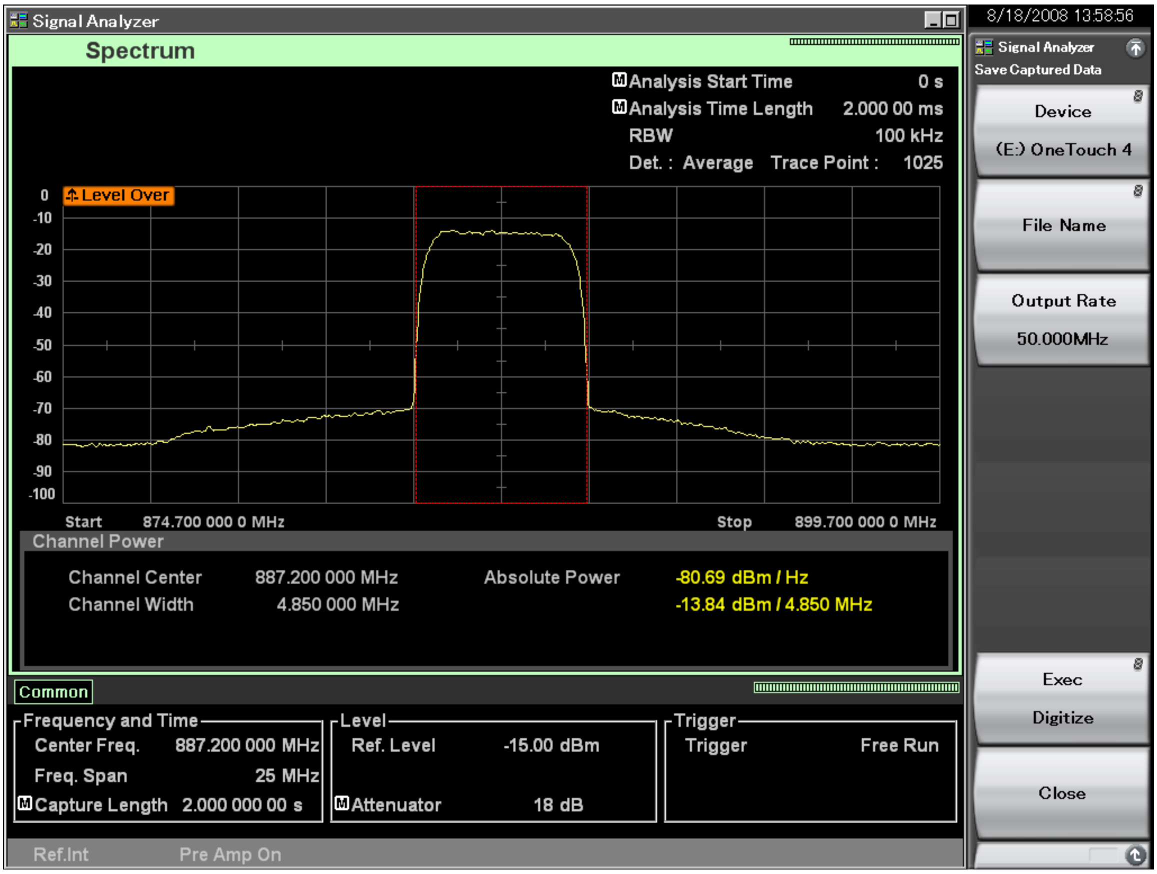
8 Field survey results

8.1 Downlink signal analysis

8.1.1 Downlink signal spectrum shape

FIGURE 23

Spectrum chart at Gosse Court (picked up via a phased array antenna at 10 m height)



8.1.2 Downlink signal levels received with a roof top antenna

Table 10 summarizes the measurements made with the vehicle equipped with the 10 m mast.

TABLE 10

Summary of downlink signal measurements made with the vehicle equipped with the 10 m mast

Site	ERP W	Study location GPS	Distance (m)	Received input power (dBm)	Comments
Gosse Court	40.6	33 47 24.2 S 150 47 37.2 E	463	−40	
Gosse Court	40.6	33 47 31.5 S 150 47 22.4 E	28	−29	Vertical antenna pattern has an effect
Gosse Court	40.6	33 47 31.0 S 150 47 24.0 E	65	−14.5	Signal captured for off-line measurements
Potter Field	39.5	33 47 08.2 S 150 47 18.9 E	140	−22.5	Vertical and horizontal polar identical
Shepherd Street	501	33 47 28.6 S 150 48 07.2 E	467	−49	
Shepherd Street	501	33 47 31.4 S 150 48 17.0 E	282	−36	
Shepherd Street	501	33 47 34.8 S 150 48 21.7 E	308	−37	
Shepherd Street	501	33 47 22.5 S 150 48 24.5 E	80	−16.5	Vertical and horizontal polar identical

Two main outcomes are:

1) the three measured base stations use mixed polarization, this eliminates the possible protection of the broadcasting fixed reception using antenna polarization discrimination (however an equivalent protection of 3 dB is already there as the transmit power is divided equally between the two polarizations);
2) the levels received at the receiver input could reach relatively high values (a signal level of −14.5 dBm was received at a distance of 65, in a point located between houses equipped with roof top antennas, see table above).

Taking into consideration the measured levels, two typical levels were selected for the compatibility tests:

- −20 dBm representing high level of interference, and
- −40 dBm representing intermediate level.

8.1.3 Downlink signal levels received with a portable antenna

A significant number of measurements were collated from the study locations described in § 4. Examples are shown in § 5. They include measured levels of input signals received from the base stations with a portable receiving antenna.

The main outcomes are:

1) the levels received from base stations with portable antennas (Yagi, dipole) exceed −20 dBm at certain locations. The levels measured in Sydney suburbs and in the city range from −20 to −62 dBm;

2) in areas of high traffic (in the city) two downlink signals are measured, sometimes with equal levels (see § 5);

3) the signal received from a base station in an urban environment with high traffic varies continuously. It reaches its maximum level by frequent bursts. For this reason, measured levels are obtained from max-hold plots of channel power.

8.1.4 Compatibility tests

According to the methodology described in § 3.4, with the availability of a signal analyser that is capable of digitizing the captured UMTS uplink/downlink signals and down-converting the respective signals to a nominated frequency for analyses, both downlink and uplink studies were conducted in a laboratory environment.

Tables 11 and 12 below show a synthesis of these measurements for Australian set-top boxes (7 MHz signal bandwidth) and for European set-top boxes (8 MHz signal bandwidth) respectively. The aim of this form of presentation is to assess:

− the required guardband for the two selected levels of UMTS signals at the DVB-T receiver input;

− the allowable level of UMTS signal at the DVB-T receiver input for given values of guardbands and for the image channel configuration.

TABLE 11

Synthesis of compatibility tests with downlink interference for Australian set-top boxes (7 MHz signal bandwidth)

Average allowable level of the UMTS input (dBm)	UMTS input (dBm)	Guardband at limit of coverage area Pw = −80 dBm (MHz)	Average allowable level of the UMTS input (dBm)	UMTS input (dBm)	Guardband inside the coverage area Pw = −60 dBm (MHz)	Set-top boxes
Required guardband for a given unwanted signal level						
	−20	Overload		−20	5.725	STB1-7 MHz
	−20	Overload		−20	6.425	STB2-7 MHz
	−20	Overload		−20	8.925	STB3-7 MHz
	−40	7.325		−40	0	STB1-7 MHz
	−40	5.625		−40	0	STB2-7 MHz
	−40	9.325		−40	0	STB3-7 MHz
Maximum allowable unwanted signal level for a given guardband						
−43.4	−42.3	5.025	−22.7	−21	5.025	STB1-7 MHz
	−40.5	5.025		−21.5	5.025	STB2-7 MHz
	−47.5	5.025		−25.5	5.025	STB3-7 MHz
−49.5	−49.5	1.025	−30.2	−30	1.025	STB1-7 MHz
	−46.5	1.025		−29.5	1.025	STB2-7 MHz
	−52.5	1.025		−31	1.025	STB3-7 MHz
−54.5	−53.5	0.025	−33.7	−32.5	0.025	STB1-7 MHz
	−53	0.025		−33	0.025	STB2-7 MHz
	−57	0.025		−35.5	0.025	STB3-7 MHz
Maximum allowable unwanted signal level for image channel configuration						
−54.5	−44	64.625	−24.5	−22.5	64.625	STB1-7 MHz
	−33	66.025		N/A	66.025	STB2-7 MHz
	−48.5	66.025		−26.5	66.025	STB3-7 MHz

TABLE 12

Synthesis of compatibility tests with downlink interference for European set-top boxes (8 MHz signal bandwidth)

Average allowable level of the UMTS input (dBm)	UMTS input (dBm)	Guardband at limit of coverage area Pw = −80 dBm (MHz)	Average allowable level of the UMTS input (dBm)	UMTS input (dBm)	Guardband inside the coverage area Pw = −60 dBm (MHz)	Set-top boxes
Required guardband for a given unwanted signal level						
	−20	Overload		−20	6.525	STB4-8 MHz
	−20	Overload		−20	32.225	STB5-8 MHz
	−20	Overload		−20	32.025	STB6-8 MHz
	−40	5.925		−40	0	STB4-8 MHz
	−40	15.525		−40	0	STB5-8 MHz
	−40	9.525		−40	0	STB6-8 MHz
Maximum allowable unwanted signal level for a given guardband						
−44.7	−41	5.025	−23.7	−21.5	5.025	STB4-8 MHz
	−44.5	5.025		−22.5	5.025	STB5-8 MHz
	−48.5	5.025		−27	5.025	STB6-8 MHz
−48.3	−45	1.525	−28.2	−27	1.525	STB4-8 MHz
	−48	1.525		−27	1.525	STB5-8 MHz
	−52	1.525		−30.5	1.525	STB6-8 MHz
−54.3	−55.5	0.025	−32.3	−34.5	0.025	STB4-8 MHz
	−53.5	0.025		−30	0.025	STB5-8 MHz
	−54	0.025		−32.5	0.025	STB6-8 MHz
Maximum allowable unwanted signal level for image channel configuration						
−42.2	−47	65.025	−20.0	−25.5	65.025	STB4-8 MHz
	−46.5	65.525		−23	65.525	STB5-8 MHz
	−33	65.525		−11.5	65.525	STB6-8 MHz

8.1.5 Analysis

The measured levels of the downlink UMTS signal at the receiver input is to be compared to the average allowable level for each guardband.

Table 13 below shows the main outcome of this analysis. See explanation and discussion below the table.

TABLE 13

Analysis of the compatibility tests results

Guardband (MHz)	Maximum allowable level (dBm)	Possible received level at around 100 m (dBm)	Assumed interfering e.i.r.p (dBm)	Lack of protection (dB)	Possible additional protection by cross-polarization valid only for fixed reception (dB)[9]	Possible additional protection by improved filtering (reduction of out-of-band emission level) assumption (dB)	Remaining lack of protection (dB)	Maximum allowable power (dBm)	Maximum allowable power (W)
Interior of the broadcasting coverage area (Wanted level at receiver input: −60 dBm)									
0	−33	−14	46	−19	13	6	0	46	40
1	−29	−14	46	−15	13	6	4	50	100
5	−23	−14	46	−9	13	6	10	56	398
Image channel	−22	−14	46	−8	13		5	51	126
Edge of the broadcasting coverage area (Wanted level at receiver input: −80 dBm)									
0	−54	−14	46	−40	13	6	−21	25	0.32
1	−49	−14	46	−35	13	6	−16	30	1.00
5	−44	−14	46	−30	13	6	−11	35	3.16
Image channel	−42	−14	46	−28	13		−15	31	1.26

[9] The “nominal” protection by cross-polarization is 16 dB according to Recommendation ITU-R BT.419. However, as the BS uses slant polarization, half of the power is delivered in each polarization (H and V). The measured level with a linearly polarized antenna of a slant polarization signal affords already a 3 dB protection. Therefore, the use of full cross-polarization would only afford 13 (i.e. 16-3) dB additional protection.

The −60 dBm level of the DVB-T wanted signal corresponds to the interior of the broadcast coverage area of a broadcasting transmitter. For this wanted signal level, and with no guardband (0.025 MHz), the average allowable UMTS signal level is −33.7 dBm for the Australian STBs and −32.7 dBm for the European STBs. A common level of −33 dBm is considered in the following.

For fixed reception through roof top antennas, the measurements have shown that the UMTS signal at the receiver input could reach levels as high as −14 dBm at typical distances between houses and base stations transmitting at 40 W e.i.r.p. (46 dBm). In this configuration, a lack of protection of −19 dB is noted. Using cross polarization between the UMTS base station and the DVB-T transmitter would afford an additional 13 dB (in addition to the 3 dB protection due to the use of slant polarization; see footnote under Table 13). Moreover, improved filtering of the base station signal could afford additional protection by reducing the out-of-band emission level which falls in the broadcasting channel. This possible additional protection is assumed here to be 6 dB, but assessing its effective value would require laboratory measurements with different out-of-band levels. With these measures, the lack of protection would be cancelled and the e.i.r.p of 46 dBm could therefore be used in this configuration. If higher e.i.r.p.s are foreseen, the table shows that a guardband would be needed. A guardband of 5 MHz permits an average allowable UMTS signal level of −22.7 dBm for the Australian STBs and −23.7 dBm for the European STBs according to the compatibility tests. A common level of −23 dBm is considered. This would permit a 10 dB increase of the e.i.r.p., up to 56 dBm (398 W).

The −80 dBm level of the DVB-T wanted signal corresponds to the edge of the broadcast coverage area. For this wanted signal level and with no guardband (0.025 MHz), the average allowable UMTS signal level is −54.5 dBm for the Australian STBs and −54.3 dBm for the European STBs. A common level of −54 dBm is considered in the following. A similar analysis as above shows that in this case the configuration with no guardband is very restrictive in terms of maximum allowable e.i.r.p (25 dBm or 0.32 W). As above, a 5 MHz guardband would permit a 10 dB increase of the maximum allowable e.i.r.p., up to 35 dBm (3.16 W).

Concerning the image channel (72 MHz frequency offset for the European set-top boxes and around 70 MHz frequency offset for the Australian set-top boxes), the maximum allowable unwanted signal level is −42 dBm (average between −41.8 dBm for Australian set-top boxes and −42.2 dBm for European set-top boxes), corresponding to a wanted DVB-T signal representative of the edge of broadcast coverage area, and −20 dBm (average between −24.5 dBm for Australian set-top boxes and −20 dBm for European set-top boxes), corresponding to a wanted DVB-T signal representative of the interior of the coverage area. The reduction of the out-of-band emission level has no effect on the protection as the interference is caused by translation of the interfering image channel into the wanted channel at intermediate frequency. The cross-polarization is still effective to improve protection. The e.i.r.p. limitation resulting from the consideration of the image channel is significant and numerically close to the limitation corresponding to a guardband of 1 MHz. However, the tests have shown large differences between the receivers with regard to their immunity to image channel interference. The risk of image channel interference for a given e.i.r.p. of the mobile service downlink and a given wanted DVB-T signal level will depend on the type of set-top box used in the vicinity of the base station. Installation of rejection filters at the victim receiver side could be the ultimate solution to solve the possible cases of interference.

For the protection of portable DVB-T reception, the maximum UMTS received levels at several points in suburban and urban areas range from −20 to −62 dBm. It was not possible to identify which base station(s) was measured in the urban area and what was the corresponding e.i.r.p. However, available information suggests that there is a mixture of different e.i.r.p. values like 0.06 W, 5.6 W, 31.6 W and 501 W. Further investigation would therefore be needed with regard to the impact of the downlink on portable DVB-T reception.

8.2 Uplink signal analysis

8.2.1 Uplink signal spectrum shape

FIGURE 24

Spectrum of the UMTS uplink signal (generated with an HSDPA card with direct connection between the antenna socket and the spectrum analyser)

The screen shot above shows the spectrum of the UMTS uplink signal generated with an HSDPA card with direct connection between the antenna socket and the spectrum analyser. Therefore, the level of −5.6 dBm corresponds approximately to the output power of the terminal. This power level is determined by the network according to the link budget between the terminal and the base station. According to the UMTS specifications, a UMTS terminal can have a maximum transmit power of +21 dBm or +24 dBm depending on its category.

