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Sharing and compatibility issues between electronic news gathering and other systems in frequency bands allocated to the fixed, mobile and broadcasting services

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REPORT ITU-R F.2379-0

Sharing and compatibility issues between electronic news gathering and other systems in frequency bands allocated to the fixed, mobile and broadcasting services

(2015)

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Scope

This Report provides general consideration of electronic news gathering (ENG) deployment in the fixed service and sharing/compatibility studies between ENG systems and other systems and services.

The sharing studies cover transmissions in both directions. This means that the potential interference both to and from existing services with respect to ENG is addressed.

1 Introduction

This Report including all its Annexes is primarily intended to be used as a guide in performing sharing / compatibility studies between ENG systems in the fixed service (FS) and other systems in the FS and other services. It provides models and methodologies for analysing and determining the interference between ENG FS systems and other systems in fixed, mobile and broadcasting bands. It also provides the results of sharing studies that utilize such models and methodologies.

Many countries have made national spectrum allocations for analogue and digital ENG (DENG), television outside broadcast (TVOB) and electronic field production (EFP). Typical radio link paths for ENG are depicted in Fig. 1.

Within some countries the introduction of digital techniques and technologies is being viewed as a development that may lead to more efficient use of spectrum for ENG, TVOB and EFP.

Many sound and television broadcast organisations consider that the interchange of news program material and the operation of ENG, TVOB and EFP equipment would be enhanced through interoperability of sound and television systems for news, sports and current affairs applications.

Certain bands in the fixed service are used by broadcast organisations to provide auxiliary services which are "contribution" links (i.e. an input to the broadcast studio/facility), vital for the production of various sound and television programs. These services are commonly known as:

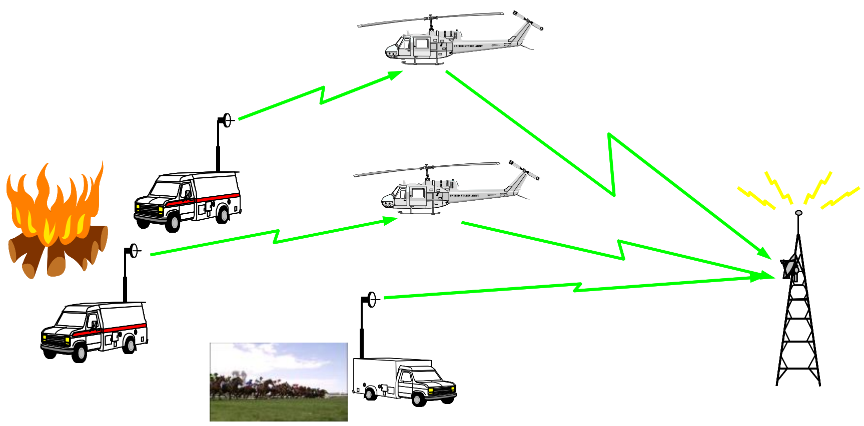
– TVOB – A planned use of group links using a variety of techniques to provide specialist coverage of an event;

– ENG – The rapid, unplanned deployment of links to cover breaking news events, generally for short periods of time; and

– EFP – A planned use of links to provide elements of a sound and television production, which can be "live" to air or recorded for later broadcast, generally with more elaborate sound and television production values.

FIGURE 1

Communications links in electronic news gathering



1.1 Abbreviations

For the purposes of this document, the following abbreviations apply. Where possible, abbreviations align with the integrated Database ITU Terms and Definitions. Some abbreviations that are used in the case studies include a short explanation.

ACA	Australian Communications Authority; the Australian regulatory authority which was replaced by the ACMA in 2005
ACMA	Australian Communications and Media Authority
ACIR	Adjacent channel interference ratio
ACLR	Adjacent channel leakage ratio
ACS	Adjacent channel selectivity
APEC	Asia-pacific economic cooperation
CBD	Central business district
CDMA	Code division multiple access
COFDM	Coded orthogonal frequency division multiplex
DSNG	Digital satellite news gathering
DVB-S	Digital video broadcasting – Satellite; a modulation technique to provide digital video broadcast via satellite
DVN	Digital video network; a video communications network of an Australian telecommunications carrier
EFP	Electronic field production
e.i.r.p.	Effective isotropic radiated power
ENG	Electronic news gathering
ETSI	European telecommunication standards institute
E-UTRA	Evolved - universal terrestrial radio access
FDD	Frequency division duplex
HDTV	High-definition television
IMT	International mobile telecommunications
LTE	Long term evolution
M2006	Melbourne 2006 Commonwealth Games Corporation; the organising committee of the 2006 Commonwealth Games in Melbourne
MPEG	Motion picture expert group
POP	Point of presence
PSK	Phase-shift keying
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase-shift keying
RF	Radio frequency
SDTV	Standard-definition television

SNG	Satellite news gathering
SNV	Satellite news vehicle
SOBO	Sydney Olympics Broadcasting Organisation; an organisation established to co-ordinate all media coverage of the Sydney Olympic Games
SOCOG	Sydney Organising Committee of the Olympic Games; the governing body of the Sydney Olympic Games.
TDD	Time division duplex
TVOB	Television outside broadcast
UTRAN	UMTS radio access network
UHF	Ultra high frequency
UMTS	Universal mobile telecommunications system
VHF	Very high frequency
WCDMA	Wideband CDMA
WCS	Wireless camera systems
WiMAX	Worldwide interoperability for microwave access

2 Differences between typical fixed service applications and television outside broadcast, electronic news gathering and electronic field production

Broadcast organisations apply TVOB, ENG and EFP in a number of configurations and operational locations. They are not characterized with operational characteristics typical to other applications in the fixed service and this has led to many difficulties in ensuring global sharing between various applications operating in the bands. The operation of TVOB, ENG and EFP can be likened to "nomadic" fixed services.

By their very nature, TVOB, ENG and EFP links are not deployed in the same manner as other fixed links as they are deployed in response to breaking news events or to follow action at a sporting or other event.

The principal difference between conventional FS applications and those deployed for TVOB, ENG and EFP operations is the wide range of antenna types, with wider main beam radiation patterns, deployed for TVOB, ENG and EFP. Many of these antennas exhibit considerable asymmetry in the azimuth versus elevation planes, e.g. a narrow beam in the azimuthal plane and a broad beam in the elevation plane. TVOB, ENG and EFP "collection" stations are fixed receiving stations utilizing antennas that may be vulnerable to interference from emitters with arrival angles somewhat higher than those used in conventional point-to-point systems.

TVOB, ENG and EFP operations may be bidirectional point-to-point, but more usually involve one or more one-way transmissions from nomadic/mobile news cameras to a fixed network access point, for transmission to a central location, with the transmissions relayed via other nomadic transmission sites, including terrestrial vehicles and airborne platforms such as helicopters or airships.

3 Operational requirements for television outside broadcast, electronic news gathering and electronic field production

3.1 TVOB, ENG and EFP deployment

Operational locations for ENG range from central business districts of capital cities, including sites close to major airports, through rural and remote areas where helicopter-based operations often provide a transmission path for uplinking live events.

The operational duration of a TVOB/ENG/EFP link may range from a few minutes for a live newsfeed through temporary installations for single and multiple day outside broadcasts up to permanent installation at relay sites and collection stations.

By their very nature, TVOB, ENG and EFP links are deployed in response to breaking news events or to follow action at a sporting event.

Whilst a broadcast organisation will predominantly operate within the bounds of their *home* country, globalization of news and sport often requires broadcasters to temporarily relocate their equipment to operate cross border in other countries.

The operational deployment of TVOB, ENG and EFP links are typically as follows:

Geographic deployment: Fixed ENG collection stations are located near major centres. Nomadic news collection and sporting events are located principally around the major city and urban areas, but potentially anywhere where news events occur. EFP and TVOB operations are located on an event-by-event basis. A number of example deployments can be found in Annex B.

Link densities: Major broadcast organisations operate TVOB/ENG collection stations in major cities. For ENG operations news crews perform between one to five ENG collection operations per day, each of between ½ an hour and 1 hour duration per broadcaster. The very nature of competitive news broadcasting creates peak usage times where all channels are operated simultaneously. Deployment of wireless cameras has meant many broadcast organisations' operations use multiple frequencies in the central business districts of major cities. Analysis of ENG system density for modelling purposes is to be found in Section 5.

Operational times/duration: TVOB/ENG collection stations operate continuously, picking up program material from nomadic news teams using mobile and transportable ENG equipment. Events take place, typically, at any time of the day, with fewer events taking place at night (between about 12 midnight and 4 am). ENG collections have been typically between about ½ and 1 hour in duration, with special event collections involving durations of 2 to 5 hours. On occasions some operations have extended over days or even weeks. EFP operations tend to be between 3 and 8 hours duration. With the introduction of digital ENG technology, the different functionalities of digital systems has offered broadcast organisations more flexibility to cover an increased number of events with reduced bandwidth being assigned to TVOB, ENG and EFP.

3.2 System deployment considerations including transmission aspects for TVOB, ENG and EFP

3.2.1 Introduction

The range of microwave signal links to service TVOB/ENG/EFP include ground-to-air and air-to-ground transmissions of live-to-air broadcast material from news and sporting event broadcasts, from portable cameras at sporting venues, from ground based mobile link vehicles, and from airship platforms and collection stations on prominent buildings.

ENG operations are concentrated around major city and urban areas, with centrally located collection stations. These collection stations are fixed receiving stations utilizing antennas that may be vulnerable to interference from emitters with arrival angles somewhat higher than those commonly used by conventional point-to-point fixed systems.

3.2.2 Analogue, digital and high definition television data requirements

Many countries have commenced, are planning or have deployed digital sound and television services including broadcasts of high definition television. The migration from analogue to digital technology for TVOB, ENG and EFP has been planned to support feeds for high definition television broadcast requirements. For this and for the ongoing improvement in the quality and/or other capabilities of video, audio and associated data channels, the design of digital systems must accommodate both standard definition as well as high definition television signals, this impacting upon the equipment performance and spectrum requirements.

3.2.3 Bandwidth/data requirements for TVOB, ENG and EFP systems

Digital TVOB, ENG and EFP systems add encoders and decoders to the television toolkit allowing the broadcast organisation to modify spectrum utilization to suit the event. Coded orthogonal frequency division multiplex modulation (COFDM) in ENG system design is specified in three ETSI standards, EN 300 744, EN 300 421 and EN 301 210. ETSI EN 300 744 offers different levels of QAM modulation and inner code rates in 6, 7 or 8 MHz bandwidths to trade usable bit rate (for the video encoder) versus ruggedness of the link. As TVOB/ENG links are on the input or contribution side of a broadcast system, the highest bit-rate is preferred in order to minimize concatenation effects of multiple video encode/decode cycles through the broadcast chain. Hence a spectrum plan based on 8 MHz channels is preferred, providing a range of usable data rates from 4.976 Mbit/s to 31.668 Mbit/s by selection of bandwidth, guard interval, forward error correction and modulation type.

ETSI EN 300 421 and EN 301 210 offer QPSK, 8PSK and 16 QAM modulation over a variable bandwidth. Selection of forward error correction, modulation type and channel bandwidth may be used to trade ruggedness of the link versus usable bit rate. Adjacent 8 MHz channels may be combined into a wider channel to establish higher usable bit rate links for high definition video paths. For example, in a 24 MHz channel, bit rates of up 64.51 Mbit/s may be transmitted, or in a 32 MHz channel, rates exceeding 85 Mbit/s may be achieved. High definition video encoding systems utilizing MPEG-2 are widely available which produce a satisfactory video quality at these bit rates, however advanced coding techniques under development promise to lower the bit rates required for high definition links.

In addition, three adjacent 8 MHz channels may also be combined to provide an analogue link during the transition of the broadcaster’s equipment from analogue to digital.

For digital COFDM transmissions television broadcast organisations have had to assess the coding, bandwidth, multi-path and *C/N* requirements for mobile digital link operations.

Other digital modulation and encoding schemes are being deployed for TVOB, ENG and EFP system design, in particular for high definition systems that require higher bit rates. Some of these are based on proprietary modulation schemes and some on DVB-S modulation schemes. These tend to use channel rasters based on multiple 8 MHz or 10 MHz channels.

3.2.4 Link characteristics for TVOB, ENG and EFP

The principal difference with respect to conventional FS operations is that TVOB, ENG and EFP operations utilize a wide range of antenna types with wider main beam radiation patterns.

Operations may be bidirectional point-to-point, but more usually involve one or more one-way transmissions from nomadic/mobile news cameras to a fixed network access point, for onward transmission to a central studio location. However, the upward transmission may be relayed via other nomadic transmission sites, including terrestrial vehicles and airborne platforms such as helicopters or airships.

Use of low frequency bands tends to provide better propagation characteristics over obstructed paths, thereby increasing the probability of a successful transmission from any particular venue. Lower bands also provide a greater margin of power for the operation of the link, i.e. the link can tolerate larger transmission losses because of the availability of higher transmitter powers and better receiver sensitivities and are less affected by weather conditions. These factors are particularly important in the context of news reporting where the operator has no control over the venue of the event and virtually no opportunity to plan and optimize a transmission configuration.

Technical factors which make the spectrum bands below 3 GHz more suitable than higher frequency bands for ENG purposes include:

i) lower diffraction loss for obstructed paths;

ii) lower receiver noise figure;

iii) higher available transmitter power;

iv) avoidance of rigid / semi-rigid waveguide in telescoping masts.

Factors (i) to (iii) all contribute to an increase in available system gain, thereby maximizing the opportunity for establishing a link over an obstructed path. The nature of an ENG operation is such that line of sight paths are often not available, such that the availability of the last few decibels of margin can make the difference between successful operation or otherwise of the link.

Factor (iv) enables quick set-up of equipment, the use of telescopic masts, the use of helicopter mounted antennas etc.

Frequency bands above 6 GHz are more suitable for shorter distance links in TVOB operations.

3.2.4.1 Antenna elevation distribution

This is a probability density function with antenna elevation (0 to 90 degrees) as the independent variable and the probability of that antenna elevation as the dependent variable. The area under the line equals unity, in other words the sum of the probabilities includes all of the sample population. For populations of conventional point-to-point fixed services the probability of operation at 90 degrees of elevation will be zero, at 45 degrees almost zero, significant at elevations between 5 to 10 degrees and a maximum at around 0 degrees (i.e. most point-to-point links have elevations near the tangent line to the horizon).

However ENG links often operate with significant elevation angles. The normal range of ENG antenna elevations for receiving ENG antennas need to be considered, as these are likely to be the most affected by interfering emissions.

Since ENG operations are of various durations, it is also necessary to consider the probability density of the duration of the operations with high elevations and high gain antennas, i.e. the independent variable here is time (seconds) annually versus probability.

3.2.4.2 Elevation plane antenna radiation patterns

Recommendation ITU-R F.1336-1 is applied as the reference to obtain the elevation plane patterns for ENG antennas.

3.2.4.3 Link availability loss

Sharing studies determining the level of interference at ENG stations have taken into consideration the potential long path lengths involved and the sensitivity of the receiver. The collection stations will be those most susceptible to potential interference.

The demand for high quality sound and television ENG news coverage has increased considerably and this has produced the twofold effect of increasing the probability of occurrence of news worthy events whilst also increasing the number of news crews, vehicles and hence the number of transmission channels needed to cover wider areas.

The demand for sound and television news coverage of events and the concentration of ENG usage has led to the development of operational techniques including terrestrial spectrum sharing and increased geographical deployment by broadcasters. ENG operations provide the broadcast organisation with little control over venue and virtually no opportunity to plan and optimize a transmission. All these factors lead to high level of spectrum usage and the need for an increased level of availability.

A sharing methodology appropriate for collection stations will depend on several RF parameters including the collection station antenna radiation pattern, receiver sensitivity, antenna vertical tilt and azimuth pointing angle.

A basic probabilistic analysis would be based on a fixed set of RF parameters computed for different sets of parameters based on system configurations representative of the full range of possible configurations. This provides the probability distribution of interference (i.e. the likelihood that a given level of interference is exceeded) for the given set of RF parameters.

Broadcast organisations have estimated the location / time availability required for concentrated ENG operations in the area of 99.5%.

3.2.5 Modelling of the ENG collection station receive antenna

The ENG collection station receive antenna pattern has significant influence on the received interference. In an analysis, two antenna models were considered for the collection station receive antenna. Figure 2 presents a comparison of the two models:

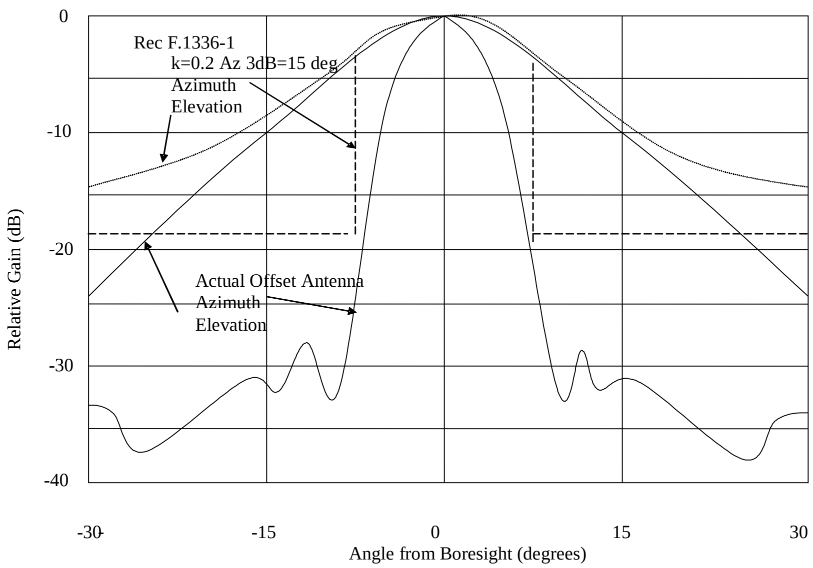
1) based on Recommendation ITU-R F.1336-1; and
2) the real pattern of an offset feed parabolic antenna, which is used in collection system operations.

The antenna pattern modelled was in accordance with Recommendation ITU-R F.1336-1. Recommendation ITU-R F.1336-1 provided an accepted model for the vertical pattern of a sector antenna as well as a model for the azimuth pattern within the azimuth sector beamwidth (see Annex 3 Equation 25 of Recommendation ITU-R F.1336-1).

A model was developed for the azimuth pattern outside the 3 dB beamwidth and a procedure for determining the gain at any combination of azimuth and elevation angle from the principal plane azimuth (at elevation equal to 0) and elevation (at azimuth equal to 0) patterns.

FIGURE 2

Collection station antenna patterns Gmax = 21 dB



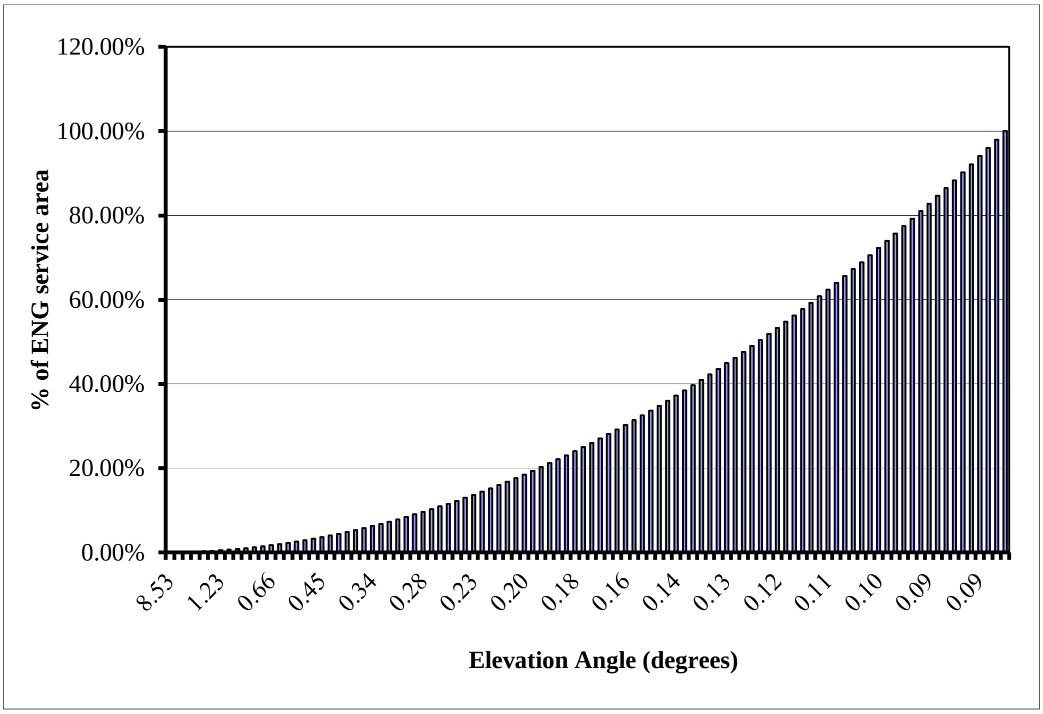
The vertical principal pattern (at azimuth equal to 0) is modelled in accordance with Recommendation ITU-R F.1336-1 with the input parameters being maximum antenna gain, beam tilt, azimuth beamwidth and the vertical pattern sidelobe shaping parameter *k*. The gain at any azimuth and elevation is the maximum gain less the azimuth and elevation discriminations taken from the principal patterns.

For the Recommendation ITU-R F.1336-1 model antenna, the receive antenna gain is varied between 15, 21 or 27 dB, thereby providing a basis for determining the sensitivity of interference to maximum receive gain. The pattern shown in Fig. 2 is for maximum gain equal to 21 dB, 3 dB azimuth beamwidth equal to 15 degrees and k (the sidelobe shaping parameter) equal to 0.2. In order to consider the full range of realistic collection station operational situations in the analysis, the receive antenna is allowed to tilt in the up direction by up to 5 degrees.

Figure 3 estimates a plane earth 100 km radius ENG service area and a Collection Station antenna elevation of 150 m. Assuming a uniform probability distribution over the service area, Fig. 3 demonstrates that only a small proportion of transmitting antennas will have elevations in excess of about 2 degrees (i.e. only those central business district locations within the immediate vicinity of the collection station).

FIGURE 3

Elevation angle vs service area (*hr* = 150 m, R_{max} = 100 km)



The vertical and horizontal patterns for the "typical" antenna are given in Fig. 2 for a maximum gain of 21 dB. Comparison of the two patterns indicates that the actual and Recommendation ITU-R F.1336-1 model are not dissimilar with both patterns being narrow in azimuth. In addition, in order to determine the sensitivity to pattern shape, an analysis is presented for the case where the "typical" antennas are reversed. For this case, the antenna is much narrower in the vertical direction and wider, outside of the 3 dB beamwidth, in the horizontal direction than the pattern for the Recommendation ITU-R F.1336-1 model. Comparison of the results obtained for two patterns with the same maximum gain demonstrates the sensitivity of level of interference to antenna pattern shape.

3.2.6 Polarization loss model

Polarization loss should be given serious consideration in any analysis. All potential interfering signals arriving within the azimuth 3 dB beamwidth of the collection station receiver are subject to polarization loss whether they originate from the main beam or the sidelobes of the interfering antenna. The polarization loss can be dependent on whether the polarization of the interfering signal is circular, elliptical or linear. If originating from the sidelobes of the interfering antenna, it can be considered as highly elliptical which can be approximated as a linear wave. In a probabilistic analysis, the polarization loss can be represented as having random orientation with respect to the collection station receive polarization.

The collection station antenna is linearly polarized so that as viewed by an interfering signal within the angle subtended by the 3 dB beamwidth, the antenna is considered to be linearly polarized. However, signals arriving at the antenna outside of the 3 dB beamwidth will arrive in the sidelobe area and it is not as clear that the polarization of the receive antenna can be modelled as being linear. Accordingly, the polarization loss is conservatively considered to be nil outside the 3 dB beamwidth.

The interfering signals arriving within the beam of the collection receive antenna could be considered as randomly polarized, since the orientation of the interfering signal polarization angle relative to the terrestrial station may be random. The polarization loss for interfering signals arriving within the base station collection station 3 dB beam is modelled as:

$$PolLoss = 20\ \text{Log}\ (\cos(\theta))$$

Where theta is the angle between polarization vectors and is modelled statistically as uniformly distributed between 0 and 90 degrees. The polarization loss within the 3 dB beamwidth is then determined from equation 1. The polarization loss for signals arriving outside of the 3 dB beamwidth is taken as 0 dB.ϴ

The polarization loss computed from the above equation can be large for theta near 90 degrees and could exceed typical polarization discrimination of the base station antenna.

Accordingly, a limit of 15 dB is placed on the polarization loss. Even the assumption of random polarization for signals received within the 3 dB beamwidth is conservative since the polarization of signals outside of this region will not be matched to the receive antenna polarization.

3.3 System design requirements for TVOB, ENG and EFP

TVOB, ENG and EFP system designs have the following requirements:

a) The ENG transmission and relay equipment must be robust and suitable for mounting in mobile vehicles.

b) The transmitter must be capable of rapid deployment and speedy set-up, allowing relatively non technical staff to arrive at a news event, select the appropriate transmit frequency/channel and commence broadcasting very quickly.

c) For successful link operations the entire system must be expandable and homogenous in its system design in terms of encoders at repeater sites or the number of repeater sites.

d) The quality and robustness of the microwave link must be sufficient to allow reliable, broadcast quality transmissions to be received from almost anywhere within the broadcast organisations' defined news coverage region for an estimated availability of 99.5%.

e) The transmission frequency must be selectable to enable avoidance of congestion that may be prevalent in some bands. The allocated frequency must be able to be accessed rapidly and without operating outside authorized frequencies

f) Mobile equipment in many systems will be required to have the capability of both transmitting and receiving so they can act as a repeater.

g) Within many administrations occupational health and safety requirements have significantly increased the use of wireless camera equipment mitigating the risk posed by camera cable runs where unplanned news events occur in areas accessible to the public.

h) TVOB, ENG and EFP repeater sites, which may be located on tall buildings for "pooled" coverage, may be required to provide reception and transmission for a number of simultaneous operations thus increasing the need to utilize standardized encoding techniques to a number of feeds to news studios/facilities.