The screen shot shows a significant level of out-of-band emissions of the terminal in the adjacent bands (shoulders) but also spurious emissions at larger frequency separations. The attenuation of the shoulders is in the order of −45 dB relative to the in-band emission level. The spurious emissions are between −45 and −60 dB below the signal level.

8.2.2 Uplink signal levels received with a roof top antenna

TABLE 14

UMTS uplink signal perceived from fixed rooftop antenna (phased array)

UMTS uplink signal perceived from fixed rooftop antenna (phased array) Frequency = 842.15 MHz

0 dBm output from signal generator with 3 dB cable loss, 0.9 dBd gain, effective radiated power is −2.1 dBm ERP or 0 dBm e.i.r.p.

Dipole as Tx antenna and phased array as fixed antenna

In axis means both antennas are tilted to form direct LoS

Off axis means phased array antenna is not tilted

Line No.	Antenna	Polarization	Height agl (m)	Distance (m)	Ch. power (dBm)	Remark
1	Dipole Phased array	Vertical Vertical	0.8 5	7.2	−38	In axis
2	Dipole Phased array	Horizontal Horizontal	0.8 5	7.2	−39	In axis
3	Dipole Phased array	Vertical Vertical	0.8 10	10.2	−44	In axis
4	Dipole Phased array	Horizontal Horizontal	0.8 10	10.2	−43	In axis
5	Dipole Phased array	Vertical Horizontal	0.8 5	7.2	−57	In axis
6	Dipole Phased array	Vertical Horizontal	0.8 10	10.2	−64	In axis
7	Dipole Phased array	Horizontal Vertical	0.8 10	10.2	−58	In axis
8	Dipole Phased array	Vertical Vertical	0.8 10	10.2	−53	Off axis
9	Dipole Phased array	Horizontal Horizontal	0.8 10	10.2	−56	Off axis
10	Dipole Phased array	Vertical Horizontal	0.8 10	10.2	−59	Off axis
11	Dipole Phased array	Horizontal Vertical	0.8 10	10.2	−56	Off axis

Assuming a minimum distance between the mobile UMTS terminal and the DVB-T fixed roof top antenna of 10 m, the following considerations are made to select the typical levels to be used for the compatibility tests:

– In the configuration "in axis": The polarization discrimination offers, according to these measurements, an attenuation of the unwanted signal between 15 and 20 dB depending on the combination of the polarizations between the two parts. However, the polarization of the uplink signal depends on the real position and orientation of the mobile terminal, which cannot be fully controlled. Therefore, for the compatibility tests, the assumed level is taken from the configuration, in line 4, corresponding to the horizontal polarization of both signals. This level is −43 dBm for an e.i.r.p. of 0 dBm. It is −22 dBm for an e.i.r.p. of 21 dBm which is the maximum transmit power in the UMTS specifications.

– In the configuration "off axis": for the same argument as above, the assumed level is taken from the configuration, in line 9, corresponding to the horizontal polarization of both signals. This level is −56 dBm for an e.i.r.p. of 0 dBm. It is −35 dBm for an e.i.r.p. of 21 dBm, which is the maximum transmit power in the UMTS specifications.

8.2.3 Uplink signal levels received with an indoor portable antenna

Within many administrations, particularly in high-density and non-owner occupied accommodation, DTV television reception is by way of indoor television antennas. This is the case in Australia. However, it is observed that the planning guidelines for DVB-T reception in Australia do not take into account portable indoor reception and building penetration loss; as is the case in some European countries.

Section 6.2 showed the uplink signal levels received with an indoor Yagi antenna from a UMTS mobile terminal in a house located in a Sydney suburban area. It should be noted that the Sydney residential suburban area where the measurements were carried out is covered with multiple UMTS base stations offering therefore an adequately high level of the downlink signal. In this configuration, the link budget requires a low level of mobile transmit power and the TPC will keep this mobile transmit power low.

In § 6.2.1, the levels measured at distances from 0.5 to 2.5 m between the mobile terminal and the portable indoor receiving antenna have been reproduced with the signal generator at a transmit power level of −24 dBm.

Section 6.2.2 shows the effect of the TPC on the mobile transmit power in a configuration where the link budget requires an increased power level. In an urban area where a low level of the downlink signal was received, the transmit power of the mobile terminal was increased to +15.5 dBm which is close to the maximum transmit power in the UMTS specifications.

The main outcomes are:

1) the levels received from mobile terminals with portable indoor Yagi antennas reach −11 dBm at certain locations. The levels measured in Sydney suburbs and in the city range from −11 to −48 dBm;

2) the signal received from a mobile terminal in an urban environment with high traffic varies continuously. It reaches its maximum level by frequent bursts.

Based on these measurements, three levels of the uplink signal were selected for the compatibility tests:

• −11 dBm: this is the maximum level received with the Yagi antenna at 0.5 m from the mobile terminal in a location where the TPC has set the transmit power to +15.5 dBm;

• −36 dBm: this is an intermediate level;

- −57 dBm: this is close to the lowest level measured from the uplink at 2.5 m separation distance between the mobile terminal and the portable indoor antenna. This was measured in a location where the TPC has set the transmit power to around −24 dBm.

8.2.4 Compatibility tests

Like in § 8.1.4, and according to the methodology described in § 3, compatibility tests have been carried out in a laboratory environment by regenerating the uplink signal captured in the field. This ensures that the spectral and temporal characteristics of the signal are consistent with the implemented UMTS downlink signal.

Table 15 below shows a synthesis of these measurements, with the aim to assess:

− the required guardband for the three typical levels of UMTS signals at the DVB-T receiver input;

− the allowable level of UMTS signal at the DVB-T receiver input for given values of guardband and for the image channel configuration.

TABLE 15

Synthesis of compatibility tests with uplink interference for Australian set-top boxes (7 MHz signal bandwidth)

Average level of the UMTS input (dBm)	UMTS input (dBm)	Guardband at limit of coverage area Pw = −80 dBm (MHz)	Average level of the UMTS input (dBm)	UMTS input (dBm)	Guardband inside the coverage area Pw = −60 dB m (MHz)	Set-top boxes
Required guardband for a given unwanted signal level						
	−11	Infinity		−11	39.375	STB1-7 MHz
	−11	Infinity		−11	15.375	STB2-7 MHz
	−11	Infinity		−11	22.675	STB3-7 MHz
	−36	20.175		−36	2.875	STB1-7 MHz
	−36	13.475		−36	2.975	STB2-7 MHz
	−36	14.075		−36	10.475	STB3-7 MHz
	−57	2.975		−57	0.075	STB1-7 MHz
	−57	2.675		−57	0.075	STB2-7 MHz
	−57	3.075		−57	0.075	STB3-7 MHz
Maximum allowable unwanted signal level for a given guardband						
−52.3	−52	5.075	−35	−30	5.075	STB1-7 MHz
	−51.5	5.075		−31.5	5.075	STB2-7 MHz
	−53.5	5.075		−43.5	5.075	STB3-7 MHz
−63.5	−63.5	1.075	−45.5	−44.5	1.075	STB1-7 MHz
	−63	1.075		−42.5	1.075	STB2-7 MHz
	−64	1.075		−49.5	1.075	STB3-7 MHz
−67.5	−67.5	0.075	−48.5	−47.5	0.075	STB1-7 MHz
	−67	0.075		−47.5	0.075	STB2-7 MHz
	−68	0.075		−50.5	0.075	STB3-7 MHz
Maximum allowable unwanted signal level for image channel configuration						
−44.3	−46.5	64.675	−27.3	−24.5	64.675	STB1-7 MHz
	−35.5	66.075		N/A	66.075	STB2-7 MHz
	−51	66.075		−30	66.075	STB3-7 MHz

TABLE 16

Synthesis of compatibility tests with uplink interference for European set-top boxes (8 MHz signal bandwidth)

Average level of the UMTS input (dBm)	UMTS input (dBm)	Guardband at limit of coverage area Pw = −80 dBm (MHz)	Average level of the UMTS input (dBm)	UMTS input (dBm)	Guardband inside the coverage area Pw = −60 dBm (MHz)	Set-top boxes
Required guardband for a given unwanted signal level						
	−11	Infinity		−11	22.175	STB4-8 MHz
	−11	Infinity		−11	37.675	STB5-8 MHz
	−11	Infinity		−11	51.475	STB6-8 MHz
	−36	14.675		−36	2.975	STB4-8 MHz
	−36	31.975		−36	2.175	STB5-8 MHz
	−36	15.275		−36	9.775	STB6-8 MHz
	−57	2.675		−57	0.075	STB4-8 MHz
	−57	2.975		−57	0.075	STB5-8 MHz
	−57	2.775		−57	0.075	STB6-8 MHz
Maximum allowable unwanted signal level for a given guardband						
−52.5	−51.5	5.075	−35.2	−31.5	5.075	STB4-8 MHz
	−52.5	5.075		−28.5	5.075	STB5-8 MHz
	−53.5	5.075		−45.5	5.075	STB6-8 MHz
−61.0	−61	1.575	−43.2	−40	1.575	STB4-8 MHz
	−62	1.575		−38	1.575	STB5-8 MHz
	−60	1.575		−51.5	1.575	STB6-8 MHz
−66.8	−66.5	0.075	−48.2	−46.5	0.075	STB4-8 MHz
	−68	0.075		−44.5	0.075	STB5-8 MHz
	−66	0.075		−53.5	0.075	STB6-8 MHz
Maximum allowable unwanted signal level for image channel configuration						
−44.3	−49	65.575	−22.8	−29	65.575	STB4-8 MHz
	−49	65.575		−26.5	65.575	STB5-8 MHz
	−35	65.575		−13	65.575	STB6-8 MHz

8.2.5 Analysis

With the −60 dBm level of the wanted DVB-T signal, representative of the interior of the broadcast coverage area of a broadcasting transmitter, the following conclusions may be drawn:

1) An unwanted uplink signal level of −11 dBm requires a large guardband, between 15 MHz for the best case and 51 MHz for the worst case, depending on the selectivity of the receiver.

2) An intermediate uplink signal level of −36 dBm requires a guardband between 2 and 10 MHz depending on the receiver. On the other hand, a guardband of 5 MHz would allow a maximum UMTS uplink signal level of −35 dB on average.

With the −80 dBm level of the wanted DVB-T signal, representative of the edge of the coverage area, the following conclusions may be drawn:

3) The high level of −11 dBm would interfere with the wanted DVB-T signal, whatever the frequency separation. The receiver front end is overloaded with such a high signal level.

4) The intermediate level of −36 dBm requires a guardband between 13 MHz and 32 MHz depending on the receiver. On the other hand, a guardband of 5 MHz would allow a maximum UMTS uplink signal level of −52 dBm on average.

In order to take into consideration the possible wanted DVB-T signal levels between the edge of the broadcast coverage area and the interior of this coverage area, a guardband between 7 MHz (intermediate between 2 and 13 MHz) and 21 MHz (intermediate between 10 and 32 MHz) would be required.

Concerning the image channel configuration, the maximum allowable unwanted signal level is between −44.3 dBm (same for Australian and European tested set-top boxes), corresponding to a wanted DVB-T signal representative of the edge of the broadcast coverage area, and −24.6 dBm (average between −22.8 dBm for Australian set-top boxes and −27.3 dBm for European set-top boxes) corresponding to a wanted signal representative of the interior of the broadcast coverage area. Furthermore, the tests have shown large differences between the receivers with regard to their immunity to image channel interference. With an unwanted signal level at the intermediate level of −36 dBm, there might be cases of image channel interference on some types of receivers when receiving close to the edge of the broadcast coverage area. The installation of image channel rejection filters at the victim receiver side could be the ultimate solution to solve the possible cases of interference.

It was observed during the measurement that when the downlink signal at one location is weakly received, the respective uplink signal is often bursty. It is believed that the TPC is activated under a weak downlink environment. When a data/voice call is first initiated, an extremely high impulsive uplink signal can be observed. The network is then endeavoured to manipulate the TPC in order to reduce the uplink signal as the call is established. However, intermittent bursts can still be observed throughout the call. As could be expected, the transmit power of the mobile terminal is higher in an upload session than in a download session and it can almost reach the maximum transmit power (according to specifications, i.e. 21 dBm).

9 Call for further studies

This study has described field and laboratory interference measurements undertaken within the coverage area of an operating UMTS (WCDMA) network and provided analysis of the impact on DVB-T reception from a UMTS base station and mobile terminal transmissions. This analysis provides insights into a case of compatibility based upon the UMTS network design, base station architectural structures and cellular service characteristics in one country.

The collaborators of this study would encourage ITU-R to call for more studies on this topic so that the globally harmonized compatibility can be realized not only from the theoretical studies the JTG may perform but from actual UMTS and DTTB deployments across the regions.

10 Definitions

Guardband: frequency separation between the upper edge of one service and the lower edge of another service to achieve frequency planning compatibility between these services.

Frequency separation: difference between the centre frequencies of two channels.

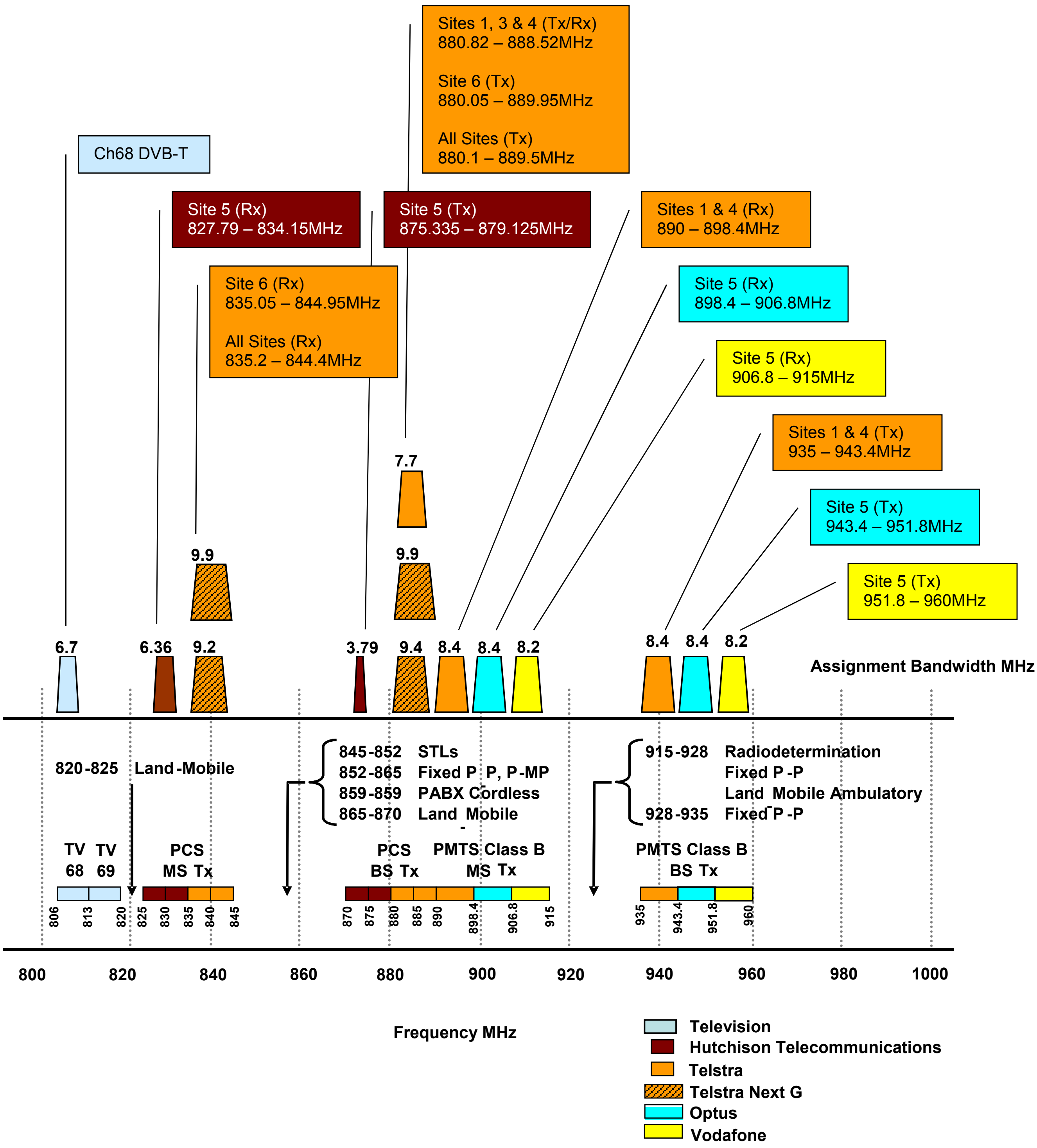
Annex 1

UMTS and DVB-T sharing study site − St Clair

884.67 MHz | 884.8 MHz | 885 MHz | 877.23 MHz

Annex 2

Channel plan and assignments



Chapter 2

Field study of uplink and downlink signals

1 Introduction

This study supports previous measurements and provides insights into a case of compatibility based upon the UMTS network design, base station architectural structures and cellular service characteristics.

The study analyses the characteristics of:

− Uplink; i.e. user equipment power levels, in the band 825-845 MHz;

− downlink; i.e. base station power levels, in the band 870-890 MHz;

within urban, suburban and rural broadcasting environments in Australia. Refer to Appendix 1 for more information on Australian radio frequency spectrum allocations in the band 750-900 MHz.

The objectives of this study are:

a) to measure the uplink power levels directly from the output of a user equipment which is positioned at 1.5 m above ground level and has an established uplink connection with a base station located in urban, suburban and rural broadcasting environments, respectively;

b) to measure the downlink power levels of the base station located in urban, suburban and rural broadcasting environments, respectively, via an external TV receive antenna positioned at 10 m above ground level.

The outcome of this study would help assessing the impact of output power levels from base stations and user equipment onto other incumbent services operating in adjacent bands, e.g. broadcast services.

2 Methodology

2.1 Uplink measurements

By connecting a spectrum analyser to the antenna output of a UMTS user equipment via a patch antenna adaptor, and positioning the user equipment at a height of approximately 1.5 m above ground, the uplink measurements were carried out according to the following steps:

1) Capture the spectrum plot for the frequency range of 750-900 MHz in max-hold mode of the spectrum analyser to observe the instantaneous level (dBm) when uplink connection is initially established without any upload/download activity.

2) Measure uplink power level (dBm/5 MHz) on the respective uplink channel raster.

3) Repeat the above steps when the user equipment is continuously uploading data.

2.2 Downlink measurements

By connecting a spectrum analyser to an external TV receive antenna positioned at 10 m above ground level, directional to the location of the respective base station, the downlink measurements were carried out according to the following steps:

1) Capture the spectrum plot for the frequency range of 750-900 MHz to observe the instantaneous transmit level (dBm) from the respective base station at some distance away.

2) Measure downlink power level (dBm/5 MHz) on the respective downlink channel raster.

3) Repeat the above steps at ±2 m from the respective location, if practicable, to check that the measurement is not affected by significant variation due to reflections and/or multipath effects.

2.3 Equipment used in the measurements

A calibrated Agilent E4440 spectrum analyser was used to measure all results presented in this study.

The user equipment used in the uplink measurements is a mobile data card with a PCMCIA interface that can be attached to a laptop computer. Measurements were conducted in an outdoor environment using a SIM card registered to the carrier network.

The receive antenna used in the downlink measurements is a 6-element Yagi antenna with a 17.5 dB front-to-back ratio, 9 dBd antenna gain and 50 Ω output impedance. It was connected to a 12 m long RG58-CU feeder cable with 8.7 dB cable loss tested at 850 MHz.

3 Locations selected for this study

The locations chosen for the survey are considered urban, suburban and rural broadcasting environments in Australia. Note that any technical information, e.g. antenna height, panel directions, maximum effective radiation power[10] (e.r.p.) levels and antenna tilt angle of base stations considered in this study were sourced from a register of radiocommunication licences[11].

3.1 Suburban environment

In the context of this study a suburban environment can be categorized as areas, usually residential, but with much less high rise clutter. It is observed that the UMTS network base station configuration in suburban areas often comprises mostly medium power (30-40 W e.i.r.p.) base stations with a few high power (398 W and/or 501 W e.r.p.) base stations. It is also noted that only one downlink channel, either 880-885 MHz or 885-890 MHz, is occupied within the coverage of a suburban environment.

As with the previous field studies reported in Annexes 1 and 2, these suburban studies were also conducted in and around St Clair − in the western suburbs of Sydney.

A number of previous and additional measurement locations in St Clair and its nearby suburbs were selected for this study and they include:

− Shepherd Street (33 47 22.56 S/150 48 23.03 E, refer to Fig. 15)

− Augusta Place (33 47 35.08 S/150 48 23.66 E)

− Gosse Court (33 47 30.87 S/150 47 24.26 E, refer to Fig. 16)

− Ballarat Avenue (33 47 29.16 S/150 47 13.49 E)

− Potter Field (33 47 7.79 S/150 47 17.62 E, refer to Fig. 17)

− Underwood Road (33 47 21.95 S/150 47 34.20 E)

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[10] Power levels for some base stations are quoted in e.r.p. due to the unavailability of e.i.r.p. values for these base stations registered in the online database.

[11] This register is maintained by the Australian Communications and Media Authority (ACMA) and published in this link: http://web.acma.gov.au/pls/radcom/register_search.main_page.

FIGURE 25

Base station at Shepherd Street cul-de-sac, St Clair

3.2 Urban environment

In the studies described in Annexes 1 and 2, ground level measurements were undertaken in a number of urban environments in central and northern Sydney city. The UMTS network configuration in urban environments in Sydney comprises a mixture of low power (0.06-2 W e.i.r.p.), medium power (30-40 W e.i.r.p.) and high power (398 W and/or 501 W e.r.p.) base stations scattered in close proximity, often with overlapped coverage. It is also noted that two downlink channels 880-885 MHz and 885-890 MHz are occupied within the coverage of these urban environments.

The previous surveys in the urban areas of Sydney as reported in Annexes 1 and 2, present considerable difficulties to deploy a field survey vehicle mounted with a 10 m telescopic mast in and around a crowded urban/business district environment without contravening a number of government regulations.

An alternative high-rise clutter urban area selected for this study is Parramatta. The central business district of Parramatta emulates a similar UMTS network configuration to those found in other crowded urban/business district environments.

Two measurement locations in Parramatta were selected for this study:

− Parramatta Park facing Marsden Street base station (33 48 44.72 S/150 59 48.74 E, refer to Fig. 26);

− Rear of Mercure Hotel base station (33 49 04.13 S/151 1 13.47 E, refer to Fig. 27).

FIGURE 26

Base station at Marsden Street, Parramatta

FIGURE 27

Base station at Mercure Hotel

3.3 Rural environment

For this study the selected rural environments are areas with low-population density and minimal building-like clutter. In many rural cities in Australia, there is a concentration of communications facilities at or nearby to positions of dominant elevated terrain to provide services such as terrestrial radio/television broadcast, mobile trunked network and point-to-point links into the respective areas. Some UMTS base stations are co-sited with these communications facilities, with many of these base stations classified as high power (398 W and/or 501 W e.r.p.).

An operating cell (Sloping Hummock) located to the east of the rural city of Bundaberg in Queensland, Australia, is considered to be an environment typical of populated rural (border) regions. The Sloping Hummock base station tower (refer to Fig. 28) is upon an elevated extinct volcano rising above a large sugar cane growing area.

The base station located at Sloping Hummock is at some distance (i.e. further than the cell coverage) from the populated town centre of Bundaberg. It was noted that another high power (501W e.r.p.) base station is at East Bundaberg (refer to Fig. 29) to complement the UMTS network coverage in this area. During the field survey, it was noted that two (or all three) downlink channels in 875-880 MHz, 880-885 MHz and/or 885-890 MHz are utilized in this rural environment.

A number of measurement locations in and around Sloping Hummock and East Bundaberg (namely Rural Case A) were selected for this study:

– Finemore Crescent cul-de-sac (24 50 36.7 S/152 25 26.6 E)
– Rehbein Avenue (24 50 26.3 S/152 25 37.5 E)
– Cattermull Avenue (24 50 51.6 S/152 24 28.3 E)
– Corner of Fe Walker Road and Windermere Road (24 51 22.3 S/152 24 21.3 E)
– Fe Walker Road (24 51 43.7 S/152 23 55.5 E)
– Hill Street (24 51.13.1 S/152 22 2.3 E)
– Hofer Crescent (24 51 19.1 S/152 22 40.2 E)
– Corner of Victoria Street and Ann Street (24 51 31.6 S/152 22 15.8 E)
– Corner of Victoria Street and Scotland Street (24 51 43.7 S/152 22 4.9 E)
– Collins Street (24 51 13.9 S/152 22 20.8 E).

FIGURE 28

Base station at Sloping Hummock, East of Bundaberg

FIGURE 29

Base station at East Bundaberg

To compare the characteristics of an operating UMTS base station site in a rural environment, this study also covered another area that exhibits a similar network configuration to that found at Sloping Hummock. It is located at Goulburn, a rural town centre in New South Wales, Australia.

Goulburn is also served by one high power (501 W e.r.p.) base station located at a dominant elevated terrain, Mt Gray (refer to Fig. 30), which is also the site of various other communications facilities. Similarly, another high power (501 W e.r.p.) base station is found at Goulburn city centre (refer to Fig. 31) to complement the UMTS network coverage.

A number of measurement locations in and around Goulburn (namely Rural Case B) were selected for this study:

- Mt Gray South (34 45 30.90 S/149 45 47.30 E)
- Mt Gray North (34 45 21.22 S/149 45 48.59 E)
- Sydney Road service station (34 44 54.25 S/149 44 57.78 E)
- Corner of Chiswick Street and Common Street (34 45 26.94 S/149 44 48.06 E)
- Goulburn Woodworks (34 44 09.69 S/149 44 11.52 E)
- Blackshaw Road (34 45 27.60 S/149 43 19.55 E)
- Goldsmith Street School (34 44 59.81 S/149 43 06.25 E)
- Corner of Australia Street and Bourke Street (34 45 35.13 S/149 42 37.82 E)
- Tourist Centre (34 45 19.78 S/149 43 15.59 E)
- Market Place (34 45 28.31 S/149 43 01.18 E)
- Corner of Bathurst Street and Emma Street (34 45 37.82 S/149 43 42.38 E).

FIGURE 30

Base station at Mt Gray, East of Goulburn

FIGURE 31

Base station at Goulburn city centre

4 Main results

4.1 Uplink measurements

The user equipment (i.e. PCMCIA card) was positioned at approximately 1.5 m above ground level during outdoor uplink measurements. Figures 32 to 38 are results of the measurements taken directly from the external antenna port of the user equipment via a patch antenna adaptor.

There are three lines in these figures individually representing: i) the average uplink channel power emitted from the user equipment when it was continuously uploading a large file as an attachment onto a webmail server; ii) the average uplink channel power emitted from the user equipment when an uplink connection was initially established (without upload/download activity); and iii) the downlink levels as received by the internal antenna embedded in the user equipment.

The first two lines are provided to indicate differences in uplink power levels when the user equipment establishes initial connection and when the user equipment continuously uploads data. The third line is included to provide some insight into the correlation between uplink and downlink levels. However, this only gives an indication of the downlink levels as received by the internal antenna of the user equipment through the antenna output. More data on this characteristic is not available due to insufficient information being readily available from the manufacturer of the internal antenna and the receiver design of this user equipment.

Note that the average channel power is determined in channel power mode by averaging 100 samples at 300 kHz resolution bandwidth (Res BW) within a 5 MHz channel bandwidth.

FIGURE 32

Average uplink channel power in suburban environments − St Clair

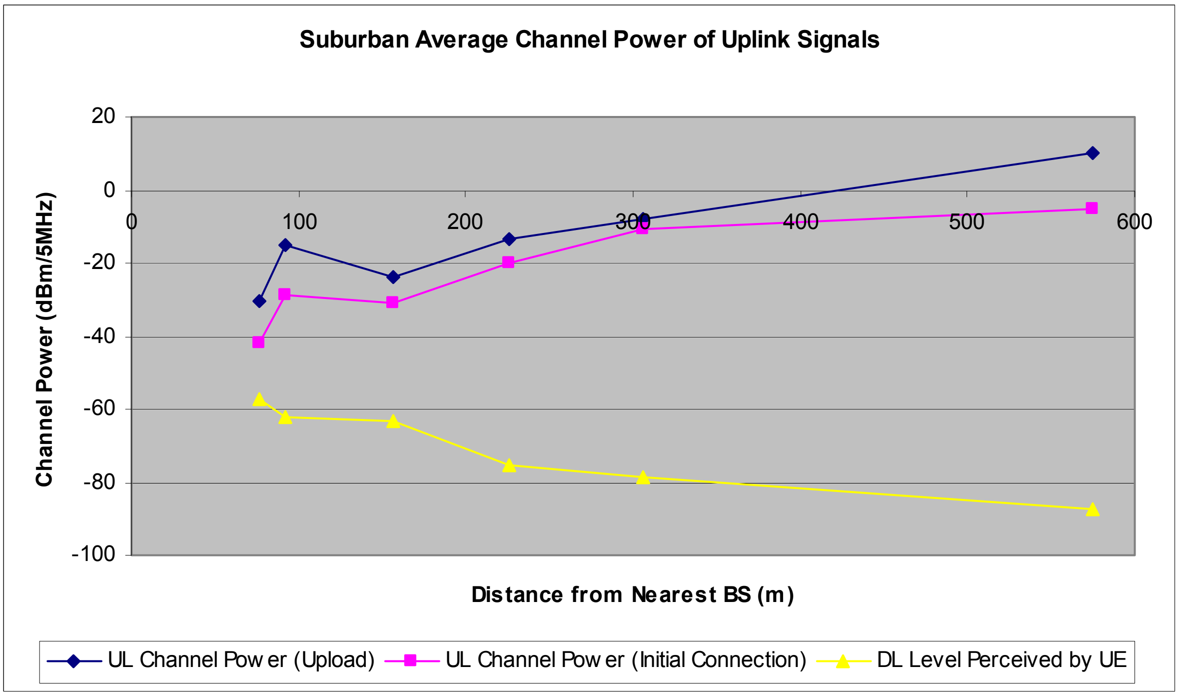


FIGURE 33

Average uplink channel power in urban environments – Parramatta

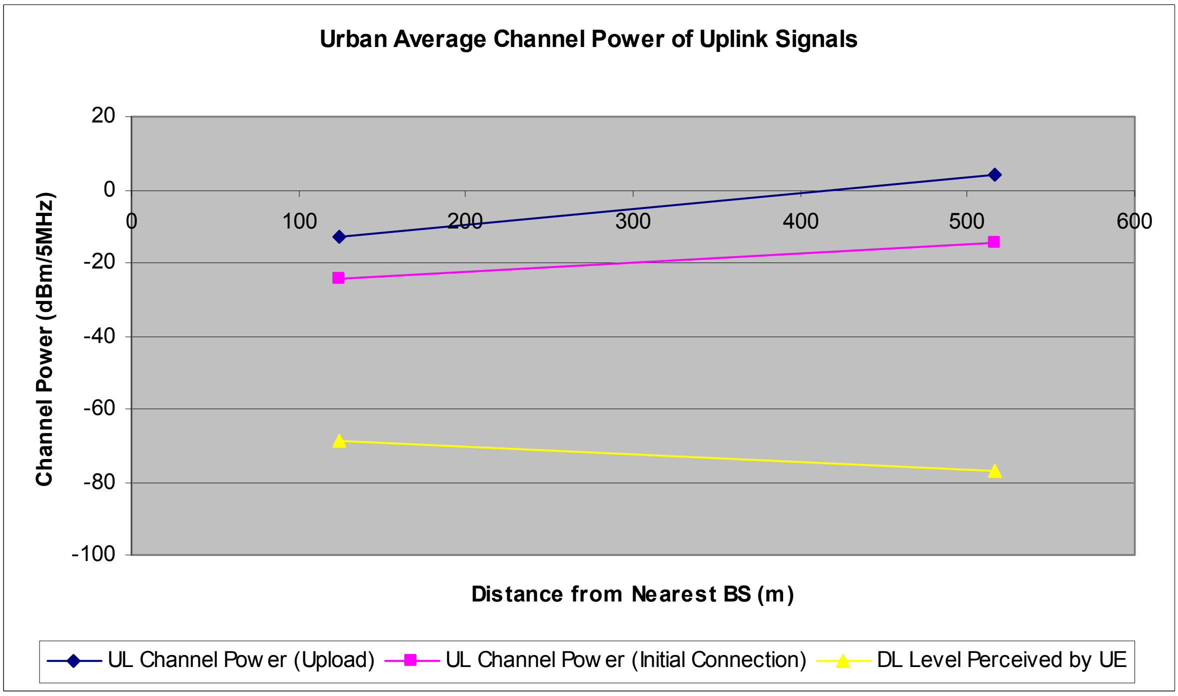


FIGURE 34

Average uplink channel power in rural environments − Case A (Sloping Hummock)