4 Television outside broadcast, electronic news gathering and electronic field production equipment characteristics

TVOB, ENG and EFP operations involve a variety of equipment including transmitters mounted on the back of cameras and in other specialized applications such as in race cars, temporary fixed links and vehicle mounted links.

Likewise a variety of receivers are deployed to suit the operational situation. These range from a small antenna deployed at a TVOB for reception of camera-back transmitters to the use of a central receiving site.

4.1 Central receiving sites

Analogue TVOB/ENG operations have utilized a variety of antennas, including parabolic dish and co-linear with ENG collection receiving stations typically using medium-gain horn arrays with terrestrial coverage over the full azimuth range. The characteristics of analogue FM modulated video signals dictated that only one antenna could be used into one receiver at a time.

Digital technology allows numerous antennas to be connected in an array to a diversity receiver which selects the optimum signal automatically at any instant in time. The antenna types may be a mixture of steerable (e.g. parabolic dish), fixed (e.g. horn array with 360 degrees of azimuthal coverage) or panel arrays with up to 360 degrees of azimuthal coverage.

Additionally, diversity reception techniques are employed between collection stations to feed one “master” decoder and hence provide continuous coverage for mobile applications over a wider area.

For digital helicopter platform applications bottom mounted antennas have been used which have an estimated antenna pattern discrimination (vertical and horizontal) of up to 20 dB. The downlink from the helicopter back to the local collection station often operates at elevation angles of up to 90 degrees.

DENG systems have now moved to a cellular-type of operation whereby a network of collection stations provides coverage over the wanted service area.

The TVOB/ENG/EFP collection station feeds the television studio either directly or through wireline whereas the helicopter provides a relay capability from the video (on location) source to the collection station. A collection station receives from ground-based or helicopter relay stations, not just ground-based relay stations alone. Collection stations can also receive from helicopter line of sight relays where the helicopter station typically transmits at 10W. In both cases the elevation of the arriving signal is low, less than 5 degrees.

4.2 Nomadic receiving sites

Similar to a central receiving site, a temporary (nomadic) receiving site for ENG consists of either a steerable directional antenna or an array of panel antennas. These are typically a rapid deploy setup involving temporary platforms, masts tripods and can be located either on the ground or as rooftop installations.

They are categorized by the fact that such an installation is temporary in nature and are deployed to serve immediate needs for a particular event or disaster either as a pre-planned event or in an unplanned mode, this especially for coverage in remote areas and coverage of disasters out of areas served by central DENG facilities.

Usually these receivers are used in conjunction with other backhaul facilities to on-pass the material to a studio and these could be something like a Fibre POP, SNG or SNV earth station or another point-to-point terrestrial microwave link.

The primary function of the temporary receiving site is to provide enhanced coverage by way of extending receive points otherwise un-served by fixed ENG or by increasing capacity by adding extra channels of receiver capability. It is also used in conjunction with low powered wireless cameras to provide coverage of an event that would otherwise be unsafe to cover using conventional methods such as long cables and other hazards.

A temporary receiving site is capable of receiving signals from the full range of transmitters including wireless cameras, ENG vehicles, helicopters, portable links etc. Note that especially in DENG mode a single receive point could be operating simultaneously with multiple receive channels by using multiple receivers sharing a common antenna system.

Antenna gains and patterns are in the same range as those at the fixed central receiving sites right down to those of a simple omnidirectional antenna.

Such a receive system is commonly integrated into DENG vehicles. This would provide local (to the vehicle) coverage of lower powered portable or camera mounted units for on-passing to the permanent receive sites by way of the vehicle mounted link.

4.3 Mobile platforms

For television broadcast news coverage, mobile video links have been typically deployed where a camera is mounted on a moving vehicle (e.g. motorcycles, race cars and helicopters). In the case of terrestrial mobile (e.g. 'race-cam') cameras operating to a ground based receive site via an airborne platform (e.g. helicopter), each link fits into the mobile platform category. Race cars have typically operated with 10 W transmitter operating into a vertically polarized 2 dBi patch uplook antenna. The on location ground segment typically operates with elevations from 0 degree to 45 degree elevation. Higher elevations are occasionally used during sporting coverage for local helicopter relay.

Helicopter platforms use bottom mounted downlook antennas with an estimated antenna pattern discrimination (vertical and horizontal) of up to 20 dB. The downlink from the helicopter back to the local collection station often operates at elevation angles of up to 90 degrees.

Helicopter platforms are often used as repeater stations to extend the range of the city collection stations. Hovering at elevations up to 2 500 m the helicopter provides a relay platform for ground-based news crews to transmit news back to the city collection station, which may be of the order of 170 km away. Although these operations are not frequent, often they are used during major natural disasters such as bushfires, thus both informing the public and providing vital information for emergency services operations.

5 Analysis of ENG system density for modelling purposes

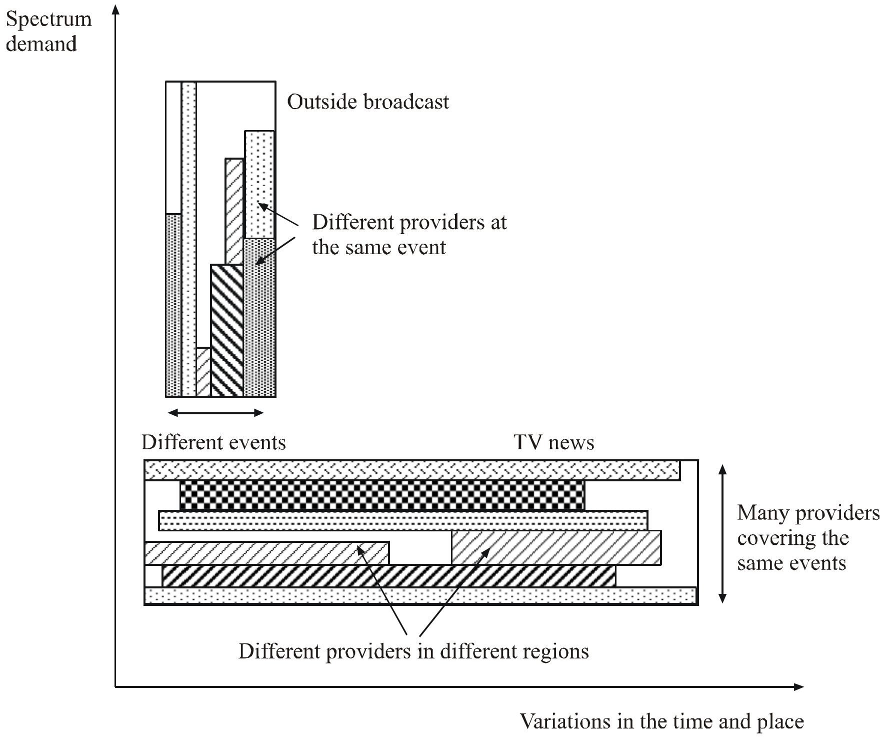
Studies within ITU-R on tuning ranges and operational characteristics of terrestrial ENG, TVOB and EFP systems as reported in Report ITU-R BT.2069 indicate that use in most cases may be characterized as having a high degree of locality, as such use is normally confined to the limits of specific locality/event. Therefore demands for resources normally occur in parallel. For example if events in two cities have a demand for tuning ranges, the total demand for ENG tuning ranges is equal to the larger of the two demands.

Similarly, if events on different days each have a demand for tuning ranges, the overall demand for tuning ranges is again equal to the larger of the two demands, as tuning ranges used for one purpose on one day can be reused for another purpose on another day. Demand measured in this way is *peak* demand and is the correct measure to use to determine whether current tuning range assignments are sufficient.

To illustrate this schematically, a graph can be drawn of demand for ENG tuning ranges against time and place. The horizontal axis represents different times and/or places, although there is no sense of an increase in either time or place when moving to the right – it merely represents *different* times and/or places. The vertical axis represents demand for ENG tuning ranges. Example in Fig. 4 shows this with two rectangles, one representing schematically the way demand might arise for outside broadcasts, the other doing the same for TV news.

FIGURE 4

Illustration of how demand arises in different ENG sectors



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Tuning ranges for ENG can be reused at different outside broadcast events, so each event has a different rectangle, and the rectangles are placed side-by-side. Demand at a single outside broadcast event is quite high so the height of each rectangle is large, but the demand is localized in time and space so the width of each rectangle is small. Where two or more broadcasters visit the same event, their rectangles have to be stacked on top of each other as they cannot use the same tuning ranges.

However for ENG applications, each broadcast organisation usually has to have its own tuning ranges, which it can use anywhere in time and space (within certain limits). Each organisation has relatively few tuning ranges, so the rectangles have small height, but can use those tuning ranges over a wide range of times and places, so the rectangles are wide.

Different organisations need to be able to visit the same event at the same time, so the rectangles representing different organisations have to be stacked on top of each other to obtain the overall demand for the sector. If two organisations operate in two sufficiently separated regions, they can share tuning ranges, so their rectangles can appear side-by-side.

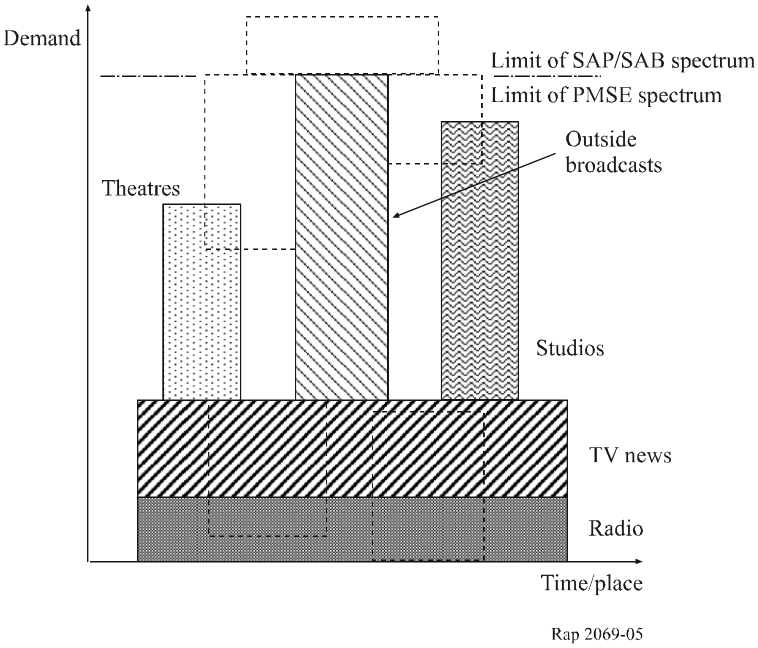
Therefore the whole of the ENG use may be illustrated as shown in Fig. 5. Each sector has its own rectangle, representing its demand.

Demand from ENG users has to be added to demand from the other sectors as these sectors require a "go anywhere" capability (in time and within a geographical region), so they have tuning ranges, which are separate from all other users. The same tuning ranges cannot (for example) be used by a theatre and for news gathering, particularly in the case of wireless microphones, as the news gatherers require the capability to use tuning ranges at the same time and place as the theatre. However, as tuning ranges can normally be reused between theatres, studios and outside broadcasts, so their rectangles are separated horizontally rather than stacked vertically.

The total demand for ENG tuning ranges is therefore equal to the sum of the demands for TV news, radio and the largest of theatres, studios and outside broadcasts.

FIGURE 5

Combination of spectrum demand in different ENG sectors



In fact, outside broadcast demand can be so heavy that tuning ranges are sometimes borrowed from the other sectors, and/or from outside the ENG tuning ranges. This is shown by the additional dotted rectangles, which represent how outside broadcast might intrude on other radio services tuning ranges.

Report ITU-R BT.2069 estimated that all together terrestrial ENG operators providing news coverage in the area covering major conurbations with high density of news events (typically capital and other big cities) may require allocation of up to:

– 15-30 wideband channels for radio microphones;

– 5-10 channels for various video links.

5.1 Wireless microphones

Recommendation ITU-R BT.1871 – User requirements for wireless microphones, contains typical system parameters and operational requirements for analogue and digital wireless microphones, which may be used by administrations and broadcasters when planning tuning ranges within broadcasting, fixed and mobile service allocations.

As specified in Recommendation ITU-R BT.1871, wireless microphones use spectrum below 1900 MHz and do not share spectrum with fixed services and therefore, although they are an important resource for ENG, are outside the scope of this report.

5.2 Operational density for digital HDTV/SDTV wireless cameras

Recommendation ITU-R BT.1872 “User requirements for digital electronic news gathering” provides technical parameters in terms of basic video and audio quality for transmission of digital HDTV/SDTV signals in the fixed service for a transmission power of 1.76-7 dBW as:

Transmission bandwidth	8 MHz, 9 MHz, 18 MHz and 24 MHz
Frequency band	6-7 GHz, 10 GHz and 13 GHz

Within a specific locality, Recommendation ITU-R BT.1872 specifies corresponding transmission distances in the fixed service:

6-7 GHz:	50-100 km (depending on necessary margin)
10 GHz:	7 km (with necessary rain margin)
13 GHz:	5 km (with necessary rain margin)

And in the mobile service for a transmission power of 7dBW transmission distances:

<table>
<tr><td colspan="2">800 MHz band</td><td>4 km</td></tr>
<tr><td colspan="2">6-7 GHz,
10 GHz
13 GHz bands</td><td>4 km</td></tr>
<tr><td rowspan="3">Airborne</td><td>6-7 GHz:</td><td>50-65 km (depending on necessary margin)</td></tr>
<tr><td>10 GHz:</td><td>7 km (with necessary rain margin)</td></tr>
<tr><td>13 GHz:</td><td>5 km (with necessary rain margin)</td></tr>
</table>

Report ITU-R BT.2069 indicates digital video ENG applications, such as cordless cameras, should be accommodated in a 8 / 10 MHz width channel raster for SDTV combining of two channels within the 20 MHz raster when higher quality HDTV transmission is required.

6 Case studies on dense usage of electronic news gathering systems at times of heightened news gathering events in Australia

6.1 Beaconsfield Mine disaster – 2007

The story of the mining accident at Beaconsfield mine in northern Tasmania made headlines around the world via the ENG signals of Australian television broadcast organizations.

Throughout daily coverage of this event all Australian television broadcast networks were providing "live crosses" during hourly news bulletins to the Beaconsfield site. Coordination of frequencies at the site was provided by the utilization of a black board and crayons at the sporting oval where all news crews met on a frequent basis.

The ENG inventory for the four major Australian television broadcast networks for this news gathering event was as follows:

TABLE 1

ENG Inventory

Australian TV Network	**ABC**	**SEVEN**	**TEN**	**NINE**
ENG units	2	3	2	3
Spectrum channels used	2 × 8 MHz	3 × 8 MHz	2 × 8 MHz	2 × 8 MHz
% reuse	100%	100%	100%	100%
Hours of operation per day	20	14	18	24
Number of days	14	14	14	14
Helicopters	–	4	–	1
Radio microphone channels	4	5	5	8
DSNG units	2	–	1	3
Point to point links	–	–	2	–

FIGURE 6

Beaconsfield mine disaster – ENG link Plan

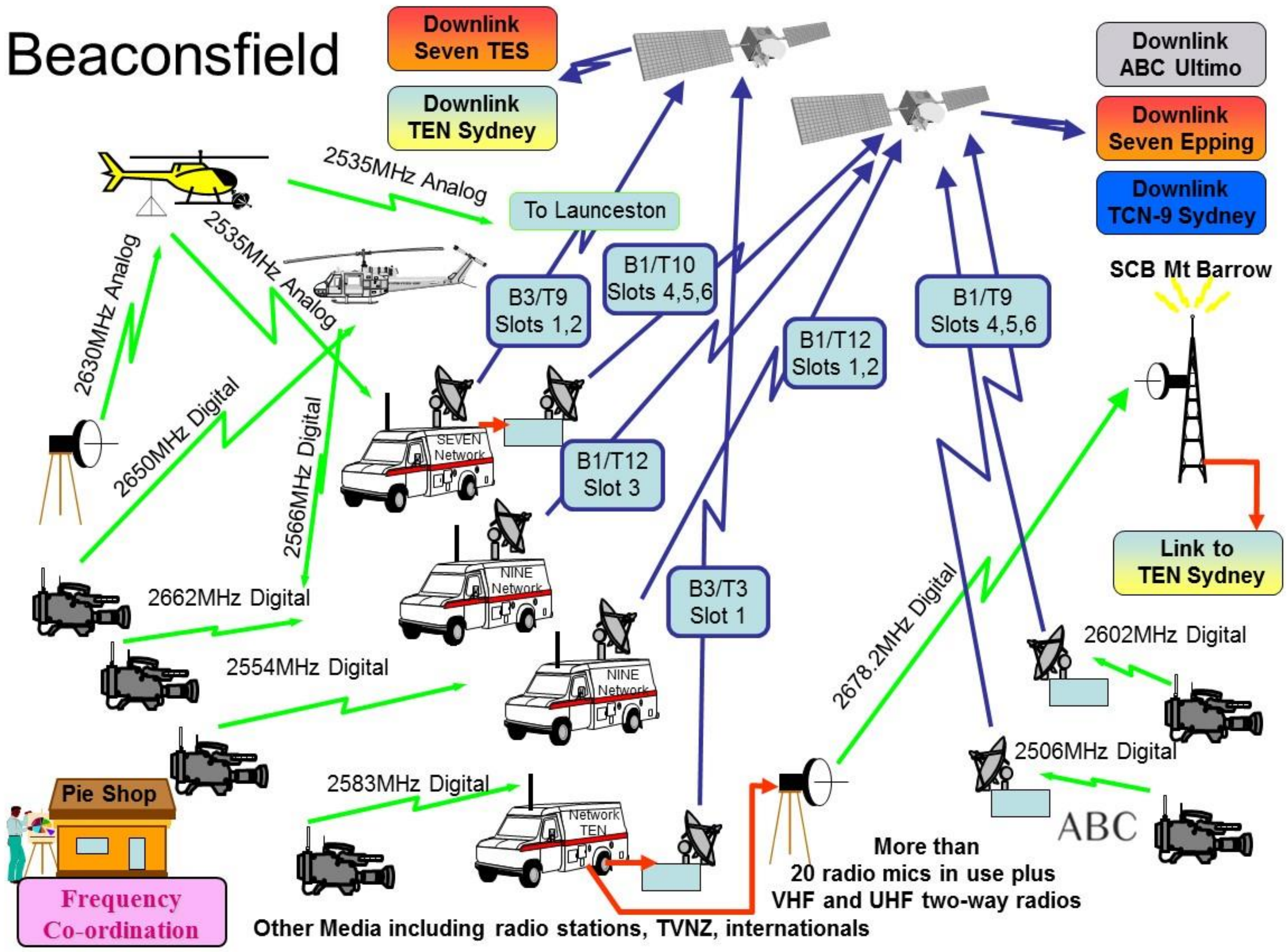


FIGURE 7

Launceston ENG International interchange link Plan

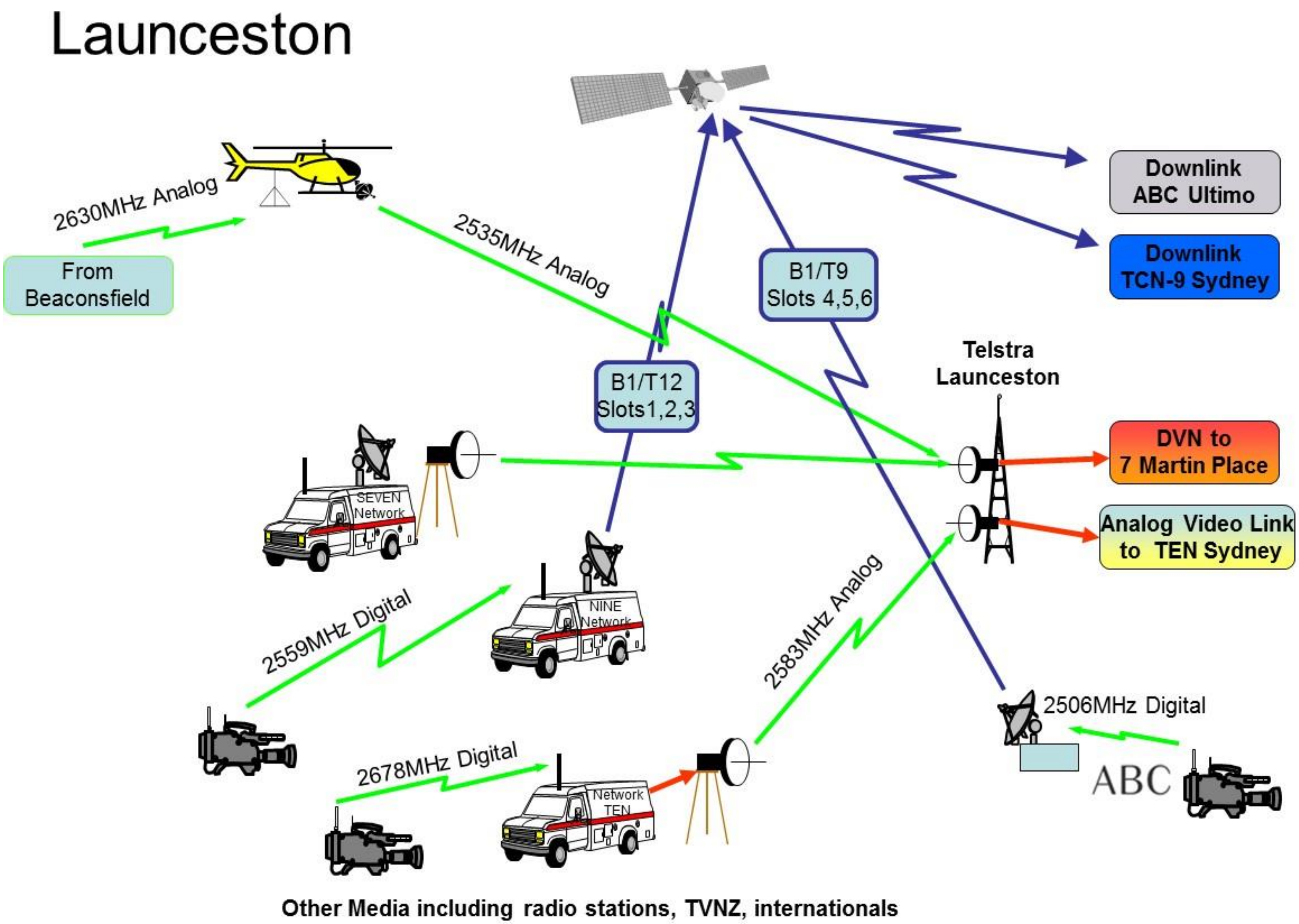
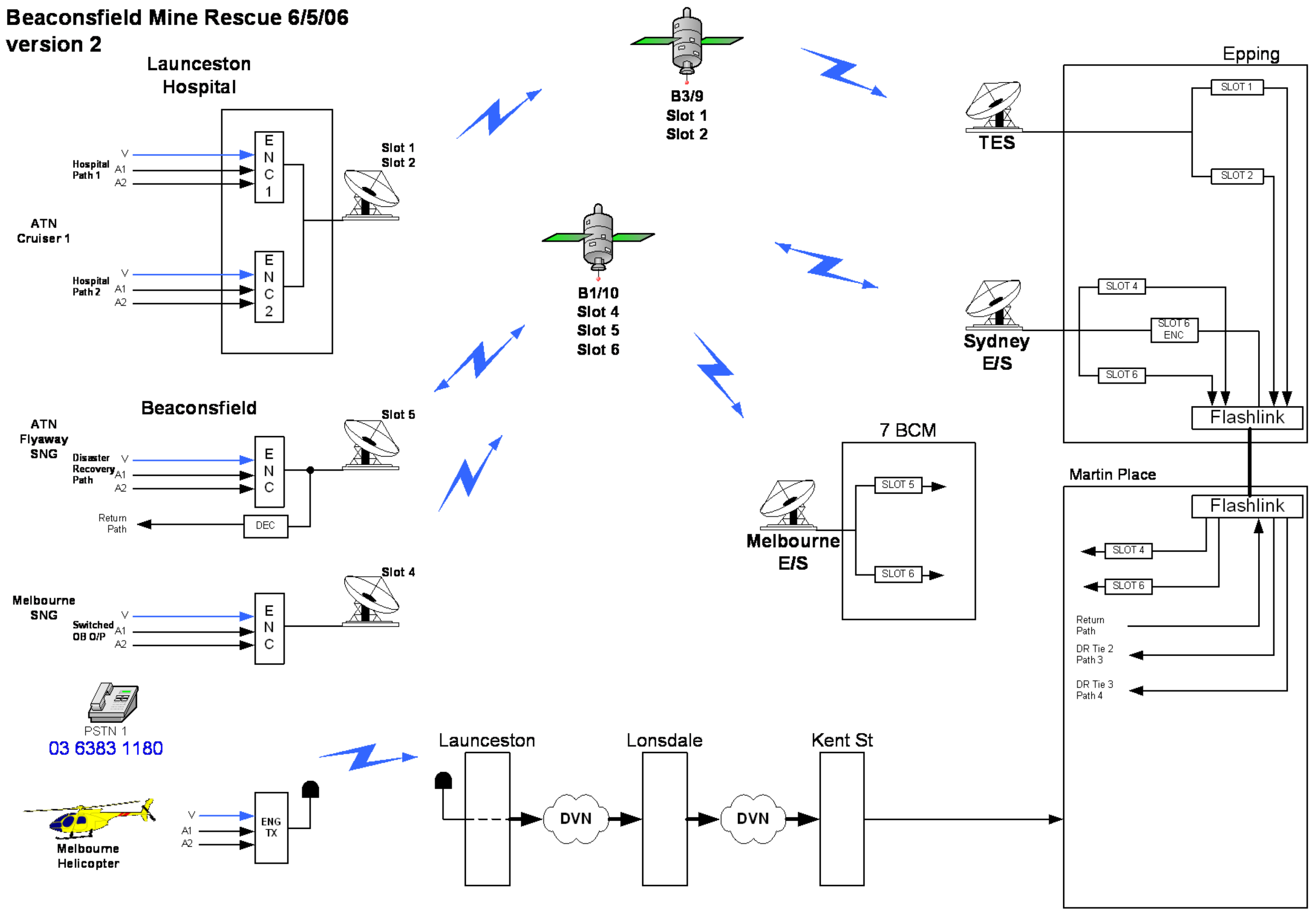


FIGURE 8

Beaconsfield mine disaster – DSNG link Plan



6.2 Asia-Pacific Economic Cooperation (APEC) meeting – Sydney

APEC Australia 2007 was a series of political meetings held around Australia between the 21 member economies of the Asia-Pacific Economic Cooperation during 2007. Various meetings were held across Australia from January to August 2007, with the event cumulating in Leaders Week, where the heads of government of each member economy attended Sydney, New South Wales from 2 to 9 September 2007.