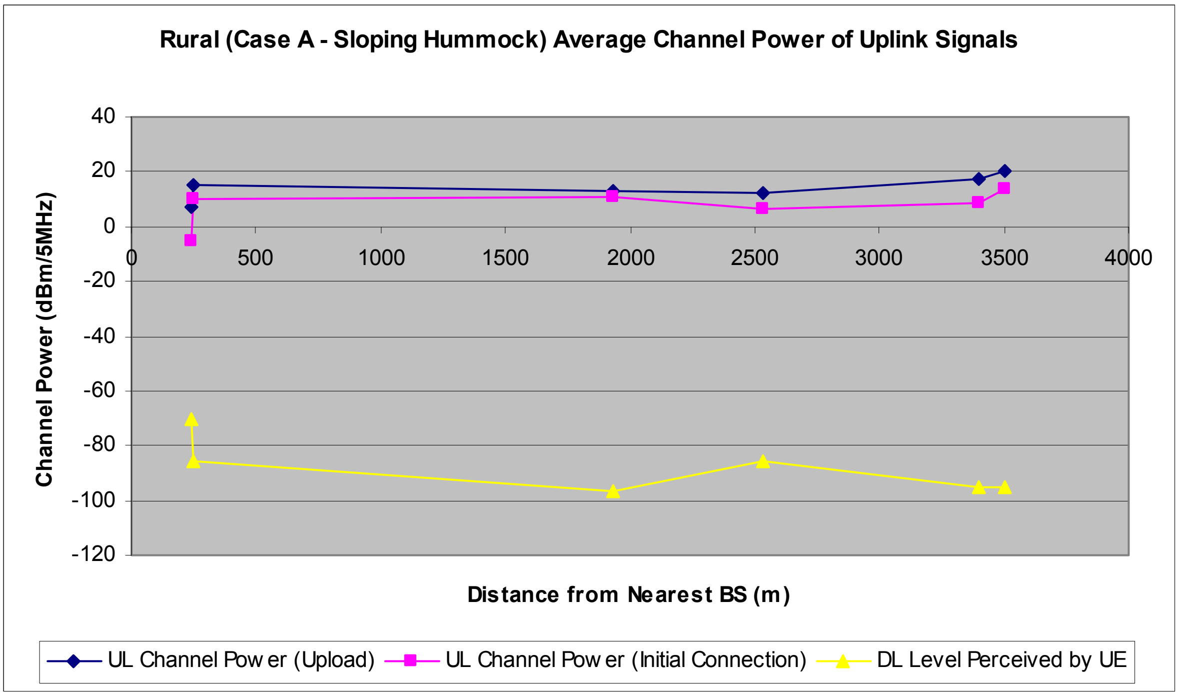


FIGURE 35

Average uplink channel power in rural environments – Case A (East Bundaberg)

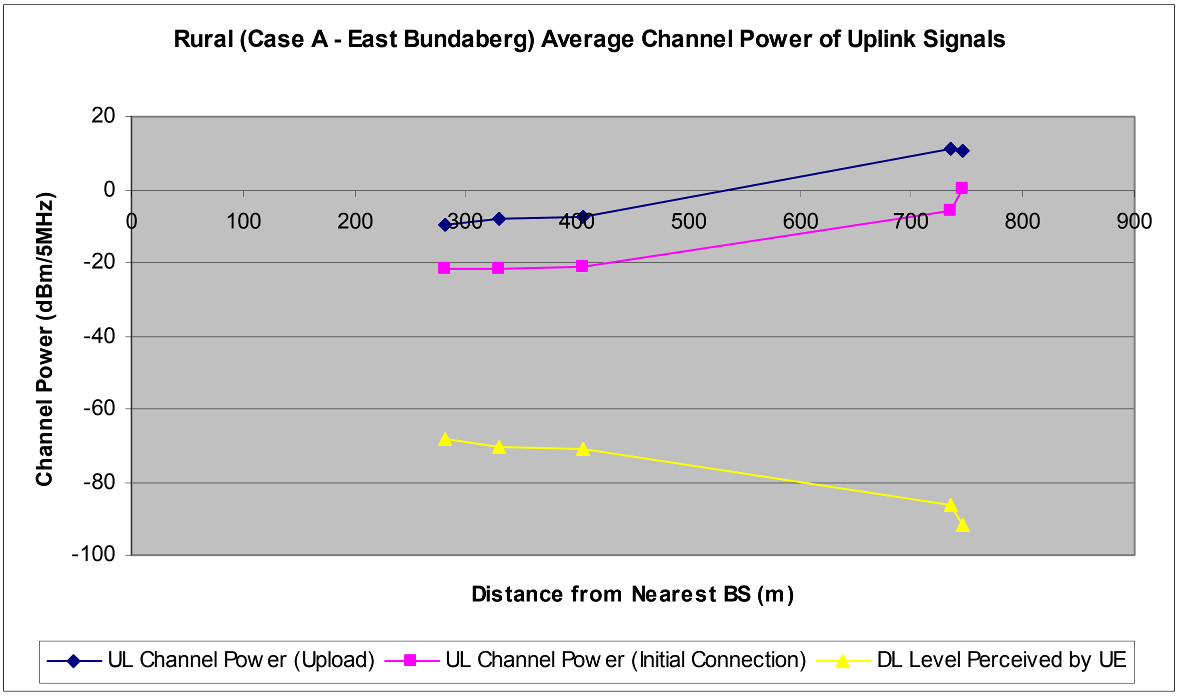


FIGURE 36

Average uplink channel power in rural environments – Case B (Mt Gray)

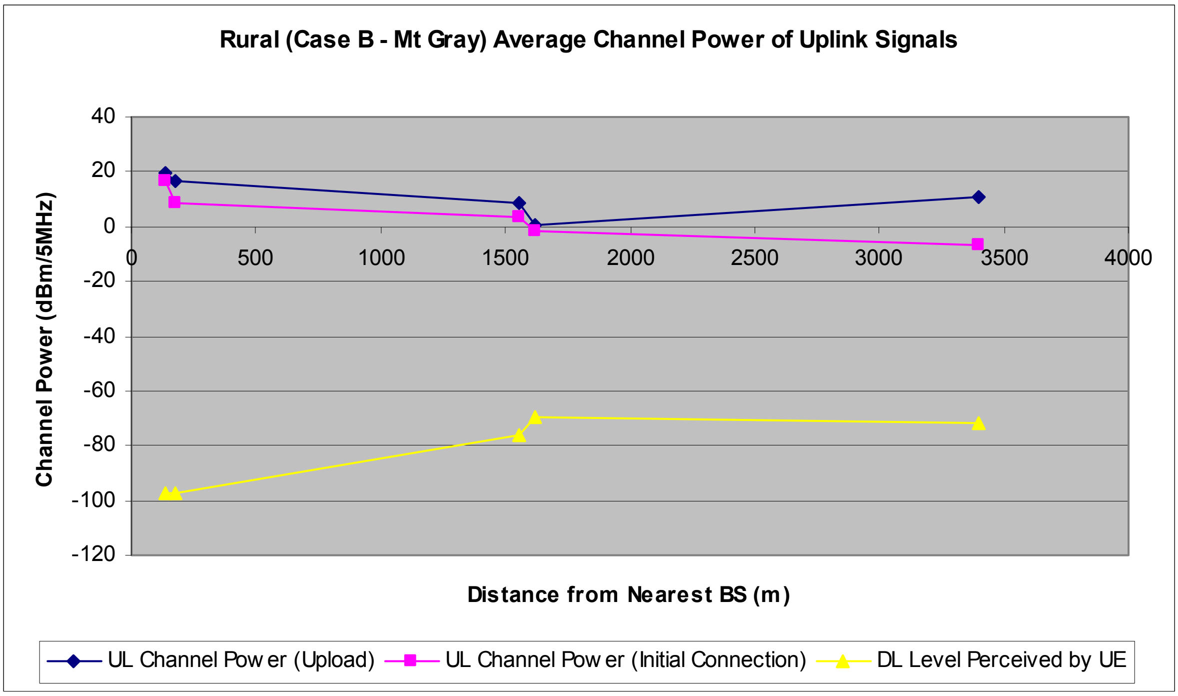


FIGURE 37

Average uplink channel power in rural environments – Case B (Goulburn city)

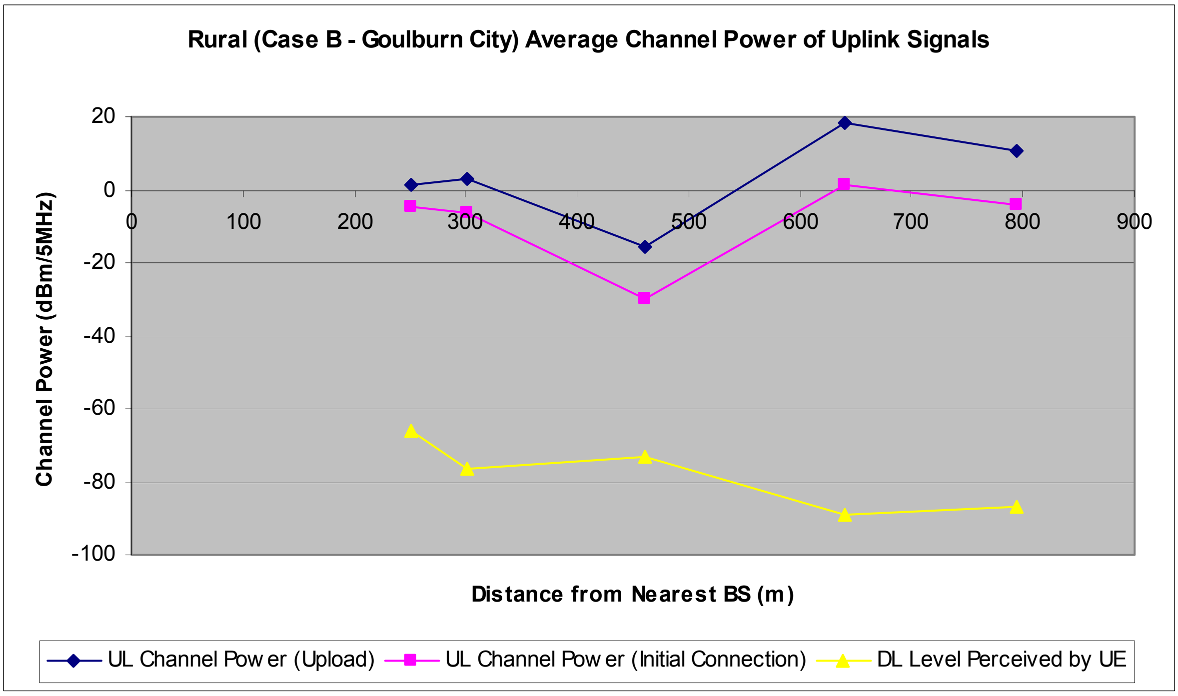
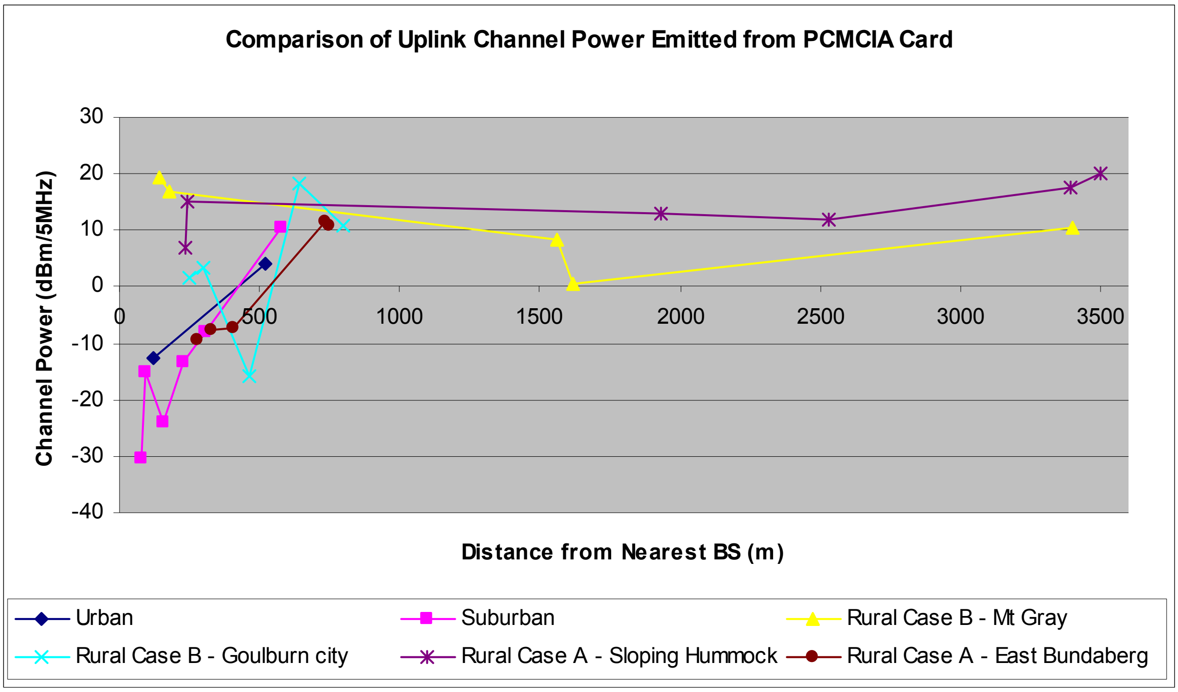


FIGURE 38

Comparison of average uplink channel power in different environments



4.2 Downlink measurements

Figures 39 to 45 are results of the downlink channel power measured from an external TV receive antenna directional to the respective base stations. The receive antenna was mounted on the telescopic mast of the field survey vehicle at 10 m above ground level. Note that the average channel power is determined in channel power mode by averaging 100 samples at a 300 kHz resolution bandwidth (Res BW) within a 5 MHz channel bandwidth.

FIGURE 39

Average downlink channel power in suburban environments − St Clair

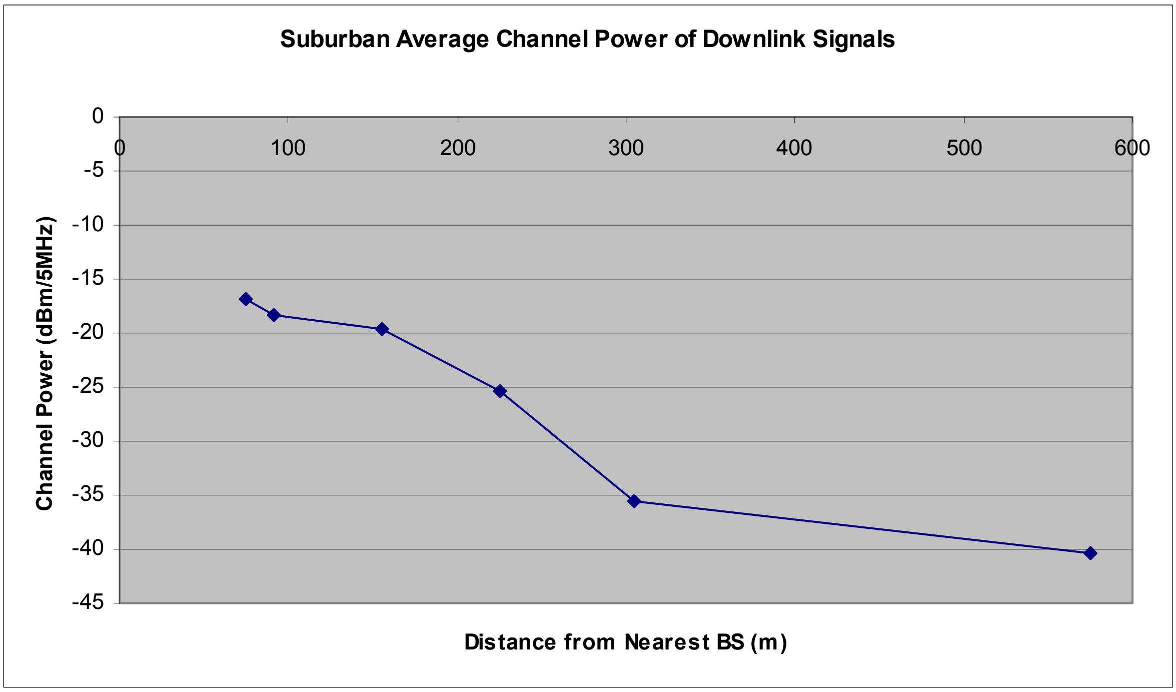


FIGURE 40

Average downlink channel power in urban environments − Parramatta

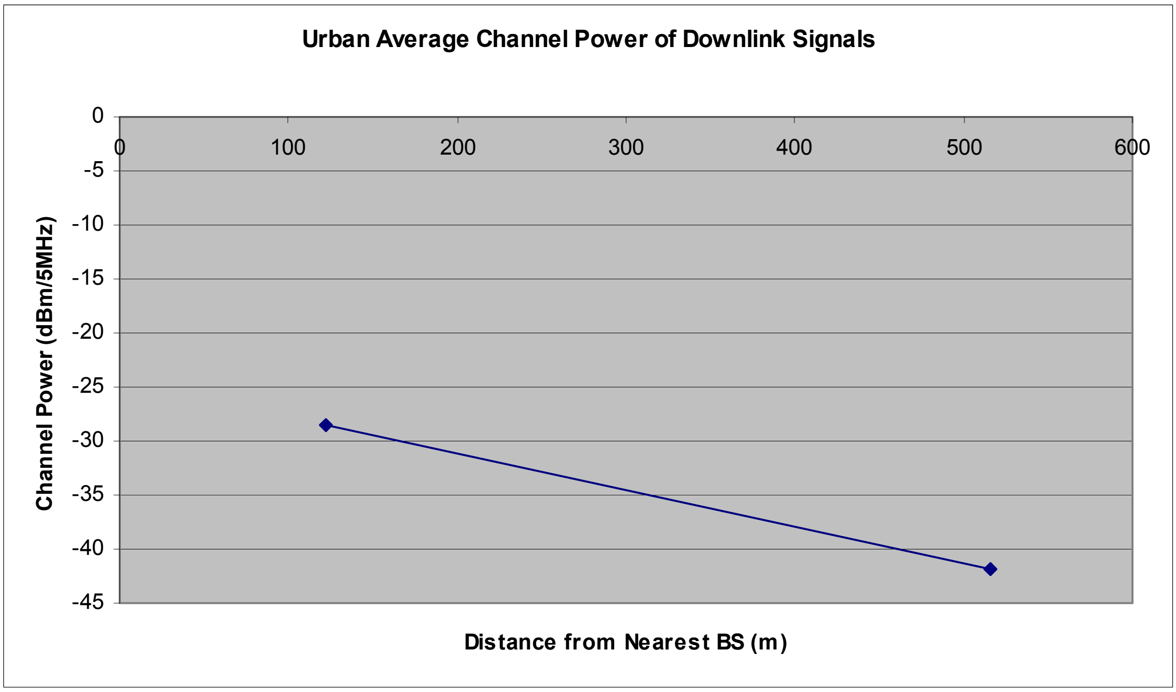


FIGURE 41

Average downlink channel power in rural environments – Case A (Sloping Hummock)

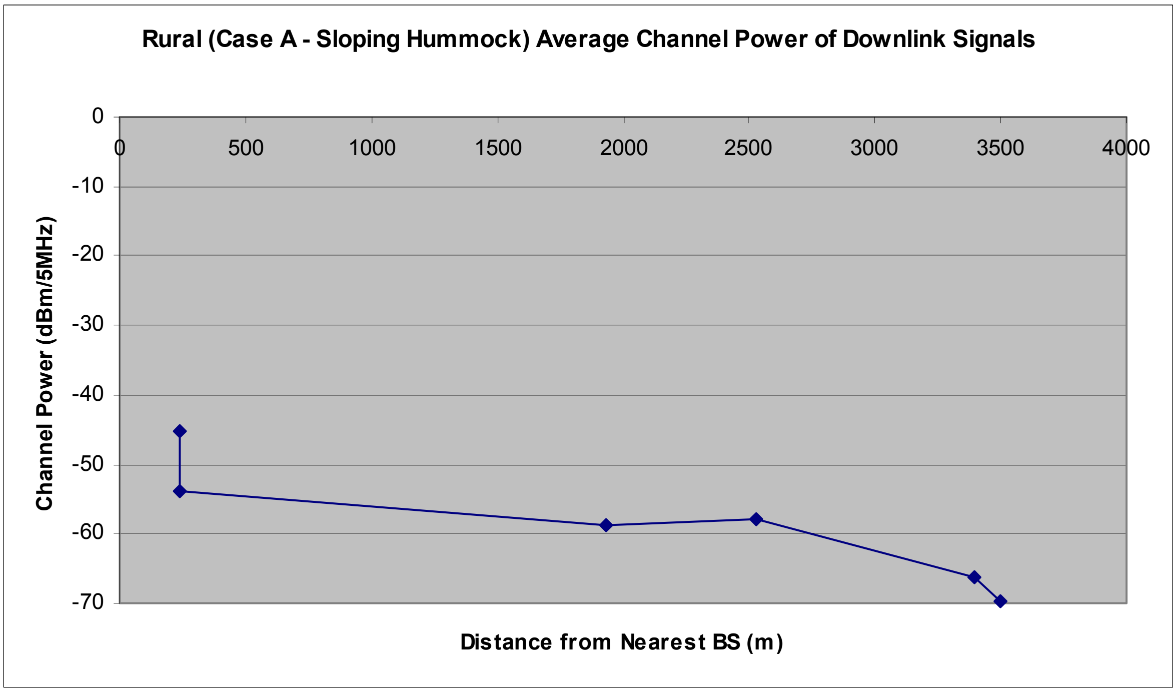


FIGURE 42

Average downlink channel power in rural environments – Case A (East Bundaberg)

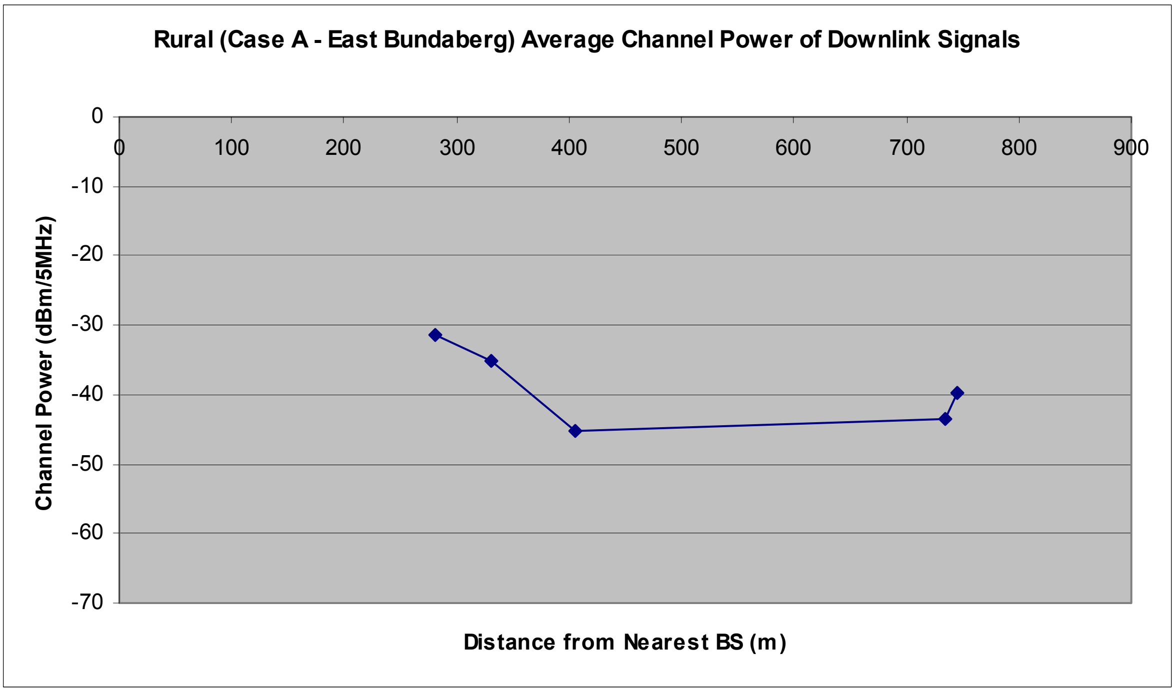


FIGURE 43

Average downlink channel power in rural environments – Case B (Mt Gray)

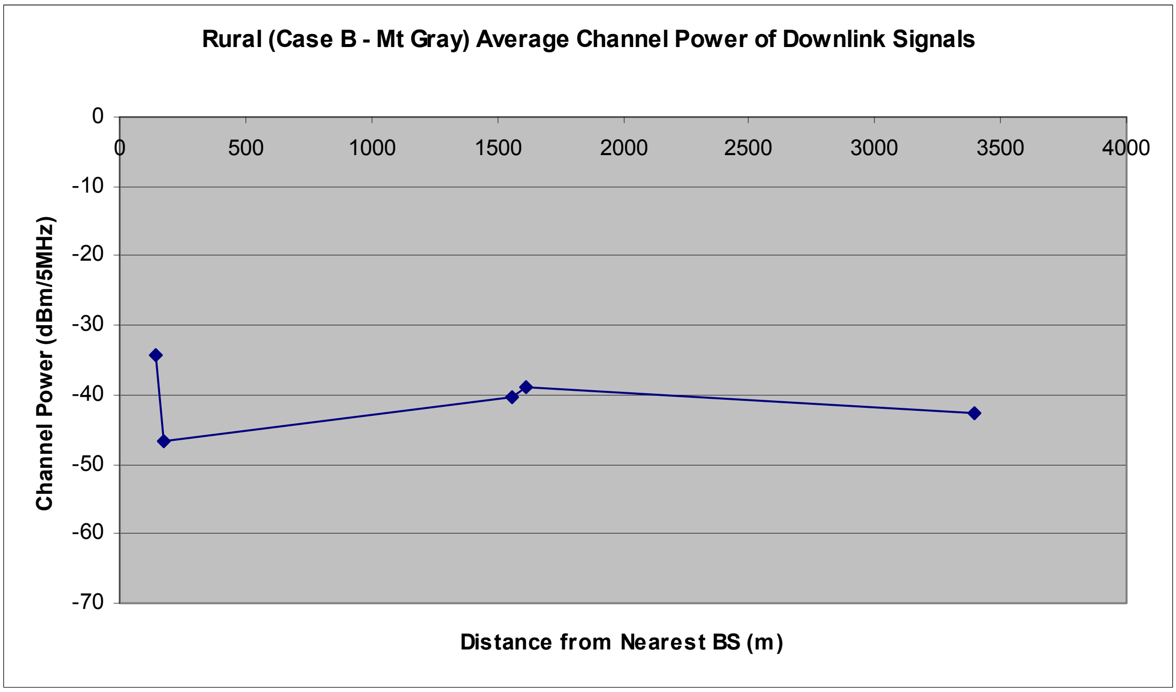


FIGURE 44

Average downlink channel power in rural environments – Case B (Goulburn city)

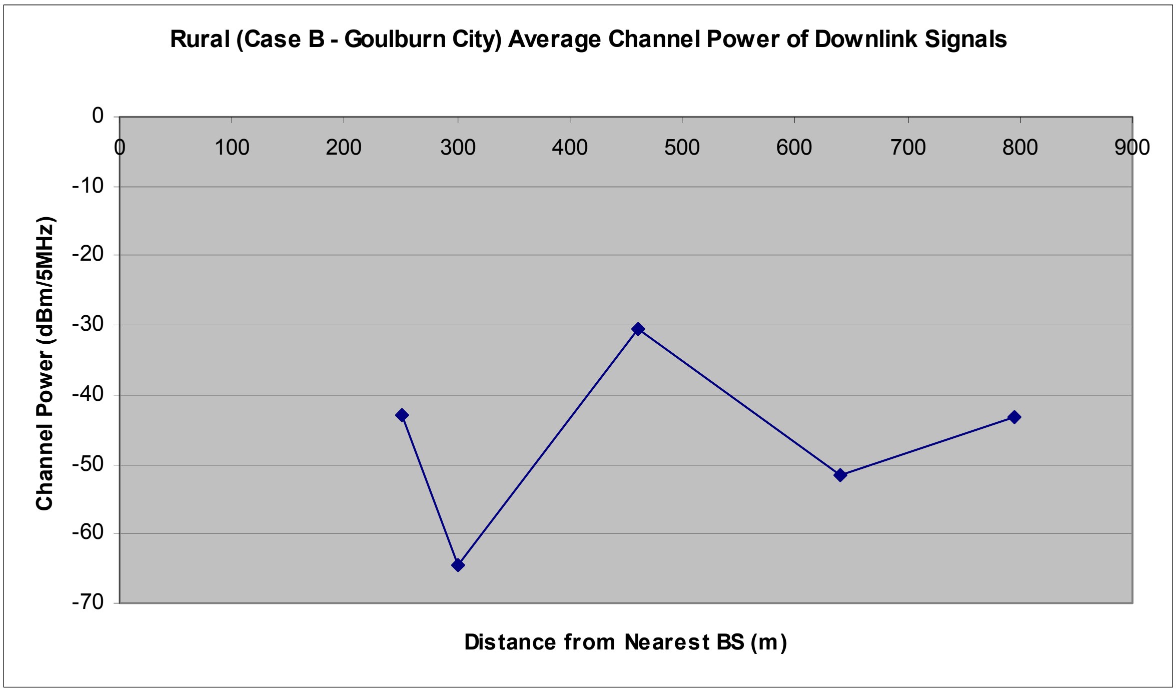
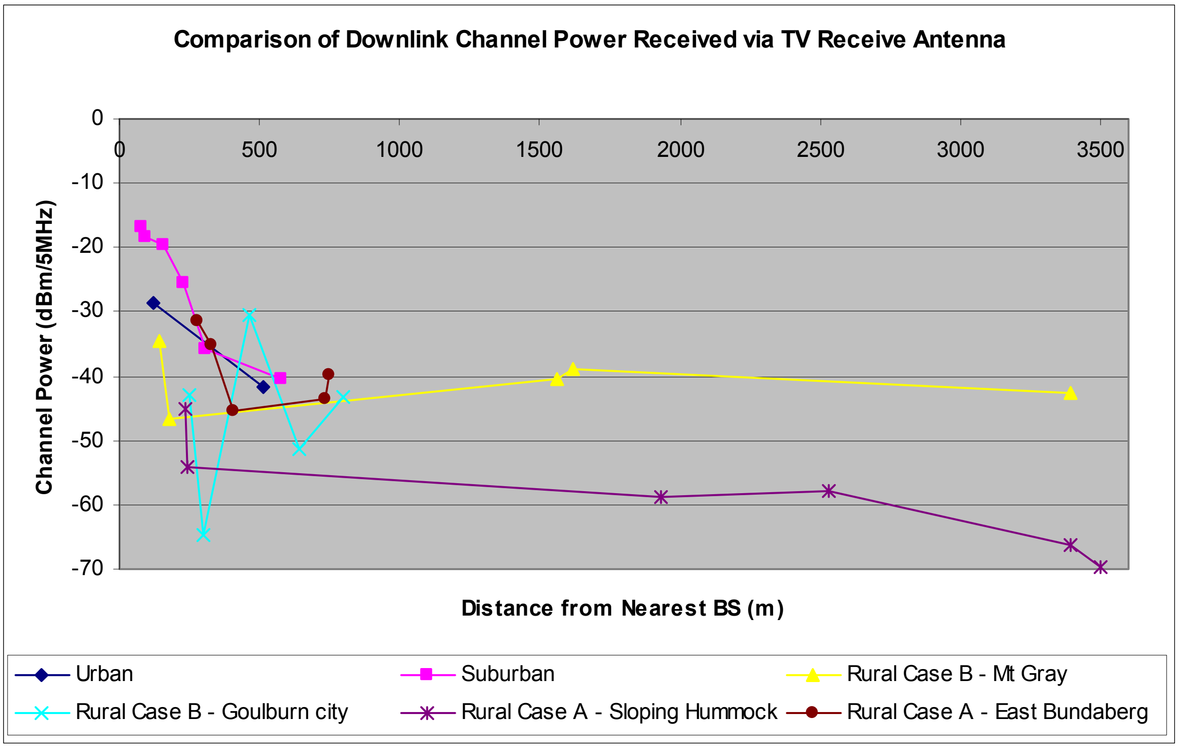


FIGURE 45

Comparison of average downlink channel power in different environments



5 Analysis and observations

5.1 Observations on uplink measurements (via PCMCIA Card)

In Fig. 32 (Suburban), Fig. 33 (Urban) and Fig. 35 (Rural Case A − East Bundaberg), the uplink channel power and the corresponding downlink levels (received by the internal antenna of the PCMCIA card) exhibit similar patterns relating to the magnitude of power levels. The uplink channel power measured in the range of −30 dBm/5 MHz to −10 dBm/5 MHz at some proximity (< 500 m) to the respective base stations. Measurements recorded further away from the base station indicate that the uplink channel power increases to +10 dBm/5 MHz or more. However, it does not reach the maximum output power of user equipment at the level of +24 dBm/5 MHz (+1/−3 dB tolerance) for power class 3 or +21 dBm/5 MHz (±2 dB tolerance) for power class 4 as specified in § 6.2.1 of 3GPP TS 25.101.