Coverage of these events involved the following ENG frequency usage schedule in central business district of Sydney.

TABLE 2

ENG FREQUENCY USAGE MONDAY 3RD SEPTEMBER 2007 - SUNDAY 9TH SEPTEMBER 2007

DATE	TIME ON / OFF	STORY	LOCATION	FREQ (MHZ)	RXER	RSS
03/09/07	1830 / 1930	APEC	Darling Harbour	2506.0	CP	
04/09/07	1130 / 1230	APEC	Darling Harbour	2506.0	CP	
04/09/07	1630 / 1930	APEC Protest	Railway Square	2506.0	CP	
04/09/07	1715 / 2030	Bush Arrival	International Airport (Mascot)	2613.5	GH	23
04/09/07	1830 / 2030	Bush Arrival	International Airport (Mascot)	2506.0	Van	24
04/09/07	1800 / 2100	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2517.5	OB's	
05/09/07	1130 / 1230	APEC	Darling Harbour	2506.0	CP	
05/09/07	1130 / 1230	APEC	CBD	2613.5	GH	17
05/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2517.5	OB's	
05/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2602.0	OB's	
06/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2517.5	OB's	
06/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2602.0	OB's	
06/09/07	1130 / 1230	APEC	Darling Harbour	2506.0	CP	
06/09/07	1530 / 1630	APEC (TVNZ)	Dawes Point	2506.0	GH	20
06/09/07	1800 / 1930	APEC	Mrs Macquarie's Chair	2613.5	GH	18
06/09/07	1830 / 1930	APEC	Mrs Macquarie's Chair	2602.0	Van	24
07/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2517.5	OB's	
07/09/07	1100 / 2300	Dignitaries Arrivals (OB's)	International Airport (Mascot)	2602.0	OB's	
07/09/07	1130 / 1230	Protest	Hyde Park	2613.5	CP	22
07/0907	1530 / 1630	APEC (TVNZ)	Kirribilly	2506.0	CP	
07/09/07	1800 / 1910	APEC	The Rocks	2613.5	CP	18
07/09/07	1800 / 1910	APEC	The Rocks	2506.0	Van	
08/09/07	0930 / 1500	APEC	Hyde Park	2613.5	GH	
08/09/07	1000 / 1230	APEC	Sydney Town Hall	2506.0	CP	
08/09/07	1530 / 1530	APEC (TVNZ)	Kirribilly	2506.0	CP	21
08/09/07	1800 / 1915	APEC	MCA Sydney	2506.0	CP	17
09/09/07	0900 / 1600	APEC	Kirribilly	2517.5	OB's	
09/09/07	1530 / 1630	APEC (TVNZ)	Kirribilly	2506.0	CP	17
09/09/07	1830 / 1930	APEC	CBD	2506.0	CP	
09/09/07	1800 / 1915	APEC	Mrs Macquarie's Chair	2613.5	GH	18
09/09/07	1800 / 1915	APEC	Mrs Macquarie's Chair	2506.0	VAN	18

6.3 Victorian bushfires – February 2009

Electronic news gathering spectrum usage

All Australian television broadcast networks made extensive use of electronic news gathering facilities in covering the Victorian bushfire disaster in February 2009.

While some networks have used satellite news gathering (SNG) for their main links, others have used ENG as the main link back to their network studio facilities.

All Australian television broadcast networks have relied on the 2.5 GHz band for electronic news gathering links to connect helicopters to their local productions at the bushfire staging areas.

Use of 2.5 GHz camera back links has been vital to connect cameramen to local facilities and avoid the need to run cables as a safety issue in areas where the victims gather and may not necessarily be fully aware of their surroundings while they are in a state of shock.

The table below is a log of the bushfire-related use of 2.5 GHz by the commercial television broadcast networks (Seven, Nine and TEN) in the week immediately following the disaster. This log does not include:

a) other uses by commercial television broadcasters (Seven, Nine and TEN networks) of the 2.5 GHz band spectrum in the Melbourne area for the normal day-to-day collection of news stories; and

b) Australian Broadcasting Corporation (the public broadcaster) usage of the 2.5 GHz band for coverage of the Victorian bushfires and ABC news gathering of other events in the Melbourne area.

TABLE 3

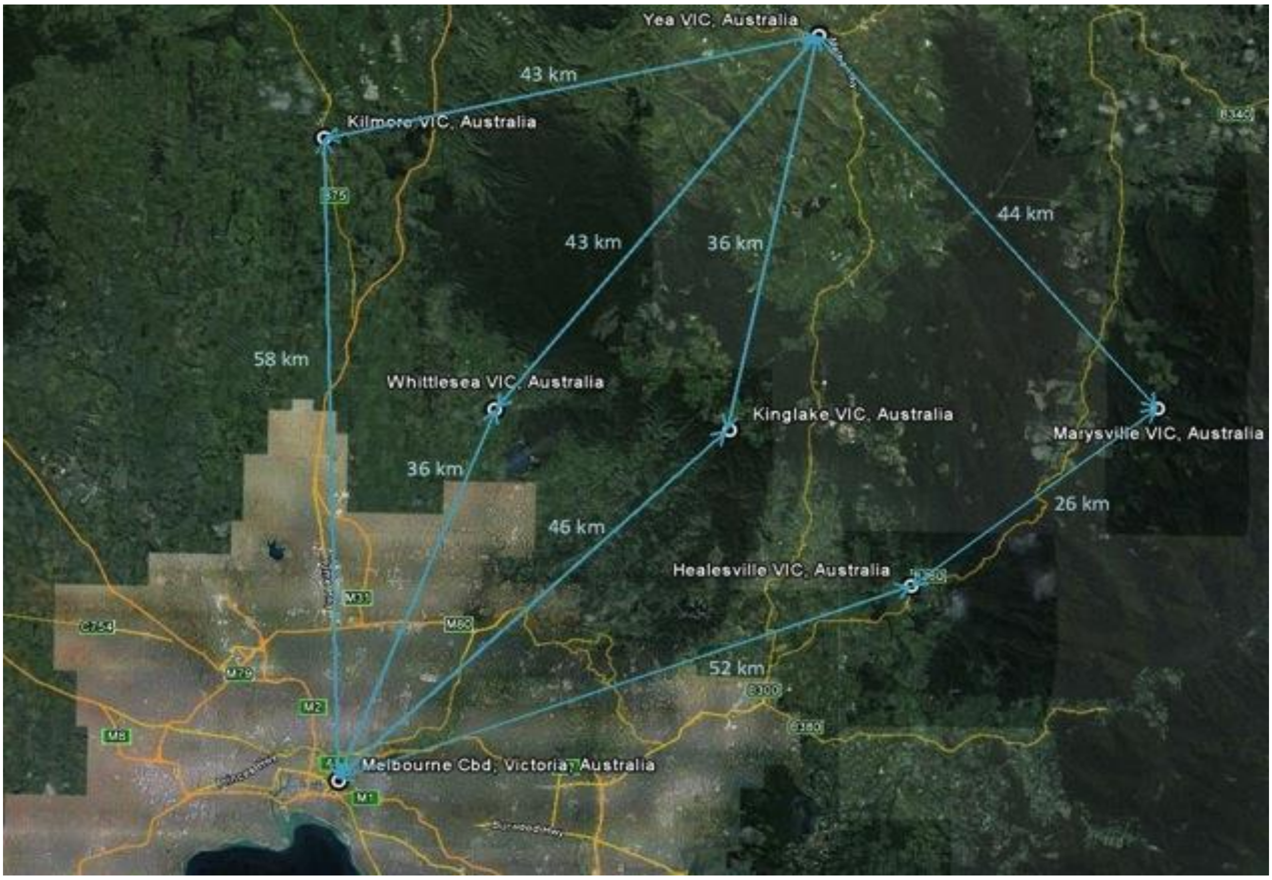
Victorian bushfire link log

Date	Usage	Application	Location
Saturday 7th Feb	5 hrs 7 minutes	Helicopter aerials	Bunyip, Kilmore, King Lake
	5 hrs 8 minutes	Terrestrial links	CFA HQ, Wallan, DSE
Sunday 8th Feb	3 hrs 55 minutes	Helicopter aerials	Marysville, Yea, Kinglake, Glenburn
	27 hrs 8 minutes	Terrestrial links	Yarra Glen, Kangaroo Ground, VPC, Treasury Place, Red Cross centre, Narre Warren, St Andrews, Whittlesea, Bendigo, Hume Freeway
Monday 9th Feb	3 hrs 19 minutes	Helicopter aerials	Marysville, Flowerdale, Kinglake, Kilmore, Wandong, Gippsland
	15 hrs 15 minutes	Terrestrial links	Whittlesea, Yea, Beechworth, Strath Creek, Worth, Yackandandah
Tuesday 10th Feb	7 hrs 20 minutes	Helicopter aerials	Marysville, Toolangi, Kinglake, Chums Creek, Whittlesea, Mt Disappointment, Latrobe Valley, Healesville, Beechworth, Melbourne CBD
	19 hrs 0 minutes	Terrestrial links	Yea, Beechworth, Healesville, Coldstream, Melbourne CBD
Wednesday 11th Feb	4 hrs 17 minutes	Helicopter aerials	Marysville, Whittlesea
	33 hrs 33 minutes	Terrestrial links	Whittlesea, Yea, Beechworth, Healesville, VPC, Toolangi, Glenvale, DSE, Red Cross centre, Traffic centre, Marysville, Melbourne CBD
Thursday 12th Feb	2 hrs 50 minutes	Helicopter aerials	Marysville, Reddy Creek, Flowerdale, Kinglake,, Ivanhoe, Melbourne CBD
	14 hrs 24 minutes	Terrestrial links	DSE, ECC, VPC, Yarra Bend, Reedy Creek,
Friday 13th Feb	5 hrs 35 minutes	Helicopter aerials	Healesville, Kinglake, Maroondah Reservoir, Marysville, Bunyip, Euroa, Melbourne CBD
	12 hrs 37 minutes	Terrestrial links	Morwell, Red Cross centre, DES, ECC, VPC, Telstra Dome, Melbourne Airport
Saturday 14th Feb	3 hrs 45 minutes	Helicopter aerials	Healesville, Marysville, Campbellfield, Cardinia Reservoir, Belgrave
	1 hr 5 minutes	Terrestrial links	Melbourne Terminal, Healesville, CFA HQ
Sunday 15th Feb	2 hrs 53 minutes	Helicopter aerials	Marysville, Cardinia Reservoir, Belgrave
	1 hr 10 minutes	Terrestrial links	CFA, DSE

Figure 9 provides a map of the geographic distances for the locations where television coverage took place with respect to link distances back to the television studios in Melbourne.

FIGURE 9

2009 Victorian bushfire locations



6.4 Sydney Olympics – 2000

This section gives a brief overview of radiofrequency spectrum management in Australia and details the way in which spectrum was allocated to various stakeholders for the Sydney Olympic Games.

The governance of the Sydney Olympic Games was vested in the Sydney Organising Committee of the Olympic Games (SOCOG) and the coordination of all media coverage was vested in Sydney Olympics Broadcasting Organisation. (SOBO).

6.4.1 Radiocommunications licensing arrangements

The staging of the Games led to increased demand for radiocommunications services in the Sydney basin. Not only did SOCOG require radiocommunications services, but all of the organizations providing facilities and services to support the Games, including organizations visiting Sydney from interstate and overseas, also had radiocommunications requirements.

The capacity of the radiofrequency spectrum to support radiocommunications services at a particular location is limited by the physical characteristics of the spectrum, and by the technical characteristics of the device to be used at that location. The radiofrequency spectrum is a finite resource. It may be that not all applications for a radiocommunications service can be satisfied simultaneously. Innovative approaches and alternatives were employed to satisfy demand for Games-time spectrum, and all organizations needed to be disciplined in radiofrequency use.

Radiocommunications licences were issued, wherever practicable, according to the usual spectrum management arrangements used in Australia. However, radiocommunications equipment that could not normally be licensed under these arrangements was accommodated. After the Games, the use of such devices was subject to all of the usual regulatory requirements and enforcement mechanisms.

Under section 46 of the *Radiocommunications Act 1992*, a radiocommunications device must be authorized for operation by an appropriate license (a class, spectrum, or apparatus license). Devices used at the Games could have been authorized by any of these three licence types.

6.4.2 Licence priority strategy for the Games

Under paragraph 100(4)(a) of the Radiocommunications Act, the ACA[1] must consider all relevant matters when deciding to issue an apparatus licence. The ACA usually issues licences to applicants on a 'first come, first served' basis. Because the Games were important to Australia, the ACA gave priority to licence applications received from SOCOG and SOBO over those from other Games-related entities. The ACA could not reserve spectrum for the Games and it was vital that SOCOG identified its radiofrequency spectrum needs as early as practicable. Once the spectrum needs of SOCOG were satisfied, then other licence applications were processed.

While the ACA gave priority to SOCOG's licence applications, SOCOG needed to be disciplined in dealing with requests it received from its clients for radiocommunications services.

Requests for a licence to use radiocommunications spectrum were scrutinized to ensure that this was an effective way to meet the client's communication need. Alternatives were explored and the opportunity to rationalize the communication needs of several parties onto a shared system was taken wherever possible.

Having fewer devices operating in Sydney Olympic Park and elsewhere reduced the chance of radiocommunications interference. Careful management of available radiocommunications channels also meant that the demand for radiocommunications services from other individuals and organizations could be met.

A starting point for a radiocommunications licensing strategy for the Games was to prioritize requests from Games-related entities for access to the radiofrequency spectrum as follows:

– Priority 1: licence applications from SOCOG.

– Priority 2: licence applications supported by SOCOG, for example, rights-holding media.

– Priority 3:all other Games-related licence applications.

To set priorities, the ACA identified Games-related licence applications. ACA staff used their licensing delegation, taking into account information available at the time. In general, the ACA followed the above priorities for licence applications.

6.4.3 Frequency Coordination Committee

A Frequency Coordination Committee (FCC) was established to assist the ACA in determining the priority of Games-related licence applications from organizations other than SOCOG. The Committee was answerable to the Sydney Olympic Communications Coordination Committee and comprised representatives of SOCOG, SOBO, the ACA and Telstra. It aimed to fast-track the decision-making surrounding the allocation of spectrum to specific users.

[1] The Australian Communications Authority (ACA) was replaced by the Australian Communications and Media Authority (ACMA) in 2005.

Within the committee, applications from the media for radiofrequency spectrum were principally reviewed by SOCOG, either through SOBO, for broadcast users, or through Press Operations for the print media. The SOCOG Spectrum Manager reviewed requirements that fell outside these two areas. After review, the committee made recommendations for the ACA to consider in licensing radiofrequency. The ACA would then process the frequency request and issue a licence to the user.

The FCC was responsible for the following.

– Advising on whether SOCOG would pay for the issue of a particular licence. The SOCOG representative had to authorize licence fee expenditure before it was charged to SOCOG's accounts.

– Advising on whether the radiofrequency spectrum related to the application was actually necessary.

Several communications services were provided within the communications infrastructure established to support the Games. This made it possible to satisfy particular communication needs using these services, rather than having to establish additional radiocommunications systems requiring additional radiofrequency spectrum. Existing commercially available systems were also an economical and convenient solution to some communications needs.

– Identifying a priority for processing an application from the FCC's perspective. This was particularly useful in early 2000 and close to the Games when applications for radiocommunications services peaked.

Recommendations made by the FCC after reviewing the application were final. They included whether the application should be rejected by the ACA or that the committee and the ACA should work together to find a solution for the user.

During the Games, members of the FCC were required for other duties and a Designated Frequency Coordinator, who was an ACA employee, worked with SOCOG to carry out the committee's functions. The coordinator worked with rights-holding broadcasters, and representatives of the ACA and SOBO in the International Broadcast Centre.

Most radiofrequency licensing work was completed well before the Games opening ceremony allowing the Designated Frequency Coordinator to concentrate on coordinating shared use of microwave outside broadcast television spectrum and wireless microphone spectrum (520 MHz to 820 MHz) by rights-holding broadcasters. SOBO supported the coordinator in this task.

6.4.4 Role of SOCOG and SOBO

Once all the radiocommunications needs for SOCOG and SOBO were identified, the licensing work was completed. The principal licensing focus was then on the needs of the rights-holding broadcasters.

While the ACA worked with SOCOG and SOBO to identify an appropriate radiofrequency channel for the required radiocommunications service, it was not appropriate for the ACA to plan SOCOG's or SOBO's radiocommunications services. The role of SOCOG and SOBO was as follows.

– Determine the communications needs of their teams.

– Explore suitable options for delivering communications including the use of the Sydney Olympic Radio.

Network, mobile phones, commercially available radio systems and optical fibre-based services. The suitability of these options for each SOBO and SOCOG team varied and these variations were considered. The provision of SOBO and SOCOG radiocommunications services also needed to be seen as a whole and these organizations needed to rationalize these variations. Wherever possible, both SOCOG and SOBO used existing commercially available systems rather than establish a new communications service.

– Make arrangements to establish any new communications service. Establishing a new communications service is a significant undertaking. For a radiocommunications service, arrangements include a survey to identify a suitable radiocommunications site, organizing access to that site and arranging purchase of all necessary equipment and its installation.

6.4.5 ACA licensing locations

The majority of licensing for the Games took place through applications mailed to the ACA's Sydney Area Office. The ACA also had a Games-time presence at the International Broadcast Centre and, during the period of the Paralympics, at the Main Media Centre.

Licence applications were processed at these locations, however the ACA's Sydney Area Office performed all frequency assignment work associated with issuing licences.

6.4.6 Interference impact certificates

In the 12 months before the Games, people accredited to issue frequency assignment and interference impact certificates (accredited persons) had performed a significant proportion of the frequency assignment work previously done by the Sydney Area Office. This continued during the Games. The ACA therefore worked closely with accredited persons to ensure frequency assignment work was orderly. This assisted in avoiding conflicts during the busy Games preparation and staging times.

Arrangements for accredited persons mean that they have the same level of access to radiocommunications licensing data as ACA frequency assignment staff. Consequently, the ACA provided real time production of adjacent channel services listings for accredited persons, as well as for certain ACA staff.

6.4.7 Radiocommunications transmitter identification labels

a) Arrangements for the Games

Devices installed well before the Games had to comply with all the usual Australian requirements, including the obligation to label for identification purposes. This applied to devices installed at communal radiocommunications sites – essentially sites that were popular for radiocommunications services. Devices brought into the country by clients at the last minute were not required, by the relevant determination, to be labelled for identification, because they were predominantly portable and not located at communal sites.

b) Special Games labelling

To assist compliance enforcement work, four special Games labels were introduced for radiocommunications devices as follows.

Licensing label

This was usually sent through the post or issued directly by the ACA. It was affixed to the licensed device by the licensee or equipment operator. The presence of this label on a device simply indicated that at some stage the licensee or operator had been in contact with the ACA about licensing matters. The label was not a reliable indicator of the particular device's authorization to operate or of the potential for the device to cause harmful interference.

Technical details label

This label indicated that the device had been inspected at the ACA's Equipment Testing Centre or an ACA mobile services team technical officer had performed a technical assessment of the device in the field. The technical parameters recorded on the label were relied on when investigating interference problems. The technical parameters included:

– a device inspection number issued by the ACA technical officer at the time of type testing or inspection;

– the measured operating frequency or frequency range;

– the spectrum access number of the device (from the relevant RADCOM licence);and

– a space for any special operating notes.

This label included the ACA logo and was designed so it would not survive any attempt to remove it from a device once affixed.

Required modification tag

This tag indicated that an ACA technical officer, who had established that the device needed to be modified before it could be licensed for use, had also inspected it. It was only practical to modify two parameters at the Games – frequency and transmitter power.

Do not operate tape

If a device was likely to cause harmful interference, or could not be modified to operate on the required frequency at the required power, an ACA officer would wrap message tape around it. The tape read: 'This device must not be operated in Australia' and included a note that it must not be removed. All messages on the tape were in several languages and included a pictogram indicating that the device must not be operated (Refer to Fig. 10).

FIGURE 10

Special Games labels for radiocommunications devices

6.4.8 Labelling to control entry of devices to Games venues

Because of the practical difficulties, unlabelled devices were not banned from Games venues. However, the use of labels allowed the ACA to concentrate its random inspections on unlabelled devices. Affixing a label was not enforceable, other than the minimum requirements under the Labelling Notice that applied to a small number of devices tested, but voluntary compliance did help speed up interference investigations.

6.4.9 Auditing of radiocommunications devices

A majority of radiocommunications devices brought into the Games were used by competing teams and the media. Inspection of devices at special entry points for these groups picked up the majority of devices. Teams and media crews arrived according to a known schedule and it was possible to coordinate inspections with these special customers in advance.

ACA Games Workforce members deployed in the field looked out for unlabelled devices operating at venues and conducted on-the-spot inspections of this equipment. ACA staff respected the rights of others while performing their duties and ensured that their actions did not compromise the smooth running of the Games, insofar as this was compatible with their statutory responsibilities.

6.4.10 Arrangements for the Games

Visitors from overseas, including sporting teams and broadcasters who imported devices for their own use, were not required to label those devices for standards compliance because they were not supplying them to the Australian market. Companies that were importing devices for sale in Australia for the Games, or otherwise, had to comply with the Labelling Notice under section 182 of the *Radiocommunications Act 1992*

All visitors were subject to the provisions of sections 157 and 158 concerning possession for the purpose of operation and operation of a non-standard transmitter.

There were no statutory requirements for individuals or organizations importing items for their own use to demonstrate compliance with the standards, but there was a duty to only operate compliant equipment. The onus was on the ACA to prove that the device was non-standard if it wanted to prosecute.

In practice, although the ACA had a presence at key venues and was able to test a device at the Equipment Testing Centre when necessary, most radiocommunications devices operating during the Games were not tested. Some of these devices may well have been non-standard. The ACA's principal focus during the Games was to maximize the safety of people using the telecommunications network and to minimize the opportunity for harmful radiocommunications interference.

6.4.11 Standards strategy for the Games

The ACA developed a special radiocommunications device standard for the Games. The standard removed the need for most devices brought in for the Games to comply with many of the usual standards. Minimizing harmful interference was the focus of the special Games standard, bearing in mind the need to ensure public and staff safety.

6.4.12 Electromagnetic compatibility standards

Given the scope and purpose of electromagnetic compatibility standards, the ACA did not want to relax the standards for the Games. The ACA believed it would be made aware of a non-standard device (such as a computer) through an interference complaint.

Although the situation did not arise, the approved course of action was for the ACA to issue a warning notice for causing interference and issue instructions to minimize the opportunity for harmful interference, rather than attempt to establish that the equipment was non-standard. Procedures were also endorsed to seize equipment if the situation required such action.

6.4.13 Electromagnetic radiation standards

The standard for human exposure to electromagnetic radiation was not relaxed for the Games. Nevertheless, individuals who were not suppliers were not required to label their devices nor were they required to declare conformity.

Because it was necessary for equipment to comply with whatever standards for human exposure to electromagnetic radiation were in place at that time, relevant agencies, that is, the Olympic Coordination Authority, SOCOG, Telstra, IBM, took these requirements into consideration during construction and installation of Games communications and other facilities.

6.4.14 Device testing

The ACA has the power under section 101 of the Radiocommunications Act to require an apparatus licence applicant to submit a radiocommunications device for testing, so that the ACA can determine its effect on radiocommunications before deciding to issue a licence.

The ACA does not routinely test radiocommunications devices before they are licensed, even though it has the power to do so. Instead, the ACA relies on the fact that products supplied for sale to the Australian market must be labelled in accordance with the labelling notice and therefore must comply with the applicable standard.

Individuals and organizations importing radiocommunications transmitters for their own use at the Games were under no obligation to establish compliance or to label the device in accordance with the labelling notice. Therefore, leading up to and during the Games the ACA exercized its discretion under section 101 of the Radiocommunications Act to require a licence applicant to submit a particular device for testing before issuing a licence. The ACA exercised judgment based on the experience of its staff in determining which devices required testing.

To ensure that a particular device would not have an adverse effect on communications, the ACA did not need to test that device against all the requirements of an applicable standard. An abbreviated testing strategy was developed, which provided the level of confidence required for a licence to be issued.

In the Games context, the ACA chose to test devices to which no standard applied, to ascertain that the potential for the device to cause harmful interference was minimal. The objective was to deal with a device where it was suspected that it could be a source of future problems. The ACA carried out the testing at the Equipment Testing Centre.

If a device failed the test, a licence was not issued and the ACA affixed a label stating, ‘This device is not to be operated in Australia’. If the device passed the test, then its operation was licensed, subject to frequency availability. If a licence was issued before the device was returned to the applicant, then the ACA affixed a label indicating that operation of the device was licensed.

The fact that operation of a device was approved for licensing did not necessarily imply that the device met the relevant standard under section 162 of the Radiocommunications Act. The device operator was still obliged to ensure that they did not knowingly operate a non-standard device. However, if the device failed the abbreviated testing at the Equipment Testing Centre, then it was inferred that the device was non-standard.

6.5 Sydney to Hobart Yacht Race Start – Sydney Harbour

The start of the Sydney to Hobart is a major television event requiring significant resources on shore, on boating tenders and on a large number of helicopter platforms.

The 628 nautical mile course starts at 1.00 pm on Boxing Day, December 26 from Sydney Harbour and takes the fleet down the East Coast of Australia, across the eastern edge of Bass Strait which divides the island State of Tasmania from the Australian mainland. Along the course Australian television networks provide on board and helicopter coverage in major news bulletins.