The first three measurement points as shown in Fig. 37 (Rural Case B − Goulburn city) were not consistent and portrayed a dissimilar pattern to those observed in Figs. 32, 33 and 35. Since the base station in Goulburn City is located in the midst of the township as shown in Fig. 31, the measurement results may be affected by severe multipath between the base station at a height of 22 m above ground level and its surrounding built-up suburban area of similar or slightly lower height than the base station.

Figure 34 (Rural Case A − Sloping Hummock) and Fig. 36 (Rural Case B − Mt Gray) are quite different from those mentioned above. The base stations at Sloping Hummock and Mt Gray have antennas at > 40 m above ground level. The uplink connections established within close proximity (< 250 m) to these base stations are often associated with low downlink levels received by the

PCMCIA card and hence resulted in the uplink channel power approaching maximum output power at +21 dBm/5 MHz. When the measurements were taken at distances within 1-3 km away, the uplink channel power decreases slightly (but still remain > 0 dBm /5 MHz) and then approaches maximum again (or exhibits an incremental trend) when > 3 km away.

Based on the observations on the uplink measurements, it is noted that the UMTS network coverage exhibits two distinctive types, independent of the operation environments and e.r.p. levels of the base stations:

− The first type correlates to a smaller cell radius (in the range of 800 m or below) with uplink patterns as shown in Fig. 32 (suburban), Fig. 33 (urban) and Fig. 35 (Rural Case A − East Bundaberg). To some extent, Fig. 37 (Rural Case B − Goulburn city) could be considered under this type.

− The second type correlates to a larger cell radius (in the range of 4 km or below) with uplink channel power remaining at >0 dBm/5 MHz and occasionally approaching a maximum of +21 dBm/5 MHz. This is evident in Fig. 34 (Rural Case A − Sloping Hummock) and Fig. 36 (Rural Case B − Mt Gray).

5.2 Observations on downlink measurements (via external TV receive antenna)

Results as shown in Figs 39 to 45 gave an indication of the type of downlink power levels that would be present at a television receive antenna positioned at 10 m above ground level.

The majority of downlink measurements in Fig. 39 (Suburban), Fig. 40 (Urban) and Fig. 42 (Rural Case A − East Bundaberg) exhibit a similar pattern relating to the magnitude of power levels, i.e. downlink channel power is observed to be in the range of around −15 dBm/5 MHz to −50 dBm/5 MHz from the respective base stations. To some extent, Fig. 44 (Rural Case B – Goulburn city) could be considered similar to these figures.

In Fig. 41 (Rural Case A − Sloping Hummock), it is clearly shown that the measurements were lower than all other plots. The reason that Fig. 41 (Rural Case A – Sloping Hummock) differs from those in Fig. 43 (Rural Case B – Mt Gray) may be the differences in antenna tilting from the respective base stations. The base station at Mt Gray (terrain height of 810 m) has deployed antennas at 2-5 degree tilting towards undulating/hilly terrain in order to serve communities around the Goulburn region (terrain height around 630-680 m). Whereas the base station at Sloping Hummock (terrain height of 95 m) did not apply any tilting to its antennas due to the flatter terrain around the Sloping Hummock region (terrain height of 20-30 m).

One observation made from the downlink measurements is that the trend for downlink signals at the dominant terrain sites (i.e. Sloping Hummock and Mt Gray) in rural environments are at a distinctive lower level than the rest. More studies may be required to verify the characteristics of these high power base stations in rural environments.

5.3 Observations on out-of-band emissions from a PCMCIA card

The following plots were captured in one of the rural measurements conducted at Mt Gray North, where the UMTS base station was located in an approximate distance of 130 m to a broadcast site that is transmitting DVB-T signals at 806-813 MHz.

There are two lines in Figs. 46, 47 and 48. The yellow line indicates the instantaneous signal level in max-hold mode for the spectrum across 750-900 MHz, whereas the blue line indicates the instantaneous level at that time when these plots were captured. For more information regarding the Australian radio-frequency spectrum allocations in 750-900 MHz band, refer to:

FIGURE 46

Instantaneous levels measured via PCMCIA card at Mt Gray North

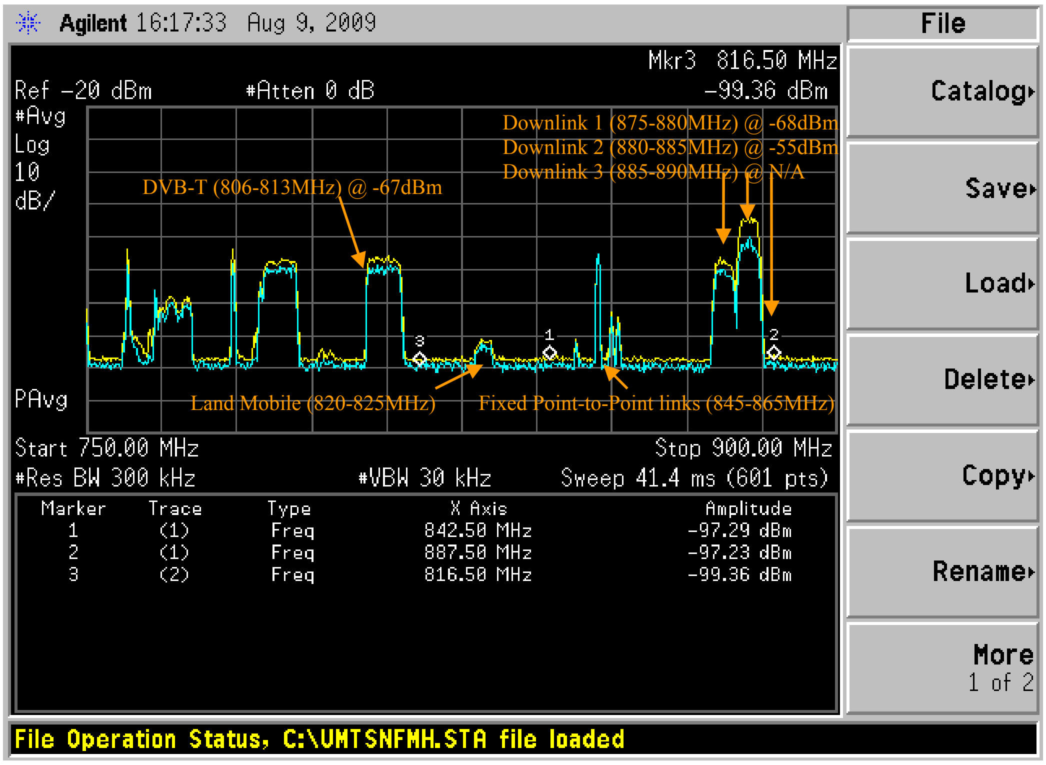


FIGURE 47

Instantaneous DL/UL levels measured via PCMCIA card when connection was initially established (note that 30 dB input attenuation was applied)

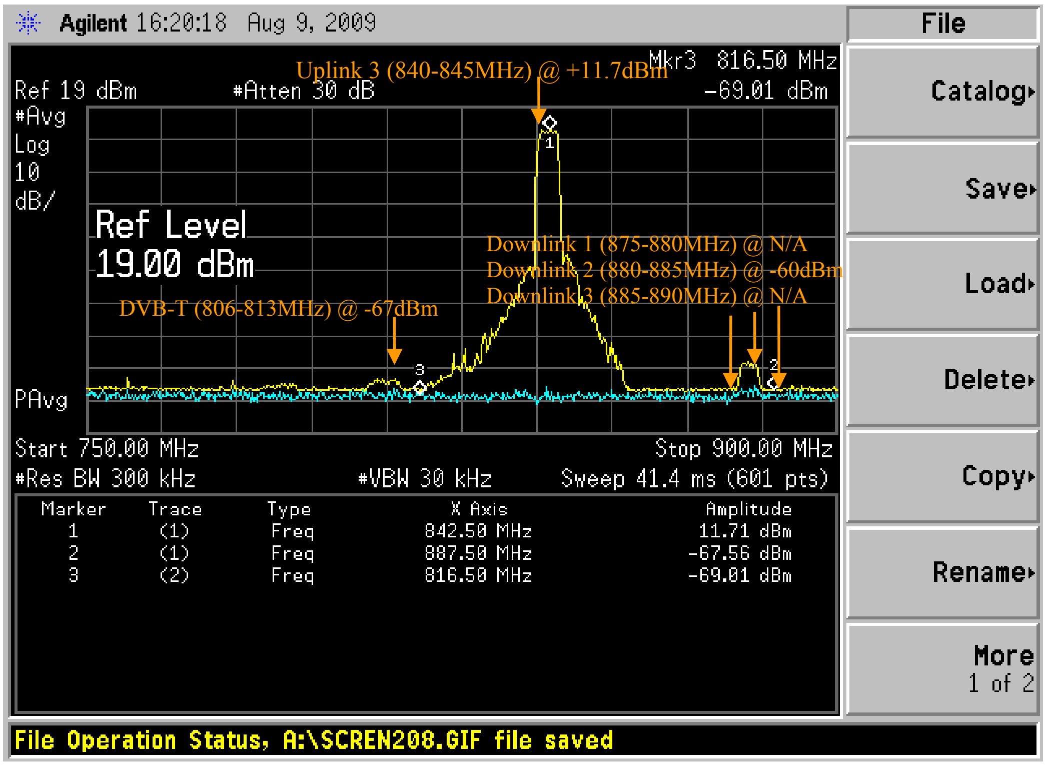


FIGURE 48

Instantaneous DL/UL levels measured via PCMCIA card when constantly uploading (note that 30 dB input attenuation was applied)

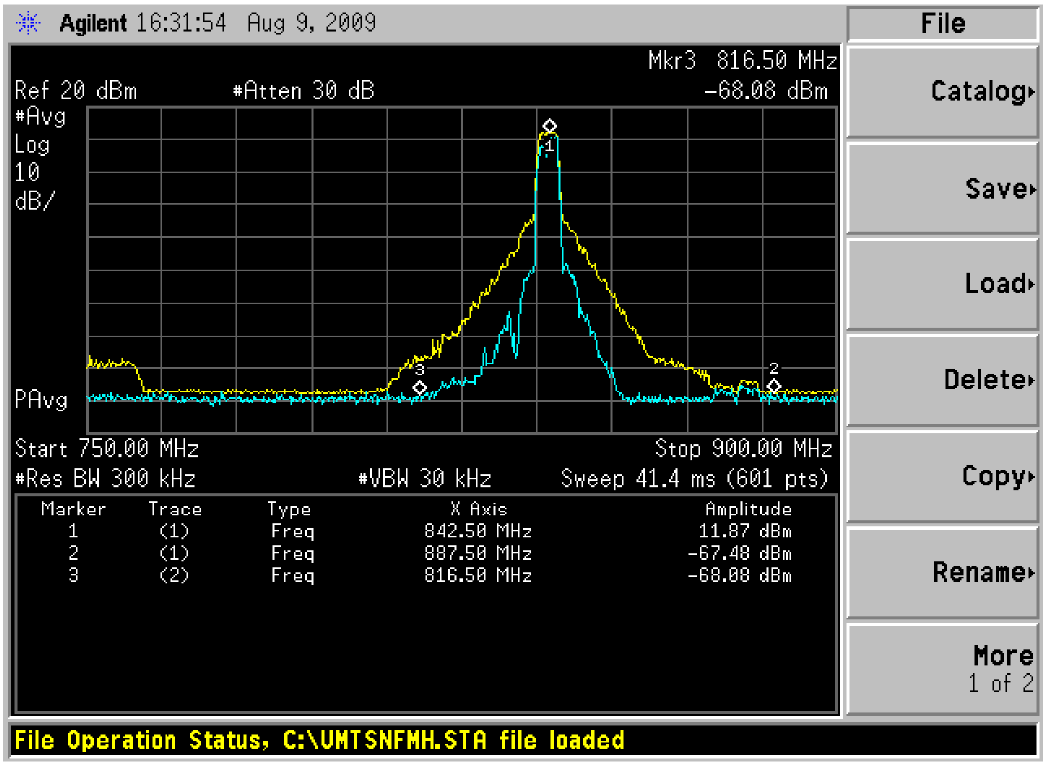
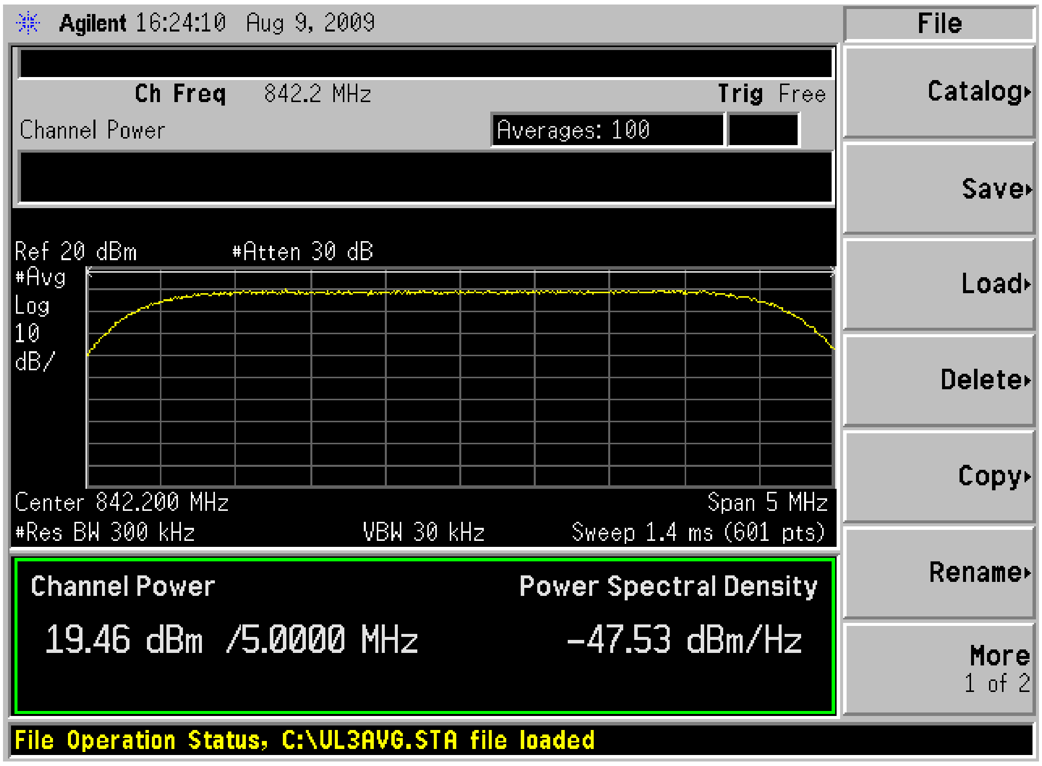


FIGURE 48*bis*

UL channel power measured via PCMCIA card when constantly uploading (note that 30 dB input attenuation was applied)



The following observations were made when analysing the above measurements:

- The uplink channel established during connection may not necessarily pair up with the strongest downlink signal. This was evident in Figs. 47 and 48. The uplink connection was established at the uplink 3 (840-845 MHz) that was paired with downlink 3 (885-890 MHz). However, it is noted that the strongest downlink channel was at downlink 2 (880-885 MHz) which would have to pair up with uplink 2 (835-840 MHz). More studies may be required to verify this phenomenon.
- An instantaneous uplink level of +11.9 dBm in Fig. 48. The measurement in channel power mode, as shown in Fig. 48*bis*, gives 19.5 dBm/5 MHz which is close to the maximum uplink power of +21 dBm/5 MHz. When this occurs, there could be potential disruption to the reception of the DVB-T broadcast channel at 806-813 MHz due to the observed and measured dispersive out-of-band emission(s) from the PCMCIA card. Moreover, there is also an unknown inter-modulation product that was measured around 750-760 MHz when the user equipment emits maximum power as shown in Fig. 48, but this was not observed in Fig. 47. More studies may be required to verify this phenomenon.

6 Further studies

The results presented in this study report and its predecessors in Annexes 1 and 2 provide insights into the possible variation in UMTS network design, base station architectural structures and cellular service characteristics for a particular mobile carrier in one country. The outcomes of these studies show that for maximum protection of reception of the digital television broadcasting service reverse-duplex of the UMTS uplink/downlink configuration is required given the consistency observed in the downlink measurements and also the number of mitigation techniques (e.g. filters for base station transmitters and/or guardbands) available to mitigate interference to digital television broadcasting. In light of the results of the measurements presented in this contribution, further study may be required to confirm appropriate mitigation techniques.

This study identified an unexplainable phenomenon from the PCMCIA card operation:

- it illustrated dispersive out-of-band emission(s) from the PCMCIA card when the uplink approaches a maximum output power at +21 dBm/5 MHz; and
- the out-of-band emissions may have exceeded the spectrum mask emission requirement as specified in § 6.6.2 of 3GPP TS 25.101, yet the filtering appeared to have a different characteristic when another manufacturer's PCMCIA card was tested.

In preparation for these studies the 3GPP specifications for user equipment (i.e. 3GPP TS 25.101) and base stations (i.e. 3GPP TS 25.104) were reviewed. A review of 3GPP specification's out-of-band emission limits (spectrum masks) for the base station and for the user equipment indicated that the out-of-band emission specifications appear to be minimal for sharing conditions with a digital terrestrial television broadcast (DTTB). As a result of existing user equipment design, DTTB would be required to potentially coexist with large numbers of user equipment which are immediately adjacent in the frequency band and have emission masks that would cause interference to the reception of DTTB signals.

This triggers the need for a potential further study on user equipment's filtering and out-of-band characteristics in UMTS and LTE networks as currently specified in § 6.6.2 of 3GPP TS 25.101 and TS 36.101, respectively.

As a result of observations made of the currently deployed UMTS network, other areas for further study for consideration are:

- Given that DTTB coverage is planned on the basis of time and location probability of the minimum median field strength, what are the potential audience losses that planned DTTB services may suffer from as a result of introduced IMT services (for the UMTS *normal* and *reverse* duplex cases) in the absence of sufficient interference mitigation techniques?

− As a corollary, given that the existing and planned IMT services are deployed on the basis of end-user reconnection in the event of signal loss, is there any degradation in quality of service in end-user disconnection from adjacent channel interference from DTTB services?

− As IMT networks migrate from legacy: 850 MHz W-CDMA and cdma2000; and 2 100 MHz W-CDMA services and overlay to wider bandwidth 700 MHz LTE onto their existing 3G network infrastructure, what likely aggregate increase in interference will occur to DTTB?

7 Conclusions

The studies undertaken to date point to potential variations in UMTS network configurations as presented in the outdoor measurements of the existing UMTS network.

The analysis of the UMTS configurations considered in this study indicate that there are two distinctive patterns as exhibited in the uplink/downlink measurements independent of the operation environments and e.r.p. levels of the base stations. The first type correlates to a smaller cell radius (in the range of 800 m or below) and it comprises the case in urban (e.g. Parramatta), suburban (e.g. St Clair) and rural township (e.g. East Bundaberg and Goulburn City). The second type correlates to a larger cell radius (in the range of 4 km or below) and it comprises the case in rural regions where base stations are located upon dominant elevated terrains (e.g. Sloping Hummock and Mt Gray).

For the uplink measurements, it is illustrated in the measurements clearly that there is a significant difference between the user equipment transmit levels when an uplink connection was initially established and when it was constantly uploading data. In the latter case, the user equipment transmit level is higher than the former.

Recommendation 1: It is therefore recommended that sharing study methodologies between UMTS and DTTB should be specified with the user equipment in continuously uploading mode.

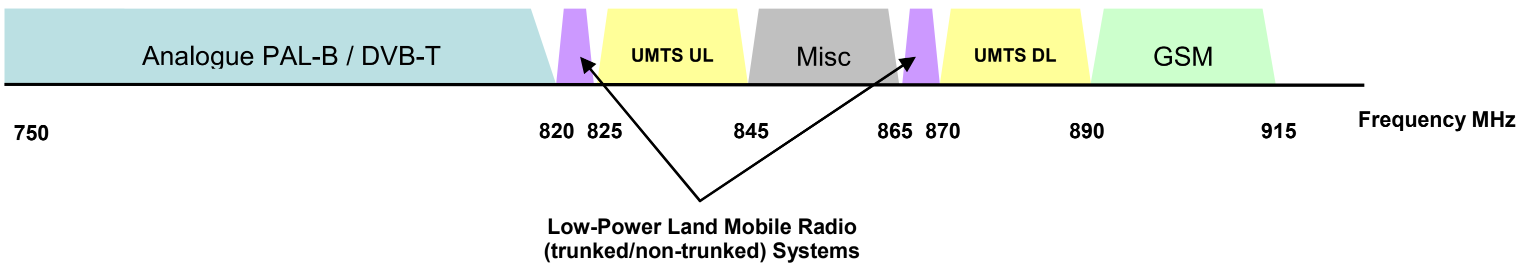
As demonstrated in these measurements, the transmit power of the user equipment reaches its highest level at the edge of the cell coverage area. This level, in the range of the +10 dBm/5 MHz to +20 dBm/5 MHz, was similar for all types of environments and cell sizes considered in this study.

Recommendation 2: For sharing studies related to country border areas, which also corresponds to the fringe of the DTTB coverage, it is recommended that the user equipment transmit levels correspond to the range of +10 dBm/5 MHz to +20 dBm/5 MHz.

While over 460 measurements were taken in these recent field surveys across this existing UMTS network, the limited number of representative measurements presented in this contribution may not draw final conclusions, however they identify some potential variations in UMTS uplink/downlink signals within rural, suburban and urban broadcasting environments. It is therefore proposed that it is not possible to suggest “typical” characteristics for a UMTS network. More studies are required to investigate further characteristics of these UMTS networks, base stations and user equipment in a number of environments.

Annex 1

Australian radio-frequency spectrum allocations in the 750-900 MHz band



Misc includes services such as fixed point-to-point links or PABX cordless system.

UMTS network in Australia operates two paired of 5MHz channels each in the bands 835-845MHz (uplink) and 880-890MHz (downlink) in metropolitan areas whereas three paired of 5MHz channels each in the bands 830-845MHz (uplink) and 875-890MHz (downlink) in regional/rural areas. Note that 825-830MHz (uplink) and 870-875MHz (downlink) are spectrum licensed but remained as unused spectrum across Australia during this field survey.

Chapter 3

Estimation of UMTS cell coverage radius

1 Introduction

A series of field studies were undertaken in Australia in 2010 and 2011 which may be used to further determine potential interference to DTTB from entry of mobile services into the UHF band.

The locations chosen for the survey are considered suburban and rural broadcasting environments in Australia.

The first location chosen is for a suburban environment at St Clair within the western suburbs of Sydney. It has an undulating topography, likely symmetrical geographic UMTS cell size and likelihood of network presence. It has one high power (501 W e.r.p.) base station and two low power sites to complement the UMTS network coverage in the immediate area.

In addition a rural environment was surveyed at Goulburn, a rural town centre in New South Wales, Australia. Goulburn is also served by one high power (501 W e.r.p.) base station located at a dominant elevated terrain, Mt Gray, which is also the site of various other communications facilities. And similarly another high power (501 W e.r.p.) base station is found at Goulburn City Centre to complement the UMTS network coverage. These were both complemented by one low power site at Garfield.

2 Measurement of cell IDs within a UMTS coverage area

2.1 Objective

The objective was to take a record of the cell ID on a UMTS hand set at a range of distances from the reference base station(s). An observation of cell handover on a UMTS hand set was undertaken to estimate cell size.

A suitable measurement point was found within a 30 m radius (but not limited) to be in line with each panel of the reference base station. At any measurement point when the cell ID varied, in order to verify if the cell handover repeated itself, further measurements were undertaken at a radial distance of ±2 m from the respective measurement point.

2.2 Premeasurements

2.2.1 Equipment

Three Nokia E51 handsets (3G/UMTS), installed with a software capable of displaying cell ID and a GPS navigator were utilized in the field surveys. Testing was undertaken on three handsets is mainly to determine any manufacturing variations.

2.2.2 Cell ID verification

At each measurement location an initial assessment was undertaken to verify the cell ID of each base station in the selected study locations.

This was achieved by launching the software via the mobile handset at various points that were in close proximity (preferably within 10 m from the base station) facing each panel of the base station(s).

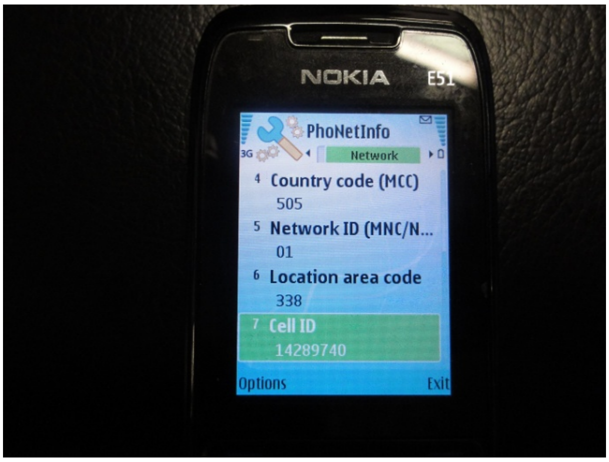
The first *N* decimal digits of the cell ID were observed not to change whereas the last digit changed indicating which panel "established" connection with the mobile handset.

FIGURE 49

Nokia E51 handsets

FIGURE 50

PhoNetInfo[12] application for cell identification



2.2.3 Selected field study areas

Suburban environment: Colyton/St Clair at Western Sydney

Rural environment: Goulburn/Mt Gray at 150 km SW of Sydney

2.2.4 Field study measurement template

The following measurement template was utilized to record measurements:

No.	Description	GPS (Lat/Long)	Cell ID	Distance from base station (m)	Remarks
P1	Street name and number or building remarks	GPS reading in WGS-84	*N* digits as displayed in the mobile handset	Desktop calculation or Google Earth	Observations (e.g. cell handover)
…	…	…	…	…	

2.3 Configuration of base stations

2.3.1 Base stations at St Clair/Colyton study area

The following base stations were selected for the study at the St Clair/Colyton areas (refer to Fig. 51):

NOTE – It was noted that the registered max ERP of 501 W as recorded in the regulators database could be max e.i.r.p.

[12] PhoNetInfo – refer http://www.patrickfrei.ch/phonetinfo/index.html

TABLE 17

“Suburban” base stations in St Clair NSW

				Uplink 835.2-844.4 MHz Downlink 880.1-889.5 MHz Bandwidth 9.2 MHz/9.4 MHz			**Uplink 835.05-844.95 MHz Downlink 880.05-889.95 MHz Bandwidth 9.9 MHz**			**Uplink 830.05-834.95 MHz Downlink 875.05-879.95 MHz Bandwidth 4.9 MHz**		
Site ID	**Lat/Long (ACMA)**	**Lat/Long (Google Earth)**	**Site Name**	**Height (m)**	**ERP/e.i.r.p. (W)**	**Azimuth (degree)**	**Height (m)**	**ERP/e.i.r.p. (W)**	**Azimuth (degree)**	Height (m)	ERP/e.i.r.p. (W)	Azimuth (degree)
9007685	33 47 26 S 150 48 27 E	33 47 25.1 S 150 48 24.9 E	Telstra Site Cnr M4 and Roper Rd COLYTON				20	501/NA	90 220 335			
133561	33 47 18 S 150 47 10 E	33 47 12.3 S 150 47 14.9 E	Telstra Site Colyton M4 Motorway Potter Field Shepherd St COLYTON	22.5	31.6/39.5	20 120 270						
133747	33 47 40 S 150 47 17 E	33 47 33.3 S 150 47 22.3 E	Bennett Rd ST CLAIR	16	31.6/40.6	60 150 290						

Legend for the following maps:

High-power sector

Low-power sector

FIGURE 51

Base stations mapping at Colyton/St Clair

2.3.2 Base stations at Goulburn/Mt Gray study area

The following base stations were selected for the study at Goulburn/Mt Gray (refer to Fig. 52):

NOTE − It was noted that the registered max ERP of 501 W as recorded in the regulators database could be max e.i.r.p.