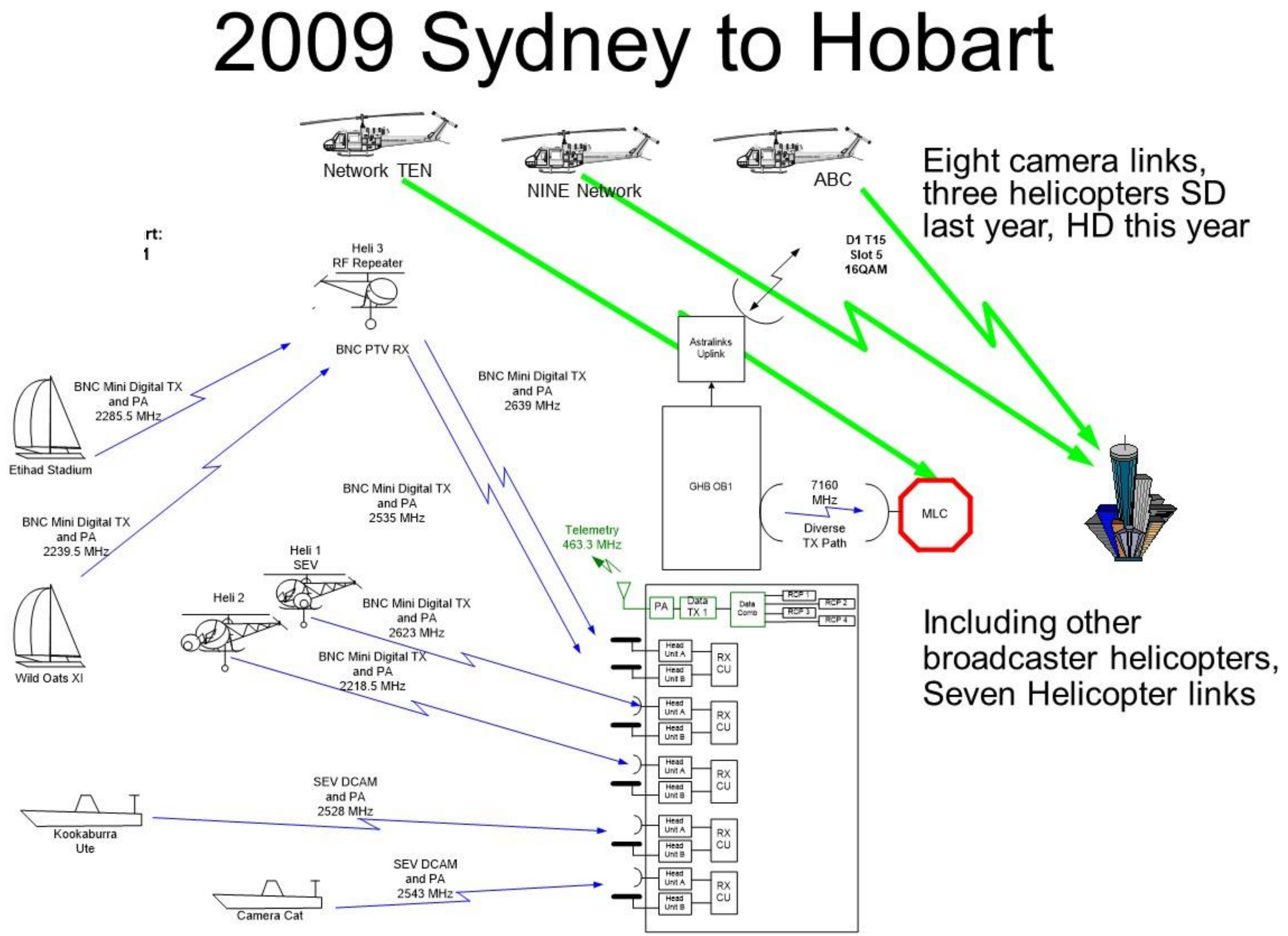
Once the fleet crosses Bass Strait it progresses down the Tasmanian East Coast where, after rounding Tasman Island, the fleet sails the final 30 nautical miles across Storm Bay and then 11 miles up the Derwent River to the finish at Constitution Dock in Hobart, Australia's second oldest city.

The Sydney to Hobart often faces conditions consisting of significant changes in wind direction and strength causing damage to boats and on occasions loss of life to crews. Few open sea / white water events in the world attracts such huge media coverage on an annual basis. It ranks with the America's Cup and the Volvo Ocean Race around the world which only happen every four or five years.

Figure 11 provides a TVOB / ENG link plan for the start of the 2009 Sydney to Hobart Yacht race.

FIGURE 11

2009 Sydney to Hobart TVOB / ENG link Plan



6.6 Indy 300 V8 Supercars

In the early 1990s the Confederation of Australian Motor Sport replaced the existing Group 3A Touring Car category (formerly based on FIA Group A rules) with a new three-class Group 3A.

In 1997 V8 Supercar events commenced in all the states of Australia except Western Australia. As well as the rounds in Australia, rounds happen in New Zealand, Bahrain and Abu Dhabi. V8 Supercars is a touring car racing category based in Australia and run as an International Series under Fédération Internationale de l'Automobile (FIA) regulations. As well as enjoying popularity in Australia, it has a considerable following in New Zealand, and is steadily growing in popularity across the world where television coverage allows.

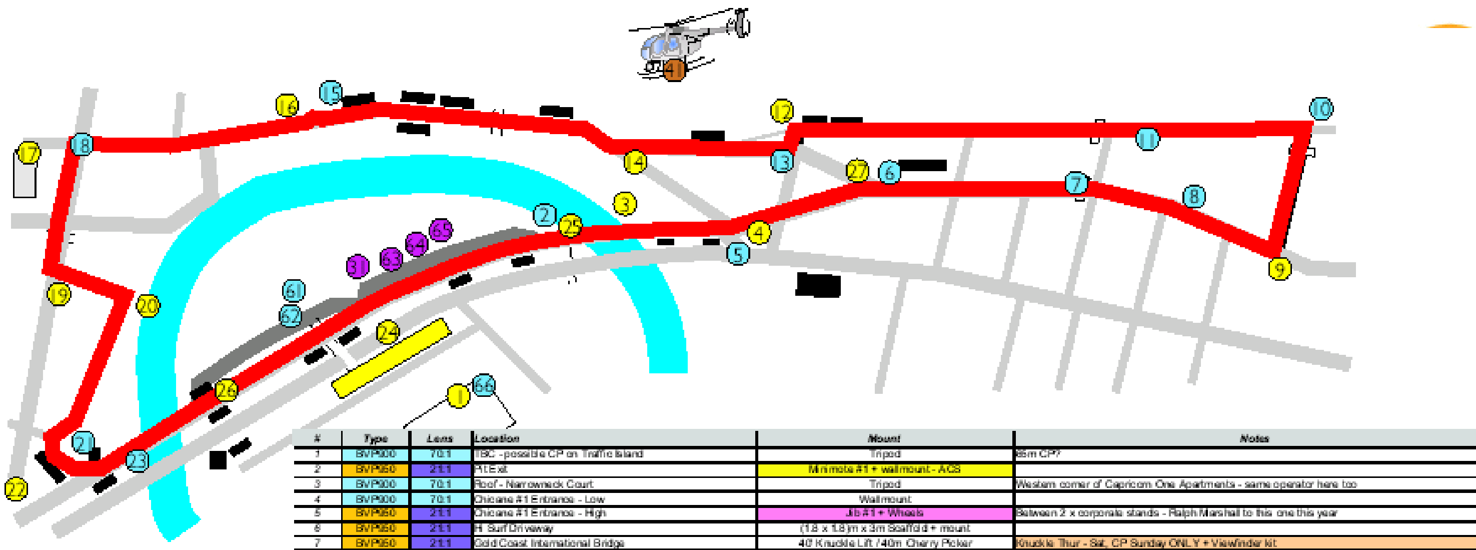
V8 Supercars have drawn crowds of over 250 000 spectators. Events are staged on various purpose-built racetracks and street circuits in the aforementioned countries. Race formats range from sprint races, with either a 100 km or 200 km race on Saturday and one 200 km race on Sunday or two; 250 km races over the weekend (Adelaide and Sydney), or endurance races such as Bathurst, which runs over a 1 000 km race distance, and Phillip Island, which runs over 500 km.

For almost two decades the Gold Coast in Queensland Australia transformed itself into a venue for a Indy Car and V8 Supercar event. On track the Australian V8 Supercars contested two 300 km races.

Figure 12 provides an example of the television link planning required for coverage of the circuit. Table 1 provided a comparative example of the spectrum frequency coordination, bandwidth re usage and overflow requirements for television coverage of this type of event in a confined geographic area.

FIGURE 12

Television camera position plan for Indy 300 V8 Supercars



#	Type	Lens	Location	Mount	Notes
1	BVP900	70:1	TBC -possible CP on Traffic Island	Tripod	65m CP?
2	BVP950	21:1	Pit Exit	Minimote #1 + wallmount - ACS	
3	BVP900	70:1	Roof - Narrowneck Court	Tripod	Western corner of Capricorn One Apartments - same operator here too
4	BVP900	70:1	Chicane #1 Entrance - Low	Wallmount	
5	BVP950	21:1	Chicane #1 Entrance - High	Jib #1 + Wheels	Between 2 x corporate stands - Ralph Marshall to this one this year
6	BVP950	21:1	Hi Surf Driveway	(1.8 x 1.8)m x 3m Scaffold + mount	
7	BVP950	21:1	Gold Coast International Bridge	40' Knuckle Lift / 40m Cherry Picker	Knuckle Thur - Sat, CP Sunday ONLY + Viewfinder kit
8	BVP950	21:1	Quarterdeck Driveway	(1.8 x 1.8)m x 3m Scaffold + mount	Viewfinder Kit
9	BVP900	55:1	Cnr View & Gold Coast Hwy	(1.8 x 1.8)m x 3m Scaffold + mount	
10	BVP950	5.5:1	Cnr View & Esplanade	Jib #2 + (6 x 6)m x 3m Scaffold - GLD	GLD #1. Snorkel in Sun AM (park) for derig
11	BVP950	21:1	Cnr Staghorn & Esplanade	(1.8 x 1.8)m x 3m Scaffold + mount	Viewfinder Kit
12	BVP900	70:1	The Esplanade Esses -Entrance	(1.8 x 1.8)m x 3m Scaffold + mount	
13	BVP950	21:1	The Esplanade Esses -Exit	Minimote #2 + wallmount - ACS	
14	BVP900	70:1	Cnr Ferny Ave & Esplanade	(1.8 x 1.8)m x 3m Scaffold + mount	
15	BVP950	21:1	V8 Chicane - Entrance	Jib #3 + (6 x 6)m x2 - 4m Scaffold - GLD	GLD #2. GLD to do this year
16	BVP900	70:1	V8 Chicane - Exit	Wallmount	New double fenced barrier to be made by Weathered Howe here - details given to DB IMG
17	BVP900	70:1	Bougainvillea Balcony	Tripod	
18	BVP950	21:1	Cnr The Esplanade & Breaker St	Minimote #3 + (1.8 x 3.6)m x3m Scaffold - ACS	
19	BVP900	70:1	Cnr Breaker & Surfers	(1.8 x 3.6)m x 4m Scaffold + mount	
20	BVP900	70:1	Cnr Surfers & Hill	Tripod	
21	BVP950	5.5:1	Cnr Hill & Gold Coast Hwy - Inside	Jib #4 + (6 x 6)m x 2m Scaffold	GLD #3. GLD to arrange this jib - Honda Corner
22	BVP900	70:1	Cnr Hill & Gold Coast Hwy - behind corporate stands	28m Cherry Picker	
23	BVP950	21:1	Cnr Hill & Gold Coast Hwy Corporate bridge - Outside	(1.8 x 1.8)m x 2.5m Scaffold + mount	Viewfinder Kit
24	BVP900	70:1	Commentary Box Roof	Tripod	
25	BVP900	70:1	Pit Exit / Pit O'view	(1.8 x 1.8)m x 3m Scaffold + mount	
26	BVP950	5.5:1	TV Cable Bridge - Forward	Bowl & bridge mount	
27	BVP950	5.5:1	Chicane #2 adjacent to Cam 6 Hi Surf Driveway	Bowl mount	
31	DNW 95X	18:1	Pit Cam - Network	Link Research Digital RF	These cameras / links to be reconfigured for Race coverage during CHAMP Car
32	DNW 95X	18:1	Pit Cam - Network	Link Research Digital RF	
41	GYRON	33:1	Helicopter	GYRON + Digital Link	ACS + Link Research
42	AWE800	W/A	FlyCam	Link Research Digital RF	Needs Digital Link & 240V >> 120V step-down transformer
51	In-Car				
52	In-Car				
53	In-Car				
31	DNW 95X	18:1	Pit Cam - Race	Link Research Digital RF	
32	DNW 95X	18:1	Pit Cam - Race	Link Research Digital RF	
63	DNW 95X	18:1	Pit Cam - Race	Link Research Digital RF	These cameras reconfigured from Domestic RF's Cam 31 & 32 when no V8 sessions
64	DNW 95X	18:1	Pit Cam - Race	Link Research Digital RF	
65	BVP950	21:1	Pits Studio	Tripod	Viewfinder Kit
66	BVP950	21:1	Pits Studio	Tripod	Viewfinder Kit
67	BVP950	21:1	TBC -possible CP on Traffic Island	Tripod	Viewfinder Kit + 65m CP
ST	BVP950	21:1	Pit Lane	Tripod	Viewfinder Kit

INDY 300
V8 Supercars
ROUND 11
Version 3
2005

6.7 Delivering communications services to assist in the staging of the Melbourne 2006 XVIII Commonwealth Games

The Melbourne 2006 XVIII Commonwealth Games (the Games) were staged in Melbourne from 15 March to 26 March 2006. The opening ceremony was followed by 11 days of competition in Melbourne and regional Victoria.

More than 4,500 athletes from 71 nations and territories competed during the Games. Along with the athletes, an estimated 1,500 team officials, 1,200 technical officials and 3,100 media representatives attended. A total of 16 sports were contested using 61 competition and training venues. Fifty five of these venues were located within the greater Melbourne area and six were located in regional Victorian.

Although the Games lasted for just 12 days, they required a complex deployment of Australian civilian resources, second only to what was required for the Sydney 2000 Olympics. The Melbourne 2006 Commonwealth Games Corporation (M2006), assisted by organizations such as ACMA, constructed the equivalent of a large, complex business within just three years – a challenging and confronting task, particularly because of the high expectations of the nation and the Commonwealth.

Of the top 50 television programs in 2006 the Opening and Closing Ceremonies of the 2006 Commonwealth Games has a television audience of 3.5 and 2.7 million people, rating them as the 1st and 4th top TV programming events in 2006.

ACMA's involvement in the Games included:

– radiocommunications frequency coordination, which included assignments and licensing;
– interference investigations;
– inspection of venues to anticipate radiofrequency interference problems and resolve telecommunications cabling problems;
– communications equipment testing;
– participation in Games readiness events and venue familiarization;
– providing visitor information through websites; and
– publication of an information brochure.

The key tasks for ACMA were to:

– identify available spectrum;
– consult with M2006 and the host broadcaster regarding frequency requirements;
– liaise with the radiocommunications and telecommunications service providers;
  • seek agreements to operate in spectrum primarily used for broadcasting and defence purposes; and
  • comply with the heightened security arrangements.

6.7.1 Regulatory framework and implementation

The objective of regulatory arrangements implemented during the Games was to strike a balance between maintaining the usual arrangements and the practical limits of such arrangements for a short-term international event.

The usual regulatory arrangements for both telecommunications and radiocommunications were applied wherever practical. Simplified regulatory arrangements, specifically for the purpose and duration of the Games, included:

– limited radiocommunications equipment testing;
– the use of unlabelled equipment; and
– connection of unlabelled equipment to the telecommunications network.

ACMA also amended its regulatory arrangements to enable the legal use of overseas communications equipment to be used for the Games. These arrangements were to:

– facilitate the importation and use of communications equipment that had an acceptable degree of risk of communications interference; and
– prevent the use of communications equipment of inappropriate technical standard or performance.

6.7.2 Spectrum management

The Games were a busy time for ACMA, primarily as a result of the sharp increase in volume of radiocommunications devices operating in Melbourne during that period. The corresponding volume of associated assignment and licensing work, venue inspections and interference investigation work also increased.

ACMA, working closely with M2006, anticipated this demand and developed appropriate working arrangements and staffing levels both prior to and during the Games to enable it to fulfil its obligations under the service agreement.

A key factor was that the city of Melbourne has one of the highest population densities in Australia and there is a correspondingly high level of spectrum use in the central business district (CBD) and surrounding areas. The Games were concentrated along the southern edge of the CBD in the area from the Melbourne Cricket Ground and the Melbourne and Olympic Parks Precinct to the Melbourne Exhibition Centre, with other venues within 10 km of this area. This placed significant demands on the use of radiofrequency spectrum because of the extreme difficulty in re-using spectrum within such a short distance. The small number of regional venues did not present any problem.

Due to a concern of spectrum scarcity, ACMA embargoed the remaining vacant channels within the two frequency land mobile segments of the 450 to 520 MHz band. The embargo applied to a coverage area of radius 100 km from the Melbourne GPO from 2 December 2004 to 31 March 2006. This greatly assisted ACMA to meet the high level of demand for spectrum required for the staging of the Games.

Additional spectrum in the 95.8 to 106.4 MHz and 540 to 820 MHz bands was also made available to support the communications requirements for the Games. These bands are typically used for radio and television broadcast services within Australia. A determination under the *Radiocommunications Act 1992* was made to allow land mobile apparatus licences to be issued in the broadcasting services bands for the Games period.

The key parties requiring radiofrequency spectrum for Games purposes were:

– M2006;
– the host broadcaster;
– rights-holder broadcasters;
– opening and closing ceremonies;
– Telstra, the radiocommunications service provider;
– organizations contracted by M2006 and the host broadcaster to provide services to the Games;
– sporting teams;

- non-rights holding broadcasters;
- visiting dignitaries;
- the general public and industry.

The major services to be provided at games time that required ACMA involvement fell into the following categories:

- VHF/UHF communications
  - voice communications (simplex)
  - voice communications (two frequency simplex and duplex)
  - remote control
  - data
  - mobile telephones
- television outside broadcasts (TOBs)
  - mobile uplinks
  - mobile downlinks
  - fixed point-to-point links
- wireless microphones
- satellite links
  - satellite uplinks
  - satellite downlinks.

6.7.3 Radiocommunications networks and systems

In September 2004, frequency assignment activities commenced for the Queen's Baton Relay Network. M2006 required one simplex and one duplex channel for the management and coordination of the Queen's Baton Relay and two high band VHF channels were assigned for this service Australia-wide. The police escorts travelling with the Queen's Baton Relay operated on channels coordinated by the Victoria Police. These channels were selected from the Police 64 channel part of the UHF band.

Dedicated frequency assignment activity for the Games commenced in September 2005 after a series of initial coordination meetings with key parties.

The M2006 Games Radio Network was provided by Telstra. It was a hybrid system using four separate networks at 170 MHz, 400 MHz, 500 MHz, and 800 MHz.

Ceremonies required a large amount of spectrum for the opening and closing ceremonies as well as during rehearsals. The network included:

- constant transmit repeaters;
- portable and base station simplex frequencies; and
- more than 70 wireless microphone frequencies in both the VHF and UHF range.

The host broadcaster used a range of systems at each venue, including:

- simplex and duplex UHF frequencies for voice;
- data transmission services for remote control cameras; and
- microwave frequencies for up and down links to helicopters above venues.

Through extensive liaison and negotiation with all stakeholders, ACMA was able to meet all spectrum demand for the Games.

6.7.4 Radiocommunications equipment arrangements

To assist equipment identification and interference investigation during the Games, three different types of label were developed for radiocommunication devices. Details of devices issued with labels were recorded on a database accessible by ACMA's Games Workforce staff.

The affixing of the special Games label was not enforceable and voluntary compliance was required. Due to the practical difficulties involved, it was not proposed to ban devices without labels from Games venues. Instead, the use of labels allowed ACMA to concentrate its random inspections toward unlabelled devices and the absence of a label made a device subject to inspection.

The design and purpose of the labels were as follows:

Class-licensed label

Even though class-licensed devices do not require individual licences, ACMA, in conjunction with M2006, needed to coordinate all radiocommunication devices, particularly wireless microphones and cordless cameras used in and around venues.

To assist with this process, the class-licensed label was developed and affixed to devices covered by a class licence. The presence of the label on a device indicated that it had been inspected at the ETC or a technical assessment of the device had been conducted by an ACMA Games Workforce officer in the field. The technical parameters of the device were recorded.

The label included a four-digit number to allow for traceability of the device and the operator.

FIGURE 13

Licensed label

This label was issued to the licensees of all apparatus licensed devices used for and during the Games. The licensee or equipment operator affixed the label to the licensed device. The presence of this label indicated that the licensee or equipment operator had been in contact with ACMA about licensing matters and the equipment, where required, had been inspected by ACMA. Each label was individually numbered.

The label included a four-digit number to allow for traceability of the device and the licensee.

FIGURE 14

Do not operate tape

If inspection of a device determined that it had the potential to cause harmful interference, or that it could not be modified to operate on the required frequency, at the required power, an ACMA officer wrapped message tape around the device. The tape stated: 'Warning: DO NOT operate this device in Australia.' The tape included the ACMA logo and a note that it must not be removed.

FIGURE 15

ACMA Games Workforce members deployed in the field were wary of unlabelled devices operating at venues and were authorized to conduct an 'on the spot' inspection. However, the ACMA Games Workforce were advised to respect other people's rights while performing their duties and needed to ensure that their actions did not compromise the smooth running of the Games, so far as this was compatible with their statutory responsibilities.

Refer to the ACMA website for the 2006 Melbourne Commonwealth Games Report: http://www.acma.gov.au/WEB/STANDARD/pc=PC_100701.

The use of radio frequency spectrum is available in Appendix 3: http://www.acma.gov.au/webwr/_assets/main/lib299/appen%203%20use%20of%20radiofreq%20spectrum%20-%20june06.doc.

7 Sharing and compatibility issues between electronic news gathering systems in frequency bands allocated to the fixed and mobile services

Introduction

This section considers the matter of compatibility issues between ENG fixed and mobile applications and other applications of fixed and mobile services. Studies undertaken to date have focused on ENG usage and sharing/compatibility issues between ENG systems and other radiocommunication systems.

The first study considers an investigation of the feasibility of sharing between digital ENG (DENG) systems and potential WiMAX systems operating in the frequency band 2 500-2 690 MHz.

The second study outlines some of the compatibility issues between IMT operating in bands adjacent to frequency bands and tuning ranges which are currently used for ENG or have potential for ENG use.

The third study outlines a methodology applied to analyse some of the sharing and compatibility issues between IMT in adjacent frequency bands and tuning ranges which have existing or potential for ENG use.

7.1 Sharing between digital electronic news gathering and WiMAX systems in the band 2 500-2 690 MHz

This study was undertaken in Australia in 2009 and investigated the feasibility of sharing between digital electronic news gathering (DENG) systems and potential WiMAX systems operating in the frequency band 2 500-2 690 MHz. This study proposed that from a frequency planning and operational perspective a successful interference mitigation strategy is the identification of geographic separation distances between DENG and mobile systems sharing the same frequency band which were being considered in Australia at that time.

The central DENG receiving system is at a fixed location. In this study interference into WiMAX base stations and mobile station end user terminals from DENG camera and vehicular transmit systems is considered as well as interference from WiMAX stationary and portable and fixed transmit base stations into the DENG receiver. Distance separation requirements are determined for the six possible interference paths and for co-channel, first adjacent channel and second adjacent channel frequency assignments. Results are presented in terms of the separation distance required so as to not exceed the allowable levels of interference for each system.

7.1.1 System parameters

Table 4 presents the parameters for the DENG and WiMAX systems in the study.

Most of the WiMAX parameters in this study are based on Report ITU-R M.2039-2.

DENG parameters included were also typical parameters for DENG systems in use in Australia in 2009.

7.1.2 Antenna patterns

In this study the major antenna influences are the side-lobe envelopes in the horizontal plane as all antennas except for the panel antenna types are either steerable or have an omnidirectional pattern (in the horizontal plane) with only minor gain changes for the range of elevation angles involved. To simplify the off-axis analysis, the WiMAX base station (BS) antenna has been modelled in the horizontal plane as a theoretical main beamwidth of 120° with a uniform side-lobe response of −21 dB at other angles (refer to Fig. 16). In practice, the WiMAX panel would have a side-lobe profile similar to the DENG panel antenna.

The WiMAX panel antennas have been set to a down tilt of 2.5° and loss in the vertical plane has been calculated using the side-lobe envelope in Recommendation ITU-R F.1336-2. The same type of antenna is also used in the DENG central site panel receive case, however, it is common to have some sites set with no down tilt to receive a both DENG vehicular and airborne transmitters, whereas in a central business district site the down tilt is set at up to 5° to receive camera back transmitters in the local area. Accordingly, no down tilt allowance has been made for the DENG panel receiver.