TABLE 18

"Rural" base stations in Goulburn/Mt Gray NSW

				Uplink 835.2-844.4 MHz Downlink 880.1-889.5 MHz Bandwidth 9.2 MHz/9.4 MHz			Uplink 835.05-844.95 MHz Downlink 880.05-889.95 MHz Bandwidth 9.9 MHz			Uplink 830.05-834.95 MHz Downlink 875.05-879.95 MHz Bandwidth 4.9 MHz		
Site ID	**Lat/Long (ACMA)**	**Lat/Long (GoogleEarth)**	**Site Name**	**Height (m)**	**ERP/e.i.r.p. (W)**	**Azimuth (degree)**	**Height (m)**	**ERP/e.i.r.p. (W)**	**Azimuth (degree)**	**Height (m)**	**ERP/e.i.r.p. (W)**	**Azimuth (degree)**
9493	34 45 31 S 149 45 45 E	34 45 25.5 S 149 45 49 E	Telstra Site MT GRAY	47.7	107.2/41.1	Omni	47	501/NA	75 185 315 295 340	47	501/NA	75 185 315 295 340 Omni
100820	34 45 26 S 149 43 01 E	34 45 20.5 S 149 43 3.5 E	Telstra Exchange Auburn Street GOULBURN	22.5	28.2/35.8	Omni	22	501/NA	0 130 240	22	501/NA	0 130 240 Omni
9011132	34 45 55 S 149 41 39 E	34 45 52 S 149 41 42 E	Telstra RBS Site 72 Knox St GOULBURN				35	501/NA	0 80 210	35	501/NA	0 80 210

Legend for the following maps:

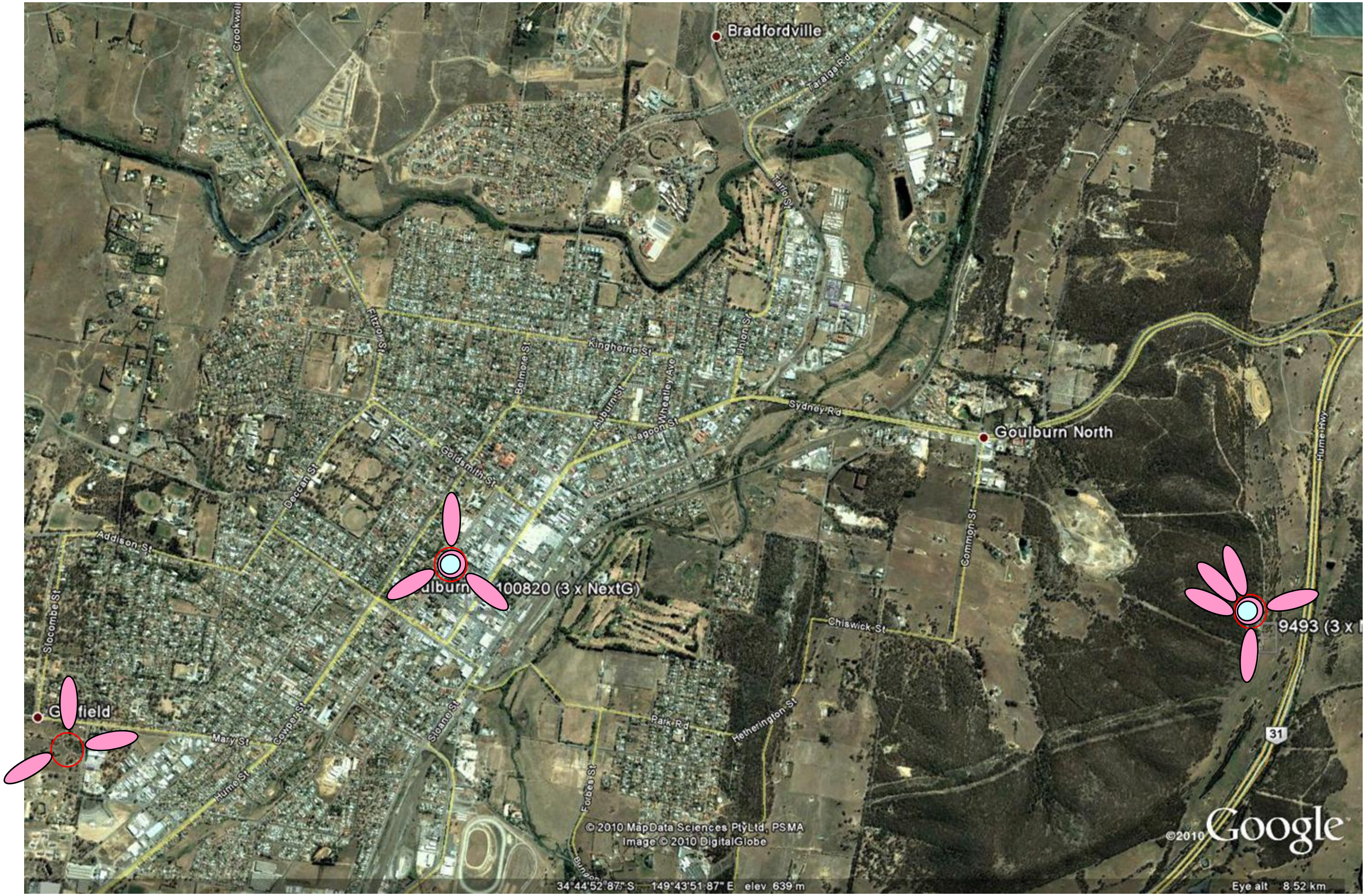
High-power sector

Low-power sector

High-power omni-sector

Low-power omni-sector

FIGURE 52
Base stations mapping at Goulburn/Mt Gray



3 Estimation of cell coverage radius

3.1 Objective

Measurement data at over 1 000 measurement spots was overlaid on aerial maps to demonstrate, to every extent possible, the estimation of the IMT base station coverage.

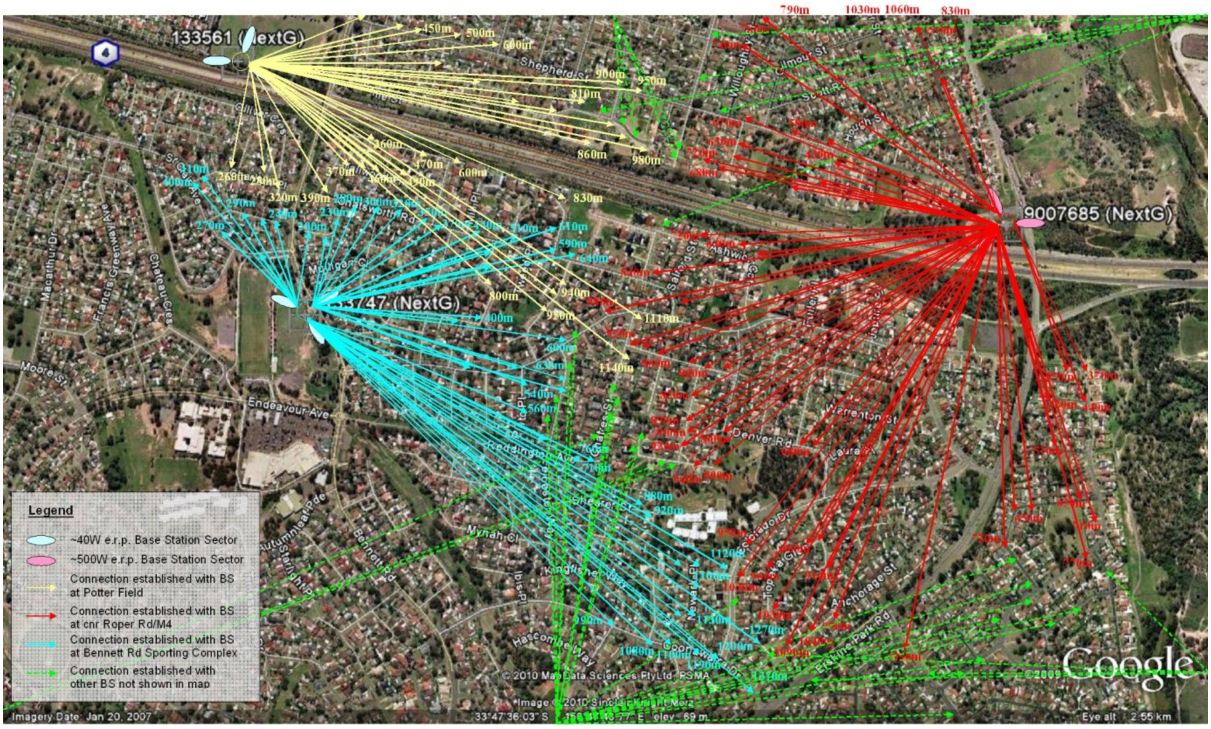
3.2 Methodology for cell coverage

3.2.1 Suburban environment − St Clair/Colyton

IMT cell coverage could be estimated by verifying the downlink signals (via cell id) from the respective base stations at selected locations within the studied area at St Clair.

FIGURE 53

Estimated base station coverage − Colyton/St Clair



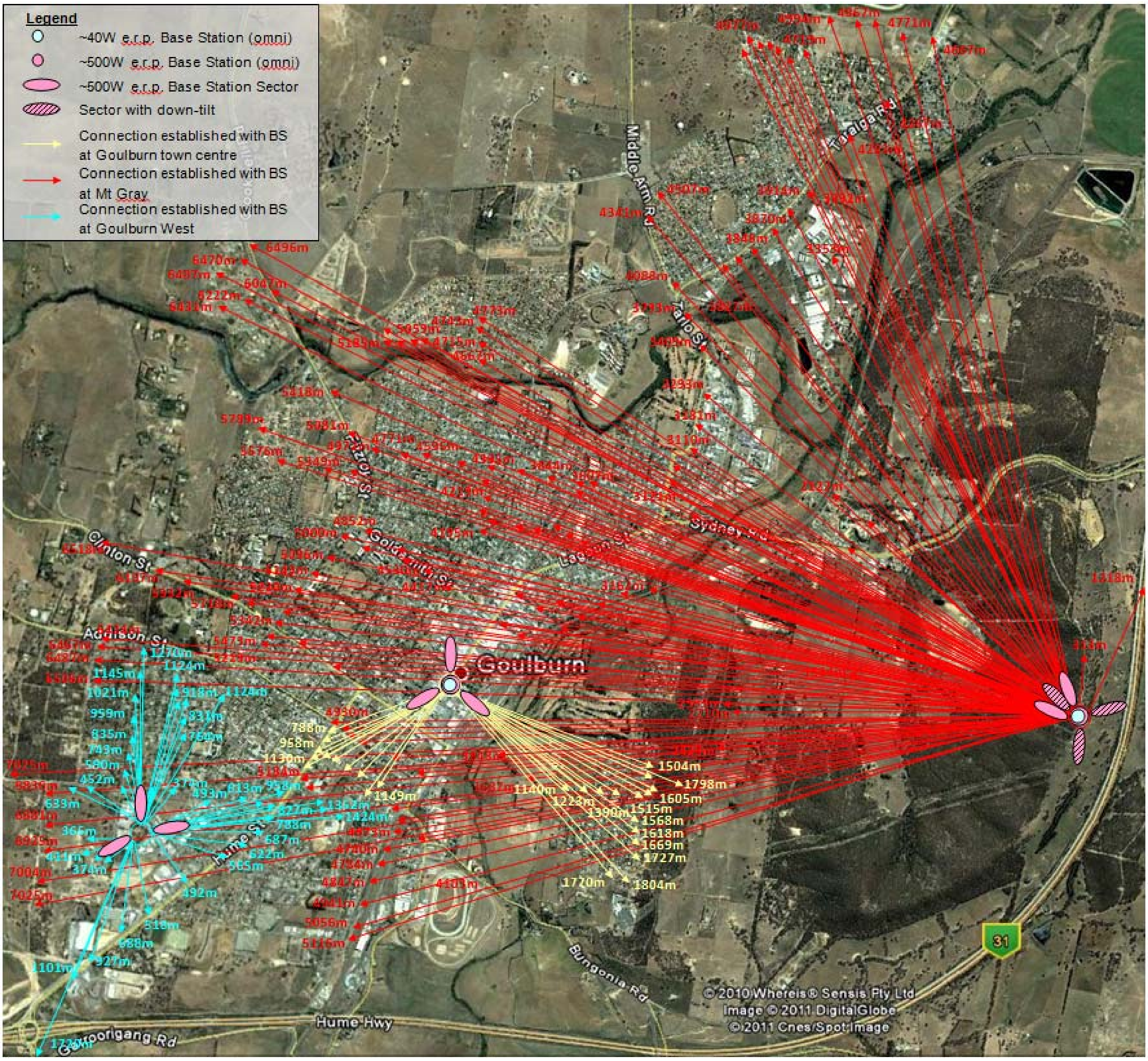
From the enclosed cell estimated coverage diagram, a number of studied areas (preferably in 100 m × 100 m study grid which is referred as one "pixel") would be selected to representatively indicate the profile of cellular coverage at Colyton/St Clair.

3.2.2 Rural environment − Goulburn/Mt Gray

IMT cell coverage was estimated by verifying real downlink signals (via cell id) from the respective base stations at selected locations within the studied area at Goulburn/Mt Gray.

FIGURE 54

Estimated base station coverage − Goulburn/Mt Gray



From the enclosed cell estimated coverage diagram, a number of studied area (preferably in 100 m × 100 m study grid which is referred as one "pixel") would be selected to representatively indicate the profile of Goulburn/Mt Gray.

4 Conclusions

Studies to date in ITU-R have determined cellular networks are based on a "typical" small mobile cell structure.

In the absence of definitive advice on determining "typical" cell coverage within a geographic area, the field studies undertaken within this campaign have provided a series of measurements to determine "actual" UMTS cell coverage radius within a geographic area.

Further studies are required to determine how these measurements may be applied to gauge potential interference to DTTB from mobile services in a geographic area.

Chapter 4

Technical analysis of LTE 800 MHz base station interference into DTT receivers

Ofcom UK is currently engaged in a consultation process on the "Coexistence of new services in the 800 MHz band with digital terrestrial television". Ofcom UK commissioned a set of measurements on the performance of TV receivers in the presence of LTE base station signals and a field trial to provide supporting input to this overall modelling analysis and assessment.

The overall technical analysis report bringing together all the aspects of this work is attached as an embedded document file below. The whole set of documents and reports in this current consultation process can be found with public access on the Ofcom UK website at:

http://stakeholders.ofcom.org.uk/consultations/coexistence-with-dtt/

There are many factors to be taken into account in modelling potential interference, and what is presented here contains a description of a modelling toolkit for others to use, amend and improve as required to fit their own particular circumstances. Example of parameters which may be varied by country or regional area are propagation, geography issues such as terrain, TV reception mode and transmitter locations, spectrum channel plans, mobile network locations and powers, any mitigation options in place, TV receiver performance both current and future, and any in home distribution network. There is also a need for considerable care in the assessment of the data to avoid double or multiple counting of potential instances of interference. Finally you will need a detailed dataset of your predicted TV and mobile reception signal levels to a high spatial resolution.

This technical report provides detailed information on all the individual factors taken into account in the modelling assessment of the potential interference into TV reception from the introduction of 800 MHz LTE base stations in the UK. The consultation process in the UK is ongoing and the toolkit detailed in this report is available for further investigation of the effects of varying all the inter-related parameters. All the parameter values used in this initial modelling are detailed in the document, but please note that the values are subject to further amendment and improvement as the consultation work continues. The modelling software relies on a detailed TV transmitter signal strength prediction across the whole of the UK to the relatively high resolution of 100 m by 100 m squares. This data is an output of the UK Planning model which is the property of and supplied by the UK Broadcasters and transmission providers.

Adobe Acrobat
Document

Chapter 5

The coexistence of LTE and digital TV services at UHF: a field trial

Ofcom UK is currently engaged in a consultation process on the "Coexistence of new services in the 800 MHz band with digital terrestrial television". Ofcom UK commissioned a field trial to provide supporting input to this process. The report on this work is attached as an embedded word file below. The whole set of documents and reports in this current consultation process can be found with public access on the Ofcom UK website at:

http://stakeholders.ofcom.org.uk/consultations/coexistence-with-dtt/

The field trial investigated the actual interactions between a set of three 10 MHz LTE base station transmissions and a test DVB-T and T2 transmission. The TV transmitter could be switched between European channels 59/60 (774-782MHz and 782-790 MHz) with controllable power level, and switchable DVB-T and DVB-T2 modulation formats.

The three 10 MHz LTE base station signals were individually controllable in the 791-821 MHz range known in Europe as blocks A, B, and C. The LTE base station signals were available as files recorded from genuine equipment and played back via signal generators. The two available signal formats used for the LTE were a fully loaded base station and an idle base station recording.

The signal strengths of these LTE and TV transmissions were evaluated around the area of a UK town to provide a set of experimental real world data which could be used in support of extensive modelling analysis work also being undertaken by Ofcom UK.

The field trial also allowed the practical testing and evaluation of some potential mitigation measures, namely filters in the TV receiver input, on channel repeaters, and polarization discrimination. The measurements provided supporting material for the typical propagation models which would be appropriate in the UK and other similar environments.

Field trial
attachment.doc

Chapter 6

Technical analysis of interference from mobile network base stations in the 800 MHz band to digital terrestrial television

Studies undertaken by Ofcom in the UK in 2011 investigated the impact of interference from future mobile network base stations in the 800 MHz band to digital terrestrial television (DTT) services below 790 MHz. These studies also drew on inputs from the UK Broadcasters to provide the TV service predicted field strengths providing the baseline for the assessments.

The studies consisted of analysis and computer modelling based on the UK's DTT network planning model (UKPM), building on our past contributions to CEPT, and drawing on the results of a number of measurement programmes that have been commissioned over the past two years.

The objectives of the studies were two-fold:

i) to investigate and to quantify, where possible, the efficacy of technical measures to mitigate the impact of interference from mobile/fixed communication network (MFCN) base stations to individual households;

ii) to assess the UK-wide impact of interference from mobile network base stations by estimating on a statistical basis the total number of households whose DTT reception might be affected.

Follow-up work by Ofcom in early 2012 resulted in the revision and updating of the original report, as well as performing a sensitivity analysis to explore the impact of different parameters, particularly relating to the MFCN network deployment and the performance of DTT receiver equipment.

They are also published on the Ofcom website for public access at:

http://stakeholders.ofcom.org.uk/consultations/coexistence-with-dtt/

http://stakeholders.ofcom.org.uk/consultations/second-coexistence-consultation/

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