TABLE 4

System parameters

System parameters			**DENG Tx**		**WiMAX TDD**	
Transmit	**Units**	**Notes**	**Camera**	**Van**	**Base station**	**Mobile station user terminal**
Transmitter antenna height above average terrain (HAAT)	M	1	2.5	10	30	1.5
Peak antenna gain	dBi	1	3	22	18	0
Transmit antenna gain pattern – horizontal plane	dB	2	Omni	F.1245	0 dB < 60° −21 dB > 60°	Omni

TABLE 4 *(end)*

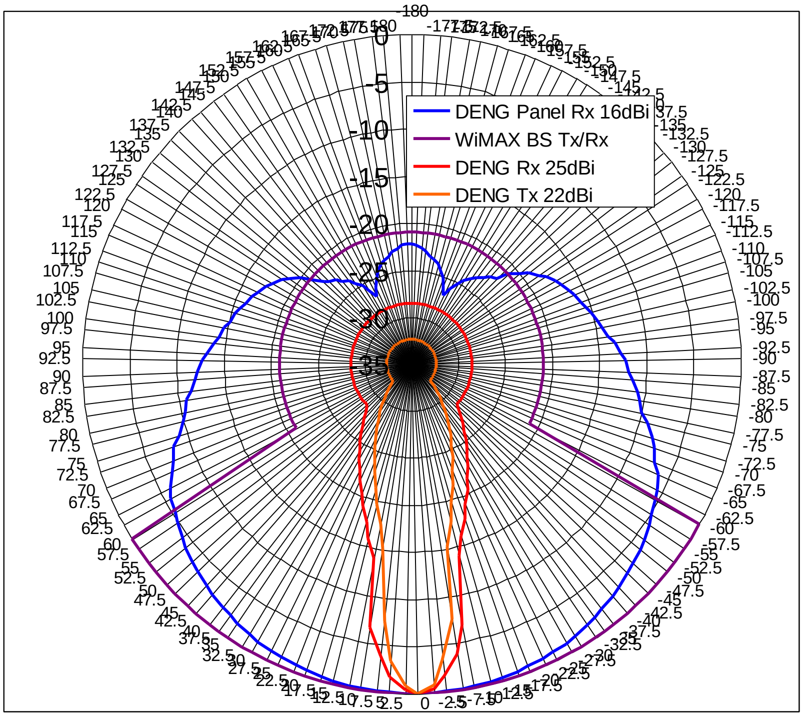
System parameters			DENG Tx		WiMAX TDD	
Transmit	**Units**	**No tes**	**Camera**	**Van**	**Base station**	**Mobile station user terminal**
Vertical plane		3			F.1336-2 k = 0.2	
Downtilt	Degrees				2.5	
Sector beamwidth	Degrees				120	
Transmitter power	dBm	1	20	36	36	24
Channel bandwidth	MHz		8	8	5	5
Transmit spectral density	dBW/MHz		−19.0	−3.0	−1.0	−13.0
ACLR 1st adj. channel	dB	1	45	45	45	30
ACLR 2nd adj. channel	dB	1	60	60	55	44
Receive			**Central rotator Rx**	**Central panel Rx**		
Peak receive gain	dBi		25	16		
Receive antenna gain pattern – horizontal plane		2	F.1245	4 × 90 degrees		
Vertical plane		3		F.1336-2 *k* = 0.025		
Receiver noise figure	dB	1	2.5	2.5	3	5
Polarization +feeder loss	dB		1	1	1	1
Receiver noise floor	dBW		−132.3	−132.3	−133.9	−131.9
Target I/N	dB		−6	−6	−6	−6
Interference target threshold	dBW		−138.3	−138.3	−139.9	−137.9
Interference density target threshold	dBW/MHz		−147.4	−147.4	−146.9	−144.9
Receiver antenna height above average terrain (HAAT)	M	1	150	150	30	1.5
ACS @ 1st adj. channel	dB	1	27	27	46	33
ACS @ 2nd adj. channel	dB	1	52	52	56	47

Notes:

1) While in some administrations WiMAX may be implemented as a FDD application this study has sourced the WiMAX TDD parameters from Tables 3 of Report ITU-R M.2039. In any circumstance where the parameter consists more than one value, the worst case is chosen for this study.
2) The DENG parabolic antenna has a different effective radius in the vertical plane to the horizontal plane. Side-lobe performance is calculated in this study using the horizontal plane side-lobe pattern which is narrower than the vertical plane.
3) Refer Section 3.1 discussion on antenna patterns.

FIGURE 16

Antenna patterns



In the above tables, ACLR is the adjacent channel leakage ratio while ACS is the adjacent channel selectivity. The six possible interference paths are:

1) WiMAX base station into DENG receiver (for panel and rotator antennas).

2) WiMAX mobile station user terminal into the DENG receiver (for panel and rotator antennas).

3) DENG van mounted transmitter into the WiMAX base station.

4) DENG camera mounted transmitter into the WiMAX base station.

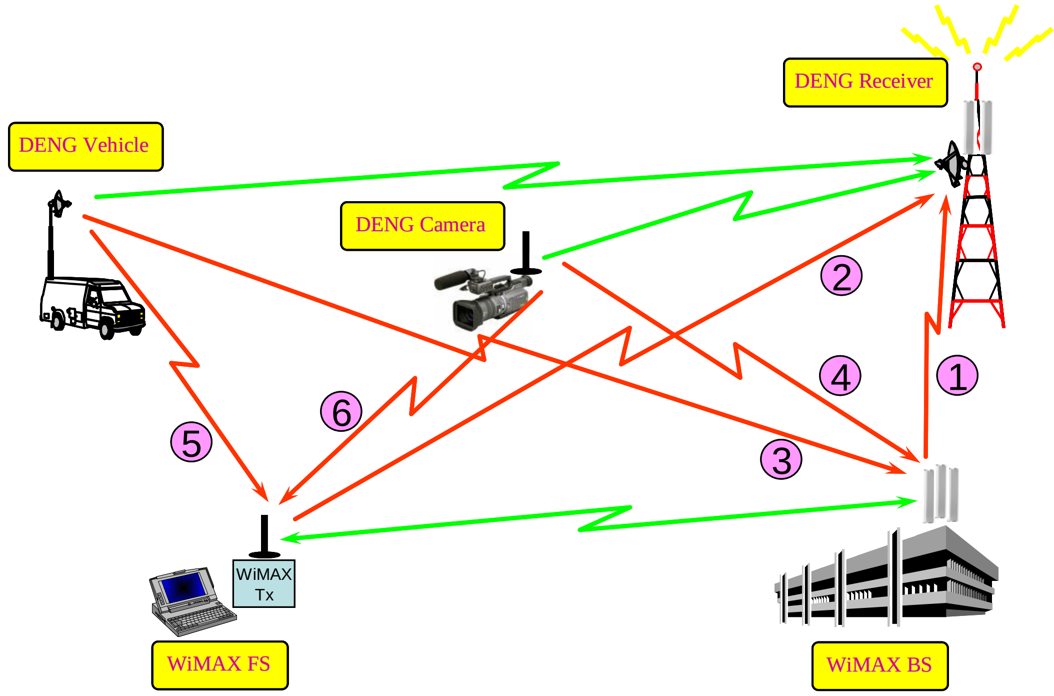
5) DENG van mounted transmitter into the WiMAX mobile station user terminal.

6) DENG camera mounted transmitter into the WiMAX mobile station user terminal.

7) These interference paths are shown in Fig. 17 below.

FIGURE 17

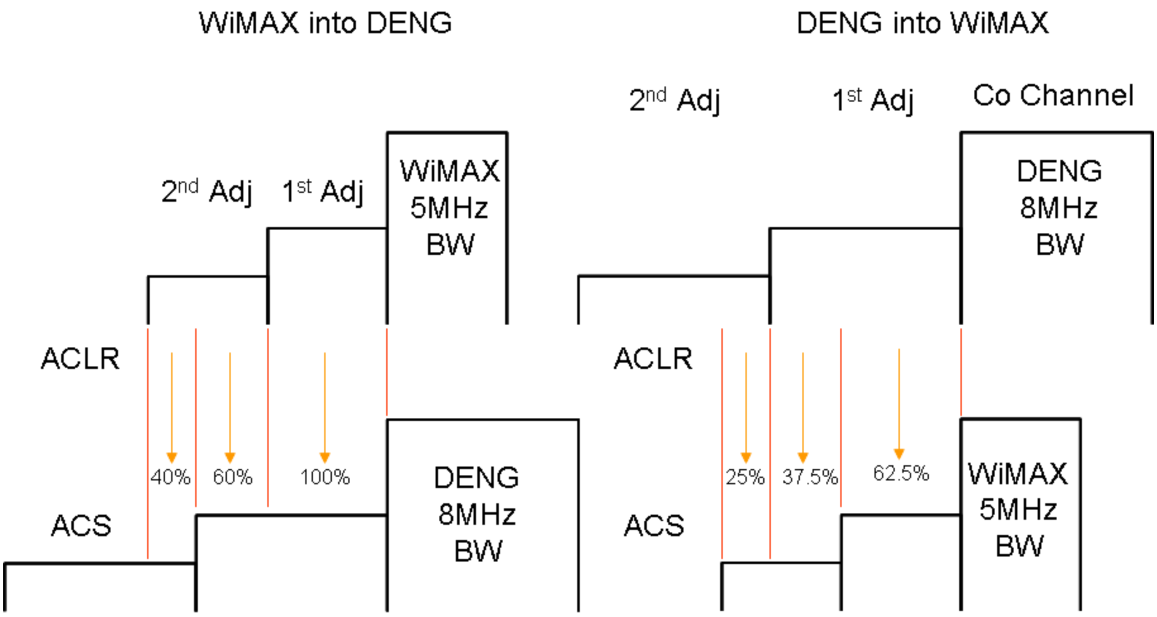
Interference paths



The system channel widths are 5 MHz for WiMAX and 8 MHz for DENG. To accommodate the differences in channelization, the study has been normalized to powers in a 1 MHz bandwidth, with the co-channel edge aligned and adjacent channel leakage and selectivity apportioned on the basis of coincident bandwidth. These are indicated in Fig. 18 below.

FIGURE 18

Adjacent channel arrangements



7.1.3 Propagation model

Due to the range of antenna heights for the DENG system, four propagation regions must be taken into account as listed below in order of proximity to the transmit station.

1) Free space region where the received signal is dominated by a direct, unobstructed wave from the transmitter. This is a line-of-sight (LoS) mode. (Refer to propagation loss L_1 in equation (1).)

2) The second region is the multipath region where the receive signal is a composite of the direct wave and a reflected wave which tends to cancel the direct wave. This is also an LoS mode. (Refer to propagation loss L_2 in equation (2).)

3) The region directly beyond LoS is the diffraction region where the main received signal results from diffraction of the signal from an object or from the smooth Earth. Attenuation as a function of distance is severe in this region. (Refer to propagation loss L_3 in equation (3).)

4) The final region considered is the tropospheric scatter region where the received signal results mainly as a result of scattering from particles in the troposphere. (Refer to propagation loss L_4 in equation (4).)

Propagation in the first two regions is modelled with the dual slope model as recommended in section 3.1 of Report ITU-R M.2030. For a frequency of 2 600 MHz, the median propagation loss is given by:

$$L_1 = 40.7 + 20\log(d) \qquad 1 \le d < d_{break1} \tag{1}$$

$$L_2 = 40.7 - 20\log(d_{break1}) + 40\log(d) \qquad d_{break1} \le d < d_{los} \tag{2}$$

of which equation (2) can be rewritten as:

$$L_2 = L_1 - 20\log(d_{break1}) + 20\log(d) \qquad d_{break1} \le d < d_{los} \tag{2*}$$

where:

d = distance (m).

The breakpoint is given by:

$$d_{break1} = 4\frac{h_t h_r}{\lambda}$$

where:

λ (m) : wavelength

h_t (m) : transmitter antenna height

h_r (m) : receiver antenna height.

The LoS distance is given by:

$$d_{los} = h_t + h_r + \sqrt{2rh_t} + \sqrt{2rh_r}$$

where:

r (m) = 4/3 earth radius.

All distances are in metres. Basically the model is "free space" propagation, with a propagation coefficient of 2, to the breakpoint. The breakpoint separates the free space and multipath regions and is a function of the antenna elevations. For distances greater than the breakpoint, the model is "multipath region propagation" with a propagation coefficient of 4. The propagation coefficient gives the exponential relationship between distance and propagation loss. At distances greater than the LoS distance of d_{los}, propagation can be considered to be beyond LoS and propagation is via the diffraction and/or troposcatter modes.

Propagation loss in the diffraction region increases severely with distance. Figure 19 presents the propagation model used here the latter two regions which is taken from NBS[2] Technote 101, "Transmission loss predictions for tropospheric communication circuits", Volume II, Fig. I.4. This model is derived from the median of measurements on 110 radio paths.

Figure 4 presents median propagation loss versus distance for the diffraction and troposcatter regions. The breakpoint between these two modes of propagation is taken as approximately 100 km. Diffraction and tropospheric loss predictions are quite complex with wide statistical variation. The simplified model, used here, is considered to be appropriate for a basic sharing study.

In these regions, the propagation loss is characterized by the following additional losses above free space loss (note that all distances in the following equations are in kilometres):

$$L_{a3} = 54\frac{d - d_{los}}{100 - d_{los}} \qquad d_{los} \le d < 100$$

$$L_{a4} = 54 + \frac{66}{937}(d - 100) \qquad d \ge 100$$

Combining the additional loss with the conventional free space losses results in the following propagation equations:

$$L_3 = L_1 - 20\log(d_{break1}) + 20\log(d_{los}) + L_{a3}; \; d_{los} \le d < 100 \qquad (3)$$

$$L_4 = L_1 - 20\log(d_{break1}) + 20\log(d_{los}) + L_{a4}; \; d \ge 100 \qquad (4)$$

Additional losses above free space are incurred in the second to fourth propagation region. The total loss to a point in any region is then the free space loss plus the additional loss incurred in that region plus the maximum additional losses incurred in the previous regions.

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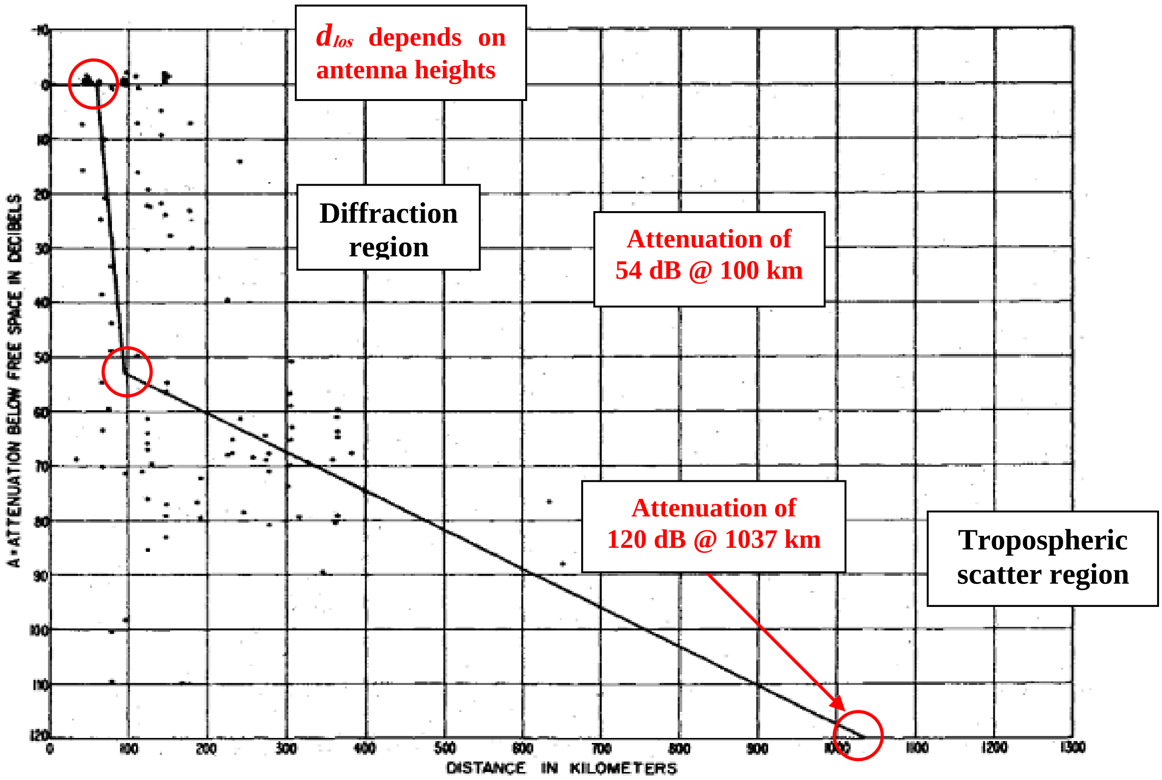
2 The National Institute of Standards and Technology is a government agency within the U.S. Dept. of Commerce and until 1988 was known as the National Bureau of Standards. Technote 101 available from http://www.its.bldrdoc.gov/pub/ntia-rpt/tn101/.

FIGURE 19

Simplified NBS Technote 101 propagation model for diffraction and tropospheric scatter regions



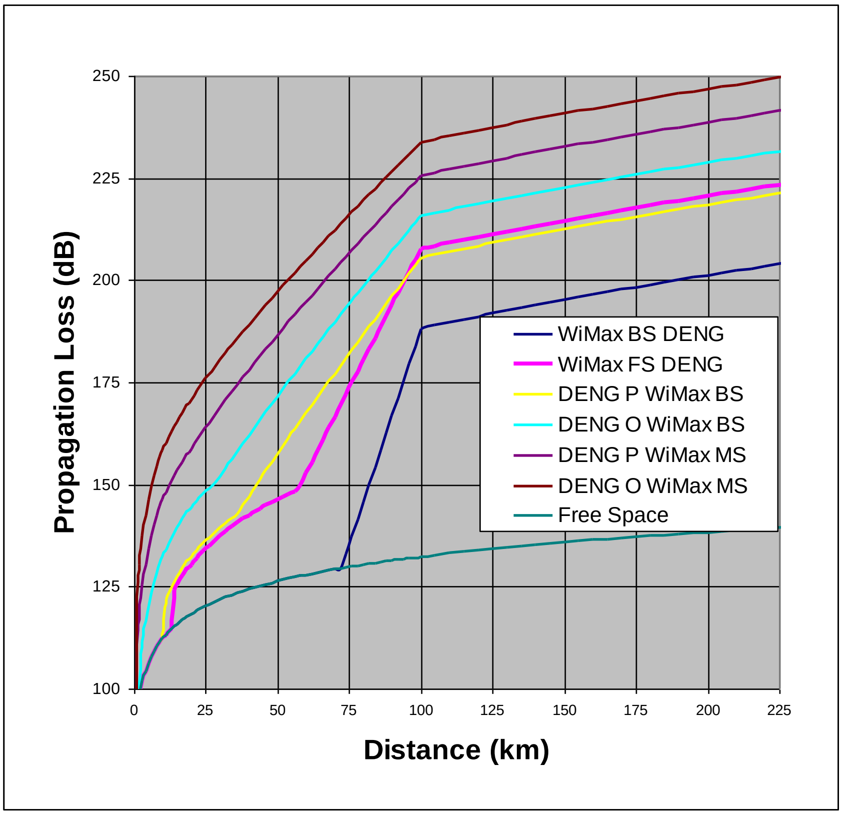
It is noted that in certain cases the LoS distance is less than d_{break} (the breakpoint between the free space and interference regions) and the multipath region is eliminated. This occurs for the case of interference between DENG and the WiMAX base station and is due to the high antenna heights of the two stations.

In this analysis, the statistical nature of the path loss is characterized with a log-normal distribution. The free space region is considered statistically invariant, while the other three regions are characterized by a log-normal distribution with standard deviation of 10 dB. The temporal and spatial variation in propagation loss at a specific distance from the transmit station is modelled as a lognormal distribution with standard deviation of 8.4 dB. Based on data presented in NBS Technote 101, a standard deviation of 10 dB is also appropriate for the diffraction and tropospheric regions.

The statistical characteristic of the propagation model ties into considerations of interference criteria as discussed in Recommendation ITU-R F.758-5 for both long and short term interference. Section 4 describes two limit value for interference, corresponding to a long term (20% of time) and a short term (< 1% of time) values. The long term, 20% criteria are considered in this study for all cases. Hence an additional 8.4 dB, corresponding to a 20% log normal distribution has been added to the required propagation model to allow for interference. This applies for all modes of propagation other than free space.

FIGURE 20

Propagation models



7.1.4 Required transmission loss

Based on the parameters for WiMAX and DENG presented in Table 4, the required transmission loss is given for the cases considered in Table 5. The minimum required separation distances corresponding to the antenna pointing angles that result in maximum interference are also shown.

The transmission loss required is:

$$L = P_{tx} + G_{tx} + G_{rx} - L_{rxp} - I - M - ACIR \tag{5}$$

where:

P_{tx} (dBm) : transmit power in 1 MHz

G_{tx} (dBi) : transmit antenna gain

G_{rx} (dBi) : receive antenna gain

L_{rxp} (dB) : polarization and receive feeder losses

I (dBm) : allowable interference power in 1 MHz

M (dB) : multiple entry factor and log normal allowance

$ACIR$ (dB) : adjacent channel interference ratio.

A 4.8 dB multiple entry factor, representing three interfering stations, is applied in the case of WiMAX into DENG as well as the 20% factor of 8.4 dB, based on Gaussian Normal Curve. In the case of DENG into WiMAX, only one interferer is assumed. There are several mitigation factors such as increased frequency separation and investigation into use of other antenna designs that can be considered and which would have the effect of reducing the minimum required transmission loss. The effects of mitigation techniques are not included in the analysis. The analysis of potential interference between WiMAX and DENG, listed in Table 5, considers the six potential interference paths.

The adjacent channel interference ratio (ACIR), which is a measure of the interference suppression resulting from adjacent channel operation is computed as:

$$ACIR = \frac{1}{\frac{1}{ACS} + \frac{1}{ACLR}} \quad (6)$$

and is taken into account in determining the required transmission loss for adjacent channel operation.

TABLE 5

Required transmission loss and maximum separation distance

	Required transmission loss			**Boresight separation distance**		
	Co-Chan	**1st Adj.**	**2nd Adj.**	**Co-Chan**	**1st Adj.**	**2nd Adj.**
	dB	**dB**	**dB**	**km**	**km**	**km**
WiMAX BS into DENG panel Rx	192.6	165.6	142.3	110	86	76
ACIR	0.0	26.9	50.2			
WiMAX BS into DENG rotator Rx	201.6	174.6	151.3	190	92	80
ACIR	0.0	26.9	50.2			
WiMAX MS into DENG panel Rx	162.6	137.4	119.2	66	28	13
ACIR	0.0	25.2	43.4			
WiMAX MS into DENG rotator Rx	171.6	146.4	128.2	72	48	17
ACIR	0.0	25.2	43.4			
DENG van into WiMAX BS	191.2	147.8	142.9	82	38	32
ACIR	0.0	43.5	48.4			
DENG camera into WiMAX BS	156.2	112.8	107.9	34	3	2
ACIR	0.0	43.5	48.4			
DENG van into WiMAX MS	171.2	138.4	126.3	32	6	3
ACIR	0.0	32.8	44.9			
DENG camera into WiMAX MS	136.2	103.4	91.3	2	0	0
ACIR	0.0	32.8	44.9			

7.1.5 Required separation distance

The separation distances displayed in Fig. 21 are for all cases analysed and those in Fig. 22 are for the remaining cases where antennas were not omnidirectional. Figures 23 and 24 show the dominant case between the WiMAX Base Station and the DENG receivers for adjacent channel operation. Results are presented for all antenna orientations of significance. The WiMAX base station antenna has an assumed theoretical sectoral pattern of 120 degrees with a fixed antenna gain within the azimuth sector beamwidth of 18 dB and a gain of −3 dB outside of the azimuth sector as described in section 7.1.2 above. Accordingly it is only necessary to provide the results for 0 and 70 degrees, to represent the full range of azimuth.

In practice the DENG receiver and WiMAX base stations should be considered omnidirectional. The DENG receiver is mounted on a rotator so it could point in any direction. A WiMAX base station would consist of a multiple antenna array however the transmit frequency may be assigned to the most critical sector. The three circled data points in Fig. 20 are used to derive the distance limits in Fig. 25.

FIGURE 21

Co-channel separation distances (WiMAX at boresight case)

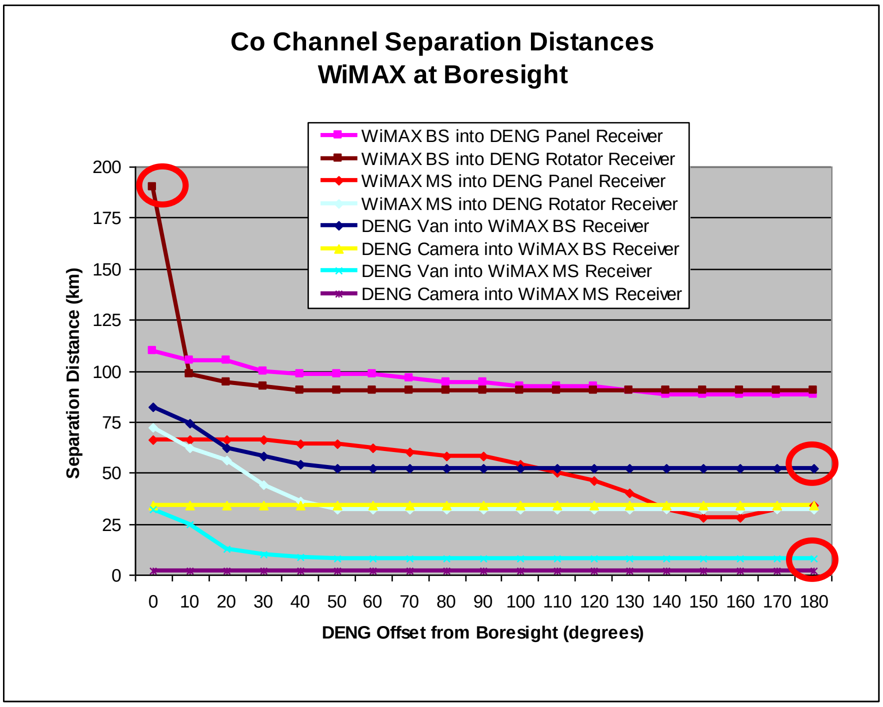


FIGURE 22

Co channel separation distances (WiMAX off main beam case)

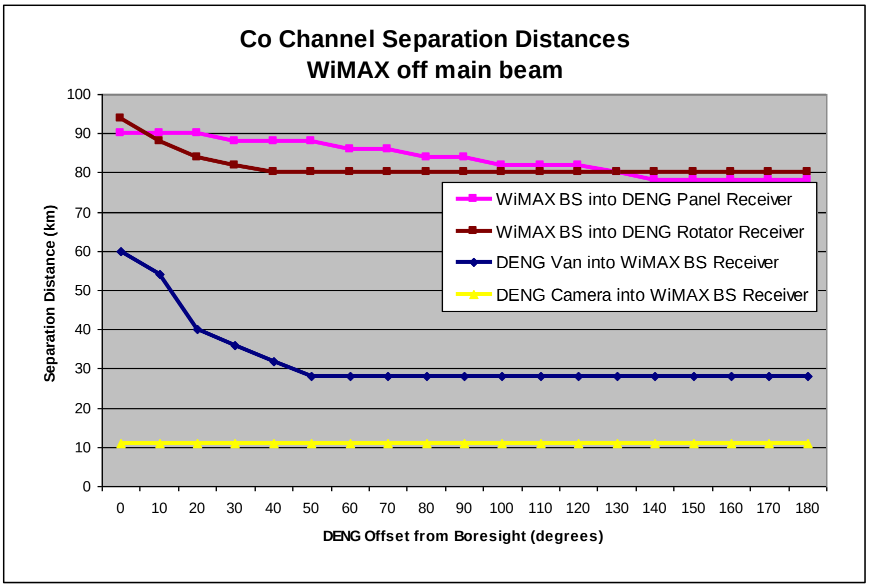


FIGURE 23

Adjacent channel separation distances (DENG panel Rx)

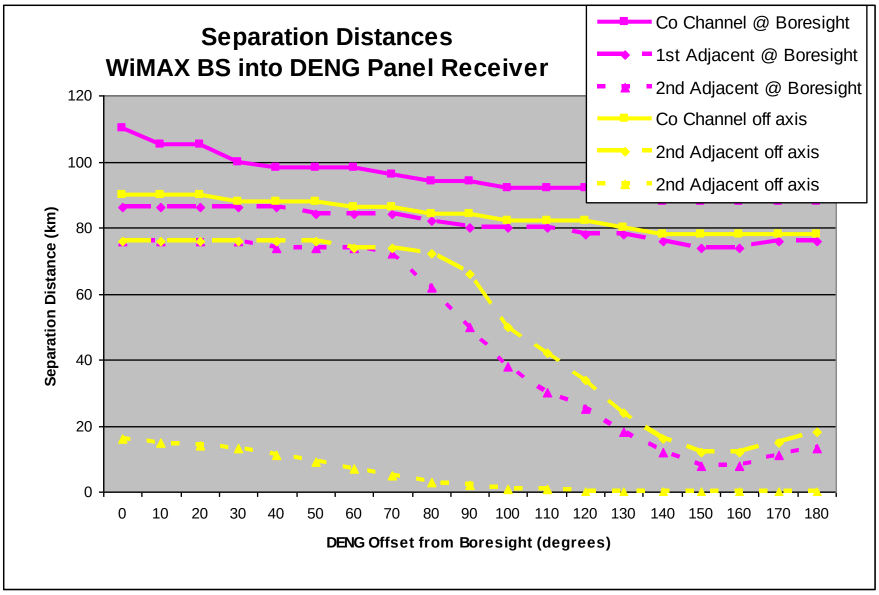
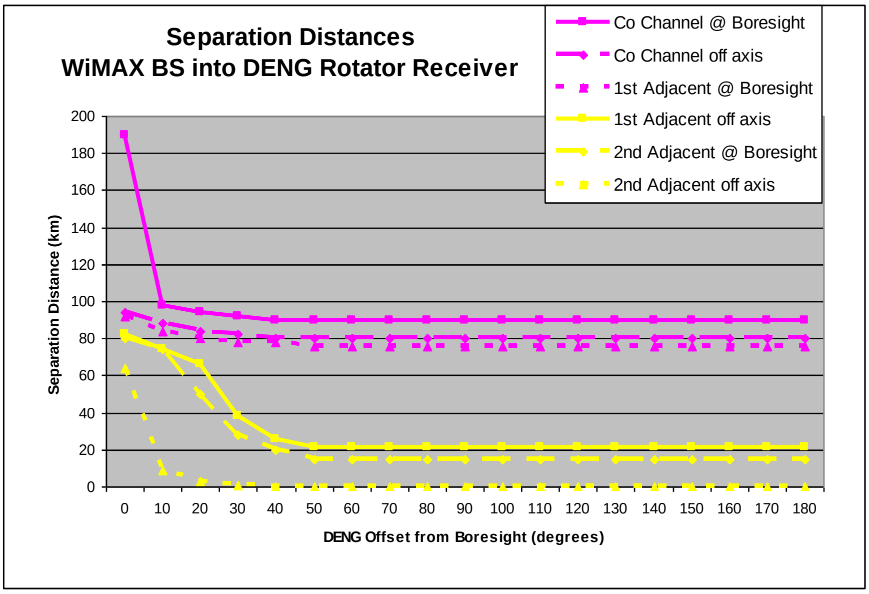


FIGURE 24

Adjacent channel separation distances (DENG rotator Rx)



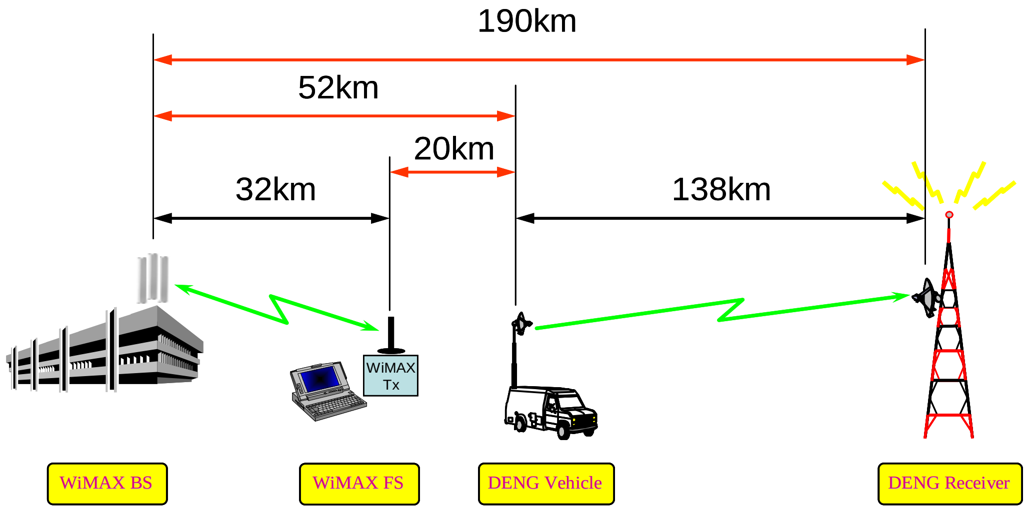
7.1.6 Conclusions

For co-channel operation, a WiMAX base station needs to be at least 190 km from a DENG receive site. Considering the distances required from the rear of a DENG van, it would be allowed to operate to within 52 km of the WiMAX base station and 8 km from a WiMAX mobile station user terminal, providing an operational radius for the DENG system of 138 km and an operational radius of the WiMAX base station of up to 44 km.

This study applies to one-on-one sharing within a geographic area. As both ENG and WiMAX systems are high density deployments the aggregate effect on both needs to be taken into account in further studies.

FIGURE 25

Co-channel operational distance limits



If the WiMAX system operated in an adjacent channel to that of the DENG system, the distance between WiMAX base stations and DENG receive sites reduces to 92 km, allowing an overlap of operational areas for each system.

With an additional 5 MHz guardband (i.e. one WiMAX channel width) this distance reduces further to 80 km, further increasing the allowed overlap of operational areas.

7.2 Compatibility issues with IMT operating in bands adjacent to frequency bands and tuning ranges which are currently used for ENG or have potential for ENG use

This study which was undertaken in early 2010 outlines some of the compatibility issues between IMT operating in bands adjacent to frequency bands and tuning ranges which are currently used for ENG or have potential for ENG use.

The scenarios for ENG described provide a number of scenarios pertinent to spectrum bands that had been identified for IMT in the Radio Regulations.

7.2.1 Adjacent channel scenarios considered

For the purpose of this study considered in this contribution "ENG services" will be constrained to DENG and wireless access services will be constrained to adjacent channel terrestrial mobile telecommunication services, described generally in this document as IMT-2000 services.

The following IMT-2000 technologies are considered in the following bands:

– IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) operating in the bands 1 920-1 980 MHz paired with 2 100-2 170 MHz;

– IMT-2000 OFDMA TDD WMAN (WiMAX) operating in the band 2 302-2 400 MHz, and

– IMT-2000 CDMA Direct Spread (E-UTRA or LTE) operating in the bands 2 500-2 570 MHz paired with 2 620-2 690 MHz.

The adjacent channel interference scenarios that are addressed are summarized in Table 6 below.

TABLE 6

Channel edge compatibility assessments required

Edge frequency (MHz)	Potential interferer	Potential interfered with application
1 980	DENG (Tx)	WCDMA (base Rx)
1 980	WCDMA (mob Tx)	DENG (Rx)
2 100	DENG (Tx)	WCDMA (base Rx)
2 100	WCDMA (base Tx)	DENG (Rx)
2 300	DENG (Tx)	WiMAX (base Rx)
2 300	DENG (Tx)	WiMAX (terminal Rx)
2 300	WiMAX (base Tx)	DENG (Rx)
2 300	WiMAX (terminal Tx)	DENG (Rx)
2 570	DENG (Tx)	WCDMA (base Rx)
2 570	E-UTRA or LTE (base Tx)	DENG (Rx)
2 620	DENG (Tx)	WCDMA (base Rx)
2 620	E-UTRA or LTE (mob Tx)	DENG (Rx)

7.2.2 Assessment methodology

a) An overview of the assessment process

The methodology used in this study to evaluate band edge compatibility between DENG and its spectrum neighbours is well established in similar reported studies[3, 4].

Essentially, by considering the in-band emission levels of the interfering service, the maximum tolerable level of interference of the victim service, and the inadvertent coupling between the two adjacent-band services that will occur, the propagation loss that is required between the two services to achieve acceptable coexistence can be calculated. From this knowledge of the required propagation loss, and using a propagation algorithm relevant to the scenario in question, the minimum separation distance that must be maintained between the interfering transmitter and the victim receiver can be calculated. Details of these calculations are described below.

b) Calculation of necessary propagation loss

The required propagation loss L (dB) is calculated as:

$$L = P_{tx} + G_{tx} + G_{rx} - I - ACIR \tag{7}$$

where:

P_{tx} (dBm) : transmit power

G_{tx} (dBi) : transmit antenna gain

G_{rx} (dBi) : receive antenna gain

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3 Report ITU-R M.2146 – Coexistence between IMT-2000 CDMA-DS and IMT-2000 OFDMA-TDD-WMAN in the 2 500-2 690 MHz band operating in adjacent bands in the same area.

4 Report ITU-R M.2113-1 – Sharing studies in the 2 500-2 690 MHz band between IMT-2000 and fixed broadband wireless access systems including nomadic applications in the same geographical area.

I (dBm) : Allowable interference power

$ACIR$ (dB) : Adjacent channel interference ratio.

c) Calculation of separation distance requirement

Assuming LoS on the unwanted path, the necessary separation distance can be calculated using the free space loss equation:

$$L = 32.45 + 20\log(f) + 20\log(d) \quad (8)$$

where:

f : frequency (MHz)

d : separation distance (km).

Use of the free space loss algorithm will result in a "reasonable[5]" worst-case result for the assessment of the necessary separation distance, i.e. it will maximize the calculated distance.

More complex propagation algorithms might be considered for more realistic assessments of separation distance where the LoS assumption is not valid, however, as will be seen, the limiting situation in all scenarios considered involves separation distances over which LoS paths might be assumed to exist.

d) Compatibility criteria

For the purposes of this study a threshold of unacceptable interference is defined as the point at which the unwanted signal rises beyond a point 6 dB below the noise floor of the receiver. A single entry interferer at this point will result in the degradation of the receiver performance of about 1 dB.

The noise floor of a receiver is calculated as:

$$Rx\ Noise = kTB + NF \quad (9)$$

where

kTB : Boltzmann's Constant (Joules/K) × Temperature (Kelvin) × Bandwidth (Hz) (dBW)

NF : (dB) noise figure.

The maximum allowable interference level in the receiver bandwidth is therefore:

$$I_{\max} = Rx\ Noise - 6\text{db} \quad (10)$$

e) Calculation of adjacent channel interference ratios

Coupling between the two adjacent-band services will occur because of the imperfections in the filtering of both the interfering transmission spectrum and the victim receiver pass band.

Imperfections in the filtering of the interfering transmitter result in leakage of energy into adjacent spectrum beyond the limits of the intended transmission bandwidth. This is described as the "adjacent channel leakage ratio" (ACLR) usually expressed as the power level in dB below the level of the in-band emission. In effect the ACLR is a measure of the power that would be received by a perfectly filtered receiver operating in spectrum adjacent to an imperfect transmitter.

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5 In theory, propagation losses up to 6 dB less than those calculated by the free space loss algorithm can be caused by positive reinforcement of the wanted signal by multipath reflections. However sustained reinforcement are unlikely to be significant within the "rough" and constantly changing urban environments considered by this study and are therefore ignored.

Similarly, imperfections in receiver filtering result in the receiver accepting emissions that are outside the intended pass band of the receiver. The adjacent channel selectivity (ACS) of the victim receiver is a measure of the power that would be received by an imperfect victim receiver operating in spectrum adjacent to a perfect transmitter.

Nominal values for ACLR and ACS are specified in Appendix 1 for the transmitters and receivers considered in this study. Figures are usually provided for the immediately adjacent channel, and for the second adjacent channel. The these values are stated on the basis of defined bandwidths equivalent to the channel bandwidth of the specified service, with the assumption that interferer and victim services are both operating on the same channel bandwidth.

Out-of-band limits are usually defined in "per MHz" in the source documents (the 3GPP Technical Specifications). As a "worst case", a factor of 7 dB has been used to translate these limits to a 5 MHz bandwidth, i.e. $10 \times \log_{10}(5\text{ MHz})$. For this particular study however the victim and interferer do not have the same bandwidth, consequently some adjustment of the ACLR and ACS figures ideally should be made.

Standard definition DENG operates on an 8 MHz channel, whereas the adjacent band mobile telecommunications services operate on a nominal 5 MHz channel (for the purpose of this study). Noting that the difference between 5 MHz and 8 MHz results in only a 2 dB adjustment, and that any adjustment from a 1 MHz bandwidth to a wider bandwidth on a simple "per MHz" basis is itself an approximation (and probably an "over-correction") the single adjustment factor of 7 dB has generally been used throughout.

The total effect of the ACLR and the ACS can be combined in an ACIR by converting the ACLR and the ACS dB figures to interfering power components (in Watts), adding them, and reconverting the resultant to a dB figure for use in equation 7 above.

The computation is as follows:

$$ACIR = \frac{1}{\frac{1}{ACS} + \frac{1}{ACLR}}$$

It is important to note that when the ACLR and ACS figures are significantly different, the resultant ACIR is dominated by the poorer of the two figures.

For example if the adjacent ACLR for the terrestrial mobile service transmitter is 45 dB and the ACS of the ENG receiver is only 27 dB the resultant ACIR is 26.7 dB. In this situation no amount of additional improvement by filtering in the mobile service transmitter will improve the overall result significantly. Having a "perfect" transmitter (an ACLR of infinity) would only improve the ACIR by 0.3 dB in this case.

As will be seen in section 7.2.4, the calculated level of interference between adjacent services is usually determined either by excessive out of band emission levels or by inadequate receiver selectivity, i.e. by one or the other.

f) Guardband assumptions

The assumptions to date anticipate that guardbands will be required between DENG and adjacent IMT-2000 services. The existence of a 5 MHz guardband alone provides some benefit, but the benefit is limited. For example, the ACLR for E-UTRA/LTE increases from 45 dB to 50 dB when a 5 MHz guardband is introduced. Similarly the ACS for DENG increases from 27 dB to 52 dB with the inclusion of a guardband. But as will be shown later in this Report considerably greater isolation is required for successful coexistence of these two service types.

This study takes as its starting point the assumption that guardbands of 5 MHz (at least) will be required. The calculation results discussed in section 7.2.4 are of principal interest are therefore those relating to the “second adjacent channel” performance, i.e. the situation pertaining to the spectrum that lies between 5 and 10 MHz from the band edge.

A preliminary calculation of the first adjacent channel situation is also done using the simple LoS assumption. The very large separation distances so calculated are unlikely to be a true indication since the LoS assumption would not be valid at such distances. However the LoS assumption would be valid in many cases for distances of the order of a few tens of kilometres, leading to the preliminary conclusion that operation without a guardband is not feasible.

g) Assumptions relating to filtering

Whilst the existence of a 5 MHz guardband alone may not be sufficient to control band edge interference it does provide the guard space in which it may be practical to implement additional filtering. And there appears to be a case to identify the need for such additional filtering. Allowances for such additional filtering to the extent assumed are therefore made in the calculations as described below.

An assumption is made that ENG stations will have an adjacent channel selectivity performance of 80 dB with respect to IMT base station transmitters. The parameters for the DENG equipment set out in Appendix 1 assume that an ACS of 52 dB can be achieved (presumably by use of additional filtering) at an offset of 5 MHz from the channel edge, i.e. within the second adjacent 5 MHz channel. An additional 28 dB of additional filtering is therefore required to meet the assumed total ACS of 80 dB. This additional 28 dB of filtering is therefore included in various calculations as appropriate.

Another measure considered is to reduce interference to key ENG receiving collection stations is additional filtering for IMT-2000 base stations in the vicinity of a collection station. This contribution assumes that out of band emissions must not exceed an absolute level of −45 dBm/ MHz in the second adjacent channel. In the worst case this implies a maximum total interfering power of −38 dBm in the 5 MHz channel, (or alternatively −36 dBm in an 8 MHz channel, offset by the 5 MHz guardband).

Using the in-band maximum e.i.r.p. figure of 60 dBm for the E-UTRA/LTE equipment (as documented in Appendix 1), a second adjacent channel limit of −36 dBm implies a total ACLR of 96 dB. The unfiltered second adjacent channel ACLR figure documented in Appendix 1 is 50 dB, implying the need for 46 dB of additional filtering. This additional 46 dB of filtering is therefore included in various calculations as appropriate.

For WiMAX, using the stated e.i.r.p. figure of 54 dBm and a stated ACLR2 of 66 dB, the additional filtering requirement to achieve an adjacent channel interference power of −36 dBm/8 MHz becomes 24 dB.

The actual band-edge interference situation will of course depend on the actual unfiltered performance of the equipment and the extent of additional filtering that can actually be achieved within the proposed 5 MHz guardband. This analysis has proceeded on the assumption that the figures postulated are reasonable and achievable. In the event that they can be exceeded, the separation distances calculated in this study may decrease in some cases.

h) Considerations for guardbands greater than 5 MHz

No attempt has been made to assess the possible benefit of an increased guardband in the event that the calculated separation distances are unworkable. Such analysis would require additional information about equipment performance beyond the 10 MHz off-set.

7.2.3 System parameters

a) DENG

Parameters of DENG for use in sharing studies are set out in Recommendation ITU-R F.1777[6]. Importantly however, DENG equipment takes on a number of different forms and not all forms will be present in all sharing scenarios. To summarize, components of DENG operations include:

- fixed central reception points;
- airborne operations (principally helicopter camera links and relays);
- vehicle (van)-based operations;
- portable wireless camera systems (WCS); and
- mobile platforms using equipment similar to WCS (e.g. race cars).

Some of the technical characteristics of DENG equipment, specifically the transmitter power and the antenna configurations, vary depending on the nature of the operation and the various components involved. Appendix 1 lists the parameters that have been used for the purpose of this study.

Appendix 1 also includes the figure of 28 dB for additional filtering of DENG receivers. When combined with the second adjacent channel ACS figure of 52 dB the resultant total adjacent channel selectivity would be 80 dB.

No allowance has been made for additional filtering on DENG transmitters. Additional filtering of the very small wireless cameras (at least) is considered impractical, and often this same equipment is used on the mobile platforms.

b) IMT-2000

IMT-2000 denotes a range of equipment, which, for the purpose of this study includes:

- IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) operating in the bands 1 920-1 980 MHz paired with 2 100-2 170 MHz;
- IMT-2000 CDMA Direct Spread (E-UTRA or LTE) operating in the bands 2 500-2 570 MHz paired with 2 620-2 690 MHz; and
- IMT-2000 OFDMA TDD WMAN (WiMAX) operating in the band 2 302-2 400 MHz.

The IMT-2000 parameters for this study have been taken from the Report ITU-R M.2039-2.

Appendix 1 also includes the figure of 46 dB for additional filtering of the IMT-2000 base stations as discussed previously.

No allowance has been made for additional filtering of IMT-2000 mobiles.

The parameters for WiMAX (IMT-2000 OFDMA TDD WMAN) are similar to those for IMT-2000 CDMA Direct Spread, but with some minor differences. Separate analyses are therefore provided for the WiMAX technology.

Summaries of the relevant parameters for all technologies as used in this study are included in Appendix 1.

[6] Recommendation ITU-R F.1777 – System characteristics of television outside broadcast, electronic news gathering and electronic field production in the fixed service for use in sharing studies.

c) Sensitivity of results to the choice of parameters

The outcome of particular calculations will depend on the choice of the parameters that are used to characterize the radio equipment. And as indicated previously there is some scope for disagreement as to what parameters might be appropriate.

However, as will be seen in Section 7.2.4 , the calculated level of interference between adjacent services is usually dominated by either excessive out of band emission levels from the transmitter or by inadequate receiver selectivity, i.e. one or the other deficiency largely determines the outcome. For some assessments it is possible to negate uncertainty by assuming either a “perfect” receiver or a “perfect” transmitter (but obviously not both together). If the calculated separation distances are unworkable under the assumption of a “perfect” transmitter for example then it matters not what the actual parameters are − the end result will still be an unacceptable adjacency scenario. The simulation of “perfection” is achieved in the calculations by entering an ACLR or ACS value of 100 dB.

Likewise by adopting the assumptions in modelling relating to filtering and out-of-band emission limits, either the transmitter performance or the receiver performance dominates in some situations thereby making uncertainties in the parameters of that device irrelevant. For example, by applying the absolute out-of-band emission limit of −45 dBm /MHz for IMT-2000 base station transmitters, it makes little difference how we choose any of the elements in the transmitter parameters to arrive at this figure. Likewise if we assume the maximum selectivity of the DENG receiver is the 80 dB, the combination of inherent ACS and additional filtering to arrive at the selectivity target and by which this is achieved does not influence the selectivity value.

To take an example in which the performance of one device dominates. The calculated interference from IMT-2000 base station transmitters into DENG receivers will be essentially determined by the performance of the DENG receiver. The total ACLR (including assumed additional filtering) of the IMT-2000 base station transmitters is some 96 dB whereas the total ACS (including assumed filtering) of the DENG receivers is only 80 dB. The receiver performance largely determines the outcome. The transmitter parameters are almost irrelevant if we accept the −45 dBm/MHz out-of-band limit.

7.2.4 Analysis (case-by-case)

This study considers one-on-one sharing. As both systems are high density deployments the aggregate effect on both needs to be taken into account in further studies.

The following analyses are based on ENG systems operating in the centre band gap of FDD IMT systems – e.g. between 1 980 and 2 100 MHz and between 2 570 and 2 620 MHz – and that the analyses are based on ENG operating above 1 980 and 2 570 MHz or ENG operating below 2 100 or 2 620 MHz.

a) DENG transmitters interfering with 3G and LTE base station receivers

This scenario will occur below 1 980 MHz (with IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and IMT-2000 CDMA Direct Spread (E-UTRA or LTE services), and below 2 570 MHz (with -UTRA/LTE).

The calculated results for this scenario are presented at Appendix 2 (Case No. 1).

(i) No guardband

This scenario considers the likely need to impose a 5 MHz guardband immediately below the frequency boundaries at 1 980 MHz and 2 570 MHz. A preliminary analysis however indicates that without such a guardband separation distances of up to 50 km may be required to protect base station receivers from helicopter borne DENG transmitters under the reasonable assumption of LoS interference paths.

For transportable links operated from DENG vans the required separation distance could exceed 200 km under LoS, though the probability of such interference would be reduced in many cases by likely blocking on the interference path and/or the angular discrimination of the DENG antenna.

Even for low powered wireless camera systems, separation distances of about 2 km appear to be necessary with LoS interference paths, a realistic scenario for this mode of operation.

Even assuming the adjacent channel selectivity of the base station receivers is considerably better than the 46 dB figure used for the analysis, the separation distances indicated above would not improve significantly. The situation remains controlled by the out of band emission (ACLR) of the DENG transmitter.

(ii) With guardband (5 MHz) and additional receiver filtering

If 5 MHz guardbands were provided within the DENG allocations (i.e. guardbands 1 980 to 1 985 and 2 570 to 2 575) the calculations indicate that separation distances would reduce significantly – but still at a point where coexistence of the two services types is likely to be problematic. The revised calculations assume that the second adjacent channel ACLR figure of 60 dB for ENG can be used, notwithstanding the fact that the DENG channel is 8 MHz, not 5 MHz.[7]

It should be noted also that Report ITU-R M.2039-2 provides no figure for the second adjacent channel selectivity (ACS2). A figure of 56 dB is shown in the calculations, this being the corresponding figure for WiMAX technology. Using this proxy figure the calculations indicate the need for a separation distance of about 12 km for the airborne DENG scenario, and about 56 km for the link van. For the portable wireless camera system the calculated separation distance is about 500 m.

To eliminate the uncertainty regarding the receiver selectivity at the second adjacent channel, the calculations were re-run under the "perfect receiver" assumption, i.e. additional receiver filtering of 100 dB was included. The calculated separation distances were then reduced to approximately half those reported above. (Those calculations are not detailed in the Appendix.)

Considering these results it can be seen that even under the "perfect receiver" assumption the required separation distances in all cases appear to be greater than might be available in many operational scenarios.

b) DENG transmitters interfering with IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and E-UTRA/LTE mobile receivers

This scenario will occur in the above 2 110 MHz (with current IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and future-UTRA/LTE services), and above 2 620 MHz (with future-UTRA/LTE).

The calculated results for this scenario are presented at Appendix 2 (Case No. 2).

The need for 5 MHz guardbands at each of the boundaries identified above have been acknowledged, specifically to protect DENG receivers from base station transmitters. Those same guardbands will assist the protection of mobiles from DENG transmitters. The immediate (i.e. first) adjacent channel

[7] This assumption relies on an expectation that most of the adjacent channel emission from the ENG transmission will lie within the first 5 MHz – but this requires further consideration. The alternative scenario would be that an 8 MHz guardband might be required.

situation is therefore not a consideration, though calculated results for first adjacent channel are included in Appendix 2.

Report ITU-R M.2039 does not provide a "second adjacent channel" ACS figure for the mobile terminals, but even under the best-case assumption of "perfect" receiver filtering (ASC figure of 100 dB used for calculation purposes) the possibility of interference into mobiles cannot be eliminated. The essential problem is the adjacent channel leakage of the DENG transmitter. Again the worst-case scenario involves mobiles within the main beam of a DENG link where a necessary separation distance of about 3 km is calculated. Such a scenario could conceivably occur in the case a relay van transmitter located on a hilltop oriented towards a population centre.

A similar calculation using the parameters of a wireless camera system, which could certainly be working on a street in close proximity to mobiles, indicates a separation distance of 28 m is required.

Having assumed the "perfect receiver", the situation could only be improved by filtering of the DENG transmitters. No such filtering has been assumed for the purpose of this study. Certainly transmitter filtering is unlikely to be feasible for wireless camera systems, though it might be feasible in limited situations such as an DENG van operation.

c) IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and E-UTRA/LTE base station transmitters interfering with DENG receivers

This scenario will occur immediately below 2 100 MHz (with IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and future-UTRA/LTE services), and immediately below 2 620 MHz (with future-UTRA/LTE).

The calculated results for this scenario are presented at Appendix 2 (Case No. 3).

The need to impose a 5 MHz guardband immediately below the frequency boundaries at 2 100 MHz and 2 620 MHz is acknowledged. Calculations confirm that without such a guardband (and without additional filtering, which might be difficult without a guardband) successful adjacent channel coexistence of the two services are not possible.

It has been recommended that DENG receivers use band or channel edge filters to improve isolation from the IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/ LTE base station transmitters, and a total adjacent channel selectivity of 80 dB for coordination purposes. Since the second adjacent channel ACS figure of the DENG receiver is a 52 dB (nominally) additional filtering of 28 dB will be required to achieve the total figure of 80 dB. Preliminary calculations on this basis indicate the need for separation distances that are still excessive, exceeding 30 km in the best-case scenario. (Calculation not included in Appendix 2.) Additional measures therefore appear to be needed.

The possible need to limit out-of-band emissions from the IMT-2000 equipment is recognized and a maximum permissible level of −45 dBm/MHz has been proposed. As discussed previously this study has translated this to imply the need for 46 dB of additional filtering beyond the nominal ACLR2 figure of 50 dB.

Under these assumptions (5 MHz guardband, ACS of 80 dB for the DENG receivers and a total ACLR2 of 96 dB for the base station transmitters), a separation distance of about 5 km is required in the worst case, that of the ENG central receiving site. A slightly lesser separation is required for DENG van receivers (approximately 3 km) because of the slightly lower antenna gain used for the calculation in that case. For helicopter borne receivers the distance is approximately 1 km. These separation distances seem unlikely be achievable for uncoordinated deployment of DENG.

d) IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and E-UTRA/LTE mobiles interfering with DENG receivers

This scenario will occur above 1 980 MHz (with IMT-2000 CDMA Direct Spread (UTRAN or WCDMA) and future-UTRA/LTE services), and above 2 570 MHz (with future-UTRA/LTE).

The calculated results for this scenario are presented at Appendix 2 (Case No. 4).

The ACLR2 figure of 43 dB for the IMT-2000 mobiles results in out-of-band emissions from the mobiles dominating this interference scenario. Additional filtering of the DENG receivers makes virtually no difference to the end result, (though it has been included in the calculations).

Calculations indicate that a separation distance of about 6 km from central DENG receivers is likely to be required, 4 km from link vans, and just over 1 km from airborne receivers. Clearly these distances are not compatible with uncoordinated ENG deployment.

In this particular case however the legitimacy of the conclusions depends critically on the ACLR2 figure (43 dB) used in these calculations. The source document for the 3G mobile performance (3GPP TS 25 101 6.6.2.2.1) provides two figures that might be used, one being the ACLR2 of 43 dB (i.e. −43 dBc) that appears in the WP 5D document and has therefore been used in the calculations, or an absolute limit of −50 dBm.

TS 25 101 states that *"...If the adjacent channel power is greater than −50 dBm then the ACLR shall be higher than the value specified in Table 6.11"* (i.e. higher than 43 dB).

Assuming the objective of the "higher value" is to limit adjacent power to −50 dBm then a total attenuation of 74 dB is required if the in-band e.i.r.p. is +24 dBm as used in this study. This is 31 dB more than the assumed 43 dB, which would change the outcome very significantly. Separation distances would then reduce to the order of one or two hundred metres if the preceding assumptions of DENG receiver filtering is also applied.

Conversely in this case there will need to be a factor included to account for multiple exposures to mobile transmitters, which will tend to increase the required separation distances. No attempt has been made at this stage to evaluate that effect.

(i) DENG/WiMAX interference scenarios (generally)

WiMAX/DENG interference scenarios will occur at the 2 302 MHz boundary for currently deployed WiMAX services. A nominal 2 MHz guardband is applied for the spectrum resource assessment (SRA) service operating below 2 300 MHz. A nominal frequency 2 300 MHz is used for all calculations in this Report.

In the event that WiMAX operators also achieve access to spectrum in the range 2 500 to 2 670 MHz there may be additional interfaces to consider. However the small difference in frequency will result in only very small changes in calculated separation distances. Those calculations have not been produced for this Report.

As anticipated in preceding studies, a 5 MHz guardband (2 297 to 2 302 MHz) is assumed. Calculations also assume the use of additional DENG filtering, and limiting out-of-band emissions from the WiMAX to −45 dBm/MHz.

e) DENG transmitters interfering with WiMAX base station receivers

The calculated results for this scenario are presented at Appendix 2 (Case No. 5).

Because the nominal parameters if the WiMAX equipment used for these calculations are quite similar to those of the IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/E-UTRA LTE equipment (in Case No. 1) it will be seen that the separation distances are also very similar.

f) DENG transmitters interfering with WiMAX mobile receivers

The calculated results for this scenario are presented at Appendix 2 (Case No. 6).

Unlike the IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE case, Report ITU-R M.2039-1 does provide a second adjacent channel ACS figure for the terminal equipment. This figure (47 dB) has therefore been used in the calculations, in lieu of the conservative "perfect receiver" assumptions. Separations distances of up to 20 km result for the DENG link van situation, 4.6 km for the airborne receivers, and 180 m for WCS.

If the best-case "perfect receiver" assumption is made, separation distances similar to those reported in Case No. 2 again result.

g) WiMAX base stations interfering with DENG receivers

The calculated results for this scenario are presented at Appendix 2 (Case No. 7).

As with the equivalent IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE case, preliminary calculations assuming a 5 MHz guardband but no additional base station filtering result in unacceptable separation distances (up to 12 km for the central DENG receiver case).

Additional filtering to reduce the out-of-band emissions to −45 dBm/MHz (−36 dBm/8 MHz) reduces the separation distance for the central DENG case to about 2.5 km. For DENG link vans the distance is about 1.6 km, and for airborne about 500 metres.

h) WiMAX terminals interfering with DENG receivers

The calculated results for this scenario are presented at Appendix 2 (Case No. 8).

Since the equipment parameters are identical in this scenario to those used in the equivalent IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE case the calculated results are very similar, the small differences being attributable to the frequency difference. The conclusions of Case No. 4 are equally relevant to this WiMAX case.

7.2.5 Results and conclusions

A summary of results of the calculations of necessary separation distances is provided in Appendix 3 for the various combinations of DENG and IMT-2000 operating modes.

Consideration of these results suggests that even with the application of the remedial measures of a 5 MHz guardband, additional filtering of the ENG receivers (to achieve 80 dB selectivity), and the limiting of out-of-band IMT-2000 transmissions to –45 dBm/MHz, the separation distances required to achieve adjacent band operation of these services will be unworkable in some DENG scenarios.

It is important however when using Appendix 3 that the qualifications and discussion provided in Section 7 and elsewhere in this contribution be noted.

This study has been based on nominal equipment parameters and it incorporates various assumptions and simplifications. The results at best therefore can be construed as "prima facie" evidence that the proposed sharing arrangements will not be unworkable.

The most problematic area of the work relates to the choice of appropriate figures for out-of-band emissions and for receiver selectivity as has been discussed in earlier parts of this contribution. The figures used purport to be worst case, and as such they are a legitimate basis for the analysis. But if actual equipment is in fact considerably better than "worst case" the calculated results will not accord with reality.

Furthermore, simplifying assumption have been made that the out-of-band performance figures given can be interpreted (or extrapolated) to apply across the full bandwidth of the affected receiver, i.e. all assessments have been done on a simple “total power”’ basis. Possible differences between current 3G and future LTE (OFDMA) in their responses to narrow band interference has also been ignored.

In some situations it has been possible to eliminate some parameter uncertainties by assuming “perfection” in either the transmitter or the receiver. However the results of such calculations still depend on the assumed parameters of the other component (receiver or transmitter) in the calculation. Perhaps the real situation can only be assessed in the light of detailed measurements of the actual field or bench interference scenarios involved.

No attempt has been made to assess the additional frequency separation that might be required to achieve workable separation distances services in the event that the proposed 5 MHz guardbands are indeed found to be inadequate. Such an assessment would require reliable information about out-of-band performance of equipment beyond the 5 MHz guardband. Access to such information is likely to be even more problematic.

A further critical assumption that underpins this study (and other similar studies) is that all receivers need to be protected down to “noise floor”, i.e. that virtually any perceptible amount of interference is unacceptable. However the reality is that high capacity cellular mobile systems operate in an interference limited environment, not a noise limited environment. Satisfactory performance of the service is achieved when a minimum “carrier/interference” ratio (C/I) is achieved, irrespective of the absolute level of the interferer. Whether this “resilience” can mitigate the effect of external interference is another question.

Likewise the study assumes that the DENG receivers require protection down to “noise floor”, or very close to it. But again however that level of protection is not afforded even to fixed point-to-point links in many scenarios. Interference in the fixed service in Australia is also managed on an “acceptable C/I” basis and the criteria for acceptability includes a significant margin to accommodate temporal fading on the wanted link.

Whilst there may be factors whereby a situation that appears unacceptable in preliminary desktop studies might in fact be workable in reality, the results of this study do present a prima facie case that the adjacent band sharing arrangements between IMT and DENG might not be workable.

The conclusions from this study stress the need for further investigation. Access to better substantiated evidence of adjacent channel performance of all devices involved would appear to be a good starting point for further study.

Attachment 1

IMT-2000 equipment parameters

LTE/ CDMA Direct Spread					
Base Station			***User Equipment***		
Tx			**Tx**		
P_t (maximum)	43	dBm	P_t (maximum)	24	dBm
G_t	17	dBi	G_t	0	dBi
e.i.r.p.	60	dBm	e.i.r.p.	24	dBm
ACLR (1[8])	45	dB	ACLR (1)	33	dB
ACLR (2[9])	50	dB	ACLR (2)	43	dB
Add'n filtering	0	dB	Add'n filtering	0	dB
Rx			**Rx**		
G_r	15	dBi	G_r	0	dBi
ACS (1)	46	dB	ACS (1)	33	dB
ACS (2)	n/a	dB	ACS (2)	n/a	dB
Add'n filtering	0	dB	Add'n filtering	0	dB
NF	5	dB	NF	9	dB
Receiver noise	−103	dBm	Receiver noise	−99	dBm
Allowable *C/I*	6	dB	Allowable *C/I*	6	dB
Interference threshold	−109	dB	Interference threshold	−105	dB

8 1st adjacent channel.

9 2nd adjacent channel.

IMT-2000 equipment parameters (*cont.*)

WiMAX
(IMT-2000 OFDMA TDD WMAN)

Base Station			***User Equipment***		
Tx			**Tx**		
P_t (maximum)	36	dBm	P_t (maximum)	24	dBm
G_t	18	dBi	G_t	0	dBi
e.i.r.p.	54	dBm	e.i.r.p.	24	dBm
ACLR (1)	54	dB	ACLR (1)	33	dB
ACLR (2)	66	dB	ACLR (2)	43	dB
Add'n filtering	0	dB	Add'n filtering	0	dB
Rx			**Rx**		
G_r	15	dBi	G_r	0	dBi
ACS (1)	46	dB	ACS (1)	33	dB
ACS (2)	56	dB	ACS (2)	47	dB
Add'n filtering	0	dB	Add'n filtering	0	dB
NF	3	dB	NF	5	dB
Receiver noise	−104	dBm	Receiver noise	−102	dBm
Allowable *C/I*	6	dB	Allowable *C/I*	6	dB
Interference threshold	−110	dB	Interference threshold	−108	dB

Digital electronic news gathering equipment parameters

		Central Rx	Airborne	Van	Mobile platforms	WCS
Tx						
P_t	dBm		40	43	40	20
G_t	dBi		11	21	2	3
e.i.r.p.	dBm		51	64	42	23
ACLR (1[10])	dB		45	45	45	45
ACLR (2[11])	dB		60	60	60	60
Add'n filtering	dB		0	0	0	0
Rx						
G_r	dBi	25	11	21		
ACS (1)	dB	27	27	27		
ACS (2)	dB	52	52	52		
Filter	dB	28	28	28		
Feeder loss	dB	0.2	0.2	0.2		
NF	dB	2.5	2.5	2.5		
Receiver noise	dBm	−102.3	−102.3	−102.3		
Allowable *C/I*	dB	6	6	6		
Interference threshold	dB	−108.3	−108.3	−108.3		

[10] 1st adjacent channel.

[11] 2nd adjacent channel.

Attachment 2

Case 1 – ENG Tx interfering with E-UTRA & LTE BS receivers

		No Guardband	**Guardband**			**No Guardband**	**Guardband**			**No Guardband**	**Guardband**
Frequency	MHz	1 980	1 980	Frequency	MHz	1 980	1 980	Frequency	MHz	1 980	1 980
Interferer:				Interferer:				Interferer:			
ENG (Airborne Tx)				ENG (Van Tx)				ENG (WCS Tx)			
P_t	dBm	40	40	P_t	dBm	43	43	P_t	dBm	20	20
G_t	dBi	11	11	G_t	dBi	21	21	G_t	dBi	3	3
e.i.r.p.	dBm	51	51	e.i.r.p.	dBm	64	64	e.i.r.p.	dBm	23	23
ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60	ACLR (2)	dB	n/a	60	ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0	Add'n filtering	dB	0	0	Add'n filtering	dB	0	0
Interfered with:				Interfered with:				Interfered with:			
E-UTRA/LTE BS receivers				E-UTRA /LTE BS receivers				E-UTRA /LTE BS receivers			
G_r	dBi	15	15	G_r	dBi	15	15	G_r	dBi	15	15
ACS (1)	dB	46	n/a	ACS (1)	dB	46	n/a	ACS (1)	dB	46	n/a
ACS (2)	dB	n/a	56	ACS (2)	dB	n/a	56	ACS (2)	dB	n/a	56
Add'n filtering	dB	0	0	Add'n filtering	dB	0	0	Add'n filtering	dB	0	0
NF	dB	5	5	NF	dB	5	5	NF	dB	5	5
Receiver noise	dBm	−103	−103	Receiver noise	dBm	−103	−103	Receiver noise	dBm	−103	−103
Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6
Interference limit	dBm	−109	−109	Interference limit	dBm	−109	−109	Interference limit	dBm	−109	−109
ACIR	dB	42.5	54.5	ACIR	dB	42.5	54.5	ACIR	dB	42.5	54.5
Loss (needed)	dB	132.5	120.5	Loss (needed)	dB	145.5	133.5	Loss (needed)	dB	104.5	92.5
d (for FSL)	km	51.025	12.694	*d* (for FSL)	km	227.922	56.703	*d* (for FSL)	km	2.031	0.505

Case 2 – ENG Tx interfering with E-UTRA & LTE mobile receivers

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (airborne) Tx			
P_t	dBm	40	40
G_t	dBi	11	11
e.i.r.p.	dBm	51	51
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
E-UTRA /LTE mobile receivers			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	100
Add'n filtering	dB	0	0
NF	dB	9	9
Receiver noise	dBm	−99	−99
Allowable *C/I*	dB	6	6
Interference limit	dBm	−105	−105
ACIR	dB	32.7	60.0
Loss (needed)	dB	123.3	96.0
d (for FSL)	km	16.463	0.713

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (Van Tx)			
P_t	dBm	43	43
G_t	dBi	21	21
e.i.r.p.	dBm	64	64
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
E-UTRA /LTE mobile receivers			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	100
Add'n filtering	dB	0	0
NF	dB	9	9
Receiver noise	dBm	−99	−99
Allowable *C/I*	dB	6	6
Interference limit	dBm	−105	−105
ACIR	dB	32.7	60.0
Loss (needed)	dB	136.3	109.0
d (for FSL)	km	73.537	3.186

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (WCS Tx)			
P_t	dBm	20	20
G_t	dBi	3	3
e.i.r.p.	dBm	23	23
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
E-UTRA /LTE mobile receivers			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	100
Add'n filtering	dB	0	0
NF	dB	9	9
Receiver noise	dBm	−99	−99
Allowable *C/I*	dB	6	6
Interference limit	dBm	−105	−105
ACIR	dB	32.7	60.0
Loss (needed)	dB	95.3	68.0
d (for FSL)	km	0.655	0.028

Case 3 – E-UTRA & LTE base stations interfering with ENG receivers

		No guardband	Guardband			No guardband	Guardband			No guardband	Guardband
Frequency	MHz	2 110	2 110	Frequency	MHz	2 110	2 110	Frequency	MHz	2 110	2 110
Interferer:				Interferer:				Interferer:			
E-UTRA /LTE base station Tx				E-UTRA /LTE base station Tx				E-UTRA /LTE base station Tx			
P_t	dBm	43	43	P_t	dBm	43	43	P_t	dBm	43	43
G_t	dBi	17	17	G_t	dBi	17	17	G_t	dBi	17	17
e.i.r.p.	dBm	60	60	e.i.r.p.	dBm	60	60	e.i.r.p.	dBm	60	60
ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	50	ACLR (2)	dB	n/a	50	ACLR (2)	dB	n/a	50
Add'n filtering	dB	0	46	Add'n filtering	dB	0	46	Add'n filtering	dB	0	46
Interfered with:				Interfered with:				Interfered with:			
ENG (central Rx)				ENG (van Rx)				ENG (airborne Rx)			
G_r	dBi	25	25	G_r	dBi	21	21	G_r	dBi	11	11
ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28	Add'n filtering	dB	0	28	Add'n filtering	dB	0	28
NF	dB	2.5	2.5	NF	dB	2.5	2.5	NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3
ACIR	dB	26.9	79.9	ACIR	dB	26.9	79.9	ACIR	dB	26.9	79.9
Loss (needed)	dB	166.4	113.4	Loss (needed)	dB	162.4	109.4	Loss (needed)	dB	152.4	99.4
d (for FSL)	km	2353.055	5.292	*d* (for FSL)	km	1484.677	3.339	*d* (for FSL)	km	469.496	1.056

Case 4 – E-UTRA & LTE mobiles interfering with ENG receivers

		No guardband	**Guardband**
Frequency	MHz	1 980	1 980
Interferer:			
E-UTRA /LTE mobile Tx			
P_t	dBm	24	24
G_t	dBi	0	0
e.i.r.p.	dBm	24	24
ACLR (1)	dB	33	n/a
ACLR (2)	dB	n/a	43
Add'n filtering	dB	0	0
Interfered with:			
ENG (central Rx)			
G_r	dBi	25	25
ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28
NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3
ACIR	dB	26.0	43.0
Loss (needed)	dB	131.3	114.3
d (for FSL)	km	44.106	6.250

		No guardband	**Guardband**
Frequency	MHz	1 980	1 980
Interferer:			
E-UTRA /LTE mobile Tx			
P_t	dBm	24	24
G_t	dBi	0	0
e.i.r.p.	dBm	24	24
ACLR (1)	dB	33	n/a
ACLR (2)	dB	n/a	43
Add'n filtering	dB	0	0
Interfered with:			
ENG (van Rx)			
G_r	dBi	21	21
ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28
NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3
ACIR	dB	26.0	43.0
Loss (needed)	dB	127.3	110.3
d (for FSL)	km	27.829	3.943

		No guardband	**Guardband**
Frequency	MHz	1 980	1 980
Interferer:			
E-UTRA /LTE mobile Tx			
P_t	dBm	24	24
G_t	dBi	0	0
e.i.r.p.	dBm	24	24
ACLR (1)	dB	33	n/a
ACLR (2)	dB	n/a	43
Add'n filtering	dB	0	0
Interfered with:			
ENG (airborne Rx)			
G_r	dBi	11	11
ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28
NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3
ACIR	dB	26.0	43.0
Loss (needed)	dB	117.3	100.3
d (for FSL)	km	8.800	1.247

Case 5 – ENG Tx interfering with WiMAX base station receivers

		No guardband	Guardband			No guardband	Guardband			No guardband	Guardband
Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300
Interferer:				Interferer:				Interferer:			
ENG (airborne Tx)				ENG (van Tx)				ENG (WCS Tx)			
P_t	dBm	40	40	P_t	dBm	43	43	P_t	dBm	20	20
G_t	dBi	11	11	G_t	dBi	21	21	G_t	dBi	3	3
e.i.r.p.	dBm	51	51	e.i.r.p.	dBm	64	64	e.i.r.p.	dBm	23	23
ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a	ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60	ACLR (2)	dB	n/a	60	ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0	Add'n filtering	dB	0	0	Add'n filtering	dB	0	0
Interfered with:				Interfered with:				Interfered with:			
WiMAX receivers				WiMAX receivers				WiMAX receivers			
G_r	dBi	15	15	G_r	dBi	15	15	G_r	dBi	15	15
ACS (1)	dB	46	n/a	ACS (1)	dB	46	n/a	ACS (1)	dB	46	n/a
ACS (2)	dB	n/a	56	ACS (2)	dB	n/a	56	ACS (2)	dB	n/a	56
Add'n filtering	dB	0	0	Add'n filtering	dB	0	0	Add'n filtering	dB	0	0
NF	dB	5	5	NF	dB	5	5	NF	dB	5	5
Receiver noise	dBm	−104	−104	Receiver noise	dBm	−104	−104	Receiver noise	dBm	−104	−104
Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6
Interference limit	dBm	−110	−110	Interference limit	dBm	−110	−110	Interference limit	dBm	−110	−110
ACIR	dB	42.5	54.5	ACIR	dB	42.5	54.5	ACIR	dB	42.5	54.5
Loss (needed)	dB	133.5	121.5	Loss (needed)	dB	146.5	134.5	Loss (needed)	dB	105.5	93.5
d (for FSL)	km	49.286	12.261	*d* (for FSL)	km	220.152	54.770	*d* (for FSL)	km	1.962	0.488

Case 6 – ENG Tx interfering with WiMAX terminals

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (airborne) Tx			
P_t	dBm	40	40
G_t	dBi	11	11
e.i.r.p.	dBm	51	51
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
WiMAX terminals			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	47
Add'n filtering	dB	0	0
NF	dB	5	5
Receiver noise	dBm	−102	−102
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108	−108
ACIR	dB	32.7	46.8
Loss (needed)	dB	126.3	112.2
d (for FSL)	km	23.254	4.611

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (van Tx)			
P_t	dBm	43	43
G_t	dBi	21	21
e.i.r.p.	dBm	64	64
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
WiMAX terminals			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	47
Add'n filtering	dB	0	0
NF	dB	5	5
Receiver noise	dBm	−102	−102
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108	−108
ACIR	dB	32.7	46.8
Loss (needed)	dB	139.3	125.2
d (for FSL)	km	103.873	20.599

		No guardband	Guardband
Frequency	MHz	2 110	2 110
Interferer:			
ENG (WCS Tx)			
P_t	dBm	20	20
G_t	dBi	3	3
e.i.r.p.	dBm	23	23
ACLR (1)	dB	45	n/a
ACLR (2)	dB	n/a	60
Add'n filtering	dB	0	0
Interfered with:			
WiMAX terminals			
G_r	dBi	0	0
ACS (1)	dB	33	n/a
ACS (2)	dB	n/a	47
Add'n filtering	dB	0	0
NF	dB	5	5
Receiver noise	dBm	−102	−102
Allowable *C/I*	dB	6	6
Interference limit	dBm	−108	−108
ACIR	dB	32.7	46.8
Loss (needed)	dB	98.3	84.2
d (for FSL)	km	0.926	0.184

Case 7 – WiMAX base stations interfering with ENG receivers

		No guardband	Guardband			No guardband	Guardband			No guardband	Guardband
Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300
Interferer:				Interferer:				Interferer:			
WiMAX base station Tx				WiMAX base station Tx				WiMAX base station Tx			
P_t	dBm	36	36	P_t	dBm	36	36	P_t	dBm	36	36
G_t	dBi	18	18	G_t	dBi	18	18	G_t	dBi	18	18
e.i.r.p.	dBm	54	54	e.i.r.p.	dBm	54	54	e.i.r.p.	dBm	54	54
ACLR (1)	dB	53.5	n/a	ACLR (1)	dB	53.5	n/a	ACLR (1)	dB	53.5	n/a
ACLR (2)	dB	n/a	66	ACLR (2)	dB	n/a	66	ACLR (2)	dB	n/a	66
Add'n filtering	dB	0	24	Add'n filtering	dB	0	24	Add'n filtering	dB	0	24
Interfered with:				Interfered with:				Interfered with:			
ENG (Central Rx)				ENG (Van Rx)				ENG (Airborne Rx)			
G_r	dBi	25	25	G_r	dBi	21	21	G_r	dBi	11	11
ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28	Add'n filtering	dB	0	28	Add'n filtering	dB	0	28
NF	dB	2.5	2.5	NF	dB	2.5	2.5	NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3
ACIR	dB	27.0	79.6	ACIR	dB	27.0	79.6	ACIR	dB	27.0	79.6
Loss (needed)	dB	160.3	107.7	Loss (needed)	dB	156.3	103.7	Loss (needed)	dB	146.3	93.7
d (for FSL)	km	1074.627	2.520	*d* (for FSL)	km	678.044	1.590	*d* (for FSL)	km	214.416	0.503

Case 8 – WiMAX mobiles interfering with ENG receivers

		No guardband	**Guardband**			**No guardband**	**Guardband**			**No guardband**	**Guardband**
Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300	Frequency	MHz	2 300	2 300
Interferer:				Interferer:				Interferer:			
WiMAX mobile Tx				WiMAX mobile Tx				WiMAX mobile Tx			
P_t	dBm	24	24	P_t	dBm	24	24	P_t	dBm	24	24
G_t	dBi	0	0	G_t	dBi	0	0	G_t	dBi	0	0
e.i.r.p.	dBm	24	24	e.i.r.p.	dBm	24	24	e.i.r.p.	dBm	24	24
ACLR (1)	dB	33	n/a	ACLR (1)	dB	33	n/a	ACLR (1)	dB	33	n/a
ACLR (2)	dB	n/a	43	ACLR (2)	dB	n/a	43	ACLR (2)	dB	n/a	43
Add'n filtering	dB	0	0	Add'n filtering	dB	0	0	Add'n filtering	dB	0	0
Interfered with:				Interfered with:				Interfered with:			
ENG (central Rx)				ENG (van Rx)				ENG (airborne Rx)			
G_r	dBi	25	25	G_r	dBi	21	21	G_r	dBi	11	11
ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a	ACS (1)	dB	27	n/a
ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52	ACS (2)	dB	n/a	52
Add'n filtering	dB	0	28	Add'n filtering	dB	0	28	Add'n filtering	dB	0	28
NF	dB	2.5	2.5	NF	dB	2.5	2.5	NF	dB	2.5	2.5
Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3	Receiver noise	dBm	−102.3	−102.3
Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6	Allowable *C/I*	dB	6	6
Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3	Interference limit	dBm	−108.3	−108.3
ACIR	dB	26.0	43.0	ACIR	dB	26.0	43.0	ACIR	dB	26.0	43.0
Loss (needed)	dB	131.3	114.3	Loss (needed)	dB	127.3	110.3	Loss (needed)	dB	117.3	100.3
d (for FSL)	km	37.969	5.380	*d* (for FSL)	km	23.957	3.395	*d* (for FSL)	km	7.576	1.074

Attachment 3

Summary of calculated separation distances[12]

		Separation distances (km)			
Scenario	**Ref.**	**Central Rx**	**Airborne**	**Van link**	**WCS**
ENG Tx into IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE base stations	Case 1	N/A	12.7	56.7	0.55
ENG Tx into IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE mobiles	Case 2	N/A	0.71	3.2	0.03
IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE base stations into ENG Rx	Case 3	5.3	3.3	1.06	N/A
IMT-2000 CDMA Direct Spread (UTRAN or WCDMA)/LTE mobiles into DENG Rx	Case 4	6.25	3.94	1.25	N/A
ENG Tx into WiMAX base stations	Case 5	N/A	12.3	54.8	0.49
ENG Tx into WiMAX mobiles	Case 6	N/A	4.6	20.6	0.18
WiMAX base stations into ENG Rx	Case 7	2.5	1.6	0.5	N/A
WiMAX mobiles into ENG Rx	Case 8	5.4	3.4	1.07	N/A

[12] The separation distances have been calculated based on the use of a 5 MHz guardband between the ENG and IMT systems.

8 Methodology for capturing spectrum mask of IMT and DENG transmissions in the 2.1 GHz and 2.5 GHz bands

This study outlines a methodology applied to analyse some of the sharing and compatibility issues between IMT operating in bands adjacent to frequency bands and tuning ranges which are currently used for ENG or have potential for ENG use. It documents the results and analysis that have been carried out to assess the feasibility of adjacent band-sharing scenarios.

A number of scenarios particularly in regard to the discussion on potential tuning ranges for ENG which includes several tuning ranges that incorporate spectrum bands that had been identified for IMT in the Radio Regulations, are considered.

The methodology used in this preliminary study to evaluate band edge compatibility between DENG and its spectrum neighbours is well established in similar ITU-R studies.[13] [14]

The DENG system under study is standard definition operating in an 8 MHz channel, whereas the adjacent band mobile telecommunications services operate on a nominal 5 MHz channel.

It is noted the assumptions anticipate that guardbands will be required between DENG and adjacent IMT-2000 services. The existence of a 5 MHz guardband alone provides some benefit, but the benefit is limited.

This study takes as its starting point the assumption that guardbands of 5 MHz (at least) will be required. The results discussed in section 7 of the working document toward a preliminary draft new Report are of principal interest as are those relating to the “second adjacent channel” performance, i.e. the situation pertaining to the spectrum that lies between 5 and 10 MHz from the band edge. Whilst the existence of a 5 MHz guardband alone may not be sufficient to control band edge interference it does provide the guard space in which it may be practical to implement additional filtering.

Within many administrations a significant feature of the design of modern digital news gathering systems are the fixed “collection stations” in major city areas where broadcast network operators consolidate ENG transmissions from multiple nomadic operations over a large (up to 100 km radius) area often involving unplanned daily news gathering events (refer Report ITU-R BT.2069 section 7.2).

A measure considered in this study is to reduce interference to key ENG receiving collection stations by additional filtering for IMT-2000 base stations in the vicinity of an ENG collection station.

8.1 Objective

The objective of this measurement field study was to investigate the general characteristics and out-of-band emissions of IMT (existing UMTS base stations) and DENG equipment in 2.1 GHz band and 2.5 GHz bands, respectively.

Electronic news gathering is a dynamic and non-planned event. In order to capture the characteristics of DENG signals typical in densely populated locations where the incidence of DENG coverage and mobile telephone coverage are likely to occur simultaneously, the measurement field study was undertaken in the Australian city of Sydney. In addition a portable spectrum analyser, Anritsu

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[13] Report ITU-R M.2146 – Coexistence between IMT-2000 CDMA-DS and IMT-2000 OFDMA-TDD-WMAN in the 2 500-2 690 MHz band operating in adjacent bands in the same area.

[14] Report ITU-R M.2113-1 – Sharing studies in the 2 500-2 690 MHz band between IMT-2000 and fixed broadband wireless access systems including nomadic applications in the same geographical area.

spectrum analyser (Spectrum Master MS2711D), was deployed that would facilitate minimum delay by comparison to a bulkier laboratory equipment that may also require mains power operation.

8.2 Pre-measurements

8.2.1 Background on IMT base stations (2.1 GHz band)

There are two spectrum licensees, i.e. Vodafone and Vodafone-Hutchison Australia (VHA, formerly Hutchison THREE) that operate UMTS networks in the frequencies immediately adjacent to the candidate ENG alternate bands (e.g. above 2 170 MHz and below 2 110 MHz).

VHA was granted the spectrum licence to operate in a few frequency bands and one of them is 2 110-2 125 MHz in five Australian cities, i.e. Sydney, Melbourne, Brisbane, Adelaide and Perth.

VHA also has downlink configurations in 2 110.05-2 124.95 MHz and/or 2 110.605-2 114.595 MHz in some areas in Sydney.

The field survey location selected for this study is the urban/suburban area of Mosman in Sydney where the UMTS network is covered by the base stations as specified and mapped out in Table 7 and Fig. 28.

After assessing each base station and its surrounding locations based on access and parking measurements were undertaken at 14 Thrupp Street in order to monitor the base station at 112 Kurraba Road, Neutral Bay.

FIGURE 26

Base station at 112 Kurraba Road

FIGURE 27

Measurement spot at 14 Thrupp Street

TABLE 7

VHA Base Stations in Mosman/Cremorne/Neutral Bay NSW

			Downlink 2 110.05-2 124.95 MHz Bandwidth 14.9 MHz			**Downlink 2 110.605-2 114.595 MHz Bandwidth 3.99 MHz**		
Site ID	**Lat/Long (Google Earth)**	**Site Name**	**Height (m)**	**Tx Power/e.i.r.p. (W)**	**Azimuth (degree)**	**Height (m)**	**Tx Power/e.i.r.p. (W)**	**Azimuth (degree)**
203046	33 49 43 S 151 13 46 E	Optus Site 287 Military Rd CREMORNE JUNCTION	23 26 23	200/NA 200/NA 200/NA	30 170 250			
201738	33 49 49 S 151 13 43 E	Metropole Hotel 287-305 Military Rd CREMORNE JUNCTION				23.7 26.3 23.7	20/41.9 20/42.4 20/41.5	30 160 250
101010	33 49 29 S 151 14 25 E	CMTS Site Bridgepoint Centre Military Rd & Vista St MOSMAN				18.5 18.5 18.5	20/41.1 20/41.1 20/40.2	20 125 255
53741	33 49 46 S 151 13 05 E	CMTS Site 116 Military Rd NEUTRAL BAY				30 30 30	20/41.7 20/41.4 20/42.7	80 190 310
206059	33 50 26 S 151 14 02 E	Hutchison Site Rooftop 40 Raglan St MOSMAN				24.1 24.1 24.1	20/44.8 20/45.3 20/45.8	10 80 290
204008	33 50 23 S 151 13 14 E	CMTS Site 112 Kurraba Rd NEUTRAL BAY	25	200/NA	350	25.2 25.2 25.2	0.10/20.2 0.10/20.2 0.10/20.2	0 90 240
206083	33 49 50 S 151 12 50 E	Monopole RTA Corridor Cnr Falcon St and Warringah Fwy - Bridge & tunnel Onramp				12 12 12	20/45.6 20/45.6 20/45.6	100 220 350

FIGURE 28

Base stations mapping at Mosman/Cremorne/Neutral Bay area

8.2.2 DENG equipment (2.5 GHz band)

For many decades the band 2 500-2 690 MHz has been assigned as a frequency range used by DENG and television outside broadcast applications.

There are different configurations for DENG operations. This preliminary study covers some of the common configurations.

DENG transmissions for this field study were operated at 100 mW output power in frequency range 2 642.5-2 650.5 MHz (centre carrier at 2 646.5 MHz) and two combinations of transmit antennas and transmitters were measured:

Case 1: DENG Portable Link with Rod Antenna.

Case 2: Wireless Backpack Camera Unit with "Spring" Mount Antenna.

Both are typical of DENG operations in Australia.

8.2.3 Field measurement equipment

1) Anritsu spectrum analyser (Spectrum Master MS2711D).
2) Panel antenna in the band 1 710-2 170 MHz, for typical IMT base station use.
3) 10 m SPUMA 400-FR cable.
4) DENG rod antenna, typically use as transmit antenna at fixed location.
5) DENG mount antenna, typically use as transmit/receive antenna on wireless camera.

8.3 Methodology and results

8.3.1 Measurement methodology

The objective was to measure field strength and the corresponding out-of-band emissions from the reference IMT and DENG systems transmission(s). To achieve this objective, the following readings were recorded during the measurements:

IMT base station

– Channel power (dBm per *BW* MHz) within the desired signal bandwidth.
– Spectrum plot of at least 5 MHz offset from band edges (both ends) of the measured signals to observe out-of-band emission.
– Measurements taken at one fixed location within proximity and LoS to the base station.

DENG transmission

– Channel power (dBm per *BW* MHz) within the desired signal bandwidth.
– Spectrum plot of at least 5 MHz offset from band edges (both ends) of the measured signals to observe out-of-band emission.
– Multiple measurements taken with transmit and receive antennas at 30 cm, 1 m, 2 m and 3 m apart.

8.3.2 Measurements in 2.1 GHz band

Figures 29 and 30 show the spectrum plot captured at 14 Thrupp Street with the panel antenna (1 710-2 170 MHz) at ground level facing directionally to the targeted base station, measured approximately 100 m from the base station antennas.

FIGURE 29

Measurement at 14 Thrupp Street (1.5 m above ground level)

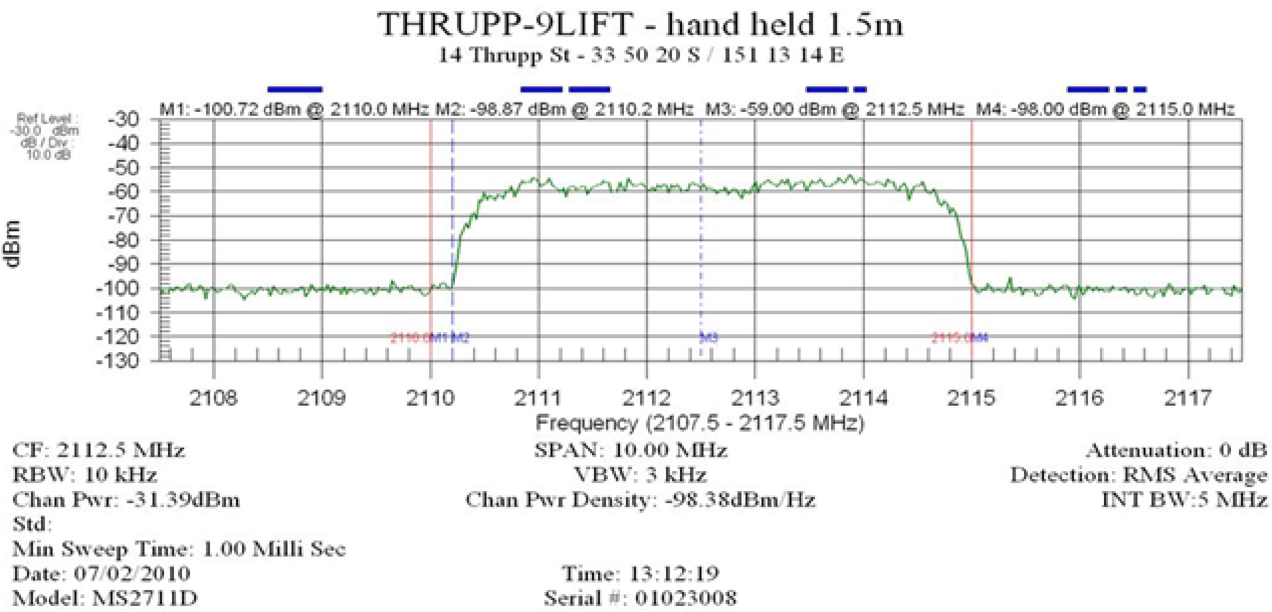
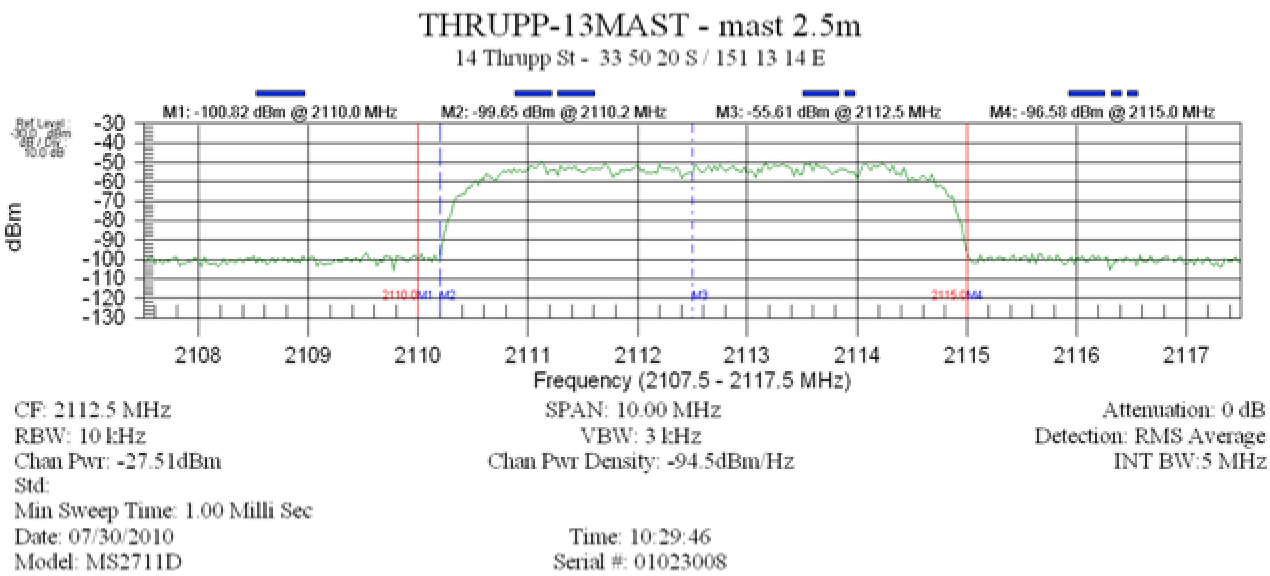


FIGURE 30

Measurement at 14 Thrupp Street (2.5 m above ground level)



Preliminary observations – As anticipated, the levels received varied significantly at different heights. This factor will need to be taken into account in sharing studies. The UMTS downlink signal is not positioned at the centre of the 5 MHz channel, but with a 200 kHz offset from the band edge (2 110 MHz). This results in additional spectral space or for a guard against out-of-band emissions into an adjacent frequency band. This may assist adjacent band operation with DENG systems. Further study with laboratory equipment may confirm these results.

The noise figure of a DENG receiver is 2.5 dB. In an 8 MHz channel bandwidth, this equates to a noise power of −102.3 dBm. Allowing degradation in link margin of 1 dB due to interference, it requires the interference level to be 6 dB below the noise power level, i.e. −108.3 dBm.

From Fig. 5, the carrier power level received is −27.5 dBm (in a 5 MHz bandwidth) and the spectrum analyser noise density is 45 dB below the carrier level. It is noted that the adjacent noise power from the base station is not known (not measureable from the spectrum analyser), but it would expected to be below the measurement limit of the spectrum analyser, i.e. channel power at a level of $-27.5 - 45 + 10 \log (8/5) = -70.5$ dBm (in an 8 MHz bandwidth) or less.

To be below the allowable interference level to a DENG receiver, the noise power of the base station at this location would need to be $-70.5 - (-108.3) = 38$ dB below the spectrum analyser noise level or 83 dB below the carrier level if IMT and DENG systems were to operate in adjacent channels. Further study on the out of band emissions of implemented IMT systems is therefore required.

8.3.3 Measurements in 2.5 GHz band

As stated previously DENG systems have been operating in Australia for many decades the band 2 500-2 690 MHz for coverage of news events and television outside broadcast applications. Figures 31 and 32 indicate the test configuration for capturing the spectrum lots of the DENG signals.

FIGURE 31

DENG portable link transmission within proximity to a mount antenna typically use in a backpack wireless camera (30 cm-as shown, 1 m, 2 m and 3 m)

FIGURE 32

DENG transmission from mount antenna to emulate a backpack wireless camera

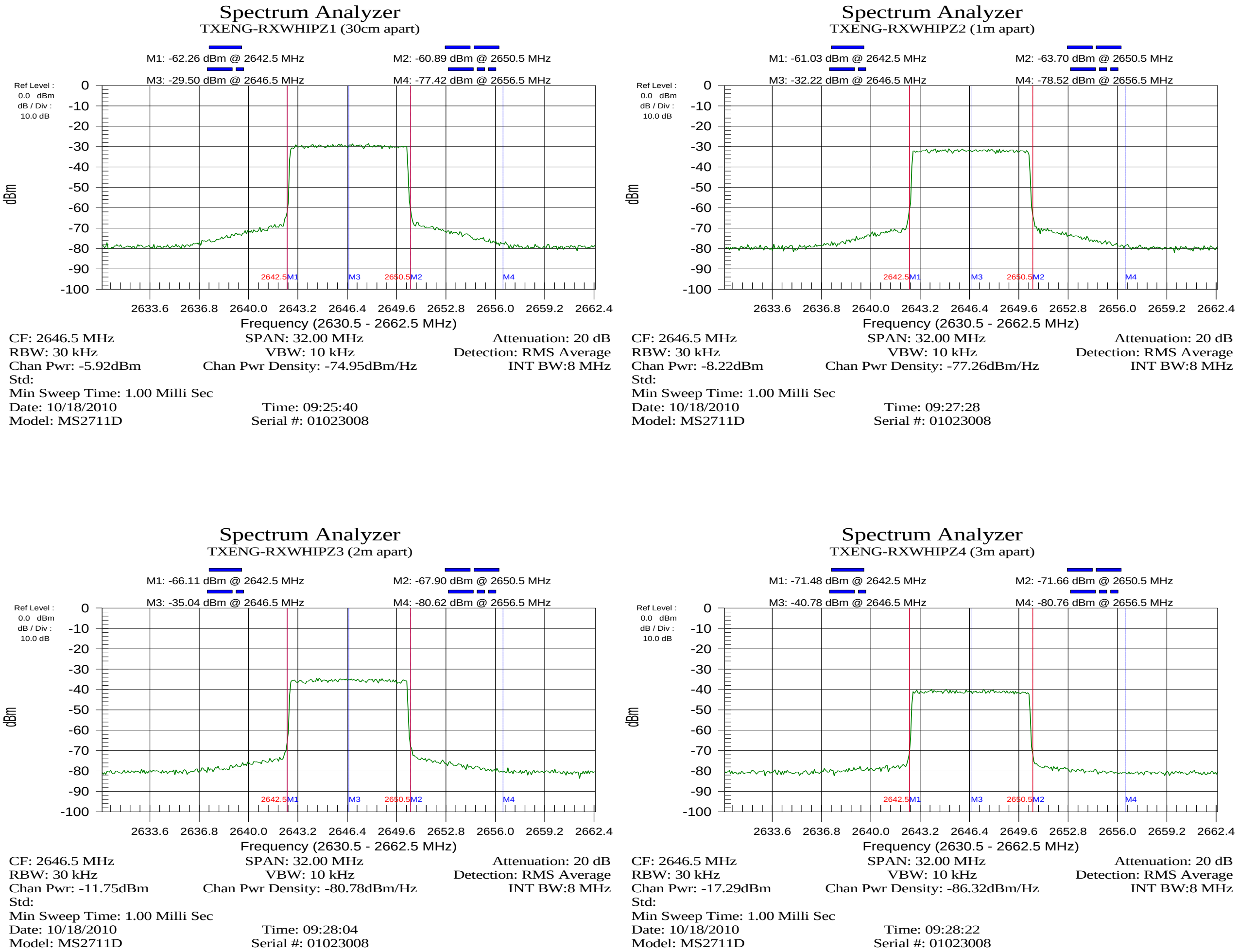
Case 1: DENG Signals from a DENG portable link with rod antenna

Transmit − DENG portable link with rod antenna.

Receive − Mount antenna on a backpack wireless camera.

FIGURE 33

DENG measurements − Tx (rod antenna) and Rx (mount antenna) in 30 cm, 1 m, 2 m and 3 m apart



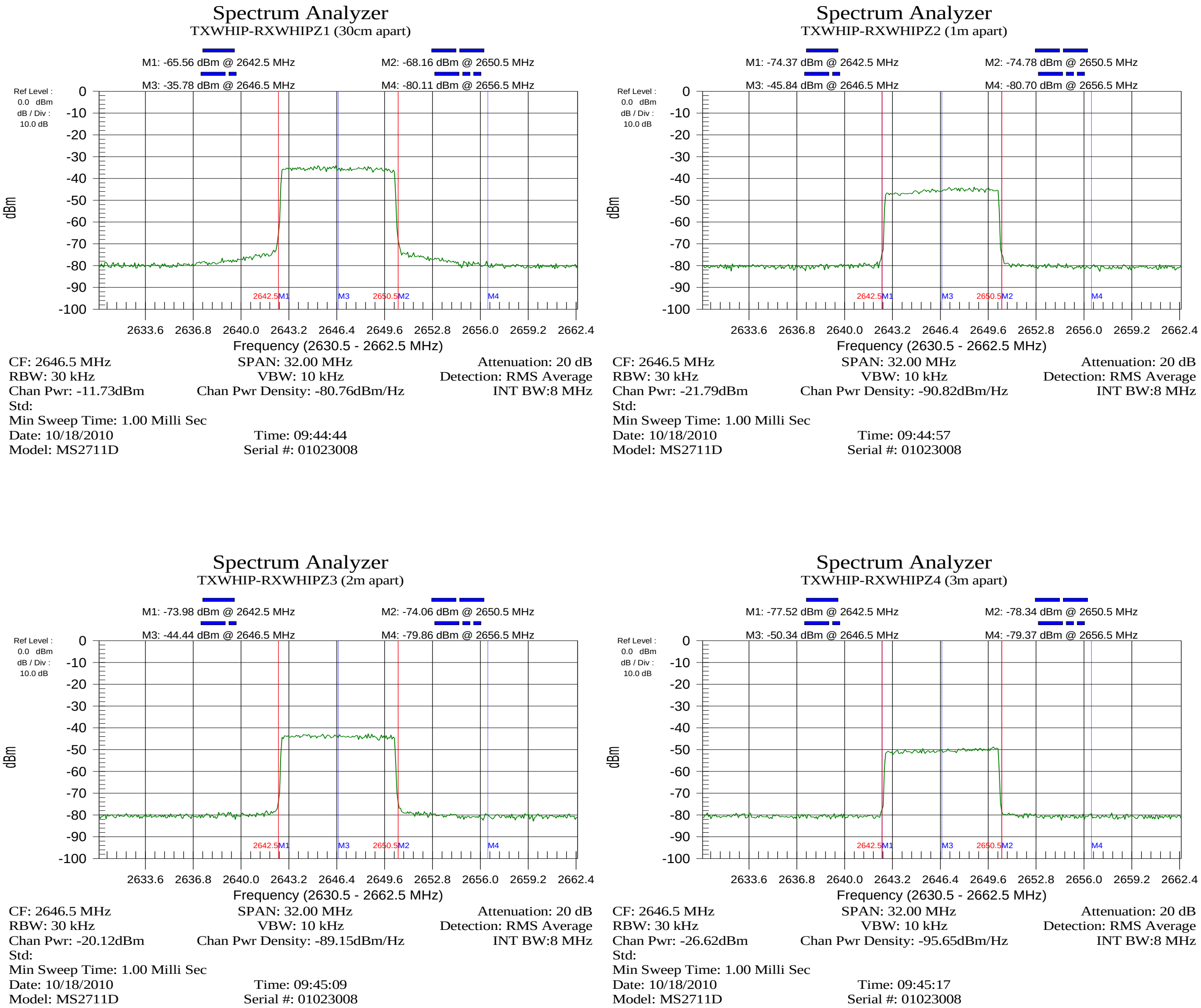
Case 2: DENG signals received from a wireless backpack camera unit with "Spring" mount antenna

Transmit − Spring mount antenna from backpack wireless camera.

Receive − Mount antenna on the rooftop of OB van.

FIGURE 34

DENG measurements − Tx (mount antenna) and Rx (mount antenna) in 30 cm, 1 m, 2 m and 3 m apart



Preliminary observations – Figures 33 and 34 indicate that the DENG systems signals are positioned within the 8 MHz channel. As DENG systems are dynamic in nature and have to operate on different frequencies, channel filtering is not possible, but filtering at the edges of operational bands is possible. These plots indicate that the systems out-of-band emissions conform to the DVB-T modulation mask of ETSI EN 300 744, whereby emissions in the adjacent band are approximately 40 dB below the carrier spectrum and falling further away from the carrier centre frequency.

Some scenarios may require out of band mitigation techniques such as increased filtering. This may assist adjacent band operation with IMT systems. Further study is required into the discrimination between circular and linear polarization that further reduces the likelihood of interference from DENG into IMT.